“Sectorial analysis of the long-term dynamics of business R&D intensity”

In relation to (DG-RTD-2005-M-02-01):

“Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators”

Final Report
Revised version

Technopolis Group (assignment manager)
Idea Consult (coordinator)
SPRU, NIFU STEP

Brussels, 12 November 2009
# Table of contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>3</td>
</tr>
<tr>
<td>1 Introduction</td>
<td>1</td>
</tr>
<tr>
<td>2 Methodology</td>
<td>2</td>
</tr>
<tr>
<td>2.1 Data availability</td>
<td>2</td>
</tr>
<tr>
<td>2.2 Methodological framework for analysis</td>
<td>2</td>
</tr>
<tr>
<td>2.3 Survey of cases to refine BERD analysis</td>
<td>3</td>
</tr>
<tr>
<td>2.3.1 Analytical framework for the survey</td>
<td>3</td>
</tr>
<tr>
<td>2.3.1.1 Selection of case studies examined through the Survey</td>
<td>3</td>
</tr>
<tr>
<td>3 Literature Survey of the factors driving R&amp;D intensity</td>
<td>5</td>
</tr>
<tr>
<td>3.1 The micro level: Drivers from within the firm or organization</td>
<td>6</td>
</tr>
<tr>
<td>3.2 The meso level: Drivers from the industry</td>
<td>9</td>
</tr>
<tr>
<td>3.3 Drivers from the market</td>
<td>10</td>
</tr>
<tr>
<td>3.4 Endowments and location</td>
<td>13</td>
</tr>
<tr>
<td>3.5 The macro level: Public policies</td>
<td>14</td>
</tr>
<tr>
<td>3.6 International comparisons at sectoral level</td>
<td>17</td>
</tr>
<tr>
<td>3.7 Research propositions</td>
<td>26</td>
</tr>
<tr>
<td>4 Major trends in BERD based on the collection of statistics and calculation of indicators</td>
<td>27</td>
</tr>
<tr>
<td>4.1 Main BERD trends for the EU27</td>
<td>28</td>
</tr>
<tr>
<td>4.2 &quot;Successful&quot; and &quot;Unsuccessful&quot; countries based on statistical analysis of BERD</td>
<td>28</td>
</tr>
<tr>
<td>4.3 BERD in Europe and its comparison with other third countries</td>
<td>29</td>
</tr>
<tr>
<td>5 Main findings on BERD trends based on the survey of country and sectoral case studies</td>
<td>30</td>
</tr>
<tr>
<td>5.1 Summary of main findings for each case</td>
<td>30</td>
</tr>
<tr>
<td>5.2 Summary of identified BERD drivers</td>
<td>34</td>
</tr>
<tr>
<td>6 Conclusions and policy lessons</td>
<td>42</td>
</tr>
<tr>
<td>6.1 Conclusions and policy lessons from case studies</td>
<td>42</td>
</tr>
<tr>
<td>6.2 Identified policy measures driving BERD in selected countries and sectors</td>
<td>45</td>
</tr>
<tr>
<td>7. Bibliography</td>
<td>50</td>
</tr>
<tr>
<td>List of annexes</td>
<td>58</td>
</tr>
</tbody>
</table>
Foreword

This Final report has been prepared in the context of the RINDICATE Framework Contract assignment "Progress towards the 3% target: an analysis of the longterm dynamics of business R&D intensity".

Lorena Rivera León and Alasdair Reid (Technopolis) have prepared this report based on the contributions of:

- Pari Patel and Nick Von Tunzelmann (SPRU, University of Sussex)
- Mark Knell (NIFU STEP), and
- Vincent Duchene (IDEA Consult)

Activities were performed as follows:

- Nick Von Tunzelmann was in charge of the Literature Review
- Pari Patel and Mark Knell were in charge of the Collection of Statistics and the Calculation of Indicators
- Lorena Rivera León coordinated the production of case studies and assured overall co-ordination of the inputs of other experts.

The following experts performed the case studies:

- The pharmaceutical sector in Belgium, Vincent Duchene and Eveline Durinck (IDEA Consult)
- The automotive industry in Germany, Hannes Leo (Technopolis Group)
- The ICT industry and the radio, television and communications equipment sector in Sweden, Rurik Holmberg (Technopolis Group)
- The ICT sector in Finland, Rurik Holmberg (Technopolis Group)
- The telecommunications services sector in Spain, Lorena Rivera León (Technopolis Group)
- The chemicals sector in Poland, Thomasz Jerzyniak (Technopolis Group)
- The aerospace industry and the radio, TV and communication equipment sectors in Italy, Alessandro Muscio
- BERD in Ireland, John Clark (Technopolis Group)
- The ICT sector in Estonia; Katrin Mannik, Rutta Rannala and Alasdair Reid (Technopolis Group)
- The aerospace industry in France, Lorena Rivera León (Technopolis Group)
1 Introduction

This document is the Final Report for the study ‘Sectorial analysis of the long-term dynamics of business R&D intensity’, carried out under Framework Service Contract N° PP-CT-M2-2005-0001. The study builds upon the sector-based analysis of business expenditure on research and development (BERD) dynamics since 1990 for selected Member States developed in the Key Figures 2007 report (European Commission, 2007). The analysis highlighted that the growth of BERD was concentrated in a limited number of sectors in the Member States concerned.

In this context, the purpose of the study was:

• to extend the same kind of analysis to all Member States for which BERD data by sector are available,
• to develop a similar sectorial analysis at EU-27 aggregate level as well as a sectorial comparison of the EU with the US, Japan and China (to the extent data is available),
• for the "successful" countries (in term of BERD growth), to deepen the analysis on the role of the modifications in the industry structure (i.e the sectoral composition of a given national economy) in the growths of BERD and of R&D intensity and to analyse which policies have fostered such modifications in the industry structure,
• for the "non-successful" countries (in terms of BERD growth), to analyse for each of them the reasons behind the stagnation or decrease of business R&D intensity,
• to draw policy lessons in relation to the 3% target and the way it has been implemented by the Member States through the setting of national targets.

The study was structured in three phases and seven activities as follows:

• Phase 1. Literature Review, Feasibility study, Collection of Statistics, Calculation of Indicators and Production of an Analytical text (Activities II, III IV, V and VII)
• Phase 2: Survey (Activity VI)
• Phase 3: Final report: production of an analytical text (Activity VII)

As set out in the request for services, this Final Report presents the results of all project activities. The structure of this report is as follows:

• Section 2 presents the methodology used in the study that is a summary of the feasibility study (Activity III) and the methodological framework for the Survey (Activity VI – Phase 2). Both complete activity reports can be found in annexes.
• Section 3 sets out a revised version of the results of the literature review (Activity II); and presents the research propositions based on the literature review, the statistical analysis and the expectations from the case study surveys.
• Section 4 presents the major trends of BERD based on the collection of statistics and indicators (Activity IV and V). All individual country reports can be found in annex.
• Section 5 presents a Synthesis of the main findings on BERD trends based on the Survey and national and sectoral case studies (Activity VI). All 10 case studies can be found as annex.
• Section 6 provides the conclusions and policy lessons.
2 Methodology

2.1 Data availability

The study team compared two databases in order to choose the best one for the statistical analysis: the official business enterprise R&D data (OFFBERD) provided to the OECD by its member countries through the joint OECD/Eurostat R&D survey (Research and Development Statistics, Vol. 2007, release 01, Updated: Aug 2008); and the OECD ANBERD (Analytical Business Enterprise Research and Development) database (2009).

Based on the respective pros and cons of databases and an analysis of data availability and coverage for each of the databases, the study team decided to use the OECD ANBERD (Analytical Business Enterprise Research and Development) database (2009). For a full discussion of this choice see Annex A.1.

2.2 Methodological framework for analysis

One of the key aims of the study was to systematically analyse the evolution of sectoral R&D intensities of EU countries and compare them with US, Japan, Norway, China and Korea. This involved answering two questions:

• Which are the sectors in which R&D intensity has increased per country?
• In relation to the sectors with growing R&D intensity how have their shares in total R&D and total output changed over time?

The methodological approach these questions using ANBERD data was as follows:

1. Choice of sectors: focus on the most important sectors in terms of BERD shares
2. Choice of years
3. Measures (R&D intensity, shares of BERD and value added). Relative importance rather than absolute growth due to problems of R&D prices by sector and country.

Accordingly, each country report is based on graphs and tables that show:

• Trends in BERD shares
• Trends in R&D intensity
• Trends in value added shares
• Comparison of (relative) growth in BERD, value added and R&D Intensity
• Typology of sectors (through tables and/or graphs) based on categorising them according to changes in BERD share and changes in R&D intensity
2.3 Survey of cases to refine BERD analysis

Following the specifications, the objective of the survey is to derive, extend and strengthen explanations for particular identified trends following the data analysis. The survey aims to deepen the analysis of Phase 1 and examine trends and hypotheses based on these results. The role of public policy in influencing the evolution of BERD intensities is of particular interest and hence the survey sought to link BERD trends to policy initiatives, such as the 3% Action Plan.

2.3.1 Analytical framework for the survey

This subsection provides a summary of the methodological framework for Activity VI (Survey). For a detailed methodology see Annex A.2. The survey case studies are structured around three main topics:

- BERD performance and drivers. Reasons for changes in BERD, BERD-intensity and relative performance over time (EU27 comparisons, relative to EU aggregate and international comparisons when possible)
- The role of public policy on BERD performance. The extent to which specific public policies were influential in the observed trends. The focus will be on national and regional policies, national structural funds, EU Framework Programmes and other EU funding (by order of focus importance).
- Policy recommendations. The extent to which desirable/undesirable changes can be encouraged/reversed given the degree of efficacy of public policies and the potential of BERD changes due to national R&D resources, absorptive capacities, etc.

Main themes of analysis

The case studies analysed through the survey are structured in four main sections:

- Statistical overview
- Analytical overview of BERD trends: drivers, obstacles, and their different components
- Policy context analysis
- Lessons learned and uniqueness of case study

2.3.1 Selection of case studies examined through the Survey

Four selection criteria were used for identifying the proposed sample of case studies:

- ‘Best’ and ‘Worst’ performers. Sectors and countries according to BERD expenditures and BERD intensity, in order to identify key drivers and obstacles.
- Mixture of high-tech and medium-high tech sectors. Both sectors are studied in the light of the relative importance of the latter sectors in the EU economy.
• Mixture of large and small countries (including New Member States). Even though small countries are biased (one single company can make the difference with respect the sector-specific BERD), the fact remains that EU consists mostly of small countries.

• Level of development of the research system. Some small countries have experienced impressive growth rates in the last years, but this is mainly because of the low level of development of private research in the country. The cases will look at countries that were able to grow substantially, starting from an existing level of BERD intensity.

Via a telephone, and whenever possible a face-to-face survey of some 50 experts in total using a standard list of interview questions (see Annex A.2), ten sectoral/country cases were developed. These are:

• The pharmaceutical sector in Belgium
• The automotive sector in Germany
• The ICT industry and the Radio, television and communication equipment in Sweden
• The ICT industry in Finland
• The telecommunications services sector in Spain
• The chemicals sector in Poland
• The Aerospace and radio, TV and communication equipment sectors in Italy
• BERD in Ireland
• The ICT sector in Estonia
• The Aerospace industry in France

The accompanying material such as the case study template, the case study guide, and the survey guideline are included in Annex A.2.
3 Literature Survey of the factors driving R&D intensity

Drivers of R&D intensity, in any of its variants (expenditures, investments, activities, and so on), could be enhanced from within the firm, from the industry, from market pressures, from public policies, by locational factors and institutional characteristics, as well as any combination of these. A multiplicity of social sciences perspectives have raised these issues, at least in the context of 'innovation', including economics, geography, history, political science, management and business studies, as well as 'innovation studies' itself. Since a detailed comprehensive survey of all these drivers would greatly outstretch our resources, we limit our survey primarily to studies that cast light on sectoral differences in R&D intensity.

A first clarification is that R&D intensity can be measured differently, not only according to the level of analysis (firm, industry, nation), but also to the characteristics and controls over the variables assessed (intensity relative to sales, employees, assets, profitability, etc.). In this light, we focus on some of the main empirical (rather than theoretical) contributions to understanding what drives R&D intensity in sectors and the forms of organization that affect them, especially though not exclusively in the EU and its member states. First, we need to clarify what is meant by a 'sector'.

Defining and measuring 'sectors'

Most studies, especially those by economists, appear to regard the definition of the 'sector' as unproblematic – other than perhaps some straightforward issues relating to the level of aggregation. With this view we here strongly disagree. To the economist the issues in formal terms amount to appraising the cross-elasticities of transformation (from the product/consumer side) and the cross-elasticities of substitution (from the technology/producer side) – a reasonable assessment; but little empirical work has been carried out in this respect (though see Sutton, 1991, 1998), and in any case what happens if the two sets of cross-elasticities are in conflict?

There indeed appears to lie a distinction between the 'sector' as envisaged from the supply side – traditionally inputs of materials but nowadays more often of technology (e.g. the 'biotechnology sector' or the 'ICT sector') – and those observed from the demand side of the product structure (e.g. the 'food and beverages sector'). In times gone by the two sides of technology and product could largely be matched, but this is no longer the case, especially in so-called 'high-tech' areas – think of the biotechnology as being split between 'red biotech' (applications to pharmaceuticals etc.) and 'green biotech' (applications to food etc.), to say nothing of 'grey biotech' (for industry), 'white biotech' (for environmental clean-up), and no doubt other colours. Thus the biotech 'sector' as seen from the supply side of technology has quite a high degree of homogeneity (highly elastic cross-substitution), basically held together by the near-ubiquity of DNA sequencing in relevant research in the modern era, but seen from the demand side its products appear very heterogeneous (inelastic cross-transformation) and spread across low-tech as well as high-tech industries. The situation for the ICT 'sector' – nowadays qualifying as a 'general-purpose technology' (Bresnahan & Trajtenberg, 1995; Helpman, 1998; Lipsey et al., 2005) – is even less coherent. Conversely, all 'low-tech' sectors of the present day have some high-tech niches and impacts from advanced technologies – thus the food industry today obtains significant technological inputs from
biotechnology, pharmaceuticals, nanotechnology, smart materials, lasers, etc., characterised by low cross-elasticities of (research) substitution.

The customary OECD industry categories of ‘high-tech’, ‘medium-high’, etc. (Hatzichronoglou, 1997), are themselves limited by having a largely product-based focus, and packaging together many different segments with differing degrees as well as kinds of technological content. The more recent FTSE-based schema of industries (the ICB classification) is less of a compromise, as a clearer reflection of the product side, but by doing this it distances itself yet further from any close alignment with technologies and thus with R&D. Different ways of categorizing the industrial activities (by demand content, by technology content, by skills content, etc.) lead to very different scales for advanced vs. lagging sectors (Peneder, 2003; von Tunzelmann & Acha, 2005). The classic Pavitt taxonomy (1984) was intended to be a supply-side schema to set against product-focused classifications like the OECD’s, but the links between the two have subsequently become far more complex. For example, Leiponen & Drejer (2007) show that, for Finland and Denmark, there is little or no correspondence between the Pavitt categories and modes of innovation at the industry level, but there is such an association at firm level.

3.1 The micro level: Drivers from within the firm or organization

Many studies focusing on the factors internal to the firm are broadly or loosely based on the ‘Resource Based View’ (RBV) of the firm, since according to this view it is internal factors that ultimately lead firms to success. The main internal factors included in the empirical studies are related to the size of the firm (which has a longer history), its strategies and structure, and its resources.

The size of the firm

A fundamental factor attributable to Schumpeter is the size of the firm. The main notion is that large firms are better endowed (many regard this proposition as ‘late Schumpeter’ (1928), or ‘Schumpeter Mark II’; with the ‘early Schumpeter’ (‘Mark I’) instead stressing the role of entrepreneurial start-ups – see the discussion of ‘sectoral systems of innovation’ below). Empirical studies have argued that larger firms may have more liquidity, and may be more diversified, and more likely to show higher market concentration than smaller firms. This can translate into their ability to diversify risks more easily than smaller firms (Hirschey, 1981).

Furthermore, large firms have more output over which to apply their R&D, inducing higher productivity levels than smaller firms (Cohen & Klepper, 1996). In fact, other studies have discovered that large firms invest more in R&D regardless of R&D productivity levels (Piga & Vivarelli, 2004; Veugelers, 1997), though part of the disparity may arise from the accepted undervaluing of explicit R&D in SMEs (Kleinknecht, 1987). Furthermore there is a substantial debate over the extent of non-linearities in the relationships between R&D/innovation and firm size, or concentration. The pioneering empirical studies by Kamien & Schwartz (1982) reported an inverted-U shaped (quadratic) specification, with R&D intensity ‘maximised’ at medium sizes of firms or levels of concentration, whereas other studies using different indicators have found proper-U shapes (Pavitt et al., 1987, based on ‘numbers of innovations’) or higher polynomial forms (Soete, 1978, based on patents).

The primary issues here are thus, i) the incidence of structural differences across the sectors in terms of inherent size (minimum size thresholds in each sector, cf.
Pratten, 1971); ii) whether there are long-term patterns favouring the progress of (dis)economies of scale in particular sectors. In the former respect, the 'specialized suppliers' category of the Pavitt taxonomy has always been the antithesis of the 'scale intensive' category, and in almost all countries in all periods has been largely populated by SMEs (instruments, machine tools, etc.). On the latter score, the general presumption is that, in the advanced technologies of today, there are path-dependent scale economies in technology operating in some segments, like microprocessors in the semiconductor industry, but not in others like software (where any scale economies arise more in marketing etc.)

**Corporate strategy and structure**

If the business unit belongs to a corporation, its R&D intensity will be heavily determined by the corporate headquarters. If firms stand alone, their business strategies may instead reflect alterations in the product life cycle, e.g. when a product is close to obsolescence, the firm may search for new products or markets, which may lead it to intensify its R&D (Hambrick, Macmillan & Barbosa, 1983). New investment strategies are assumed to drive R&D intensity (Guerard, Bean & Andrews, 1987). Firms may follow short-term and low-risk strategies, thereby undertaking relatively low investments in R&D (Hoskisson & Hitt, 1988).

Strategic diversification is an important factor tending to drive down private R&D expenditures (Hoskisson & Johnson, 1992); thereby R&D activities may be reduced within the firm as a result of complementing R&D assets with those of other firms. The opposite strategy, of ownership concentration, may lead to higher propensity to engage in R&D activities, though Arrow’s classic study of 1962 rejects this on theoretical grounds. Moreover, innovative activities tend to centralise within holding companies, rather than decentralising among subsidiaries (Piga & Vivarelli, 2004). Businesses pursuing diversification strategies of ownership or production and thereby complementary R&D resources may be pursuing more profitable R&D activities (as defined by Gonzalez & Pazo, 2004), with a lesser commitment of resources.

In regard to the impact of mergers and acquisitions (M&A), Cassiman et al. (2003), based on 31 in-depth cases, found that M&A between technologically related companies reduced overall R&D, whereas that between companies related on the demand side (markets) were more ambiguous – if the firms had previously not been rivals in their markets, the results were more positive. However, Hagedoorn & Duysters (2000) are more optimistic about the role of strategic fit and relatedness for M&A in the computer industry, albeit using patents rather than R&D as the measure of technological performance. Contrary to many rather negative findings in this area, Cefis (2009, forthcoming) in a recent analysis of data for the Netherlands finds more positive outcomes; partly she suggests because of a recent upsurge of concern with technology as a driver of M&A activity, and partly because older results were usually based on atypically large M&A operations in stock markets.

A significant critique of the role of the corporate strategy hypothesis found that risk management along with the liquidity and economies of scope were not in any way related to R&D investments (Cohen & Klepper, 1996). To the best of our knowledge, the attempts to compare sectoral patterns of corporate strategy systematically have been mainly by business historians, led by the late Alfred Chandler (1962, 1977, 1990), who traced the 'M-form' (multidivisional system of locating R&D etc. within product divisions in multi-product firms) primarily in scale-intensive and some supplier-dominated activities (especially branded consumer goods). Faced with high volatility in both technologies and products, as would seem to be the case for present-day 'high-tech' industries, such a patterned structure however breaks down. Instead the attention in the strategic
management literature seems to have moved to needs for flexibility and agility, most often perhaps through providing relatively short-lived project teams to cope with new technological and market conditions.

**Resources**

The empirical studies of determinants of R&D expenditures have covered mainly two types, financial and human (knowledge) resources. Internal financial resources are believed to be important; this is especially true for small firms, for whom capital markets are imperfect and therefore hard to access. The availability of internal finance e.g. through cash-flow is therefore the main constraint on small firms and high-tech industries trying to acquire technology through R&D (Barlevy, 2007; Himmelberg & Petersen, 1994; Ughetto, 2008). It has been found that cash-flow helps determine the course of R&D intensity for mature firms as well (Hambrick et al., 1983). Hence, a firm with higher dividends and net working capital (Guerard et al., 1987) should experience less severe financial constraints, driving up R&D intensity, so long as it does not become too complacent. On the basis of some elegant econometric analysis of panel data, Hall et al. (1998) conclude that, “both investment and R&D are more highly sensitive to cash flow and sales in the United States than in France and Japan.”

The same constraints can be experienced by subsidiaries, especially if they have to face tight financial controls, leading to relatively lower investments in R&D. A study based on Italy showed that another important driving financial factor is long-term debt, as it lowers interest rates and allows internal R&D investments (Hoskisson & Hitt, 1988).

However, external funding constraints also limit business R&D expenditures (Czarnitzki, 2006). Much attention has been paid to the allegedly low levels of venture capital funding in the EU member states as compared with those more evident in the USA, especially for the start-up phases of new company formation. Others claim that the basic difference between the US and European situations lies less in the magnitudes of venture or ‘seedcorn’ capital than in the degree of control that the US venture capitalist would expect to exercise over the company it was funding (Steinmueller, 2004). The issue has sectoral significance, in view of the role of venture capital in US high-tech activities, although Asian countries largely find other ways to start up high-tech firms.

Similarly, a major determinant of R&D intensity is R&D productivity, which depends on technological competencies/capabilities (Lee, 2002). Employees (or ‘human resources’) hold the expertise embedded in the firm, which in turn determines its search for innovation, but such expertise can be contingent and random, hence any firm would present a degree of unexplained variation in R&D intensity (Cohen & Klepper, 1992). A useful summary of the rapidly growing field of ‘knowledge management’, from an economist’s point of view, is given in Hall & Mairesse (2006). In regard to ‘entrepreneurship’, Barlevy (2007) argues for a procyclical R&D effect of an entrepreneurial kind (Schumpeter Mark I), on the basis of US macro-level data. For France, Aghion et al. (2008) find that the share of R&D in total investment is usually counter-cyclical, on the basis instead of a large set of firm-level data, though that share becomes increasingly procyclical as credit constraints tighten – a message for our times.

On the other hand, slack organisational processes could well trigger human resources to search for solutions to low performances, driving up investments in R&D (Greve, 2003). A more recent study argues that, notwithstanding, R&D intensifies when a firm’s performance is high (Wu & Tu, 2007); perhaps the difference comes from the fact that those studies were conducted in Japan and in the US respectively. A more managerial explanation is that the latter response, to
good performance is likely to lead to ‘incremental’ or path-dependent changes in technology, whereas the former situation of responding to weak performance may lead sometimes to radical change, to stave off bankruptcy. We are not aware of any concerted efforts in the literature to establish sectoral differences in relation to resource concerns.

3.2 The meso level: Drivers from the industry

It is commonly supposed, e.g. from neoclassical views of the ‘representative firm’, that industries are composed of typical firms, so that a high-tech industry, for instance, is made up largely of high-tech firms. A new study by Kirner et al. (2009) shows that – for the important case of Germany – this is not the case. Although there are relatively more high-tech firms in high-tech industries, the situation across different OECD classes of industries is much more even than might be expected – there are many high-tech firms in medium-high, medium-low and even low-tech industries. Their study finds that process innovation, for example, is if anything stronger in low-tech than high-tech sectors.

Part of the problem here is that ‘innovation’ and R&D are more consistently in line with each other in high-tech industries than for the other industrial groups of the orthodox OECD classification (Hatzichronoglou, 1997). We will return to this point later. Here it is important to stress that efficiency and productivity measures appear to align better with ‘innovation’ than with ‘R&D’ across industrial sectors more generally.

For each industry R&D profitability can be expected to determine whether to undertake R&D activities or not; this will be given by the ability of the industry or firm to increase product quality or lower production costs from these R&D expenditures, or by the different minimum expenditures required to attain R&D profitability (Gonzalez & Pazo, 2004). In other words, each firm can set its own minimum R&D expenditure to reach R&D profitability in an evolutionary fashion. While the evolutionary standpoint may help clarify the technological ‘paradigms’, ‘heuristics’ and ‘regimes’ in the long run (Aghion, 2002; Dosi, 1982; Nelson & Winter, 1977), such variables as R&D profitability are however likely to be inherently endogenously determined in the shorter term (as in the popular model of Crepon, Duguet & Mairesse, 1998). Aral et al. (2006) show by using US data that the two-way interrelationship between the technology and productivity growth varies in kind from one area of IT application to another.

It is known that some industrial sectors invest more in R&D as a consequence of their competitive behaviour, specialisation in innovative activities, interrelationship with technical and technological improvements, and institutional factors including appropriability of IPRs (Pavitt, 1982). For example, it has been found that the size of a nation’s agricultural sector makes a difference in explaining private R&D investment within that sector (Alfranca & Huffman, 2003). In Italy, at least, it has been established that the agricultural and other traditional sectors record disproportionately low levels of R&D expenditures, in part because such industries tend to leverage R&D benefits from collaboration rather than by increasing their own private investment in R&D (Falk, 2006; Piga & Vivarelli, 2004).

These considerations have underlain the emergence of the ‘sectoral systems of innovation’ approach (Malerba, 2004, 2005, and references therein). Breschi et al. (2000) showed that most industries in the EU could be classified as either Schumpeter Mark I (more traditional sectors, usually composed largely of SMEs, with low economies of scale and scope), or Schumpeter Mark II (more capital-intensive sectors, usually built around large firms, with high scale/scope economies). In addition to these ‘opportunity’ variables (particularly in regard to
technologies though also to ‘market opportunities’), the remaining key sets of variables, concerning ‘appropriability’, ‘cumulativeness’ and the ‘knowledge base’, all tended to favour the Mark II sectors rather than Mark I. This however left out of account the remaining industries, some of which (like food and beverages) were simply too heterogeneous to permit clear classification, others of which constituted an apparent third category of industries dominated by small high-tech firms. There are again some definitional problems associated with these ‘sectoral’ systems, which are regarded as product-based categories (Malerba, 2004: 16) yet talk of (say) ‘biotechnology’ as such a sector. Another perspective is offered by the ‘technological systems’ view of a set of scholars based mainly in Sweden (Bergek et al., 2008), who reverse the primary association within the ‘sector’ from products to technologies, and enumerate the emergent ‘functions’ that these technological systems forge.

High-tech vs. low-tech

The Lisbon strategy and associated Barcelona target are premised on the assumption that the EU faced particular shortfalls in relation to so-called high-tech industries. However, a host of recent studies have aimed to restore some of the reputations of low- and medium-tech (LMT) industries (e.g. Hirsch-Kreinsen & Jacobson, 2008; Robertson & Patel, 2007; Robertson et al., 2009; von Tunzelmann & Acha, 2005).

Although there is no space to review all of that work here, one statistic that is worth emphasizing is that in both the EU-15 and the US, the OECD category of high-tech manufacturing accounts for fewer than 3% of total output and employment. Even quite dramatic improvements in productivity or related variables within the group of high-tech sectors would thus have only minor aggregate consequences for the overall competitive position of the EU.

It also needs emphasizing that we are here talking about high-tech (etc.) sectors in the OECD sense mentioned previously. We are not at this point considering the high technologies (etc.) themselves, i.e. as inputs (Mendonça, 2009). So this finding may be perfectly consistent with more spending on ICT, biotechnology, nanotechnology, etc., so long as the technologies so developed are then properly and adequately commercialized, be it in high-tech or LMT industries (e.g. nanotechnology in the cosmetics or food industries).

3.3 Drivers from the market

Demand pull vs. technological competencies (supply push)

Since sectoral systems of the kinds just described tend to highlight supply-push issues, even if rather inadvertently, we are left with a broad range of material to cover when we turn to the demand side more generally. Our views are both wider and narrower than many conventional views regarding the role of demand-pull effects – wider for instance than those orthodox neoclassical economists who can envisage demand as playing a role only when the economic system is out of its usual equilibrium state (e.g. Lucas, 2003), but narrower than some other social scientists who attribute most innovation to an expressed response to ‘need’ (for a critique of this prevailing view, see Mowery & Rosenberg, 1979). The former neglects for instance circumstances where innovation, spurred by say expansionist fiscal policies, can ‘permanently’ build in higher levels of aggregate supply (von Tunzelmann, 2004) and thus downplays any autonomous role for demand-pull on innovation, while at the other extreme the latter fails to account for why most of our critical health ‘needs’ (to take only one area for illustration),
Certainly there are a number of situations in which demand-pull causes seem inescapably part of the explanation for raising R&D expenditures. One that has yet to attract much interest from economists concerns the impact of inequality (in earnings etc.) on innovation, although there has been a considerable amount of work on the reverse link, i.e. from innovation to inequality (e.g. Aghion et al., 1999; Aghion, 2002). This would seem beyond our scope to have to discuss, if this literature were itself not linked to factor-saving arguments that purport to describe the time path of technological innovation over the past quarter-century or so. In particular it is widely argued that innovation can be characterised empirically by a ‘skill bias’, favouring regions or activities where the provision of advanced skills is high enough, but disfavouring the rest (Acemoglu, 1998, 2002). Current views tend to support a greater reliance of any ‘skill bias’ on organizational change rather than (simply) on technological change (Bresnahan et al., 2002; Caroli & Van Reenen, 2001; Hitt & Brynjolfsson, 1997; Piva et al., 2005).

The broader ‘Keynesian’ viewpoint promoted originally by Schmookler (1966) also has resonance at this present time of a recession-led contraction of global demand. In his seminal study, Schmookler argued, mostly on the basis of historical data on US patents, that firstly the fluctuations in patents preceded the fluctuations in economic indicators such as sectoral investment patterns (when both were assessed for medium-term variability), so that causation ran from investment to innovation hence representing ‘demand-pull’; and that secondly all the components of the patents series – the boilers and steam engines, the wheels and axles, the locomotives and carriages, the fuel and the rails of a ‘railroad system’ – tended to rise and fall together, despite their very different technological origins. The first was mildly criticised by Kleinknecht & Verspagen (1990) who used more sophisticated econometrics to show the existence of two-way causation in Schmookler’s data, while the second was the subject of a piece of self-criticism by Schmookler, who later in his book pointed out that his method of aggregation was by product (the ‘railroad system’ etc.) rather than by technology (mechanical engineering, iron and steel, etc.), so biasing the result in favour of ‘demand-pull’.

Lee (2002) aims to demonstrate that R&D intensity is jointly driven by consumer preferences in relation to quality and price and firm-specific technological competencies (interacting multiplicatively). This argument amounts to matching firms’ capabilities with consumers’ capabilities, by hypothesising similar consumer preferences within industries; however, others contend that consumer preferences for the products of an industry are not given per se, but are also determined by the consumer capabilities to use the products or technologies with which they are supplied (von Tunzelmann & Wang, 2003, 2007). The argument that consumer capabilities may vary substantially leads to a view that R&D and innovation can segment markets, e.g. between expert users and entry-level buyers. This in turn becomes an issue in relation to the view that it may be the variety as much as the quantity of R&D that counts – here applied to the matter of conforming the product innovations that result to the tastes and capabilities of the end-users. This line of argument is being extended by Guerzoni (2009), who classifies markets into 4 kinds, in the two dimensions of market size (‘breadth’) and user sophistication (‘depth’), namely: mass markets (high breadth, low depth), dual markets (high breadth and depth), passive markets (low breadth and depth), and niche markets (low breadth, high depth).

Most of the recent attention has focused instead on intermediate demand rather than final demand, particularly the renewal of interest in ‘user-led innovation’ (von Hippel, 1988, 2006). Von Hippel claims that a dominant share of innovations...
in certain industries such as instruments or computers are introduced by the 'users', although his definition of the scope of the latter seems to be quite encompassing (thus a computer company is regarded as a 'user' so far as computer innovations are concerned, because the only alternative offered by the author is to be a 'supplier'). Nonetheless, this view has helped sponsor a widespread interest among scholars (and policy-makers) of business studies in what is referred to as 'open innovation' (Chesbrough, 2003; Chesbrough et al., 2006). We will return to this point below.

**Competition**

Possibly the basic issue in this connection is whether competitive pressures can be so intense as to rule out any margin to set aside for investing in R&D in that particular line of business. The relationship that the firm’s response to competitive pressures drives R&D intensity (Piga & Vivarelli, 2004) however turns out to be less clear in reality, since though firms may well be facing competitive pressures and experience lower profitability levels, unless the latter drop below a minimum threshold, no major R&D efforts might be forthcoming. In fact, young firms with no institutionalised search for innovations are more likely to display such a pattern, as was the conclusion of a study conducted in Italy (Antonelli, 1989).

Aghion et al. (2001, 2005) try to reconcile the theoretical explanation of a negative association between competition and innovation (as in Aghion & Howitt, 1992) and an empirical finding by others of a positive association (e.g. Blundell et al., 1995; Nickell, 1996) by positing that competition rather perversely generates pressures to innovate precisely so as to escape from such relentless competition. The empirical significance of this may be queried.

On theoretical grounds, Aghion & Howitt (1996) maintain that distinguishing between research on the one hand, and development on the other might offset the negative impact. A recent study refines the effects of competitive pressures on R&D investment decisions, and suggests that market structures can influence the long-run decision to conduct R&D activities or not, but the short-term decision of how much to invest is not affected (Artes, 2009). This calls for more analysis of short-term decision-making in regard to how much to invest, which is ultimately what drives R&D intensity.

Many in the industry and government thus believe, for instance, that the UK government’s auction of licences for 3G mobile-multimedia transmission depleted the 'successful' firms of financial support to such an extent that their subsequent technological viability was seriously threatened (Ansari & Munir, 2008). A finding that has come from macro-level studies of ‘national systems of innovation’ is that perfectly competitive sectors (e.g. agriculture) often have to rely on ‘exogenous’ government funding for R&D, since the returns to the individual investor would be too low (Nelson, 1992). Conversely, the ‘new growth’ school of economists stresses the role of imperfect competition in permitting ‘endogenous’ growth through private R&D (Krugman, 1979; Krugman & Venables, 1995).

Technological expectations, linked to the issue of ‘technological opportunities’ as in the sectoral systems of innovation literature, constitute an element of risk and uncertainty in any such decision-making. Rosenberg (1976) went so far as to argue that the acceleration of technical progress that he was observing at the time he was writing actually could lead to decisions to postpone the adoption of (say) new ICTs, since potential adopters might always see the benefit of holding off until the following period, when capacity would be greater and prices lower, and so on ad infinitum. Some sort of stopping rule might have to be conjectured.
National and supranational differences appear to matter here. In Japan, competitive pressures may not be enough to drive firms to invest more in R&D, especially if they do not belong to any industrial group, whilst US firms’ R&D intensity seems to move directly with the profitability levels caused by competitive pressures (Hundley et al., 1996).

Cooperation or contracting

Firms are not generally alone when investing in R&D. They can opt to compete (in-house R&D), cooperate (combining R&D resources externally), or contract out their technological development. However each of these strategies relies heavily on the availability of absorptive capacity within the firm in the form of full-time staff in R&D departments (Veugelers, 1997).

In a study of the German service sector, a game-theoretic approach showed that cooperating firms tend to invest more in R&D than non-cooperating firms. A problem with the study is that it was not possible to distinguish between vertical and horizontal cooperation (Kaiser, 2002).

It is therefore important to identify the factors that drive cooperation among firms. A study from Spain argued that the main factor is cost-risk sharing (Hoskisson & Hitt, 1988). This may explain why under cooperation firms invest more in R&D than individually, as risk (uncertainty) reduction is a critical driver of R&D intensity; while from the cost-sharing point of view, it is even easier to suppose that individually they may not be able to pool the necessary financial resources for R&D, but this can be done by sharing costs. A study of Flemish firms active in R&D showed that they dedicate resources to R&D in collaboration with other firms, and interestingly that total private R&D expenditure is higher than if efforts had been paid for individually (Veugelers, 1997). This is a notion that would be worth exploring at European level, since only national insights have been generated to date, and also for multinational companies (see below).

In sectoral terms, studies of networking and strategic alliances tend to divide into four categories: i) linkages among the large firms (typically formal strategic alliances); ii) linkages between large firms and small firms (typically ‘hub and spoke’ in structure, often with a large foreign multinational company acting as the ‘hub’); iii) linkages among smaller high-tech firms (typified by the Silicon Valley cluster); iv) linkages among smaller lower-tech firms (typified by the ‘Third Italy’ structure, giving rise to ‘flexible specialization’, though usually more flexible in products rather than in technologies). In practice there are probably as many overlaps between these categories as pure instances.

3.4 Endowments and location

This leads into the growing literature on ‘clusters’. Proximity to technological spillovers is expected to drive up R&D intensity, as the ‘new economic geography’ would contend (e.g. Venables, 1996), but arguably only in conditions of market growth and technological development (Jaffe, 1988).

It was noted above that a restructuring strategy towards less diversification may increase the firm’s R&D intensity (Hoskisson & Johnson, 1992). However, the main issue is where the centralised R&D laboratory should be located, and this is a major problem for countries seeing their entire private R&D laboratories being moved to foreign locations (‘hollowing out’), because that implies an immediate reduction in the private R&D intensity in the region that is left behind.
This has been the case for a number of European companies that have migrated to the US. The factors driving the decision to build R&D capacity at distant locations thus has a major impact on the European strategy of increasing private R&D intensity (Voelker & Stead, 1999). The decentralisation of R&D laboratories follows the traditional idea of adapting to regional and local market conditions, to local supply conditions like the availability of cheaper and/or better high-skilled labour, and to political elements like pressures for greater local content (the *centrifugal* factor), whereas among the notions behind the centralisation tendency (the *centripetal* factor) are the greater control over global activities, the minimisation of communication and transaction costs and the reaping of scale economies internal and external to the firm (Granstrand et al., 1993). Whether discussing immigration or emigration, the factors leading to relocation outside Europe should be taken as drivers of R&D intensity, at least at national levels. Recently more concern has been addressed at the large numbers of EU companies that seem to be relocating their R&D labs to large developing countries, especially China and India, in search of cheap skilled labour.

Another interesting factor driving R&D investment is regional integration, as developed in the burgeoning literature on ‘clusters’ and on ‘regional systems of innovation’ (e.g. Braczyk et al., 2004; Cooke & Morgan, 1998). For French manufacturing firms in 2005, Abdelmoula & Etienne (2009, forthcoming) estimate interactive firm-level and regional level panels. The firm-level results show the strongest consistent correlations of R&D expenditures with ‘local’ spillovers (i.e. same-sector, same-region), concentration, high-tech industries, and firm age (negative); the equivalent regional results correlate with regional spillovers, industry subsidies, and (negatively) patents. From an empirical cross-section study of Spanish manufacturing firms, regionalisation is claimed on the one hand to have reduced R&D intensity due to improved regional access to factor markets, on the other hand to have increased private investments in R&D through greater competition – the outcome was that competition drove firms to invest more in R&D, but also to purchase more external R&D (Cuervo-Cazurra & Un, 2007). Therefore the overall effect was positive for the country, from both trade-diversion (positive for the region) and trade-creation effects linked to ‘deep integration’.

### 3.5 The macro level: Public policies

*Public and private expenditures on R&D*

Private R&D investment may be complemented by resources from public sources as well. Linked to the competitive pressures as driver for R&D intensity, market uncertainty is also an important driver. According to conventional views about ‘market failure’, uncertainty of technological success limits the incentives of the firm to invest in R&D, and this is when the participation of public R&D becomes crucial, namely in waiting for the initial development of technological or product markets to reduce market uncertainty and eventually induce private R&D investment in such technologies (Czarnitzki & Toole, 2007).

Central government expenditures on R&D can stimulate private-sector investment in basic research, which may be explained by the complementarity of the relationships, meaning that the spillover and infrastructural creating effects outweigh any detrimental effects on R&D prices or volumes (Robson, 1993). More generally, an authoritative survey of the ‘crowding-out’ literature in relation to that between public and private R&D concludes that fears of such crowding-out have been exaggerated (David, Hall and Toole, 2000).
Confirmation that internal and external sources of funding R&D are complementary not substitutes was tested using panel data for Spain, covering industrial sectors from 1989 to 1998 (Callejon & Garcia-Quevedo, 2003). Italian and OECD studies show similar results (Falk, 2006; Piga & Vivarelli, 2004). There are various studies rejecting the hypothesis of the crowding-out effect of public R&D subsidies on private R&D investment (Aerts & Schmidt, 2008; Gonzalez & Pazo, 2008; Hoskisson & Hitt, 1988). The positive effects of public support on private R&D are not exclusive to developed countries, since an evaluation of the Turkish experience produced similar results (Ozcelik & Taymaz, 2008).

However, an interesting phenomenon studied with regard to German SMEs’ R&D expenditure was that public R&D subsidies crowded out the financial markets for private R&D investments (Czarnitzki, 2006). This issue of the dynamic indirect effect of public subsidy of private R&D and the crowding out effect on the financial markets needs to be taken into account. In turn, it may eliminate the funding opportunities to firms that on some selection criteria are not being given public R&D subsidies.

It has also been shown by a pooled sample of a cross-section study in nine European countries that for some low-tech industries public R&D does crowd out private R&D, however complementarities were found at high levels of private R&D (Alfranca & Huffman, 2003). A different study using cross-country panel data from the OECD nevertheless indicated that public R&D is complementary to private R&D (Falk, 2006). The policy implications of these findings include that differential treatment should be given to low-tech private R&D investors to prevent crowding-out effects from public R&D.

Public policies to boost R&D

A prolific set of empirical studies has tried to evaluate public policies that aim to promote private R&D activity. The ‘direct’ policy options include: direct subsidies, R&D funding, R&D tax credits, public procurement, and public R&D laboratories and research institutes. From a broad range of ‘indirect’ policy options, particular attention might be paid to: education policy to develop skilled labour, supporting the development of strong financial markets, opening up markets for competition, regulatory policy including IPRs, and macroeconomic demand management; although we have no space to develop these at length here.

As already observed, public subsidies continue to be an important policy instrument, and apparently are complementary to private R&D intensity. Public procurement of R&D activities is among the policy instruments to promote private R&D, and for the US at least there is an interesting relationship between previously supplying the government and the probability of being selected in future trials, which drives firms to invest in R&D to maintain or increase the governmental share in their total sales (Lichtenberg, 1987).

Equally controversial is the provision of R&D tax credits, with several scholars highly sceptical of the contribution they make, at least over and above their cost to the taxpayer. However one study for the USA found that tax credits increase the level of private R&D spending more than proportionally (Berger, 1993). Similar results have emerged from cross-country panel data from the OECD employing regression analysis, arguing that tax incentives are positive and significantly driving R&D intensity (Falk, 2006; Warda, 2001).
A Dutch study has suggested that financial constraints require a broader policy mix that combines R&D tax incentives to increase cash-flows, venture capital financing to avoid crowding out financial markets by public subsidies, among others (Mohnen et al., 2008). In relation to IPRs, one common suggestion is that governments protecting the monopolistic profits of patents (innovations) will drive up R&D intensity (Falk, 2006; Kanwar, 2007; Varsakelis, 2001). However this, too, has long been controversial (e.g. Andersen & Konzelmann, 2008), not least because excessive terms linked to the usage of IPRs (e.g. charging very high licence fees, or limiting access) could restrict the diffusion of patented or copyright technologies, and thus the ‘spillover’ effects on secondary downstream innovation. It could also be desirable to strengthen the institutional setting if the country wishes to augment private R&D, since patent rights, better contract enforcement, efficient civil bureaucracy, and protectionism of local firms all helped private agricultural R&D investments to expand (Alfranca & Huffman, 2003). Several scholars have thus underlined the need to assess patent protection policies in the wider context of competition policy etc. (e.g. Aghion et al., 2001).

National vs. international systems and effects

In the case of the UK, the appreciation of the real effective exchange rate in the years from 1996 until recently is seen as having outweighed the positive effects on R&D intensity from rising private R&D by foreign-owned firms, notwithstanding other supporting influences (Becker & Pain, 2008).

Indeed many countries, including the majority of the EU’s ‘new member states’, have come to place great faith in inward foreign direct investment (FDI) as a key to growth, in that such inflows of FDI bring not just more investment into the country, but advanced technology, better management systems, higher skills, etc. More broadly, the multinational companies (MNCs) that are the agents responsible for the bulk of the FDI assist in the ‘globalization’ of catching-up countries, including effects of raising their R&D intensities nearer to world levels.

It is still not clear though that there are, on balance, positive effects of foreign-owned firms on the R&D intensity of a country. If the firm is a subsidiary of a foreign-owned MNC, the subsidiaries may spend less on R&D due to the fact that they have access to knowledge and technologies through their headquarters or their subsidiaries from various locations (Un & Cuervo-Cazurra, 2008).

The motives of the MNCs can be summarised as cost seeking, market seeking and efficiency seeking (Dunning, 1981; Caves, 1986). The first – generally the quest for ‘cheap’ labour or materials – often is deemed to be ‘short-termist’ and anathema to enhancing conditions in the receiving country, except perhaps in the cases where the cheap labour being targeted is skilled, as already noted. Apart from such exceptions, the motivations here are perhaps strongest in the more mature ‘scale-intensive’ sectors of the Pavitt taxonomy (e.g. motor vehicles). The second – looking to capture ‘easy’ markets – also tends to be sectorally specific (e.g. taking over the domestic markets of recipient countries in sectors such as food processing). Only the third context of seeking higher efficiency is likely to produce sustained improvements in the R&D intensities of the FDI hosting countries, and – at least until quite recently – for much of this category those host countries were probably themselves already well developed, like the USA.
### 3.6 International comparisons at sectoral level

There have been several sustained attempts to gauge the impact of the EU’s alleged deficiencies in terms of R&D as compared with the USA and/or Japan, as this influential view has underpinned the European Commission’s approach since 2000, through the so-called ‘Lisbon strategy’. In particular, there have been a number of efforts to decompose the aggregate national and ‘continental’ data into the various sectors, in order to try to detect whether the overall lower R&D intensity of the EU relative to the other nations making up the so-called Triad can be ascribed to sectoral composition factors, i.e. that the member states of the EU tend to congregate in less dynamic sectors.

Unfortunately, the existing data do not allow sufficiently clear-cut distinctions into between-sector effects and within-sector effects to provide strong answers to this question; in other words the matter remains unresolved as to whether the EU’s lower overall R&D intensity is due to its greater specialisation in low- and medium-tech (LMT) industries – the ‘between’ effect – or instead to having lower R&D intensities in each industry (or most industries) – the ‘within’ effect. The kind of data source deployed evidently has some part to play in giving rise to this ambiguity. Specifically, it matters whether one adopts industry-level data – particularly the OECD’s ANBERD and STAN databases (now EU-KLEMS), or instead firm-level data – particularly the EU’s R&D Investment Scoreboard. Although the latter dataset is clearly much less comprehensive than the former, being by definition restricted to the largest firms measured by their R&D investments, it still has some (partially) offsetting advantages, not least in being more up-to-date. A recent study for the IPTS by von Tunzelmann et al. (2008) concludes that the two datasets are complementary rather than substitutes, and so long as their different bases can be borne in mind, there is little harm from deploying both (though for each specific issue one or other may of course prove more suitable).

As it happens, in that study R&D intensities from the Scoreboard are systematically larger than those obtained from the OECD data, to be expected from the fact that the Scoreboard national and sectoral samples are made up of the top R&D investors and hence the computed R&D intensities reveal a uniform upward bias. Some decomposition exercises were then run to single out the role of the structure of the economy (structural or ‘between’ effect) vis-à-vis the intensity of R&D efforts in each sector (intrinsic or ‘within’ effect). According to the official OECD data, the EU10 lag in terms of overall R&D intensity is totally due to the intrinsic effect, since the European sectoral structure turns out to be disproportionately characterised by a high incidence of R&D-intensive sectors. In other words, according to OECD data the European R&D deficit is not due to an inadequate sectoral structure, but rather to an overall under-investment in R&D activities within the different economic sectors. This is also true for the three main European countries. Once we turn to the Scoreboard data, the outcomes are diametrically opposite to those from the OECD. However, other studies come to different conclusions (e.g. Duchêne et al., 2009).

Moreover, these results do not necessarily carry over to other times and locations. In terms of US/EU gaps in Total Factor Productivity, McMorrow et al. (2008) find R&D significant in the case of the ‘electrical and optical equipment’ industry, for one. Further testing, especially using panel-data techniques, appears crucial.

Although in the preceding discussion we have not stressed the location and methods of analysis of each study, the table below contains some of the main empirical contributions to the study of drivers of R&D intensity. The studies included are selected because of being a reasonably representative of the topic of explaining differences in R&D intensity, principally at the micro level (although
may of these studies make use of industry dummies, they often do not report them, so there is as yet insufficient information available on a comparable basis to allow strong sectoral conclusions.

In short, studies in the field more generally are characterised by a lack of systematic comparisons across industries, countries and time. To counter this calls for more tailor-made analytical methods, of course taking into consideration that R&D intensities will always pose unexplained random variations (Cohen & Klepper, 1992). The scope for comparative panel data investigation, allowing time lags to pick up causality effects, is being enhanced by the increase in the associated statistical databases.
<table>
<thead>
<tr>
<th>Author</th>
<th>Quantitative Methods</th>
<th>Empirical study</th>
<th>Theories</th>
<th>Innovation System (Firms and Sectors)</th>
<th>Data sources</th>
<th>Main Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavitt, 1982</td>
<td>Correlation and simple regression</td>
<td>Cross-section, US, large EU, Japan</td>
<td>RBV; capabilities development</td>
<td>40 Industrial activities (Chemical, non-electrical machinery, electric and electronic products, aerospace, transport, metal and metal products, and food)</td>
<td>USA Scientific Indicators; NSF; OTAF; Business Week data collected by SPRU; and the Science and Technology Indicators Unit at the OECD.</td>
<td>Patents, Industrial R&amp;D, Industry-financed R&amp;D, employment of qualified scientists and engineers, total employment, and sales.</td>
</tr>
<tr>
<td>Hambrick et al., 1983</td>
<td>Multiple regression</td>
<td>Longitudinal</td>
<td>Resource and knowledge base view; Evolutionary Economics</td>
<td>242 Non-consumer products industrial business units mainly from Fortune-500 list. No sectoral disaggregation.</td>
<td>&quot;Profit Impact Market Strategies&quot; project</td>
<td>Cash flows, change in new product sales of main competitors, change in the new product sales of the focal business unit – new product sales of main competitors (relative innovative position).</td>
</tr>
<tr>
<td>Guerard et al., 1987</td>
<td>Simultaneous equations - two-stage SLS</td>
<td>Cross-section</td>
<td>Financial economics; RBV</td>
<td>140 manufacturing firms. Sectors: Petroleum, Metals, Machinery, Electronics, Drugs, and Chemicals.</td>
<td>Bureau of Census R&amp;D survey; Compustat</td>
<td>R&amp;D expenditures; new investment; net working capital; cash flows; cost of debt; debt to equity; tax rates; return on equity.</td>
</tr>
<tr>
<td>Lichtenberg, 1987</td>
<td>Least-squares regression</td>
<td>Time-series US aggregate; cross-section firm-level</td>
<td>Neoclassical; Evolutionary Economics</td>
<td>Two datasets: US aggregate, and 187 industrial firms jointly accounting for 66% of US private industrial R&amp;D expenditure. No sectoral disaggregation.</td>
<td>Compustat Industry Segment File</td>
<td>Federally funded industrial R&amp;D; privately funded R&amp;D expenditure; total sales; sales to the government (procurement); sales to all customers</td>
</tr>
<tr>
<td>Hoskisson &amp; Hitt, 1988</td>
<td>ANOVA; ANCOVA and Correlations</td>
<td>Cross-section</td>
<td>Evolutionary economics; dynamic capabilities</td>
<td>124 industrial firms from Fortune 1000. No sectoral disaggregation.</td>
<td>Business Week Corporate Scoreboard (1975-1979); survey with usable sample from Fortune 1000 industrial firms; Federal Reserve</td>
<td>R&amp;D expenditure/sales; R&amp;D intensity of the firm and the industry; categorical measures for structure and diversification; market return; mean annual stock return; mean annual riskless rate/beta</td>
</tr>
</tbody>
</table>
### Table: Key Studies on Dynamics of Business R&D

<table>
<thead>
<tr>
<th>Author</th>
<th>Quantitative Methods</th>
<th>Empirical study</th>
<th>Theories</th>
<th>Innovation System (Firms and Sectors)</th>
<th>Data sources</th>
<th>Main Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jaffe, 1988</td>
<td>Multiple regression</td>
<td>Cross-section</td>
<td>Resource and knowledge base view, sector innovation systems.</td>
<td>573 firms with positive R&amp;D. 49 Technological categories and 2 and 3 SIC groups, to estimate industry and technological areas effects. Sectoral or technological disaggregation not explicit in the analysis.</td>
<td>National Bureau of Economic Research (combines Compustat and patent data)</td>
<td>R&amp;D expenses; sales; capital stock; sales-weighted by average market shares; pool of spillover research potentially available (location of firms in technology and market place).</td>
</tr>
<tr>
<td>Antonelli, 1989</td>
<td>OLS</td>
<td>Cross-section, Italy</td>
<td>RBV; evolutionary economics</td>
<td>86 Italian manufacturing firms, accounting for 72% of Italian BERD. Main sectors: Energy, chemicals, computers, electrical machinery, motor vehicles, other transport, others.</td>
<td>ISTAT (Italy)</td>
<td>R&amp;D expenditure; Size of firm by value added; group dummy if belonging to financial groups or active in more than three digit sectors; ratio of public subsidy to total R&amp;D expenditures; profitability (value added-wages/sales)</td>
</tr>
<tr>
<td>Hoskisson &amp; Johnson, 1992</td>
<td>Pooled cross-sectional time series regression</td>
<td>Cross-section; time-series</td>
<td>Evolutionary economics; dynamic capabilities</td>
<td>189 industrial manufacturing firms between 4-digit SIC codes 1999 and 4000. No sectoral disaggregation.</td>
<td>Random selection of firms from Compustat II Business segment tape</td>
<td>R&amp;D intensity; restructuring variable; industry R&amp;D intensity; ownership concentration; debt/sales; relative ROA; level of diversification; firm size</td>
</tr>
<tr>
<td>Berger, 1993</td>
<td>Multiple regression</td>
<td>Time-series</td>
<td>Transaction costs economics</td>
<td>231 manufacturing industry firms. Industrial machinery and computer equipment, electronics, measuring equipment, food, chemicals, petroleum refining, rubber and plastics, primary metals, fabricated metals, transportation equipment.</td>
<td>Firms from Compustat with data from 1975-89</td>
<td>R&amp;D; sales; R&amp;D/sales; total sales; market capitalisation; net income; NOL carried forward; tax liability; cash flows; GNP; Tobin’s q; Time dummy, R&amp;D credit dummy; ability to use credit dummy; capital expenditures</td>
</tr>
<tr>
<td>Robson, 1993</td>
<td>Multiple regression</td>
<td>Time-series, US</td>
<td>Transaction costs economics; Industrial Organisation</td>
<td>US aggregate data.</td>
<td>Historical statistics for the US (1967-1988), Statistical Abstract of the United States, various issues.</td>
<td>Private expenditure on basic research in industry; federal spending on basic research in industry; private expenditure on applied research and</td>
</tr>
</tbody>
</table>
### Table: Quantitative Methods and Main Variables

<table>
<thead>
<tr>
<th>Author</th>
<th>Quantitative Methods</th>
<th>Empirical study</th>
<th>Theories</th>
<th>Innovation System (Firms and Sectors)</th>
<th>Data sources</th>
<th>Main Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Himmelberg &amp; Petersen, 1994</td>
<td>OLS; general method of moments, GMM</td>
<td>Panel, US</td>
<td>RBV; Evolutionary Economics; Industrial Organisation</td>
<td>179 manufacturing high-tech industries (chemicals, drugs, machinery, electrical equipment and communications, and instruments)</td>
<td>Compustat</td>
<td>development; federal funds for applied research and development in industry; federal government purchases of goods and services; non-government purchases of goods and services.</td>
</tr>
<tr>
<td>Cohen &amp; Klepper, 1996</td>
<td>Regression and pooled regressions</td>
<td>Panel</td>
<td>RBV; Evolutionary Economics</td>
<td>75 industries, 99 FTC line of business (between three and four-digit SIC level), 1200 observations (excl. regulated industries) mainly from the Fortune 1000 firms. Controlling for industries. No sectoral disaggregation provided.</td>
<td>FTC’s line of business program</td>
<td>Overall company sales; industry specification; unit sales and growth and its interaction effects; liquidity; scope; economies of scope or risks.</td>
</tr>
<tr>
<td>Veugelers, 1997</td>
<td>OLS; two-stage OLS; Probit Model; two-stage probit model</td>
<td>Cross-section, Flanders</td>
<td>Resource and knowledge base view; co-evolutionary economics; dynamic capabilities</td>
<td>290 Flemish firms. Sectors: chemical (incl. pharmaceutical), IT, electronics, metal manufacturing, software services, food, and others.</td>
<td>Flemish companies surveyed for 1992-1993 biannual questionnaire.</td>
<td>Internal R&amp;D; size (sales); diversification dummy; industry dummy; multinational dummy; subsidies received from governments; extramural expenditure on R&amp;D; cooperation dummy; expenditure for technology acquisition; absorptive capacity dummy; % of R&amp;D</td>
</tr>
<tr>
<td>Author</td>
<td>Quantitative Methods</td>
<td>Empirical study</td>
<td>Theories</td>
<td>Innovation System (Firms and Sectors)</td>
<td>Data sources</td>
<td>Main Variables</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------------------</td>
<td>-------------------------------------------</td>
<td>-------------------</td>
<td>--------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Voelker &amp; Stead, 1999</td>
<td>Statistical</td>
<td>Cross-section/small sample/non-parametric/qualitative/Case Studies EU</td>
<td>Transaction costs; RBV</td>
<td>20 MNCs: Chemicals/pharmaceuticals, electrical/electronics, vehicles, and engineering and process plant</td>
<td>Interviews with 20 European multinationals</td>
<td>Laboratory costs; communication and transfer costs; location-specific factors (e.g. spillovers); contact with customers; contact with other departments; proximity to firm’s other R&amp;D laboratories; connection with research region; legal/regulatory regimes; proxy for development laboratories; coordination; expertise</td>
</tr>
<tr>
<td>Kaiser, 2002</td>
<td>Simultaneous econometric model; nested logit model</td>
<td>Cross-section, Germany</td>
<td>Game-theoretic model; RBV</td>
<td>1233 of firms from the service sector. No sectoral or industrial disaggregation.</td>
<td>Mannheim Innovation Panel in the Service Sector (MIP-S), a data set collected by the ZEW for Ministry</td>
<td>Project Risk; market risk; innovation costs; unexpected costs; amortisation of previous project; equity; debt; qualified personnel; technical equipment; non-matured technologies; resistance; administrative procedure; legislation; spillover pools (firms’ concentration sectoral and location); information sources</td>
</tr>
<tr>
<td>Lee, 2002</td>
<td>Econometrics and statistical</td>
<td>Cross-section, cross-country (6)</td>
<td>RBV, capabilities development, evolutionary economics</td>
<td>1574 Firms. Cross-sectoral analysis: Polymers, Foundries, Textiles, Autoparts, Machinery, Electronics, Others. Cross-country analysis: Canada, Japan, Korea, Taiwan, India, and China.</td>
<td>World Bank for the project &quot;Institutional and policy priorities of industrial technology development&quot;.</td>
<td>Market share; R&amp;D expenditure; vector of price and R&amp;D level of competitor's products; maximum amount of potential demand for the market (maximum possible number of consumers in the market); unit cost of production</td>
</tr>
<tr>
<td>Alfranca &amp;</td>
<td>Multiple</td>
<td>Panel, cross-country</td>
<td>Resource and</td>
<td>Agricultural aggregates for OECD statistical</td>
<td>Aggregate private investments</td>
<td></td>
</tr>
</tbody>
</table>
### Table: Dynamics of Business R&D

<table>
<thead>
<tr>
<th>Author</th>
<th>Quantitative Methods</th>
<th>Empirical study</th>
<th>Theories</th>
<th>Innovation System (Firms and Sectors)</th>
<th>Data sources</th>
<th>Main Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huffman, 2003</td>
<td>Regression</td>
<td>EU</td>
<td>knowledge base view</td>
<td>nine countries: Austria, France, Germany, Italy, Netherlands, Portugal, Spain, Sweden, and UK. No sectoral disaggregation.</td>
<td>compendiums</td>
<td>in agricultural R&amp;D; real interest rate; aggregate private R&amp;D capital; potential transnational private R&amp;D spill-in; aggregate public agricultural capital; aggregate agricultural production; crop share; index of patent rights; bureaucracy efficiency; contract enforcement; openness; country dummy variable</td>
</tr>
<tr>
<td>Callejon &amp; García-Quevedo, 2003</td>
<td>Pooled OLS with fixed effects; Two-stage GMM (dynamic panel data)</td>
<td>Panel, Spain</td>
<td>RBV, evolutionary economics</td>
<td>Sectoral data. High to low technology Spanish manufacturing sectors. ISIC-3</td>
<td>OECD; Spanish National Institute of Statistics</td>
<td>Private funding of R&amp;D; public funding of private activity in R&amp;D; gross industrial value added; control for low to high technology.</td>
</tr>
<tr>
<td>Greve, 2003</td>
<td>Panel data Regression</td>
<td>Panel, Japan</td>
<td>Organisational behaviour</td>
<td>11 Japanese shipbuilding firms, and 185 firm-years.</td>
<td>Nikkei NEEDS; journals: New Technology Japan, Techno Japan</td>
<td>R&amp;D intensity; Return on assets; aspiration levels (social, historical); slack (absorbed, unabsorbed, potential)</td>
</tr>
<tr>
<td>Piga &amp; Vivarelli, 2004</td>
<td>Bivariate probit model with censoring setting</td>
<td>Cross-section, Italy</td>
<td>RBV, Industrial Organisation,</td>
<td>4495 representative Italian manufacturing firms; 10 industry dummies and a Pavitt taxonomy dummy</td>
<td>Survey conducted by Italian investment bank (Microcredito centrale)</td>
<td>Choice to engage in R&amp;D (binary); choice to engage in external R&amp;D (binary); choice of R&amp;D partner; diversification of R&amp;D strategy</td>
</tr>
<tr>
<td>Czarnitzki, 2006</td>
<td>OLS</td>
<td>Cross-section, Germany</td>
<td>RBV, Industrial Organisation</td>
<td>1978 observations of German manufacturing SMEs. 13 industry dummies (not presented).</td>
<td>Mannheim Innovation Panel (MIP), a database from Creditreform and another from DPMA: the German patent office.</td>
<td>R&amp;D expenditure at firm level; physical assets; gross investment; stock of patents (knowledge stock); number of patent applications; sales; staff costs; material costs; credit-ranking index; dummy for public funding; time dummies and industry dummies</td>
</tr>
<tr>
<td>Falk, 2006</td>
<td>GMM</td>
<td>Panel, cross-country</td>
<td>Dynamic capabilities and Industrial</td>
<td>Aggregate OECD countries</td>
<td>MSTI; OECD unpublished data;</td>
<td>Government funded BERD, %GDP; B-Index; Higher</td>
</tr>
<tr>
<td>Author</td>
<td>Quantitative Methods</td>
<td>Empirical study</td>
<td>Theories</td>
<td>Innovation System (Firms and Sectors)</td>
<td>Data sources</td>
<td>Main Variables</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------------</td>
<td>-----------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>---------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Cuervo-Cazurra &amp; Un, 2007</td>
<td>Multiple regression</td>
<td>Cross-section, Spain</td>
<td>Knowledge and technological development; Resource and knowledge Based View, Industrial Organisation, Economic Integration, Economic Theory.</td>
<td>1441 Spanish manufacturing firms. Industry dummy at two digit level.</td>
<td>Survey of the Ministry of industry and energy and Foundation State-Owned Enterprise in Spain.</td>
<td>Education R&amp;D expenditures, %GDP; Government R&amp;D, %GDP; high-tech export share; GDP per capita; Ginarte-Park Index of patent rights; average schooling years; share of university graduates; openness; investment ratio; private investment ratio.</td>
</tr>
<tr>
<td>Czarnitzki &amp; Toole, 2007</td>
<td>Tobit regression</td>
<td>Pooled cross-section, Germany</td>
<td>Evolutionary economics, industrial economics, Knowledge and technological development</td>
<td>702 German manufacturing innovative firms. 11 industry dummy variables not presented.</td>
<td>Mannheim Innovation Panel (MIP)</td>
<td>R&amp;D; R&amp;D/sales; uncertainty= volatility of revenue from new market introductions; government subsidy dummy; average share of new product sales; price-cost margin; employees; location dummy; physical assets; east dummy; industry concentration; credit rating; year dummy; group dummy; market share</td>
</tr>
<tr>
<td>Aerts &amp; Schmidt,</td>
<td>Conditional difference-in-</td>
<td>Cross-section, Germany, Flanders</td>
<td>Knowledge and Resource Based</td>
<td>3903 German and Flemish firms with more than 10</td>
<td>Flemish and German part of the</td>
<td>Subsidies dummy for recipient; R&amp;D expenditure at</td>
</tr>
<tr>
<td>Author</td>
<td>Quantitative Methods</td>
<td>Empirical study</td>
<td>Theories</td>
<td>Innovation System (Firms and Sectors)</td>
<td>Data sources</td>
<td>Main Variables</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------------------------------------</td>
<td>----------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>2008</td>
<td>differences estimator with repeated cross-sections (CDiDRCS)</td>
<td></td>
<td>View; Crowding out thesis; Evolutionary economics; Industrial Organisation</td>
<td>employees. Industry dummies not reported.</td>
<td>Community Innovation Surveys (CIS III and IV); European Patent office; National Bank of Belgium (Belfirst database)</td>
<td>the firm level; R&amp;D intensity; employees; Firm's patent stock; Dummy group; Dummy foreign patent; Exports/turnover; Dummy East Germany; Industry Dummy; Interaction effects; Count project proposals submitted for RD subsidy; capital intensity; fixed assets; cash flow; technological information (lack of); financial difficulties for innovation; information from competitors absorbed by the company</td>
</tr>
<tr>
<td>Becker &amp; Pain, 2008</td>
<td>Autoregressive distributed lag model</td>
<td>Panel, UK</td>
<td>RBV, Evolutionary economics; macroeconomics</td>
<td>UK aggregate of 11 manufacturing industries. No sectoral disaggregation in the analysis.</td>
<td>Detailed surveys undertaken in the UK on a triennial basis for the manufacturing sector</td>
<td>R&amp;D expenditure; market size; import penetration; proportion of R&amp;D undertaken by business and funded by government; R&amp;D undertaken by foreign-owned firms; other influences such as financial conditions and macroeconomic policies; industry-specific fixed effects.</td>
</tr>
<tr>
<td>Abdelmoula &amp; Etienne,</td>
<td>Two-part hierarchical model with correlated random effects</td>
<td>Regional panel, regions and firms, France</td>
<td>Neoclassical and new growth; Schumpeterian; sectoral systems; regional systems</td>
<td>3308 French manufacturing firms (&gt; 50 employees), in 18 sectors and 19 (out of 22) French regions. Regional dummies analysed; also dummy for high-tech industries, but not other sectoral breakdowns.</td>
<td>Data from Amadeus, REGIO and French Ministry of Finance, for 2005</td>
<td>Local vs. international markets; export intensity; age of firm; concentration (Herfindahl index); spillovers (local, industry and regional); high-tech industries; industry and R&amp;D subsidies; patents</td>
</tr>
</tbody>
</table>
3.7 Research propositions

A number of research propositions were formulated in three sets, based on the literature review, but also issues to be addressed through the survey (Phase 2), and the policy implications of the study results. The following list of propositions was used as a basis for the development of the survey questions (see section 5).

Research propositions based on the literature review and to be potentially addressed through the survey

- What is the role of the firm specific characteristics: size of the firm, corporate strategy, organisational structure, access to resources (financial and human) in determining BERD intensity?
- What are the factors driving BERD intensity at the industry level (i.e. competitive behaviour, specialisation in innovative activities, interrelations with technical and technological improvements, institutional factors, etc.)?
- What is the role of the framework conditions such as financial, strategic and regulatory factors, in influencing the decision of companies to invest in R&D?
- What is the role of public funding for corporate R&D in influencing trends in BERD intensity? Does this effect differ by sector?
- Are the effects of foreign-ownership of subsidiaries on the R&D intensity of the host country positive or negative?
- How do national culture, patent protection and the institutional context of the country influence BERD performance?
- How do consumer preferences and market competition influence BERD performance in the country/sector?

Facts and research propositions based on statistical analyses

- Which are the sectors in which R&D intensity has increased per country?
- In relation to the sectors with growing R&D intensity, how have their shares in total R&D and total output changed over time?
- How much of the BERD intensity gap is caused by the country’s structure and its over- or under-specialisation on particular industries/sectors?
- How does the shift from manufacturing to services in relation to R&D is appropriate in itself for achieving the 3% Barcelona target? What is the role of downsizing in manufacturing in impeding progress towards the Barcelona target?
- Does high R&D intensity lead to higher economic and/or productivity growth?
- What is the impact of structural change on R&D intensity both within and across industries?

Research propositions related to policy implications of BERD trends

- To what extent and how have the policy options/measures adopted by a given country impacted upon the evolution of BERD in a given sector?
- To what extent desirable/undesirable changes can be encouraged/reversed given the efficacy of public policies?
- Which policy directions should be adopted in order to support technological progress and sustain/improve competitiveness of a sector?
4 Major trends in BERD based on the collection of statistics and calculation of indicators

In 2005, 90% of total BERD for the 27 countries of the European Union was carried out in only nine countries. Germany, France and the United Kingdom, account for 63% of BERD in Europe as a whole. The inclusion of Italy, Sweden, Spain, the Netherlands, Austria and Belgium brings the cumulative total to 90% of total BERD. Differences in the structure of BERD in the small countries would have a negligible effect on the structure of BERD for Europe as a whole.

The European total used for this analysis comprise of 11 countries: Germany, France, UK, Italy, Sweden, Spain, the Netherlands, Belgium, Finland, Denmark, and Ireland. A justification of this selection is presented in the Annex A.3 of this report.

Country studies for each of the EU27 countries, as well as for the United States, China, Japan, Korea, Norway and Iceland can be found also in the Annex A.3 of this report.

Background to a European structural analysis

In the EU, the manufacturing industries generated about 20% of total value added on average from 1995 to 2000, and about 18% of total value added on average from 2001 to 2006. The services industries generated about 55% of total value added during the first period and about 57% during the second period. Agriculture, mining, electricity, water and gas, and construction generated the rest. The share of BERD in services was just over 12% in the first period, increasing to almost 15% in the second period, while the share of BERD in manufacturing decreased from 86% to 83% over the two periods. Average BERD intensity, measured as BERD over value added, increased slightly from 1.36% in the first period to 1.41% in the second period. In manufacturing it increased from 5.8% to 6.5% and in services it increased from 0.31% to 0.37% over the two periods.

Distribution of BERD

The top 10 industries performing R&D from 2001 to 2006 in Europe accounted for 80% of total BERD, of which motor vehicles (34), pharmaceuticals (2423) and Radio, TV and communication equipment (32), explain more than 41% of it.

Changes in the distribution of BERD

Regarding the evolution of BERD for the top 10 industries in Europe from the six year prior to 2001 and six years from 2001, the three top winners are computer and related activities (72), pharmaceuticals (2423), and motor vehicles (34); and the three biggest losers are chemicals, excluding pharmaceuticals (24-2423), Radio, TV and communication equipment (32), and aircraft and spacecraft (353).

Trends in BERD Intensity

BERD intensity increased by a very small percentage in the EU11 for the six years prior to 2001 and six years from 2001. Radio, TV and communication equipment (32), motor vehicles (34), software (72), and pharmaceuticals (2423) were top winners that are also in the top 10. Aircraft and spacecraft (353), Coke and petroleum (23), and chemicals excluding pharma (24-2423) were among the greatest losers.

Trends in Value-added by Sector

Regarding the top 10 industries, while these made up 80% of total BERD from 2001 to 2006, on average, they make up slightly less than 17% of value added.
4.1 Main BERD trends for the EU27

Both 'pharmaceuticals' and 'motor vehicles' play a key role in Europe due to both their large share of BERD and their increase in BERD share and BERD intensity since 1995. Another important sectoral cluster to be considered is the ICT-driven one, partly manufacturing, partly services.

Regarding 'pharmaceuticals', interesting cases are definitely the UK, BE, SE, DK (SI is interesting but it is mainly driven by one company). This sector has shown a tremendous increase in R&D expenses over the past 15 years, but this went together with a decrease in measurable outputs of R&D (R&D productivity slowdown, less drugs patented, less drugs getting through clinical trials, compared to increasing R&D cost, etc).

For 'motor vehicles', interesting cases are Germany and the countries around it (in particular CZ and SK, PL), into which the German automotive sector has moved part of its value chain. The increase in BERD intensity in the German automotive sector may be due to the fact that the lower-end segments of the value-added chain has been moved out to CZ and SK, leaving in DE the parts with a higher R&D component.

Finally, the ICT-driven sectoral cluster is less prominent in terms of share in BERD, but it is an important player in terms of (growth of) valued added, and in terms of switch to services. Here, interesting country cases are IE, SE, FI, and HU.

4.2 “Successful” and “Unsuccessful” countries based on statistical analysis of BERD

“Successful” countries
Successful countries are those with increasing BERD intensities in the period 1995-2006, and BERD intensities approaching to a value of 2 or more.

Successful countries with BERD intensities close to a value of 2 or more are: Austria, Denmark, Finland, Germany and Romania.

Successful countries with BERD intensities close to a value of 1 are: the Czech Republic, Malta and Slovenia.

Countries with increasing and contrasting BERD trends
These countries have seen their BERD trends increased over a specific period of time and then decreased to arrive to a slightly higher level of BERD to the one at the beginning of the period of analysis.

Countries with increasing and contrasting BERD trends are: Belgium and Sweden.

Countries with increasing BERD trends but very far from the Barcelona targets
These countries have seen their BERD trends increased over the period of analysis but their highest level of BERD intensity is below 1.

Countries with increasing BERD trends but far from the Barcelona targets are: Italy, Portugal and Spain.

Countries with increasing BERD trends but considerably far from the Barcelona targets (i.e. BERD intensities are lower than 0.5) are: Cyprus, Estonia, Hungary, Latvia, and Lithuania.

“Unsuccessful” countries
“Unsuccessful” countries have seen their BERD trends decreased consistently over the period of analysis no matter their level of BERD intensity.

The only “unsuccessful” country is the United Kingdom.
“Unsuccessful” countries and very far for the Barcelona targets (i.e. BERD intensities below a value of 0.5) are: Poland and Slovakia.

“Unsuccessful” countries with stagnating sectors
These are countries that had experienced stagnating levels of BERD intensity over the period of analysis.

“Unsuccessful” countries with stagnating sectors are: France, Ireland and the Netherlands.

“Unsuccessful” countries with stagnating sectors and very far from the Barcelona targets
These are countries that had experienced stagnating levels of BERD intensity over the period of analysis and their level of BERD intensity is considerably lower than 1.

“Unsuccessful” countries with stagnating sectors and very far from the Barcelona targets are: Greece and Bulgaria.

4.3 BERD in Europe and its comparison with other third countries

The evolution of BERD in Europe and comparison with the United States
The US is one of the most dynamic economies in terms of changes in BERD intensity. Computer and related activities (72) was the biggest winner, with the largest increase in BERD intensity and in the share of BERD. Several other industries were winners, including pharmaceuticals (24-2423), and transport, storage and communications (60 to 64), which mainly contains telecommunications (R&D activity). Chemicals minus pharmaceuticals were the biggest loser (24-2423). Other losing industries include radio, TV and communication equipment (32), electrical machinery (31), and Office, accounting and computing machinery (30). Aircraft and spacecraft (353) was a clear loser in terms of BERD share, but maintained the same intensity, automotive vehicles (34) increased its share in BERD, but did not increase its intensity and other business activities (74) increased its BERD intensity, but did not increase its share in BERD.

In comparison with the United States, pharmaceuticals (24-2423) and Computer and related activities (72) were also winners in this country, but their intensity increased much more rapidly there. Other transport (35-353), Radio, TV and communication equipment (32), and Instruments, watches and clocks (33) also showed rapid growth in BERD intensity in the United States, whereas they experienced declines or little change in Europe. Aircraft and spacecraft (353) and Chemicals minus pharmaceuticals (24-2423) declined in the US and Europe.
5 Main findings on BERD trends based on the survey of country and sectoral case studies

This section presents the main BERD drivers identified in the Survey of experts and case studies. At the end of this section, a summary of identified drivers is presented. These are compared with the drivers identified in the literature review.

5.1 Summary of main findings for each case

The Belgian Pharmaceutical Industry

The drivers of R&D spending in the Belgian Pharmaceutical sector exceed the Belgian-specific setting and are mostly determined by the global context in which the pharmaceutical companies are operating. Four are the drivers of R&D spending: the evolution towards the open innovation model; the increased costs of R&D; more stringent and complex regulation with regard to market authorizations, price setting and reimbursement and; Belgium-specific drivers (i.e. high concentration of highly educated people, the world-level standard of biomedical research and the top-level hospital infrastructure available in Belgium to perform clinical trials).

The more rigorous price setting and reimbursement regulatory framework is an important but negative driver for business R&D expenditures.

The French Aerospace Industry

France is the second largest contributor to the EU aerospace industry in terms of value-added and it is the top contributor in terms of turnover. The industry is characterised for having long product cycles, high levels of capital and R&D intensity, and strong competition from the US. The so-called ‘Airliner Wars’ between Airbus and Boeing are driving R&D performance. China is emerging as potential competitor in the near future and most notably as an important exporter of aircraft components. The Aerospace industry is not a homogenous industry since it consists of several sub industries that face different industrial structures, innovation systems and challenges. Notable differences are between military and civil aeronautics; and between space and aeronautics. The major difference being that space is subsidised, whereas aeronautical companies are not, which impacts on their R&D performance. Competition drives BERD in the Aerospace industry.

BERD drivers in the French aerospace industry are environmental issues and sustainable development; and implications stemming from the globalisation of industry. Other important drivers are security issues, international and national regulations, IPRs and R&D collaboration between industry stakeholders. R&D drivers in the space sub-industry are institutional programmes, international regulations (mainly related to climate change) and EU specific research frameworks (i.e. the Galileo global navigation satellite system). R&D efforts in the military side of the industry have been decreasing, mainly because of rather static military budgets, and high political and financial costs of Programmes. Public funds and Programmes remain strong drivers of BERD in the industry.

The German Automotive Industry

German business expenditure on R&D (BERD) accounts for 31% of all business R&D expenditures in the European Union. About 30% of the German spending comes out of the automotive sector which is not only larger but also more research intensive than in most other countries. The increasing R&D investments in the automotive industry are partly due to
the premium car strategy of the German industry, national and European regulations and climate change – as the most pressing environmental issue – together with (at least long term) rising costs and scarcity of fossil fuels and the substantial external costs of individual mobility and transport. The German automotive industry has reacted to these challenges by increasing R&D investment to reduce fuel consumption and pollution, to increase car safety and to introduce electronics and communications systems. R&D is strongly influenced by regulation that impacts both on the supply side (motor vehicle production) and the demand side (use of motor vehicles). Climate change and rallying raw material prices have led to an intensified search for alternative ways to satisfy the huge demands for (individual) mobility and transport services within the given environmental constraints.

**Ireland**

Ireland has been involved in a ‘catching up’ process of investment in R&D from very low levels in the 1980s to a BERD intensity still below, but approaching, that of the average for the OECD countries. This has been accompanied by large inputs of public support to R&D in higher education and in business itself, which have helped pull R&D in the desired directions of higher BERD and, at least until recently, increased concentration in particular sectors, notably information and communication technologies (ICT) and biotechnology. The rise in BERD intensity has arguably, and somewhat perversely, been constrained by the exceptionally high rate of economic growth. Rapid growth in GDP and BERD has been accompanied by certain unevenness in development, with overseas-based multinationals rather than indigenous companies contributing most of the increase in BERD.

**The Aerospace industry and the radio, TV and communications equipment sector in Italy**

Business R&D in Italy is concentrated in just 5 sectors. Over the period 1995-2006 there were some substantial changes in sectoral R&D intensity: which increased in the Aircraft industry and steeply declined in the Radio, TV and Communications equipment industry. BERD investment in these two sectors can be attributed to the strategic decisions and to changes occurred to two leading companies in these sectors: Finmeccanica, a leading manufacturer in Europe in the aerospace industry, and Telecom Italia, for the telecommunication industry. Since 1995 the Italian government dismissed much of its participation in Finmeccanica (retaining one third of the capital) and liberalised the telecommunication industry, privatising Telecom Italia.

The Italian government sector did not implement relevant policy initiatives in support of high-tech industries. However, whilst R&D activity in the aerospace and defense industry was still able to thrive because of large business orders that permitted to Finmeccanica to readjust its strategy in the international scenario, the sudden increase in competition brought by market liberalisation of telecommunication had devastating effects on the whole industry.

**The chemicals sector in Poland**

Although the sector has not been hit strongly by the 2008-2009 economic downturn, the sector continues to under-spend on R&D activities, which account for a mere 10% of all investments. Competition as well as incentives from consumers are important factors for the chemical companies when deciding to introduce new or improved technologies. Cooperation with public research institutes, although still not well developed, is a strategic and indispensable element of the long-term growth of the chemical sector as the companies are reliant on the R&D infrastructure and R&D results of public research institutes. Public sector investment in support of BERD, notably due to the inflow of EU Structural Funds, is perceived as a decisive element to enhance the innovative potential of Polish chemical firms. More institutional policy measures, most notably tax incentives for technology implementation are necessary for boosting BERD. Furthermore, more financial inputs are necessary for applied research instead of fundamental research. Measures oriented at developing practical applications of chemical knowledge for students and young researches need to be supported as well.
Policy options to improve support for BERD in the Polish chemical sector include reviewing the selection criteria for public grants, most notably the industrial applicability potential as well as public-private partnership, fiscal incentives for implementation of R&D results and stability with respect to pursuing long-term R&D strategies.

**The telecommunications services sector in Spain**

The telecommunications services sector is global and its R&D trends and strategies respond to the global strategies of a small group of world leaders. Since 2001, the sector in Spain has moderately lost its dynamism after a strong expansion due to a boom of mobile services and broadband access. The sector is characterised by having most of their investments in fixed assets and equipment, whereas internal and external business R&D represent each 12% of the total. The Spanish market is highly concentrated in terms of players, and also geographically. There is no real critical mass for R&D outside the main focal centres that account for 76% of total R&D in the country. Market competition has increased due to the emergence of mobile virtual operators creating pressure for cost reductions by all market players.

Most public incentives for R&D expenditures are allocated to innovations that solve the problem of lack of accessibility and the introduction of infrastructures to rural areas. Competitive advantages in terms of accessibility to highly qualified personnel remains an important determinant of BERD. One of the biggest challenges of Spain is moving the production activities towards more technology intensive sectors, and/or towards those creating greatest value added to the economy. The main focus should be in increasing the capacity of the sector in producing new and innovative demanded services (i.e. through open innovation models). Two main challenges related to R&D investment and innovation have been identified in this case study: the increase in the number of medium high and high technology industries; and the increase in the availability of human capital and skills.

**The ICT industry and the Radio, TV and communications equipment sector**

Swedish business enterprise research and development (BERD) is remarkably high in relative terms in an international context. Approximately one-fourth of Swedish BERD takes place in the ICT sector, with telecom giant Ericsson as the key player. Thus, developments in the Swedish ICT sector are of interest well beyond Sweden. The business environment in the ICT sector has changed profoundly since the early 2000s. Rapid technological development has spread ICT to several other sectors, especially other technologies. To keep up with the pace of the changes is a fundamental challenge for companies in the traditional “core ICT”. There is increasingly less scope for the production of general-purpose hardware, but instead several niches have emerged for producers of solutions including software. Also sub-contractors are increasingly required to produce entire solutions instead of single parts.

The profound changes have caused a shift in R&D from research towards development and innovation. At present, conducting basic or even applied research appears to be too far away from the market and these segments are increasingly the responsibility of governmental agencies. Furthermore, R&D in the ICT sector is characterised by many small steps, but taken at a very rapid pace. A result of the changes is that major companies tend to look for cooperation instead of outright competition. The relatively few government regulations in the sector have caused a certain degree of internal consolidation within the industry.

**The ICT sector in Estonia**

The ICT sector in Estonia contributes significantly to the total BERD in Estonia. Observing the contents of innovation activities of ICT businesses in general, R&D activity consists of a minimum share of research. The situation reflects the ICT businesses' performance more towards operational and short-term innovative activities instead of more strategic research projects. However, the situation is likely to improve, for instance, through technology competence centres (two in ICT sector) established jointly by public and private resources. One of main drivers of the Estonian ICT sector lies in the leading role of public sector. The public sector has acted to create a market through large-scale infrastructure investments as
well as public procurement in the ICT field. The need to increase the export share of ICT businesses is a priority of the sector. Due to the smallness of the market and resources of businesses joint actions between themselves and in co-operation with research institutions are necessary to sustain competitive positions internationally. The performance of major players like Skype but also Playtech in Estonia has stimulated developments in and improved the image of the sector as a whole. The need to create and develop several additional major players in the ICT field is considered to be a critical success factor for future economic competitiveness.

So far, information policy related activities in Estonia have mainly been focused on the development of ICT infrastructure and the creation of systems necessary to implementing sectoral policies. However, in future, more emphasis needs to be put on the development of citizen-centres and inclusive society and a knowledge-based as well as transparent public administration.

**The ICT sector in Finland**

The Finnish Business Expenditure on R&D (BERD) is dominated by telecom giant Nokia, which accounts for approximately 50% of total BERD in Finland. Since 2000, the ICT sector in Finland has been characterised by rapid internationalisation, and consequently the Finnish ICT sector has become adjusted to a global field of activity. The domestic market is no longer decisive. The ICT sector is also characterised by increased technological convergence.

The very rapid development in the ICT sector has a profound impact on R&D. First, there is a shift from research to development. Second, the way R&D is conducted changes. Open innovation is increasingly a part of R&D in the ICT sector. In particular this implies that users have a bigger part in the development of technology and as a result R&D is increasingly sensitive to demands by the users. Another new development is the creation of “lablets”, which are institutionalised cooperation between firms and universities. The success of Nokia has not been followed by neither a general upswing in ICT-related R&D in Finland nor significant FDI in R&D. This is perceived a major problem, because a big influx of foreign R&D would likely intensify the R&D efforts of ICT firms, which tend to be below expectations despite Nokia’s success. Foreign FDI in ICT R&D would also contribute to a diversification and consequently less reliance on Nokia only.
5.2 Summary of identified BERD drivers

This section identifies the main BERD drivers in the selected countries and sectors studied in the case studies. Changes in BERD can be quantitative, and thus being reflected in official statistics; but they can also be qualitative, referring to changes in the ways BERD is undertaken or the way enterprises do business.

Because of the implications related to the methodological structure of the survey-based case studies, the BERD drivers identified in this report are case dependent, and policymakers must have this in mind when using these and their implications and conclusions in a policymaking process.

All drivers are classified according to the initial classification presented in the Literature Review of this study.

Enterprise-level strategies and structures, or drivers from the micro level

Access to financial resources and the cost of R&D

- (Barrier) Increased costs of R&D in the Belgian pharmaceutical industry. The increased R&D costs associated with the development of a new drug have the logical upward effect on BERD. The cost expansion is due to two reasons: the first lies in the scientific domain where only complex pathologies are left in the disease-spectrum making it more difficult and expensive to develop new drugs; and the second relates to regulatory factors where higher demands by the marketing authorisation agencies with regard to the number of patients and tests per patient in clinical trials increase the costs significantly.

- (Barrier) Lack of funds in enterprises in the chemical sector in Poland. Among the factors hampering innovation activities in Polish industrial enterprises, the cost factors (lack of funds within the enterprises or from sources outside the company) play the most decisive role; the gravity of this factor was inversely proportional to the size of a company.

New 'trend': open-innovation and collaboration models

- The evolution towards the open innovation model in the Belgian pharmaceutical industry. The knowledge growth in the pharmaceutical industry is expansive, making it impossible for the pharmaceutical companies to have all the required know-how in house. This “knowledge boom” leads the pharmaceutical companies towards cooperation with external high-technological third parties. Companies perform only those processes and products in which they excel themselves, while outsourcing the remaining processes and products to other parties that can handle these better and/or cheaper. The outsourcing occurs mostly vertically, towards smaller companies; horizontal cooperation is much less prevalent.

- Open innovation in the ICT industry in Finland. Open-innovation in RD&I has been growing in importance since 2000. Open innovation in this context means cooperation with a rather free flow of knowledge and information. Furthermore, it puts more focus on users and thus there is no development without the users, of both equipment and services. The customers are naturally assumed to have the ultimate expertise especially in the area of services. The agenda is increasingly set outside the companies performing R&D, which thereby tend to respond to demand instead of creating or steering it.
Access and quality of human resources (knowledge)

- (Driver) High concentration of highly educated workers in Belgium.
- (Driver) The ICT industry in Finland. The human resources in Finland are sufficient for maintaining and edge in ICT; not only the absolute numbers of skilled personnel justify this claim, but also the specific cooperation culture and competitive universities.
- (Barrier) Absorptive capacity in Ireland. The weak absorptive capacity in indigenous Irish industry is an ongoing problem. Although there is recognition of the problem and initiatives to ameliorate the situation, the national infrastructure is not ideal in this respect, with 'no specialist or sector-based research institutes in Ireland.
- (Barrier) The shortage of qualified staff and its impact on the ICT industry in Estonia. The main obstacles to undertaking innovative activities for the Estonian ICT sector is the shortage of qualified staff (especially acute in the ICT industry). The existence and availability of human resources, i.e. high-skilled and educated people, is a key input for innovation. In overall terms, Estonia is characterised by high educational attainment. The rate of Estonia’s tertiary graduates (in science, engineering, social sciences and humanities) equals the EU mean but it falls behind in the rate of doctoral graduates.

Corporate strategies of leading companies (industry "keystones")

- The Swedish ICT industry. The performance of the Swedish ICT industry has so far been extraordinary, but the industry relies on a small number of companies. In particular one company, Ericsson, is synonymous to the Swedish ICT industry. However, the cornerstone of the Swedish performance in the ICT sector was initially the cooperation between the public sector and Ericsson.
- The ICT industry in Finland. Nokia’s R&D expenditure accounts for approximately 50% of BERD in Finland. By and large, Nokia sets the entire Finnish R&D agenda in the ICT industry.
- The Aerospace industry and the radio, TV and communications equipment sector in Italy. BERD investment in these two sectors can be attributed to the strategic decisions and to changes occurred to two leading companies in these sectors: Finmeccanica, a leading manufacturer in Europe in the aerospace industry, and Telecom Italia, for the telecommunication industry. The Italian aerospace industry comprises a small number of large firms and a much larger number of smaller businesses. Finmeccanica is Italy’s second-largest manufacturing conglomerate and a leading high-tech business. Telecom Italia is the leading telecommunications company in Italy. At present, the highest investor in R&D in the Radio, TV and communication equipment sector is Italtel.
- The telecommunications services sector in Spain. The Spanish market is highly concentrated in terms of players, and also geographically, following the corporate strategies of the main players. Telefonica, the main operator, has followed different strategies (i.e. internationalisation) in order to respond to increasing competition in the internal market.

Mergers, joint ventures, acquisitions and alliances

- The ICT industry in Finland. Mergers, acquisitions, and alliances are of significant importance in deciding the direction and capacity of large enterprises in terms of R&D. Many acquisitions made by large enterprises have been large in terms of new R&D capacity acquired. The ICT industry increasingly consists of elements of other industries and thus mergers tend to create complementary advantages.
Joint ventures in the aerospace industry in Italy. Business size is a key factor for platform integrators in the aerospace industry. Finmeccanica, the leader company in aerospace, signed several joint ventures in order to achieve adequate critical mass in its areas of expertise. This together with substantial technological progresses has allowed the national industry to maintain and expand the current position in global markets. The possibility to carry out R&D in co-operation with other firms is a key driver to R&D efforts in the aerospace industry. Considering the costs of R&D in this industry, alliances allow to concentrate efforts only in the areas of real expertise, leaving to others research activity in areas where the company has no competitive advantage. Therefore, R&D collaborations and partnerships are necessarily driven by both increasing scale and cost of R&D and by the need to access complementary technologies.

**Ownership structure of firms**

- The radio, TV and communication equipment sector in Italy. BERD trends can be attributed to the strategic decisions of Telecom Italia. The change in the ownership structure of the company had dramatic effects on the R&D strategy, on investments and on the organisation of the whole industry. After the privatisation, the main provider of telecommunications in Italy was not as competitive as when the industry was operating under a monopolistic market structure. Telecom dismissed a large part of its R&D activity in the telecommunication equipment sector, starting to focus on R&D in services (software, etc.), pursuing short-term objectives. As a consequence of this, the company lost much of the competencies in key areas such as multimedia.

- The chemicals sector in Poland. The ownership structure is a specific factor with a potential impact on BERD trends in the Polish context, as the most important players in the chemical sector are still state-owned. It is obvious that the long-lasting problems with privatisation and continuously projects regarding its implementation keep the sector in strategic suspense and uncertainty.

**The size of firms**

- The chemicals sector in Poland. The size of the company in the chemical sector is a crucial factor determining BERD intensity. The chemical sector is very capital-intensive and entry barriers are very high, which makes entrepreneurial start-ups intricate. The larger companies have an advantage when performing R&D activities due to the fact that they are much better equipped with material and financial resources as well as the awareness of the need to invest in R&D is stronger.

**Drivers from the meso level**

**The access and cost of infrastructures**

- (Driver) The world-level standard of biomedical research and the top-level hospital infrastructure available in Belgium to perform clinical trials in the pharmaceutical industry.

- (Barrier) The chemicals sector in Poland. R&D expenditure in the sector is not the heaviest investment burden for a firm; decisive are the costs related to the implementation of new technology (implementation costs), most notably construction of new installations and other infrastructure.

**Drivers from the market**

**The internationalisation of R&D**

- The ICT industry in Sweden. In the last decade, R&D in the ICT industry has been characterized by the rapid change towards a global market. National boundaries have lost their meaning for the ICT industry and R&D activities are increasingly
concentrated where they are most productive. Also the rapid pace of renewal in the ICT industry requires constant product improvement, often as a sequence of a large number of small steps, but at an extraordinary speed. In order not to split resources, companies have to focus. This in turn favours the creation of alliances around particular technologies.

**Consumer preferences**

- “Hybrid” investments in the automotive industry in Germany. While German car producers do still “insist” on the larger saving potential of diesel engines compared to hybrid engines, consumers increasingly opt for hybrid cars and have triggered substantial innovation investments to develop this sort of cars in Germany. The success of hybrid cars indicates stronger and more precise demand from consumers.
- The ICT industry in Finland. Due to the open innovation model in the industry, users are having a bigger part in the development of technology and as a result R&D is increasingly sensitive to demands by the users.

**Competition**

- (Driver) Cooperation strategies of major companies in the ICT industry in Sweden. The business environment in the ICT sector has changed profoundly since the early 2000s. Rapid technological development has spread ICT to several other sectors, especially other technologies. To keep up with the pace of the changes is a fundamental challenge for companies in the traditional “core ICT”. Therefore, it has become crucial to understand several sectors and to cooperate with companies possessing specific knowledge. A result of the changes is that major companies tend to look for cooperation instead of outright competition. This is particularly important in developing technology standards and platforms. This in turn allows for faster development and therefore the amount of R&D increases when initial uncertainty about future standards is removed. The relatively few government regulations in the sector have caused a certain degree of internal consolidation within the industry.
- The globalisation of the ICT industry and its effect on Sweden. In the last decade, R&D in the ICT sector has been characterized by the rapid change towards a global market. National boundaries have lost their meaning for the ICT industry and R&D activities are increasingly concentrated where they are most productive.
- The globalisation of the aerospace industry and its implications in France. The aerospace industry is more global and more competitive than ever. The industry’s main R&D driver is the market pull of competition push. Industry’s players are forced to follow the market trends in order to remain competitive.
- The globalisation of the aerospace industry and its impact in Italy. R&D efforts in the aerospace industry are hardly driven by firm-level investments decisions. R&D investments costs in this industry are extremely high and are necessarily driven by two factors, government incentives and business orders. Italy has provided since 1985 special incentives (in the form of R&D funding) to the aerospace industry. However, what has really driven the increase in R&D efforts in the Italian industry over the last 10 years has been receiving a constant stream of funding from foreign business orders. The increase in R&D expenditures in the last decade was driven by the commercial success of Finmeccanica.
- The globalisation of the radio, TV and communications equipment sector in Italy. The sector is extremely dynamic and the Italian industry was already exposed to international competition before it was liberalised. The industry dynamics are one of the causes for the reduction of BERD in the telecommunication industry. When technologies (i.e. telecommunication services) turn into commodities, R&D efforts are minimised, and the whole value chain (i.e. telecommunication equipment) is affected.
• The globalisation of the telecommunications sector and its impact in Spain. The telecommunications services sector is global and its R&D trends and strategies respond to the global strategies of a small group of world leaders, regardless of their location. Global competitive pressures had forced operators to internationalise, delocalise, externalise and/or cut some of their operations.

• The globalisation of the ICT industry and its impact in Estonia. There is a positive trend amongst Estonian companies towards a „global approach“ to access foreign markets and not to limit themselves to satisfying domestic demand. Increasing global competition as well as ”visionary“ view of companies in the field is considered to be drivers in the sector. The capacity to invest into R&D or other fields is mostly dependent on the growth of market share and the possibility to enter new markets than other factors. The availability of specialists is becoming a determining factor in scale and scope of expanding activities to abroad.

Foreign Direct Investment

• (Barrier) The ICT industry in Finland. One of the biggest concerns in connection with Finnish R&D is the poor capacity to attract foreign investment. Foreign R&D related investment is expected to bring new know-how to Finland, while at the same time it can be observed that it has an intensifying effect on R&D performance in Finland. The reasons behind the absence of significant influx of foreign R&D are manifold, complex, and somewhat obscure. It nevertheless appears that chances have been lost due to insufficient efforts from the side of the entire innovation system.

• (Driver) The influx of FDI in Ireland. The large and unexpected influx of (mainly US) multinational corporations in the 1990s, attracted by a low-wage, low-tax economy made Ireland a base for production but not, initially at least, for R&D. Irish R&D policy since the late 1990s can be seen as an attempt to capitalise and consolidate this trend by establishing Ireland as an international base for R&D by supporting the development of facilities to attract researchers from abroad, efforts to increase the stock of domestically-trained researchers, grants to companies and promotion of their collaboration with higher education institutes (HEIs) particularly targeted to ICT and biotechnology, and (later) R&D tax incentives, representing a form of more general support for R&D applicable to all sectors. While this increased the level of BERD in high-tech sectors, most of the R&D base of the incoming companies remained at home. There was a perceived need to embed R&D in Ireland to retain investments and sustain growth.

Drivers from the macro level

Regulations

• (Barrier) More stringent and complex regulations with regard to market authorisations, price setting and reimbursement in the Belgian pharmaceutical industry. The stricter regulatory environment induces extra costs to the pharmaceutical industry and poses delays in the market access of a new drug, thus shortening the time span to regain initial R&D investments and therefore discouraging R&D spending.

The environment and environmental regulations

• (Driver) Environmental regulations and climate change. The increasing R&D investments in the German automotive industry are partly due to national and European regulations and climate change – as the most pressing environmental issue – together with rising costs and scarcity of fossil fuels. The industry has reacted to these challenges by increasing R&D investment to reduce fuel consumption and pollution. R&D is strongly influenced by regulation that impacts both on the supply side (motor vehicle production) and the demand side (use of motor vehicles). Climate
change and rallying raw material prices have led to an intensified search for alternative ways to satisfy the huge demands for (individual) mobility and transport services within the given environmental constraints.

• Environmental issues and sustainable development in the aerospace industry in France. The so called “grenelle de l’environnement” became an important driver of BERD since 2007. The main three priorities are climate change, biodiversity protection and the reduction of pollution. The grenelle set clear quantifiable objectives relevant to the aerospace industry. These objectives became drivers of R&D in order to prevent technological crashes and enhance the development of future technologies for aircrafts. Regarding the space sub-industry the environment has been set as a priority, notably by the implementation of meteorological satellites for monitoring carbon emissions and enhancing R&D related to climate change. The European Space Agency has been using its platforms for global climate change research.

**Technology standards**

• The ICT industry in Sweden. The industry’s R&D decisions are affected by the fact that new products need to be compatible with older equipment.

**The macroeconomic framework**

• The ICT industry in Sweden. There is one Swedish macroeconomic development that might have contributed to the persistence of R&D in Sweden. For decades, Sweden kept up its industrial competitiveness through a series of devaluations. Together with the compressed salaries, which have been a cornerstone of the Swedish labour market (i.e. small difference between low and high wages), this has probably led to more investment in Swedish R&D staff, which thus has been perceived cheap in comparison to foreign R&D staff.
### Summary of BERD drivers

The following table presents a summary of identified BERD drivers presented above.

<table>
<thead>
<tr>
<th>BERD drivers</th>
<th>Expected factors (drivers/barriers) in specific countries and sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise-level strategies and structures, or the micro level (the size of the firm, corporate strategy and structure, resources)</td>
<td>Access to financial resources and the cost of R&amp;D: increased costs of R&amp;D in the Belgian pharmaceutical industry (barrier); lack of funds in enterprises in the chemical sector in Poland (barrier).</td>
</tr>
<tr>
<td></td>
<td>New ‘trend’ Open innovation and collaboration models: the evolution towards the open innovation model in the Belgian pharmaceutical industry; open innovation in the ICT industry in Finland.</td>
</tr>
<tr>
<td></td>
<td>Access and quality of human resources (knowledge): High concentration of highly qualified workers in Belgium (driver); the ICT industry in Finland (driver); the shortage of qualified staff and its impact on the ICT industry in Estonia (barrier).</td>
</tr>
<tr>
<td></td>
<td>Corporate strategies of leading companies (industry “keystones”): the Swedish ICT industry; the ICT industry in Finland; the aerospace industry and the radio, TV and telecommunications equipment sector in Italy.</td>
</tr>
<tr>
<td></td>
<td>Mergers, joint ventures, acquisitions and alliances: the ICT industry in Finland; joint ventures in the aerospace industry in Italy.</td>
</tr>
<tr>
<td></td>
<td>Ownership structure of firms: the radio, TV and communication equipment sector in Italy; the chemicals sector in Poland.</td>
</tr>
<tr>
<td></td>
<td>The size of firms: the chemicals sector in Poland.</td>
</tr>
<tr>
<td>The meso level (competitive behaviour, specialisation, institutional factors)</td>
<td>The access and cost of infrastructures: the world-level standard of biomedical research and top-level hospital infrastructure in Belgium (driver); the chemicals sector in Poland (barrier).</td>
</tr>
<tr>
<td>Drivers from the market (demand pull and technological competencies, competition, cooperation or contracting)</td>
<td>The internationalisation of R&amp;D: the ICT industry in Sweden.</td>
</tr>
<tr>
<td></td>
<td>Consumer preferences: ‘Hybrid’ investments in the automotive industry in Germany; the ICT industry in Finland.</td>
</tr>
<tr>
<td></td>
<td>Competition: cooperation strategies of major companies in the ICT industry in Sweden (driver); the globalisation of the ICT industry and its effect on Sweden; the globalisation of the aerospace industry and its implications in France and Italy; the globalisation of the radio, TV and communications equipment sector in Italy; the globalisation of the telecommunications sector and its impact in Spain; the globalisation of the ICT industry and its impact in Estonia.</td>
</tr>
<tr>
<td></td>
<td>Foreign Direct Investment: the ICT industry in Finland (barrier); the influx of FDI in Ireland (driver).</td>
</tr>
<tr>
<td>BERD drivers</td>
<td>Expected factors (drivers/barriers) in specific countries and sectors</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Drivers from the macro level (national and international system and effects, institutional factors)</td>
<td><strong>Regulations:</strong> more stringent and complex regulations relevant to the Belgian pharmaceutical industry (barrier)</td>
</tr>
<tr>
<td></td>
<td><strong>The environment and environmental regulations:</strong> environmental regulations and climate change and its implications in the automotive industry in Germany (driver); environmental issues and sustainable development in the aerospace industry in France.</td>
</tr>
<tr>
<td></td>
<td><strong>EU standards and regulations:</strong> the chemicals sector in Poland; stringent marketing authorisation regulation and complex pricing setting and reimbursement mechanisms in the Belgian pharmaceutical industry.</td>
</tr>
<tr>
<td></td>
<td><strong>Technology standards:</strong> the ICT industry in Sweden and Finland.</td>
</tr>
<tr>
<td></td>
<td><strong>The macroeconomic framework:</strong> The Swedish macroeconomic development relevant for the ICT industry.</td>
</tr>
</tbody>
</table>
6 Conclusions and policy lessons

The first part presents the conclusions and policy lessons derived from the case studies. Based on these policy lessons for the study as a whole are presented.

6.1 Conclusions and policy lessons from case studies

The Belgian Pharmaceutical Industry

Drivers for R&D spending in the Belgium pharmaceutical industry go beyond national boundaries and are shaped at the EU and worldwide levels. Therefore Belgian national and regional policies only have a limited impact on the BERD performance and intensity of the pharmaceutical industry. Three are the policy initiatives in Belgium that have an influence on the R&D spending of the pharmaceutical industry: fiscal policies; science and education policies; and regulation policies.

In order to further stimulate R&D spending in the pharmaceutical sector in Belgium, policies oriented towards “horizontal convergence” should be pursued through harmonisation in the pricing and reimbursement decision process across different countries in the EU. The way forward for the Belgian government with regard to its public policies in favour of the pharmaceutical industry, should focus on a further strengthening of the fiscal stimuli for the pharmaceutical industry; and the additional expansion and improvement of the knowledge base and clinical infrastructure via affirmative scientific and innovation policies. The attachment of the pharmaceutical industry to Belgium is based on the presence of a strong industrial base, which should not be lost out of sight in the design of future public policies. More in particular, Belgium is encouraged to further stimulate R&D in the areas in which it has relative specialisation strengths, such as in vaccination and neurotic diseases.

The French Aerospace Industry

France has a long history of strong involvement of the government in the aerospace industry. The industry is a very special case since it is a symbol of French industry and economic sovereignty at international level and has benefited from strong political support for decades. The main indirect innovation policy measures influencing BERD in the aerospace industry are: the Research tax credit, the Carnot institutes, the financing of public research laboratories concerning the offer of fundamental research; and the CIFRE conventions. The most relevant direct innovation policy measures influencing BERD is the support to competitiveness clusters, part of the Company Competitiveness Fund.

R&D collaboration between industry stakeholders is an important driver of BERD. Increased collaboration and transparency within a vision and roadmap shared by all stakeholders is desirable. The Council for Civil Aeronautics Research reveals to be the appropriate institutional body for enhancing collaboration and R&D performance.

The German Automotive Industry

If policymakers do have the impression that the industry fails to live up to societal needs or take decisions, which undermine long-term competitiveness, then strict regulations may be the step to take. Policymakers might step in, and give the lead market concept another twist, and demand more pronounced development efforts by setting advanced regulations. Better scientific support for the industry in Germany can only be achieved by increasing the quality of scientific institutions which might form co-operations with the industry. Co-operative research programmes and horizontal alliances for the development of large pre-competitive technology fields might also be stimuli that could be further developed. An obvious area for public intervention is the creation of an environment that holistically supports e-mobility and includes the development of supporting infrastructures and research on social innovations to
cope with the restructuring of industries triggered by rallying raw material prices (including oil) and increasing global efforts to reduce CO2 emissions. Lifting the level of tertiary educated people would not only allow a more balanced growth of the economy but would lift already existing shortages of scientists and engineers. This depends on the successful introduction of reforms to primary and secondary education in Germany.

**Ireland**

The extent to which overall and sectoral trends in BERD in Ireland have been driven by ‘external’ factors on the one hand, and are attributable to public policy on the other, is (as always) difficult to delineate. A major external factor was the large and unexpected influx of (mainly US) multinational corporations in the 1990s, attracted by a low-wage, low-tax economy. These conditions made Ireland an attractive base for production but not, initially at least, for R&D. Irish R&D policy since the late 1990s can be seen as an attempt to capitalise and consolidate this trend by establishing Ireland as an international base for R&D by supporting the development of facilities to attract researchers from abroad, efforts to increase the stock of domestically-trained researchers, grants to companies and promotion of their collaboration with higher education institutes (HEIs) particularly targeted to ICT and biotechnology, and (later) R&D tax incentives, representing a form of more general support for R&D applicable to all sectors. Government policy was involved particularly in raising the science base in niche ICT and biotech areas. Policy since the late 1990s has been successful in raising the HEI science base, and BERD has continued to increase rapidly, still mainly among the foreign-owned firms.

The ability of indigenous firms in particular to take advantage of developments in the science base, and to benefit from knowledge spillovers from their foreign-owned counterparts, remains limited, and an increase in the absorptive capacity of these firms might be expected to lead to Ireland being well up in the ranks of mainstream innovative economies. Similar conclusions apply to gains from interaction with foreign companies and research organisations, which could be stimulated through greater involvement with EU R&D Framework Programmes.

**The Aerospace industry and the radio, TV and communications equipment sector in Italy**

The comparison of R&D investment in aerospace and Radio, TV and communication equipment leads to the conclusion that in both industries the role of the government has been very important in driving R&D. R&D efforts in both industries are only partially driven by firm-level investments decisions: Framework conditions have deeply affected companies behaviour and competitiveness. Excessive privatisation of state companies and market liberalisations killed technological excellence in too many cases. The aerospace industry was an exception to the rule because it was less exposed to international competition and because its customers are very often governments.

A tight relationship between government, industry and the education sector is needed to make high-tech industries prosper. High tech industries need support from governments with the creation of innovation systems, provision of skilled human capital and financial support.

**The chemicals sector in Poland**

BERD in the chemical sector is low and its intensity decreasing. The chemical firms are still largely in a phase of catching up, through investment in plant and equipment, with European and global standards. Cooperation between public and private organisations needs to be intensified. The private sector is not able to remain competitive without knowledge and R&D infrastructure of public R&D entities, which in turn need to obtain more funds from companies to deploy their whole R&D potential.

Public funds need to be directed more towards applied research, which provide solutions for industry. The industrial applicability potential of R&D results and private-public partnerships benefiting from R&D synergy effects need to be the key evaluation criteria when deciding of
funds distribution. Favourable conditions for R&D performance must be created, most notably introducing tax incentives for implementation of a technology, and not only for R&D activity. Companies must be fiscally disburdened in order to release financial resources for BERD. Temporariness of the current ownership structure of the sector must be brought to an end. Growth, development and successful R&D cooperation need stability and consequent follow-up of strategies. Public policy must ensure that favourable conditions will be created in order to pursue long-term R&D strategies (stability of high-level management).

**The telecommunications services sector in Spain**

The telecommunications services sector is global and Spanish BERD trends respond to the global strategies of the main world players, regardless of their location. Geography does not seem to be relevant in this global sector because of its intensity in knowledge and the facility to transfer it through ICTs. One of the biggest challenges in Spain is moving the production activities towards more technology-intensive sectors, and/or towards those creating greatest value added to the economy. Cooperation among participants in the innovation system is essential for boosting BERD. It also extends the scope of technological applications to more traditional sectors in the Spanish economy because of its horizontal nature of application. Demand-side policies such as transfer schemes to support access to telecommunication services to excluded niches would be of effectiveness for reaching a critical mass of users and would serve as an incentive for R&D investments. This requires the increase of Public Private Partnerships. Better use of public procurement for boosting BERD should be enhanced. There is a need for specific measures in order to reduce the brain drain in the country and attract foreign highly qualified technical workers.

**The ICT industry and the radio, TV and communications equipment sector in Sweden**

The performance of the Swedish ICT industry has so far been extraordinary, but the industry relies on a small number of companies. In particular, one company, Ericsson, is in many cases almost synonymous to the Swedish ICT industry. However, the cornerstone of the Swedish performance in the ICT sector was initially the cooperation between the public sector and Ericsson. The role of academic research and the universities’ role in training skilled engineers are of crucial importance in the development. The key factors and developments behind R&D decisions identified in this report are: the internationalisation of R&D; the spread of ICT to several industrial sectors; the increasing specialisation among ICT companies; the need for (some) new products to be compatible with older equipment; the shifting of focus from research towards development and innovation due to the very high pace of developments; the cooperation patterns partially replacing competition. In the last decade, R&D in the ICT sector has been characterized by the rapid change towards a global market. Another major trend is the movement from the production of purely hardware towards the development of software, i.e. providing products with contents and thus facing increasing specialisation.

These trends have forced ICT companies to put much more emphasis on development than research; the latter broadly speaking being left to the public sector and universities to conduct. Cooperation between companies in ICT is commonplace today. Swedish industrial policy in the last decade has been rather indifferent (not only towards ICT). Industry has been assumed to take care of itself. In many respects this has been a successful path, but now there are concerns that competing with companies from countries with strong policy support for industry may prove too much of a challenge.

**The ICT sector in Estonia**

The uniqueness of the Estonian ICT sector lies on a combination of several success factors that played a role since the beginning of 1990s. The leadership role of public sector in the ICT field has to be mentioned first, as encouraging the sector development and BERD, more specifically. An innovative mindset in the public sector and the choice of high-quality IT solutions as well as ID-card infrastructure and solutions are explanatory factors for positive trends in Estonia’s ICT sector. Wide use of ICT in education, advanced communications
network and good Internet availability add extra value to the public role in ICT developments. The performance of internationally well-known players like Skype or Playtech in Estonia is found to attract extra investments into the field and related ones. In terms of future, there is a positive trend amongst Estonian companies towards a “global approach” to access foreign markets and not to limit themselves to satisfying domestic demand. Increasing global competition as well as “visionary” view of companies in the field is considered to be drivers in the sector. The availability of specialists is becoming a determining factor in scale and scope of expanding activities to abroad. The policy activities in stimulating cooperation between businesses or businesses and the academia (such as competence centres) are most expected public initiatives by business stakeholders.

**The ICT sector in Finland**

Finnish R&D in the ICT sector is completely dominated by Nokia. In general, Finnish R&D in the ICT sector has not been characterised by radical innovation, but rather by the capacity to adjust and to utilise R&D conducted elsewhere. Partially this can be attributed to the limited human resources – an issue observed closely in Finland and which has prompted rethinking in the higher education structure. Important developments since 2000 include above all the rapid internationalisation of the ICT sector. In addition to this, the ICT sector is characterised by increasing convergence, by which is meant that several technologies are becoming intertwined. This development has forced companies like Nokia to create new alliances in order to develop competence in those technologies where it has little prior experience. Another important trend since 2000 is the growing role of open innovation.

One of the absolutely biggest concerns in connection with Finnish R&D is the poor capacity to attract foreign investment. Foreign R&D related investment is expected to bring new know-how to Finland, while at the same time it can be observed that it has an intensifying effect on R&D performance in Finland. The international standardisation process in the ICT industry has by and large been self-regulating (contrary to some other sectors) and it has not required the active intervention of authorities. Broadly speaking, consumer preferences are decisive.

### 6.2 Identified policy measures driving BERD in selected countries and sectors

The following is a list of identified policy measures driving BERD in the selected countries and sectors studied in the case studies. Deeper analyses of these measures are presented in the policy sections of each of the case studies in Annex A.4.

Examples of policy measures boosting BERD are classified in four main fields: generic policy tools; policy measures related to fundamental R&D; policy measures related to technology transfer; and policy measures related to applied research.

1. **Generic and horizontal policy measures**

**Fiscal policies**

- *(Driver) Fiscal stimuli and the fiscal environment in Belgium.* The favourable fiscal policies in Belgium positively affect the R&D spending in the pharmaceutical industry. There are five kinds of measures that create a positive fiscal environment for the pharmaceutical industry in Belgium: the fiscal deduction of own R&D investment costs and costs related to IPR; the “notional interest” regime, through which companies can fiscally deduct the investments they financed by internal (own) funding; the exemption of a part of the advance tax payment for researchers; the decrease in taxes on revenues generated by royalties; and the tax exemption of a premium of up to 2000 Euro that researchers can receive as a compensation for producing a “novel idea”.
• The Research tax credit in France and its implications to the aerospace industry. The Research tax credit (CIR) is one of the central pieces of French innovation policies. The CIR was created to promote BERD across sectors. Government experts signaled the CIR to be extremely efficient, and a world reference, in pushing enterprises to invest in R&D.

• Tax credit for R&D costs in Italy. R&D performing companies in every industry benefited greatly from the tax credit for R&D costs introduced in 2006. The initiative grants a tax credit of 10% of industrial research costs or 40% of costs for research contracts signed with universities or research centres. This initiative was so successful that the entire budget allocated for tax credits was allocated within days and not all applications were accepted.

Science and education policies

• (Driver) All related science and education policies in Belgium. The science and education policies of the Belgian federal and regional governments have a stimulating effect on the R&D spending of the Belgian pharmaceutical industry. These contribute to providing the pharmaceutical companies in Belgium with large numbers of high-quality human capital, including attracting top-research staff from abroad.

• Better quality of scientific institutions in Germany. The German automotive industry has established global and intense links to scientific institutions and is well able to tap these sources. Better scientific support for the industry in Germany can only be achieved by increasing the quality of scientific institutions, which might form co-operations with the industry.

• Increasing the level of tertiary educated people in Germany. The German automotive industry has been very successful in attracting substantial quantities of science and engineering graduates almost at the expense of other industries. Lifting the level of tertiary educated people would not only allow a more balanced growth of the economy but would lift already existing shortages of scientists and engineers.

• Availability of top researchers in Sweden. Major Swedish companies are aware of the risk of not having sufficient numbers of top researchers in the country. There are concerns that not enough is done for the promotion of innovations and for counteracting the so-called “Swedish paradox”, according to which Swedish innovative ideas turn into marketable products only abroad.

• Better training of skilled engineers in Sweden. The role of academic research and the universities’ role in training skilled engineers are of crucial importance in the development of the ICT industry in Sweden.

• The improvement of the quality of the education system and the provision of more and better skills to graduates in Spain. Other measures include motivating students to continue their education to the PhD level; the reduction of brain drain in the country and the attraction of foreign highly qualified technical workers; and policies related to the support of creativity and entrepreneurship.

2. Policy measures related to fundamental R&D

Sector specific regulation policies

• Regulation policies in support of Belgian industry. The slow regulatory decision-making in Belgium curbs BERD. Belgium should progress towards making its regulatory framework more flexible and more aligned with evolutions at the EU level. More horizontal convergence could be achieved through harmonisation in the pricing and reimbursement decision process across different countries in the EU.
3. Policy measures related to technology transfer

Collaboration between industry and academia

- Co-operative research programmes and horizontal alliances for the development of large pre-competitive technology fields in Germany.
- The transfer of research outcomes from universities or technology centres to the private sector in Spain.

Collaboration between industry and the public sector

- The promotion of the activities of public research institutes engaged in active research partnerships and socio-economic actors, including private enterprises, like the Carnot Institutes in France.
- The CIFRE Conventions in France offer a subvention to any French enterprise that hires a PhD student for placement on research collaboration with a public research laboratory, thus promoting public-private partnerships on R&D. The support has proven successful in terms of thesis defence for students and access to the job market.
- The promotion of research and innovation with targeted incentives to strengthen public-private partnerships and increase BERD in Italy.
- Cooperation between public and private organisations in the chemicals sector in Poland. More cooperation between public and private organisations is needed. The private sector is not able to remain competitive without knowledge and R&D infrastructure of public R&D entities, which in turn need to obtain more funds from companies to deploy their whole R&D potential.

Collaboration between industry, the public sector and academia

- A tight relationship between government, industry and the education sector in Italy. This is needed to make high-tech industries prosper. These industries need support from governments with the creation of innovation systems, provision of skilled human capital and financial support.
- The promotion of R&D collaboration amongst companies, universities, public research bodies and centres, and technological parks and centres in Spain. This is positive for boosting BERD as it offers opportunities for knowledge sharing, knowledge exchange, technology transfers and entrepreneurship enhancement. This is particularly relevant for the telecommunication services sector because of the recent trends in outsourcing R&D by big players.

4. Policy measures related to applied research

Support to competitiveness clusters, technology districts, technology parks and industrial clusters

- Competitiveness clusters for the aerospace industry in France. The support of competitiveness clusters (pôles de compétitivité) and industrial R&D through the inter-ministerial fund named the (FCE or Fonds de Compétitivité des Entreprises). Consequence of a call for projects in December 2004, the Association Aerospace Valley (AAV) was created in July 2005 in order to develop at the national, European and International level the competitiveness of the Aeronautical pole and space embarked systems of the Midi-Pyrenees and Aquitaine. The cluster is a world leader in civil aircraft of over 100 seats, luxury business aircraft, low-and medium-power gas turbines for helicopters, landing gear and aircraft batteries.
- Technology districts for the aerospace industry and the radio, TV and communications equipment sector in Italy. The technology districts initiative was launched in 2002-03 with the initial objective of creating territorial poles of excellence for research and
innovation. Over the following years the initial mission of research valorisation changed into the support to industrial innovation. Especially relevant for the Aircraft industry is the Aerospace technologies district located around Rome. For the TV, Radio and communication equipment, the relevant district is Torino wireless. Both districts are catalysing R&D investments from national and foreign companies.

- Technology parks and industrial clusters for the chemicals sector in Poland. Innovation measures play an important role and chemical companies are interested to locate in technology parks or join industrial clusters, which receive significant funding from national and EU funds.
### Summary of policy measures driving BERD in selected countries and sectors

<table>
<thead>
<tr>
<th>Generic and horizontal policy measures</th>
<th>Pharmaceutical sector</th>
<th>Aerospace industry</th>
<th>Radio, TV and communications equipment sector</th>
<th>Automotive industry</th>
<th>ICT industry</th>
<th>Telecommunication services sector</th>
<th>Chemicals sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science and education policies</td>
<td>Belgium</td>
<td>France</td>
<td>Italy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiscal Policies</td>
<td>Belgium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All related science and education policies</td>
<td>Belgium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Better quality of scientific institutions</td>
<td>Germany</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Poland</td>
</tr>
<tr>
<td>Increasing the level of tertiary educated people</td>
<td>Germany</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Availability of top researchers</td>
<td>Sweden</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Better training of skilled engineers</td>
<td>Sweden</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The improvement of the quality of the education system</td>
<td>Spain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Policy measures related to fundamental R&amp;D</td>
<td>Belgium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Spain</td>
</tr>
<tr>
<td>Sector specific regulation policies</td>
<td>Belgium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Policy measures related to technology transfer</td>
<td>Belgium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaboration between industry and academia</td>
<td>Germany</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Spain</td>
</tr>
<tr>
<td>Collaboration between industry and the public sector</td>
<td>France</td>
<td></td>
<td>Italy</td>
<td></td>
<td></td>
<td></td>
<td>Poland</td>
</tr>
<tr>
<td>Collaboration between industry, the public sector and academia</td>
<td>Italy</td>
<td></td>
<td>Italy</td>
<td></td>
<td></td>
<td>Estonia</td>
<td>Spain</td>
</tr>
<tr>
<td>Policy measures related to applied research</td>
<td>Poland</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support to competitiveness clusters, technology districts, technology parks and industrial clusters</td>
<td>France</td>
<td></td>
<td>Italy</td>
<td></td>
<td></td>
<td></td>
<td>Poland</td>
</tr>
</tbody>
</table>
7. Bibliography


Ansari, S., & Munir, K. (2008). How valuable is a piece of the spectrum?: determinati


OECD (1996): Technology and Industrial Performance, Paris OECD.


List of annexes

Annexes are presented in the following documents:

A.1 Feasibility study
A.2 Case study methodological framework
A.3 Country reports
A.4 Case studies
“Sectorial analysis of the long-term dynamics of business R&D intensity”

In relation to (DG-RTD-2005-M-02-01):

“Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators”

Final Report
Revised version

Annex 1: Feasibility Study
Annex 2: Survey and case study methodological framework

Technopolis Group (assignment manager)
Idea Consult (coordinator)
SPRU, NIFU STEP

Brussels, 12 November 2009
# Table of contents

1 **Annex 1: Feasibility study**
   1.1 Data availability and methodological framework for analysis
      1.1.1 Data availability with OFFBERD
      1.1.2 Data availability with ANBERD
      1.1.3 Choice of database and links to R&D
      1.1.4 Scoreboard data and value added statistics

2 **Annex 2: Methodological framework for Survey of national and sectoral cases**
   2.1 Survey of cases to refine BERD intensity analysis
   2.2 Analytical framework for the survey
      2.2.1 Statistical overview
      2.2.2 Analysis of drivers of BERD intensity based on statistical findings
      2.2.3 The policy context
      2.2.4 Conclusions and lessons learned
   2.3 Selection of cases to be examined through the survey
      2.3.1 Selection criteria
      2.3.2 Final list of cases
      2.3.3 Case study template
      2.3.4 Accompanying material and methodological support
   2.4 Survey complementary material
      2.4.1 Annotated template
      2.4.2 Survey guide
      2.4.3 Survey guide
1 Annex 1: Feasibility study

1.1 Data availability and methodological framework for analysis

1.1.1 Data availability with OFFBERD

Based on the extraction from the OFFBERD database, data availability by sector and by country was examined for the period since 1991, as most countries do not report any sectoral data before 1990. Based on the complete list of sectors for which data is potentially available (see Table A.1.1), it is clear that some sectors are better covered than others. The audit of the data suggested that using the OFFBERD database, the following sectors could potentially be included in the analysis as a large number of countries report R&D for a range of years (Table A.1.2).

The OFFBERD database covers the following EU 27 countries: Austria, Belgium, Czech Rep., Finland, Germany, Greece, Hungary Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Denmark, France, Romania, Slovak Rep., Slovenia, Spain, Sweden, and the UK. Statistics for Bulgaria, Cyprus, Estonia, Lithuania, Latvia, and Malta are obtained from the Eurostat Structural Business Statistics (SBS).

Japan, Norway, South Korea, and the United States are available in the OECD family of databases.

The last year for which complete data are available is 2005. Table A.1.3 shows the numbers of years (out of a maximum of 15) for which data are available by sector by country within the OFFBERD database.

<table>
<thead>
<tr>
<th>TOTAL BERD</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGRICULTURE, HUNTING AND FORESTRY</td>
</tr>
<tr>
<td>MINING AND QUARRYING</td>
</tr>
<tr>
<td>MANUFACTURING</td>
</tr>
<tr>
<td>Food, beverages and tobacco</td>
</tr>
<tr>
<td>Food products and beverages</td>
</tr>
<tr>
<td>Tobacco products</td>
</tr>
<tr>
<td>Textiles, fur and leather</td>
</tr>
<tr>
<td>Textiles</td>
</tr>
<tr>
<td>Wearing apparel and fur</td>
</tr>
<tr>
<td>Leather products and footwear</td>
</tr>
<tr>
<td>Wood, paper, printing, publishing</td>
</tr>
<tr>
<td>Wood and cork (not furniture)</td>
</tr>
<tr>
<td>Pulp, paper and paper products</td>
</tr>
<tr>
<td>Publishing, printing and reproduction of recorded media</td>
</tr>
<tr>
<td>Coke, petroleum, nuclear fuel, chemicals and products, rubber and plastics</td>
</tr>
<tr>
<td>Coke, refined petroleum products and nuclear fuel</td>
</tr>
<tr>
<td>Coke and nuclear fuel</td>
</tr>
<tr>
<td>Refined petroleum products</td>
</tr>
<tr>
<td>Chemicals and chemical products</td>
</tr>
<tr>
<td>Chemicals and chemical products (less pharmaceuticals)</td>
</tr>
<tr>
<td>Industry Category</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
</tr>
<tr>
<td>Rubber and plastic products</td>
</tr>
<tr>
<td>Non-metallic mineral products</td>
</tr>
<tr>
<td>Basic metals</td>
</tr>
<tr>
<td>Basic metals, iron and steel</td>
</tr>
<tr>
<td>Basic metals, non-ferrous</td>
</tr>
<tr>
<td>Fabricated metal products, machinery and equipment, instruments and transport</td>
</tr>
<tr>
<td>Fabricated metal products, except machinery and equipment</td>
</tr>
<tr>
<td>Machinery and equipment, n.e.c.</td>
</tr>
<tr>
<td>Engines and turbines, except aircraft, vehicle and cycle</td>
</tr>
<tr>
<td>Special purpose machinery</td>
</tr>
<tr>
<td>Machine tools</td>
</tr>
<tr>
<td>Weapons and ammunition</td>
</tr>
<tr>
<td>Office, accounting and computing machinery</td>
</tr>
<tr>
<td>Electrical machinery and apparatus n.e.c.</td>
</tr>
<tr>
<td>Electrical motors, generators and transformers</td>
</tr>
<tr>
<td>Electricity distribution and control apparatus (includes semiconductors)</td>
</tr>
<tr>
<td>Insulated wire and cable (includes optic fibre cables)</td>
</tr>
<tr>
<td>Accumulators, primary cells and primary batteries</td>
</tr>
<tr>
<td>Electric lamps and lighting equipment</td>
</tr>
<tr>
<td>Other electrical equipment n.e.c.</td>
</tr>
<tr>
<td>Radio, TV and communications equipment and apparatus</td>
</tr>
<tr>
<td>Electronic valves, tubes and components</td>
</tr>
<tr>
<td>TV, radio transmitters and line apparatus</td>
</tr>
<tr>
<td>TV and radio receivers, sound and video goods</td>
</tr>
<tr>
<td>Medical, precision and optical instruments, watches and clocks (instruments)</td>
</tr>
<tr>
<td>Medical appliances, instruments and control equipment</td>
</tr>
<tr>
<td>Instruments and appliances for measuring, checking, testing, navigating and other</td>
</tr>
<tr>
<td>purposes, except industrial process control equip.</td>
</tr>
<tr>
<td>Industrial process control equipment</td>
</tr>
<tr>
<td>Optical instruments and photographic equipment</td>
</tr>
<tr>
<td>Watches and clocks</td>
</tr>
<tr>
<td>Motor Vehicles, trailers and semi-trailers</td>
</tr>
<tr>
<td>Other Transport Equipment</td>
</tr>
<tr>
<td>Ships and boats</td>
</tr>
<tr>
<td>Railway and tramway locomotives and rolling stock</td>
</tr>
<tr>
<td>Aircraft and spacecraft</td>
</tr>
<tr>
<td>Transport equipment, nec</td>
</tr>
<tr>
<td>Furniture, other manufacturing nec</td>
</tr>
<tr>
<td>Furniture</td>
</tr>
<tr>
<td>Other manufacturing nec</td>
</tr>
<tr>
<td>Recycling</td>
</tr>
<tr>
<td>ELECTRICITY, GAS and WATER SUPPLY</td>
</tr>
<tr>
<td>CONSTRUCTION</td>
</tr>
<tr>
<td>SERVICES SECTOR</td>
</tr>
<tr>
<td>Wholesale, retail trade and motor vehicle repair</td>
</tr>
<tr>
<td>Hotels and restaurants</td>
</tr>
<tr>
<td>Transport, storage and communications</td>
</tr>
<tr>
<td>Telecommunications</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>Financial intermediation (includes insurance)</td>
</tr>
<tr>
<td>Real estate, renting and business activities</td>
</tr>
<tr>
<td>Computer and related activities</td>
</tr>
<tr>
<td>Software consultancy and supply</td>
</tr>
<tr>
<td>Research and development</td>
</tr>
</tbody>
</table>
Other business activities
Architectural, engineering and other technical activities
Community, social and personal service activities, etc.

Table A.1.2: Potential sectors that could be covered using the OFFBERD database

<table>
<thead>
<tr>
<th>NACE</th>
<th>TOTAL BERD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>AGRICULTURE, HUNTING AND FORESTRY</td>
</tr>
<tr>
<td>10-14</td>
<td>MINING AND QUARRYING</td>
</tr>
<tr>
<td>15-37</td>
<td>MANUFACTURING</td>
</tr>
<tr>
<td>15-16</td>
<td>Food, beverages and tobacco</td>
</tr>
<tr>
<td>17-19</td>
<td>Textiles, fur and leather</td>
</tr>
<tr>
<td>20-22</td>
<td>Wood, paper, printing, publishing</td>
</tr>
<tr>
<td>23</td>
<td>Coke, refined petroleum products and nuclear fuel</td>
</tr>
<tr>
<td>24</td>
<td>Chemicals and chemical products</td>
</tr>
<tr>
<td>24 less 244</td>
<td>Chemicals and chemical products (less pharma)</td>
</tr>
<tr>
<td>24.4</td>
<td>Pharmaceuticals</td>
</tr>
<tr>
<td>25</td>
<td>Rubber and plastic products</td>
</tr>
<tr>
<td>26</td>
<td>Non-metallic mineral products</td>
</tr>
<tr>
<td>27-28</td>
<td>Basic metals</td>
</tr>
<tr>
<td>29</td>
<td>Machinery and equipment, n.e.c.</td>
</tr>
<tr>
<td>30</td>
<td>Office, accounting and computing machinery</td>
</tr>
<tr>
<td>31</td>
<td>Electrical machinery and apparatus n.e.c.</td>
</tr>
<tr>
<td>32</td>
<td>Radio, TV and communications equipment and apparatus</td>
</tr>
<tr>
<td>33</td>
<td>Medical, precision and optical instruments, watches and clocks (instruments)</td>
</tr>
<tr>
<td>34</td>
<td>Motor Vehicles, trailers and semi-trailers</td>
</tr>
<tr>
<td>35</td>
<td>Other Transport Equipment</td>
</tr>
<tr>
<td>35.3</td>
<td>Aircraft and spacecraft</td>
</tr>
<tr>
<td>36-37</td>
<td>Furniture, recycling, other manufacturing, nec</td>
</tr>
<tr>
<td>40-41</td>
<td>ELECTRICITY, GAS and WATER SUPPLY</td>
</tr>
<tr>
<td>45</td>
<td>CONSTRUCTION</td>
</tr>
<tr>
<td>50-99</td>
<td>SERVICES SECTOR</td>
</tr>
<tr>
<td>50-52</td>
<td>Wholesale, retail trade and motor vehicle repair</td>
</tr>
<tr>
<td>55</td>
<td>Hotels and restaurants</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>60-64</td>
<td>Transport, storage and communications</td>
</tr>
<tr>
<td>642</td>
<td>Telecommunications</td>
</tr>
<tr>
<td>65-67</td>
<td>Financial intermediation (includes insurance)</td>
</tr>
<tr>
<td>70-74</td>
<td>Real estate, renting and business activities</td>
</tr>
<tr>
<td>72</td>
<td>Computer and related activities</td>
</tr>
<tr>
<td>73</td>
<td>Research and development</td>
</tr>
<tr>
<td>74</td>
<td>Other business activities</td>
</tr>
<tr>
<td>75-99</td>
<td>Community, social and personal service activities, etc.</td>
</tr>
<tr>
<td>NACE</td>
<td>TOTAL BERD</td>
</tr>
<tr>
<td>------</td>
<td>------------</td>
</tr>
<tr>
<td>1-2</td>
<td>AGRICULTURE, HUNTING AND FORESTRY</td>
</tr>
<tr>
<td>10-14</td>
<td>MINING AND QUARRYING</td>
</tr>
<tr>
<td>15-37</td>
<td>MANUFACTURING</td>
</tr>
<tr>
<td>15-16</td>
<td>Food, beverages and tobacco</td>
</tr>
<tr>
<td>17-19</td>
<td>Textiles, fur and leather</td>
</tr>
<tr>
<td>20-22</td>
<td>Wood, paper, printing, publishing</td>
</tr>
<tr>
<td>23</td>
<td>Coke, refined petroleum products and nuclear fuel</td>
</tr>
<tr>
<td>24</td>
<td>Chemicals and chemical products</td>
</tr>
<tr>
<td>24x244</td>
<td>Chemicals and chemical products (less pharma)</td>
</tr>
<tr>
<td>24.4</td>
<td>Pharmaceuticals</td>
</tr>
<tr>
<td>25</td>
<td>Rubber and plastic products</td>
</tr>
<tr>
<td>26</td>
<td>Non-metallic mineral products</td>
</tr>
<tr>
<td>27-28</td>
<td>Basic metals</td>
</tr>
<tr>
<td>29</td>
<td>Machinery and equipment, n.e.c.</td>
</tr>
<tr>
<td>30</td>
<td>Office, accounting and computing machinery</td>
</tr>
<tr>
<td>31</td>
<td>Electrical machinery and apparatus n.e.c.</td>
</tr>
<tr>
<td>32</td>
<td>Radio, TV and communications etc.</td>
</tr>
<tr>
<td>33</td>
<td>Medical, precision and optical instruments, etc.</td>
</tr>
<tr>
<td>34</td>
<td>Motor Vehicles, trailers and semi-trailers</td>
</tr>
<tr>
<td>35</td>
<td>Other Transport Equipment</td>
</tr>
<tr>
<td>35.3</td>
<td>Aircraft and spacecraft</td>
</tr>
<tr>
<td>36-37</td>
<td>Furniture, other manufacturing nec</td>
</tr>
<tr>
<td>40-41</td>
<td>ELECTRICITY, GAS and WATER SUPPLY</td>
</tr>
<tr>
<td>45</td>
<td>CONSTRUCTION</td>
</tr>
<tr>
<td>50-99</td>
<td>SERVICES SECTOR</td>
</tr>
<tr>
<td>50-52</td>
<td>Wholesale, retail trade and motor vehicle repair</td>
</tr>
<tr>
<td>55</td>
<td>Hotels and restaurants</td>
</tr>
<tr>
<td>60-64</td>
<td>Transport, storage and communications</td>
</tr>
<tr>
<td>642</td>
<td>Telecommunications</td>
</tr>
<tr>
<td>65-67</td>
<td>Financial intermediation (includes insurance)</td>
</tr>
<tr>
<td>70-74</td>
<td>Real estate, renting and business activities</td>
</tr>
<tr>
<td>72</td>
<td>Computer and related activities</td>
</tr>
<tr>
<td>73</td>
<td>Research and development</td>
</tr>
<tr>
<td>74</td>
<td>Other business activities</td>
</tr>
<tr>
<td>75-99</td>
<td>Community, social and personal service activities</td>
</tr>
</tbody>
</table>

Note: coverage from OECD OFFBERD database except for BG, CY, EE, LV, LT, MT, which come from the Eurostat BERD database.
<table>
<thead>
<tr>
<th>NACE</th>
<th>TOTAL BERD</th>
<th>RO</th>
<th>SK</th>
<th>SI</th>
<th>ES</th>
<th>SE</th>
<th>GB</th>
<th>US</th>
<th>CN</th>
<th>KO</th>
<th>JP</th>
<th>NO</th>
<th>BG</th>
<th>CY</th>
<th>EE</th>
<th>LV</th>
<th>LT</th>
<th>MT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>AGRICULTURE, HUNTING AND FORESTRY</td>
<td>13</td>
<td>11</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>13</td>
<td>2</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>9</td>
<td>6</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>10-14</td>
<td>MINING AND QUARRYING</td>
<td>13</td>
<td>8</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>2</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>15-37</td>
<td>MANUFACTURING</td>
<td>13</td>
<td>14</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>11</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>9</td>
<td>6</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>15-16</td>
<td>Food, beverages and tobacco</td>
<td>11</td>
<td>8</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>6</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>6</td>
<td>9</td>
<td>9</td>
<td>6</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>17-19</td>
<td>Textiles, furn and leather</td>
<td>11</td>
<td>4</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>2</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>9</td>
<td>2</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>20-22</td>
<td>Wood, paper, printing, publishing</td>
<td>11</td>
<td>9</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>1</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>23</td>
<td>Coke, refined petroleum products, etc</td>
<td>11</td>
<td>5</td>
<td>13</td>
<td>15</td>
<td>1</td>
<td>15</td>
<td>8</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>24</td>
<td>Chemicals and chemical products</td>
<td>11</td>
<td>8</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>7</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>9</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>24x24</td>
<td>Chemicals (less pharma)</td>
<td>2</td>
<td>2</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>4</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>9</td>
<td>6</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>24.4</td>
<td>Pharmaceuticals</td>
<td>2</td>
<td>5</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>8</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>9</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>25</td>
<td>Rubber and plastic products</td>
<td>11</td>
<td>11</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>1</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>0</td>
<td>9</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>26</td>
<td>Non-metallic mineral products</td>
<td>11</td>
<td>5</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>8</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>1</td>
<td>9</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>27-28</td>
<td>Basic metals</td>
<td>11</td>
<td>7</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>14</td>
<td>9</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>29</td>
<td>Machinery, equipment, n.e.c.</td>
<td>3</td>
<td>14</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>9</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>30</td>
<td>Office, accounting and computing machinery</td>
<td>3</td>
<td>5</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>5</td>
<td>1</td>
<td>11</td>
<td>0</td>
<td>10</td>
<td>6</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>31</td>
<td>Electrical machinery and apparatus, n.e.c.</td>
<td>3</td>
<td>13</td>
<td>13</td>
<td>15</td>
<td>4</td>
<td>15</td>
<td>3</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>32</td>
<td>Radio, TV and communications, etc.</td>
<td>3</td>
<td>13</td>
<td>13</td>
<td>15</td>
<td>6</td>
<td>15</td>
<td>5</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>9</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>33</td>
<td>Medical, precision &amp; optical instruments, etc.</td>
<td>3</td>
<td>13</td>
<td>13</td>
<td>15</td>
<td>6</td>
<td>15</td>
<td>10</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>9</td>
<td>2</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>34</td>
<td>Motor Vehicles, trailers and semi-trailers</td>
<td>3</td>
<td>8</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>4</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>35</td>
<td>Other Transport Equipment</td>
<td>3</td>
<td>5</td>
<td>13</td>
<td>15</td>
<td>2</td>
<td>15</td>
<td>2</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>35.3</td>
<td>Aircraft and spacecraft</td>
<td>2</td>
<td>4</td>
<td>13</td>
<td>15</td>
<td>0</td>
<td>15</td>
<td>11</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>36-37</td>
<td>Furniture, other manufacturing nec</td>
<td>11</td>
<td>14</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>3</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>2</td>
<td>3</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>40-41</td>
<td>ELECTRICITY, GAS and WATER SUPPLY</td>
<td>13</td>
<td>2</td>
<td>13</td>
<td>15</td>
<td>7</td>
<td>15</td>
<td>8</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>45</td>
<td>CONSTRUCTION</td>
<td>13</td>
<td>6</td>
<td>13</td>
<td>15</td>
<td>2</td>
<td>14</td>
<td>5</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>50-99</td>
<td>SERVICES SECTOR</td>
<td>13</td>
<td>14</td>
<td>13</td>
<td>15</td>
<td>8</td>
<td>12</td>
<td>11</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>50-52</td>
<td>Wholesale, retail trade &amp; motor vehicle repair</td>
<td>3</td>
<td>8</td>
<td>13</td>
<td>15</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>1</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>55</td>
<td>Hotels and restaurants</td>
<td>0</td>
<td>14</td>
<td>13</td>
<td>15</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>60-64</td>
<td>Transport, storage and communications</td>
<td>9</td>
<td>8</td>
<td>5</td>
<td>15</td>
<td>6</td>
<td>9</td>
<td>2</td>
<td>1</td>
<td>8</td>
<td>15</td>
<td>10</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>642</td>
<td>Telecommunications</td>
<td>5</td>
<td>10</td>
<td>13</td>
<td>14</td>
<td>0</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>9</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>65-67</td>
<td>Financial intermediation (includes insurance)</td>
<td>1</td>
<td>14</td>
<td>13</td>
<td>11</td>
<td>3</td>
<td>13</td>
<td>1</td>
<td>0</td>
<td>8</td>
<td>5</td>
<td>10</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>70-74</td>
<td>Real estate, renting and business activities</td>
<td>11</td>
<td>11</td>
<td>13</td>
<td>15</td>
<td>6</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>72</td>
<td>Computer and related activities</td>
<td>11</td>
<td>5</td>
<td>13</td>
<td>15</td>
<td>6</td>
<td>15</td>
<td>6</td>
<td>1</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>73</td>
<td>Research and development</td>
<td>11</td>
<td>14</td>
<td>13</td>
<td>15</td>
<td>6</td>
<td>15</td>
<td>7</td>
<td>1</td>
<td>8</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>0</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>74</td>
<td>Other business activities</td>
<td>11</td>
<td>6</td>
<td>13</td>
<td>15</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>11</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>75-99</td>
<td>Community, social &amp; personal service activities</td>
<td>11</td>
<td>10</td>
<td>13</td>
<td>15</td>
<td>6</td>
<td>15</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: coverage from OECD OFFBERD database except for BG, CY, EE, LV, LT, MT, which come from the Eurostat BERD database
Comparability across countries with OFFBERD data: product-field vs. principal activity criteria

One of the main issues when assessing comparability of OFFBERD data across countries is the method used to classify R&D by industrial activity. This is a problem that has been identified by the OECD (2005). Countries classify R&D according to either (a) the principal activity of the company undertaking the R&D or (b) the product field of the R&D. In a multi-product company it is of course essential to distribute a company’s R&D according to the different product groups that the company is involved in and this is recommended in the Frascati Manual.

Table A.1.4: Countries reporting R&D data by product field in OFFBERD

<table>
<thead>
<tr>
<th>Country</th>
<th>Product Group</th>
<th>Country</th>
<th>Product Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>N</td>
<td>Denmark</td>
<td>Y</td>
</tr>
<tr>
<td>Belgium</td>
<td>Y</td>
<td>France</td>
<td>Y</td>
</tr>
<tr>
<td>Czech Rep</td>
<td>N</td>
<td>Romania</td>
<td>N</td>
</tr>
<tr>
<td>Finland</td>
<td>N</td>
<td>Slovak Rep</td>
<td>N</td>
</tr>
<tr>
<td>Germany</td>
<td>N</td>
<td>Slovenia</td>
<td>N</td>
</tr>
<tr>
<td>Greece</td>
<td>N</td>
<td>Spain</td>
<td>N</td>
</tr>
<tr>
<td>Hungary</td>
<td>N</td>
<td>Sweden</td>
<td>N</td>
</tr>
<tr>
<td>Ireland</td>
<td>N</td>
<td>UK</td>
<td>Y</td>
</tr>
<tr>
<td>Italy</td>
<td>N</td>
<td>US</td>
<td>N</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>N</td>
<td>China</td>
<td>N</td>
</tr>
<tr>
<td>Netherlands</td>
<td>N</td>
<td>Korea</td>
<td>N</td>
</tr>
<tr>
<td>Poland</td>
<td>Y</td>
<td>Japan</td>
<td>N</td>
</tr>
<tr>
<td>Portugal</td>
<td>N</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: OECD BERD Data (Source: Research and Development Statistics, Vol. 2007, release 01 (Updated: Aug 2008))

However on the basis of the latest publicly available version of the OECD R&D database only five countries (out of a possible 25) report R&D data by product group.

As discussed by Duchene et al (2009), this problem is likely to affect some sectors more than others. They argue that this is a particularly important issue for the service sectors and affects the comparability between the EU Member States and the US. However this is not an issue that can be resolved within the current project when using the OFFBERD database, as it requires access to detailed firm level R&D data.

In fact, the OFFBERD database does not provide the two distributions (product-field and principal activity) of R&D expenditures across NACE sectors in 4 of the 5 countries that report R&D data by product group (United Kingdom, France, Denmark and Belgium). The exception is Poland that provides both data for the period 2001-2005. If the OFFBERD database was used in the scope of this study, because of time limitations and available resources, there would be no possibility of basing the above-mentioned analysis on a careful audit on national sources.
1.1.2 Data availability with ANBERD

The ANBERD database is based on the OFFBERD database but deals with some problems and inconsistencies associated with the enterprise basis of the R&D survey. Unlike the OFFBERD database, ANBERD is more comparable across countries and across time, uses a standard methodology to obtain missing data and puts the data closer to the standards set in the Frascati Manual. The database is also closer to the product-based approach, which makes it more compatible with the KLEMS and STAN databases. During 2008, the OECD worked with national statistical authorities to obtain missing values and to distribute the value added of multi-product firm across industries. In short, the quality is much higher than the OFFBERD data.

Table A.1.5 summarizes the ANBERD database. It shows that the coverage of countries is larger, information about individual industries is more complete, more years are included and finally, it contain data for 2006 in most instances. Table A.1.6 in shows the ISIC, Rev. 3.1 codes sectors covered in ANBERD. The ANBERD data is available in national currencies as well as in PPP USD for the period 1990-2007.

The ANBERD database covers the following EU27 countries: Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, Poland, Portugal, Romania, Spain, Sweden, the United Kingdom and Slovenia. Japan, Norway, Korea, and the United States are also available in the ANBERD database. Again statistics for Bulgaria, Cyprus, Estonia, Lithuania, Latvia, and Malta are from the Eurostat OFFBERD (annex table 4) with, however, an overall poorer coverage (years, sectors).
Table A.1.5: Summary of data availability and coverage of the OECD ANBERD database 2009 edition

|----------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|     |                                            |
| Austria              |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     | Stan almost complete                       |
| Czech Rep.           |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     | almost complete                             |
| Denmark              | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   |      |      |      |      |      |      |     | almost complete from 1996                   |
| Finland              |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     | missing detail                             |
| Germany              |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     | missing detail, especially in services     |
| France               |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     | missing detail in services                 |
| Greece               | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | almost complete                             |
| Hungary              |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     | almost complete                             |
| Ireland              | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   |      |      |      |      |      |      |     | missing detail; services from 1992          |
| Italy                | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | almost complete; complete from 1997         |
| Luxembourg           |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     | almost complete                             |
| Netherlands          | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   |      |      |      |      |      |      |     | no detail except some services             |
| Poland               |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     | almost complete                             |
| Portugal             | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | missing detail                             |
| Slovakia             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     | missing many industries                    |
| Spain                | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | missing many industries                     |
| Romania              |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     | missing detail                             |
| Slovenia             | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | Eurostat missing industries; better after 2003 |
| Other ANBERD         |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     | KIems missing detail                        |
| Iceland              | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | missing detail; services from 1993          |
| Norway               | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   |      |      |      |      |      |      |     | missing detail; complete from 1995          |
| Switzerland          |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     | Eurostat missing many industries           |
| Turkey               | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | Eurostat missing detail, especially in services |
| Japan                | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   | mp   |      |      |      |      |      |      |     | Eurostat missing detail, especially in services |
| Korea                | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | complete from 1998                         |
| U.S.A                | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | missing detail before 1999                 |
| China                |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     | UNIDO almost complete                       |
| Chinese Taipei       | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | Gov Stat almost complete                   |
| Eurostat OFFBERD     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     | Eurostat missing many industries           |
| Bulgaria             | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | Eurostat missing many industries           |
| Cyprus               | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | KIems missing many industries               |
| Estonia              | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | KIems missing many industries               |
| Latvia               | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | KIems missing many industries               |
| Lithuania            | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | KIems missing many industries               |
| Malta                | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    | m    |      |      |      |      |      |      |     | KIems missing many industries               |

Note: P = product field; m = main activity; mp = main activity with largest firms distributed according to product field.
### Table A.1.6 Sectoral Coverage of OECD ANBERD

<table>
<thead>
<tr>
<th>ISIC, Rev.3 codes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01...05</td>
<td>AGRICULTURE, HUNTING, FORESTRY AND FISHING</td>
</tr>
<tr>
<td>10...14</td>
<td>MINING AND QUARRying</td>
</tr>
<tr>
<td>15...16</td>
<td>TOTAL MANUFACTURING</td>
</tr>
<tr>
<td>15</td>
<td>Food products, beverages and tobacco</td>
</tr>
<tr>
<td>15</td>
<td>Food products and beverages</td>
</tr>
<tr>
<td>16</td>
<td>Tobacco products</td>
</tr>
<tr>
<td>17...19</td>
<td>Textiles, textile products, leather and footwear</td>
</tr>
<tr>
<td>17</td>
<td>Textiles</td>
</tr>
<tr>
<td>18</td>
<td>Wearing apparel, dressing and dyeing of fur</td>
</tr>
<tr>
<td>19</td>
<td>Leather, leather products and footwear</td>
</tr>
<tr>
<td>20...22</td>
<td>Wood, paper, printing, publishing</td>
</tr>
<tr>
<td>20</td>
<td>Wood and products of wood and cork</td>
</tr>
<tr>
<td>21+22</td>
<td>Pulp, paper, paper products, printing and publishing</td>
</tr>
<tr>
<td>21</td>
<td>Pulp, paper and paper products</td>
</tr>
<tr>
<td>22</td>
<td>Printing and publishing</td>
</tr>
<tr>
<td>23...25</td>
<td>Chemical, rubber, plastics and fuel products</td>
</tr>
<tr>
<td>23</td>
<td>Coke, refined petroleum products and nuclear fuel</td>
</tr>
<tr>
<td>24</td>
<td>Chemicals and chemical products</td>
</tr>
<tr>
<td>24-2423</td>
<td>Chemicals excluding pharmaceuticals</td>
</tr>
<tr>
<td>2423</td>
<td>Pharmaceuticals</td>
</tr>
<tr>
<td>25</td>
<td>Rubber and plastics products</td>
</tr>
<tr>
<td>26</td>
<td>Other non-metallic mineral products</td>
</tr>
<tr>
<td>27</td>
<td>Basic metals</td>
</tr>
<tr>
<td>271+2731</td>
<td>Iron and steel</td>
</tr>
<tr>
<td>272+2732</td>
<td>Non-ferrous metals</td>
</tr>
<tr>
<td>28</td>
<td>Fabricated metal products, except machinery and equipment</td>
</tr>
<tr>
<td>29...35</td>
<td>Machinery and equipment, instruments and transport equipment</td>
</tr>
<tr>
<td>29</td>
<td>Machinery and equipment, n.e.c.</td>
</tr>
<tr>
<td>30</td>
<td>Office, accounting and computing machinery</td>
</tr>
<tr>
<td>31</td>
<td>Electrical machinery and apparatus, n.e.c.</td>
</tr>
<tr>
<td>32</td>
<td>Radio, television and communication equipment</td>
</tr>
<tr>
<td>321</td>
<td>Electronic valves and tubes and other electronic components</td>
</tr>
<tr>
<td>32-321</td>
<td>Television, radio and communication equipment n.e.c.</td>
</tr>
<tr>
<td>33</td>
<td>Medical, precision and optical instruments</td>
</tr>
<tr>
<td>34</td>
<td>Motor vehicles, trailers and semi-trailers</td>
</tr>
<tr>
<td>35</td>
<td>Other transport equipment</td>
</tr>
<tr>
<td>351</td>
<td>Building and repairing of ships and boats</td>
</tr>
<tr>
<td>353</td>
<td>Aircraft and spacecraft</td>
</tr>
<tr>
<td>362+369</td>
<td>Railroad equipment and transport equipment n.e.c.</td>
</tr>
<tr>
<td>36</td>
<td>Furniture; manufacturing n.e.c.</td>
</tr>
<tr>
<td>361</td>
<td>Furniture</td>
</tr>
<tr>
<td>369</td>
<td>Manufacturing n.e.c.</td>
</tr>
<tr>
<td>37</td>
<td>Recycling</td>
</tr>
<tr>
<td>40+41</td>
<td>ELECTRICITY, GAS AND WATER SUPPLY</td>
</tr>
<tr>
<td>45</td>
<td>CONSTRUCTION</td>
</tr>
<tr>
<td>50...99</td>
<td>TOTAL SERVICES</td>
</tr>
<tr>
<td>50</td>
<td>Wholesale and retail trade; repairs</td>
</tr>
<tr>
<td>55</td>
<td>Hotels and restaurants</td>
</tr>
<tr>
<td>50...64</td>
<td>Transport, storage and communications</td>
</tr>
<tr>
<td>562</td>
<td>Telecommunications</td>
</tr>
<tr>
<td>65...67</td>
<td>Financial intermediation</td>
</tr>
<tr>
<td>70...74</td>
<td>Real estate, renting and business activities</td>
</tr>
<tr>
<td>72</td>
<td>Computer and related activities</td>
</tr>
<tr>
<td>722</td>
<td>Software consultancy and supply</td>
</tr>
<tr>
<td>722</td>
<td>Other computer services, n.e.c.</td>
</tr>
<tr>
<td>73</td>
<td>Research and development</td>
</tr>
<tr>
<td>74</td>
<td>Other business activities</td>
</tr>
<tr>
<td>75...99</td>
<td>Community, social and personal services</td>
</tr>
</tbody>
</table>

*see Frascati Manual TOTAL BUSINESS ENTERPRISE*
Product field data in the ANBERD database

Following the recommendations of the Frascati Manual 2002, one of the aims of the ANBERD database is to present product field data whenever possible. Table A.1.5 above presents the detail of R&D classifications per country and year related to product field data (p), main activity (m) and main activity with largest firms distributed according to product field (mp). As it can be seen in the table, some countries collect and submit product field data (Finland, Sweden, United Kingdom); for others, adjustments are made using product field data to reduce enterprise bias (Japan, Norway, Spain) or redistributing the R&D services sector by industry served; and for the rest of the countries where product field data is not available, data are reported by principal activity with additional estimations by the OECD for missing data (United States).

For the Czech Republic, data are available using both breakdowns, and both type of data are included in the ANBERD database.

1.1.3 Choice of database and links to R&D
1.1.4 Scoreboard data and value added statistics

Based on the above two sections and because of higher quality of data, the study team decided to use the **OECD ANBERD database 2009 edition** for developing the statistical analyses of the project.

**Differences between BERD and Scoreboard Data**

The aim of the project is to compare R&D intensity at the sectoral level across a range of countries. In principle there are two sources of BERD data on which such an analysis could be based:

- Data from official surveys of Business R&D (BERD) conducted largely by national statistical offices and published by Eurostat and the OECD
- Data from annual consolidated accounts of companies as recorded in the R&D Scoreboard of companies published by the EC.

The main difference between the two sources of data is that the former refer to expenditures of R&D conducted by companies within a specific country and the latter refer to total R&D expenditures of companies, regardless of where the expenditures were undertaken. By contrast, the Scoreboard’s definition of R&D is closer to the ‘funding’ definition, which might be used to finance projects outside the company. Thus the Scoreboard data are a good reflection of the R&D ‘controlled’ by national firms (i.e. firms that are headquartered in a particular country), and the BERD data are a good (and more inclusive) reflection of the total amount of R&D conducted within a country.

The main practical difficulty in using the Scoreboard data for the purposes of the current exercise is that firms are not categorized according to the NACE categories. Additionally there are differences in terms of country coverage as the Scoreboard data rely on companies publishing data on their R&D in company accounts. While this disclosure is mandatory in some countries for companies above a certain size, this is not the case with all the countries of interest in this project. Moreover company accounts data refer to all R&D financed by a company, even when this R&D might have been contracted out to another entity. On the other hand BERD data only include R&D undertaken internally by the company.

**Value added statistics**

It is necessary to collect value added data to construct an intensity measure. The best statistical source on value-added at the two- and three-digit industry level is the EU KLEMS and OECD STAN databases. Highly compatible with each other, these databases are based on the Eurostat SBS or the equivalent OECD Structural Statistics for Industry and Services (SSIS) database, which are collected primarily by national statistical institutes. Industrial surveys typically cover establishments and/or enterprises above a certain size limit (with a minimum number of employees or turnover above a certain level) and they may carry out further adjustments to the data. They can often underestimate employment and overestimate value added because of the way that employment is counted in the survey. The different survey practices limit international comparability. Moreover, volume and price data are generally not available from annual industrial surveys. To avoid some of these problems, the EU KLEMS and OECD STAN databases rely primarily on annual national accounts by activity of each country, and then use the SBS or SSIS databases to estimate missing details.
For the purposes of this study, the EU KLEMS database contains the most complete coverage of the countries that this study intends to cover. The EU-KLEMS database covers the first 25 EU Member States, plus Japan, South Korea and the United States. Of the countries considered in this study, Bulgaria, China, Norway and Romania are missing. Norway is, however, covered in the OECD STAN database. Coverage is virtually complete from 1995 to 2005, except for some individual industries.

Most countries are covered from 1991 to 1994; however, there are no data from 1991 to 1995 for the EU-25, Cyprus, Czech Republic, Estonia, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia (9 of the 10 new Member States). The database is virtually complete from 1995 to 2005 except for some individual industries. Recycling and other manufacturing will need to be aggregated and aerospace (353) is missing in the tables for EU-15, EU-25, Cyprus, Denmark, Estonia, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Slovakia and Sweden. In addition, Cyprus was missing office machinery and computers (30), Luxembourg was missing Petrol (23), pharmaceuticals (244), office machinery and computers (30), and automotive (34), Malta was missing research and development (73) before 2000.

The OECD STAN database is more up to date in that the tables contain 2006 statistics for almost every OECD Member State, and many of the tables contain 2007 statistics. However, several of the New Member States are missing from this database, which are contained in the EU KLEMS database. Some differences in the way prices are calculated make a simple ‘cut and paste’ between these two databases impossible.

**Comparability between the EU 27, US, Japan, China and Korea**

The ANBERD database estimates one-third of the individual industry entries for official total intramural BERD of the United States based on the annual National Science Foundation (NSF) data on company-financed R&D. This results in data availability for the period 1987-2007 based on main activity, although details are missing before 1999.

It is not possible to include China in the analysis as the OECD database contains sectoral information for a single year (2000).
Statistics office has additional, but non-comparable, statistics for more recent years (see: http://www.stats.gov.cn). The ANBERD database also includes data for Chinese Taipei for the period 1998-2007.

Japan and Korea are reasonably well covered in the OECD database. However there are still a number of problems associated with these two countries. For example the data for Korea only covers the period 1995 to 2006. Additionally in the case of Japan there are no data for some sectors especially in services.

Given the uneven coverage amongst the EU27 it is not possible to create an EU27 aggregate for all the sectors for all the years.
2  **Annex 2: Methodological framework for Survey of national and sectoral cases**

According to the specifications of the study, this section presents, selection criteria for the country/sector cases to be analysed; a proposed set of cases; and an analytical proposed overview of case studies based on the results of activities undertaken in Phase 1.

### 2.1 Survey of cases to refine BERD intensity analysis

#### Activity as defined in specifications

The request for services specification, Activity VI Survey (Phase 2) reads:

*Activity VI consists of a survey of both national experts for some selected countries and industry experts for some selected industries. This selection of countries and industries will have to be based on the results of phase 1 and discussed and agreed with the Commission services. These experts could for example be university professors, officials, members of think tanks or business managers. The aims of the survey will be i) to check and refine the tentative conclusions and hypothesis explaining the BERD evolutions based on the calculation of indicators and literature review carried out in phase 1, ii) to develop/deepen the understanding of the role played by public authorities in those developments (and the policy tools used).*

Following the specifications, the **objective** of the survey is to derive, extend and strengthen explanations for particular identified trends following the data analysis. The survey aims to deepen the analysis of Phase 1 and examine trends and hypotheses based on these results. The role of public policy in influencing the evolution of BERD intensities is of particular interest and hence the survey will seek to link BERD trends to policy initiatives, such as the 3% Action Plan.

### 2.2 Analytical framework for the survey

The survey will be structured around three main topics for each case:

- BERD performance and drivers. Reasons for changes in BERD, BERD-intensity and relative performance over time (EU27 comparisons, relative to EU aggregate and international comparisons when possible)
- The role of public policy on BERD performance. The extent to which specific public policies were influential in the observed trends. The focus will be on national and regional policies, national structural funds, EU Framework Programmes and other EU funding (by order of focus importance).
- Policy recommendations. The extent to which desirable/undesirable changes can be encouraged/reversed given the degree of efficacy of public policies and the potential of BERD changes due to national R&D resources, absorptive capacities, etc.

**Main themes of analysis**

The cases analysed through the survey will be structured in four main sections:

- Statistical overview
- Analytical overview of BERD trends: drivers, obstacles, and their different components
2.2.1 Statistical overview

The focus of the statistical analysis is on R&D shares (ratios) and how these have changed over time, showing which sectors have become relatively more important in the studied countries over time. The statistical overview undertake analyses for the specified sectors and countries around three main variables:

- R&D as a proportion of value added
- Proportion of total BERD accounted for by the sectors of interest
- Proportion of total value-added accounted for by the sectors of interest

The above data will be used to highlight the sectors in which R&D intensity has increased/decreased in the countries of interest. In relation to the sectors with growing R&D intensity, analyses on how have the shares in total R&D and total output have changed over time will also be presented.

2.2.2 Analysis of drivers of BERD intensity based on statistical findings

The main research question to be answered through the survey is: What drives R&D intensity in the studied sectors and countries?

The BERD Intensity Gap will be analysed through four different components:

- Drivers within the firm and organisation (micro level). The advantage of combining the statistical analysis with the case study approach is that the role of specific firms in driving BERD in certain sectors or countries that could only be examined statistically via (non-available) micro-data, can be explored. The central research question is: What drives individual firms decisions for investing in R&D? Other research questions include: What is the role of the size of the firm, the corporate strategy, the firm structure and the resources (financial and human) in determining BERD intensity?

- Drivers from the industry (meso level), or country-specific factors. This is related to a country’s industrial structure and describes how much of the BERD intensity gap is caused by a country’s over- or under-specialisation in particular industries/sectors – some of which are more R&D-intensive than others – for producing the country’s output. Research questions include: What are the factors driving R&D intensity at the meso level (i.e. competitive behaviour, specialisation in innovative activities, interrelationship with technical and technological improvements, institutional factors, etc.)?

- Drivers from the macro level and the role of the framework conditions. This includes the role of public expenditures on R&D in supporting BERD intensity; the role of foreign-owned firms (i.e. Are the effects of foreign-owned firms on the R&D intensity of a host country positive or negative?), and the institutional context (i.e. national culture and patent protection); and other financial, strategic and regulatory factors that influence the decision of companies to invest in R&D (i.e. the role of public investment in science, the role of infrastructures, etc.).

---

1 BERD ’real’ growth is not included because the study does not aim to analyse the evolution of price levels by sector by country. Analysing real growth rates at the industry level goes beyond the scope of the study and the resources available.
Drivers from the market. Including the role of consumer preferences and market competition.

2.2.3 The policy context
The survey will seek to clarify how public policy for a given sector and in a given country has had an impact on BERD performance. The cases will look at:

- The existing policy framework for R&D and technological progress. The case will seek to identify industry/sector specific policy measures (financial, legislative or regulatory) and infrastructures (e.g. competitiveness poles, technology platforms, major industrial R&D centres, sector specific incentives, etc.) that support or complement business R&D activities;

- Policy analysis and policy mix design. Based on the analysis of the existing policy framework above, the relevant policy instruments will be classified in six different routes as per the ‘Policy Mixes for R&D in Europe’ report:
  1. Promote establishment of new indigenous R&D-performing firms
  2. Stimulate greater R&D investment in R&D-performing firms
  3. Stimulate R&D investments in firms non-performing R&D
  4. Attract R&D performing firms from abroad
  5. Stimulating public-private collaboration in R&D
  6. Increase R&D in public sector

- Potential policy directions. Providing a number of observations that could give indications for shaping policy to support technological progress, and sustain/improve competitiveness of the referred sector/country.

2.2.4 Conclusions and lessons learned
This last section of the cases will highlight the conclusions on the key factors driving BERD trends in the country/sector and formulate key policy lessons to the attention of policy makers and other stakeholders (business federations, etc.). The section will seek to provide a number of observations that could give indications for shaping policy to support increased BERD intensity and improved R&D productivity resulting from the business investment into R&D.

---

2 A study commissioned by the European Commission – Directorate-General for Research. UNU-MERIT et al April 2009
2.3 Selection of cases to be examined through the survey

2.3.1 Selection criteria
Four selection criteria were used for identifying the proposed sample of case studies:

- ‘Best’ and ‘Worst’ performers. Sectors and countries according to BERD expenditures and BERD intensity, in order to identify key drivers and obstacles.
- Mixture of high-tech and medium-high tech sectors. Both sectors are studied in the light of the relative importance of the latter sectors in the EU economy.
- Mixture of large and small countries (including New Member States). Even though small countries are biased (one single company can make the difference with respect the sector-specific BERD), the fact remains that EU consists mostly of small countries.
- Level of development of the research system. Some small countries have experienced impressive growth rates in the last years, but this is mainly because of the low level of development of private research in the country. The cases will look at countries that were able to grow substantially, starting from an existing level of BERD intensity.

2.3.2 Final list of cases
Via a telephone survey of 50 experts using a standard list of interview questions (see Annex A5), it is proposed to examine ten sectoral/country cases.

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Main case features/compliance with selection criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>The pharmaceutical sector in Belgium</td>
<td>The Belgian pharmaceutical sector has been accorded a leading role in the attainment of the R&amp;D investment targets set by the Lisbon strategy. In fact, BERD in Belgium is concentrated in 3 sectors, with pharmaceuticals accounting for 22 percent of total industrial R&amp;D for the period 2001-2006, and it has increased in importance in terms of shares of total BERD and shares of value-added since the mid 1990s. Some studies (De Doncker, 2006) have highlighted as determinants for pharmaceutical firms for locating R&amp;D activities in Belgium the availability of skilled human resources, the existence of knowledge centres, and the availability of infrastructures, and a favourable legal framework for this type of research.</td>
</tr>
<tr>
<td>The motor vehicles sector in Germany</td>
<td>The country is the main player in manufacturing and it dominates the sector in the EU. The sector is one of the most dynamic in the last months due to several acquisitions by world sector leaders that are changing considerably the structure of the value chain in the sector. It is probably the best case for analysing the impact of the current world financial crisis on economic activity. The industry accounts for 32% of Germany’s BERD (US National Science Foundation, 2008). The sector has been off shoring the lowest segments of its value chain to the Czech Republic and Slovakia since the mid-nineties, and the country’s main manufacturer, Volkswagen, has raised substantially their R&amp;D (by 16.1%) in the last years (JRC European Commission, 2008).</td>
</tr>
<tr>
<td>Sectors</td>
<td>Main case features/compliance with selection criteria</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>The ICT industry and the Radio, television and communications equipments sector in Sweden</td>
<td>The sector largely corresponds to activities of only one 'national champion' in both countries that turned into global leaders in a fast-growing market segment: Nokia (FI) and Ericsson (SE). Although Sweden has repeatedly been referenced as a country where enabling framework conditions are at work, such as an integrated technology market and superior academic research environment (van Pottelsbergh, 2008), the country's 'telecommunication equipment' sector value added (in current terms) dropped more than 90% between 2000 and 2003 (European Commission, 2007). In the other hand, Nokia became the biggest EU R&amp;D investor (partly through acquisitions) in the last year (JRC European Commission, 2008).</td>
</tr>
<tr>
<td>The ICT industry in Finland</td>
<td></td>
</tr>
<tr>
<td>The telecommunications services sector in Spain</td>
<td>Although the country is still in the catching-up process, the main trend over the period 1995 to 2006 has been a decrease of the relative importance of manufacturing industries and an important increase of Services, with the share of the total going from 17% to 29% over the same period. The clearest trend has been an increase in the relative importance of three services sectors as being amongst the most important in terms of the volume of R&amp;D: telecommunications services, computer services and other services. The telecommunications services sector is of particular interest, since it shows positive trends both in terms of BERD share and BERD intensity. The leading position of Spain in the service sector might be due to the country's good capacity to work under contractual arrangements for other companies; and by the fact that less developed economies might find it easier to expand in sectors that require less capital investment, infrastructure and machinery.</td>
</tr>
<tr>
<td>The chemicals sector in Poland</td>
<td>Poland is the largest New Member State with a large decrease of BERD in the last years. BERD intensity fell about 50% between 1999 and 2002 and then increased slightly to 0.20% in 2005. The country has several significant 'loser' sectors with decreasing BERD intensity and shares over time: Chemicals; Machinery and equipment, Radio, TV and communication equipment; electrical machinery; and other Transport. The Chemicals sector has seen its share of total BERD decline from 8 to 5 percent between 1995 and 2006; its BERD intensity decline from 2 to 1.1; and the share of value added decline from 1.2 to 0.9 in the same period. Some studies (PAIiZ, 2006) reveal that among the most important challenges facing the chemical sector in Poland are the lack of investment in technological processes; the lack of cooperation and linkages with R&amp;D centres; the privatisation of the biggest chemical enterprises and lack of favourable economic conditions for SMEs operating in the sector.</td>
</tr>
<tr>
<td>Sectors</td>
<td>Main case features/compliance with selection criteria</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>The Aerospace and Radio, TV and communications equipment sectors in Italy</td>
<td>Italy is an underperforming southern EU country where several sectors have been increasing in BERD intensity and share (aircraft, machinery and equipment, instruments, computer services, other business services) whereas others have been decreasing in both indicators (radio, TV and communications equipment; motor vehicles; pharmaceuticals; chemicals; electrical equipment; R&amp;D services). BERD in Italy is concentrated in 5 sectors, where the Aircraft, and radio, TV and communication equipment sectors together accounted for 21% of the total for the period 2001-2006. While the aircraft sector has almost constant shares of total BERD since 1995, the sector has considerably increased its intensity (from 33.1 to 40.1 between 1995 and 2006), and decreased its value added. On the other hand, the radio, TV and communications sector has increased considerably its share (from 12 to 19 percent of total BERD from 1995-2006), decreased its intensity (from 20 to 14 for the same period), while maintaining constant shares of value-added.</td>
</tr>
<tr>
<td>BERD in Ireland</td>
<td>The country has experienced BERD growth since 1992. This increase has been explained by a shift in growth that started in the radio, television and communication equipment sector and in the communication services sector in the 1990s and then suffered a downturn since 2000 (European Commission, 2007). The downturn was nonetheless more than compensated by a surge of in the computer and related services sector, and other manufacturing sectors (i.e. pharmaceuticals). Also important for BERD intensity is the role of foreign direct investments (FDIs) and multinationals (responsible of two-thirds of total BERD in the country) into high-tech growth sectors. More recent reports (European Commission, 2009) indicate that BERD as a percentage of economic activity has remained statistic between 2000-2004. Additionally, the share of BERD in the software industry has increased rapidly.</td>
</tr>
<tr>
<td>The ICT sector in Estonia</td>
<td>Estonia is a small EU economy where R&amp;D activity grew quite rapidly since 2000, and at quite uneven pace across different sectors. The country shows a clear shift in the share of R&amp;D in the software and programming industries. The firm Skype is said to be an explanatory factor behind ups and downs in annual BERD; however, the role of public intervention in support of BERD may also be an explanatory factor.</td>
</tr>
<tr>
<td>The Aerospace industry in France</td>
<td>France is characterised by having a combination of 'successful sectors' with increasing shares of BERD and BERD intensity, but also many stagnating sectors, such as the Aircraft sector. France is said to be second most important world exporter of aircrafts and aircraft parts (14% of world market) just behind the United States. The aircraft sector accounted for 11% of total industrial R&amp;D between 2001 and 2006. Nevertheless, while the share of value-added of the sector has stagnated since 1995, its R&amp;D has slightly declined in the period 1995-2006.</td>
</tr>
</tbody>
</table>

2.3.3 Case study template
All case studies will be presented in publishable snapshots. The length of each case study will be between 7 and 10 pages (A4 format, plus annexes and figures).

The proposed template will contain the following sections:

<table>
<thead>
<tr>
<th>Case study Title</th>
<th>Case study Synthesis (1 page)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BERD intensity performance in selected country/sector (2 pages)</td>
<td></td>
</tr>
<tr>
<td>• Description of BERD trends (according to statistics)</td>
<td></td>
</tr>
<tr>
<td>• Importance of relevant sector(s) at country level</td>
<td></td>
</tr>
<tr>
<td>Analysis of drivers of BERD intensity at the sectoral level (3 pages)</td>
<td></td>
</tr>
<tr>
<td>• Drivers within the firm and organisation (micro level)</td>
<td></td>
</tr>
<tr>
<td>• Drivers from the industry (meso level) or country-specific components of BERD intensity and intensity gaps</td>
<td></td>
</tr>
<tr>
<td>• Drivers from the macro level and the role of the framework conditions</td>
<td></td>
</tr>
<tr>
<td>• Drivers from the market</td>
<td></td>
</tr>
<tr>
<td>The role of public policies in determining BERD performance and BERD intensities (3 pages)</td>
<td></td>
</tr>
<tr>
<td>• Description of policy context influencing the studied sector (i.e. in the support of BERD and technological innovations)</td>
<td></td>
</tr>
<tr>
<td>• Policy analysis and Policy Mix design</td>
<td></td>
</tr>
<tr>
<td>• Potential policy directions in the support of BERD performance</td>
<td></td>
</tr>
<tr>
<td>Lessons learned, case uniqueness and success factors (1 page)</td>
<td></td>
</tr>
<tr>
<td>Case study author’s and interviewees’ contact details</td>
<td></td>
</tr>
</tbody>
</table>

2.3.4 Accompanying material and methodological support

For developing the survey, the annotated case study template is accompanied by a study guide, and a survey guideline as complementary material for the case study authors.

The case study guide and the survey guideline includes the key questions to be used during interviews with relevant stakeholders as well as advice on how to conduct the survey. The guide also indicates which sections of the project analysis template should be based on desk-research and which should be a focus during interviews, as introduced in the next table.

Table A.2.1: Main research methods for case study template

<table>
<thead>
<tr>
<th>Section</th>
<th>Research method</th>
<th>Analysis and assessment during and after interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data analysis</td>
<td>Desk research prior to field research</td>
</tr>
<tr>
<td>Case study Synthesis</td>
<td>Based on all sections of description</td>
<td></td>
</tr>
<tr>
<td>BERD performance in selected sector/country</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3 See Appendix A6 for a complete annotated template.
Apart from the accompanying material a **methodological help desk** (email, phone, Skype) will be established by Technopolis Group (Belgium). One person will be available for any queries field researchers may have everyday throughout the completion of the case studies. Each field researcher will be briefed by phone before commencing fieldwork.
2.4 Survey complementary material

2.4.1 Annotated template

**TITLE OF CASE**

Please provide a simple and self-explaining title. The country(ies) and sector(s) being studied must be indicated in the title.

**SYNTHESIS (1 page)**

The synthesis is a summary of the case to be used for publicity and communication purposes. It has to be understandable as a stand-alone text. It should be written in a clear way. The summary should include a short description of the case study objectives, the country/sector BERD performance, main BERD drivers, the role of public policies in determining (current and future) BERD performance, and key lessons learned.

**IMPORTANT**: Write this text at the end of the process of filling out the template.

I. **BERD PERFORMANCE IN SELECTED SECTOR/COUNTRY (2 pages)**

This section is a descriptive analysis based on provided statistical data on BERD performance and BERD intensity. You will be provided with an initial description from the study team in charge of the statistical analyses (conducted by NIFU STEP and SPRU).

This section of the case has to be seen as an introduction for the next section (Chapter II) described below. You will have to check if the provided description complies with the requirements below, otherwise you are expected to simply complete the missing analysis.

Be sure that BERD performance in the selected sector/country is described using the following (minimum) structure:

- R&D as a proportion of value-added
- Proportion of total BERD accounted for by the sectors of interest
- Proportion of total value-added accounted for by the sectors of interest

Check that from the data above, the reader clearly understands:

- Which are the sectors in which R&D intensity has increased per country?
- In relation to the sectors with growing R&D intensity how have their shares in total R&D and total output changed over time?

*Make sure the analysis indicates the following (giving emphasis to the sectors of interest):*

- Top 5 sectors in terms of BERD shares
- 5 sectors where BERD share is increasing/declining
- Top 5 sectors where R&D intensity is increasing
- 5 sectors where value added share is increasing/declining
II. DRIVERS OF BERD INTENSITY (3 pages)

This section has to answer clearly to the main question: What drives BERD intensity in the studied sectors/countries? Base your analysis on national studies and national statistical analyses.

Describe BERD drivers considering the following structure:

Drivers within the firm and organisation (micro level)

The central question to be answered is: what drives individual firms decisions for investing in R&D?

- Other questions to be answered are: What is the role of the size of the firm, the corporate strategies, the firm structure and the resources (financial and human) in determining BERD intensity?

Drivers from the industry (meso level) or country-specific factors

- What are the factors driving BERD intensity at the industry level (i.e. competitive behaviour, specialisation in innovative activities, interrelations with technical and technological improvements, institutional factors, etc)?
- Describe how much of the BERD intensity gap is caused by the country’s structure and its over- or under- emphasis (i.e. share of total GDP) on particular industries/sectors – some of which are more R&D-intensive than others – for producing the country’s output.

Drivers from the macro level and the role of the framework conditions

- What is the role of the framework conditions such as financial, strategic and regulatory factors, in influencing the decision of companies to invest in R&D (i.e. the role of public investment in science, the role of infrastructures, etc)?
- Are the effects of foreign-owned firms on the R&D intensity of the host country positive or negative? How do national culture, patent protection and the institutional context of the country influence BERD performance? What is the role of human resources and the quality of human capital on BERD performance?
- What is the role of public expenditures on R&D in supporting BERD intensity? (The answer to this question should not be long and should be able to introduce Section III of the case study).

Drivers from the market

- How do consumer preferences and market competition influence BERD performance in the country/sector?

III. THE ROLE OF PUBLIC POLICIES IN DETERMINING BERD PERFORMANCE AND BERD INTENSITIES (3 pages)

Provide a description of the existent policy framework (at the country, regional and EU level) relevant for R&D and technological progress. Give emphasis (in order of importance) to national and regional policies, national structural funds, EU Framework Programs and other EU funding. Look at industry/sector specific platforms and infrastructures that support technological activities.

This section should address the main question: how have public policies impacted upon business R&D given what we know about factors driving R&D investment? (as per section II).
You may want to use as reference for your analysis the outcomes from INNO-Policy TrendChart and the European Commission Research – Policy Mix for R&D Reports.

If possible, try to classify the relevant policies into one of the 6 following broad routes to increase R&D investments:

- Promote establishment of new indigenous R&D-performing firms
- Stimulate greater R&D investment in R&D-performing firms
- Stimulate R&D investments in firms non-performing R&D
- Attract R&D performing firms from abroad
- Stimulating public-private collaboration in R&D
- Increase R&D in public sector

Provide a number of observations that could help shape policy to support technological progress and sustain/improve competitiveness of the referred sector.

**IMPORTANT**: After reading this section a reader should be able to understand how policy is implemented and works in practice for a given sector in a given country and their impact on BERD performance.

### IV. CONCLUSION, LESSONS LEARNED, AND POLICY OPTIONS (1 page)

This section presents key factors, key messages and key lessons based on the material presented in the previous chapters. List maximum five key messages including a short description for each of the messages.

Discuss key drivers that impact BERD intensity in the studied case. Discuss factors and conditions favouring BERD intensity. List up three lessons learned from the case study. Provide a short justification of each of the above points.

**IMPORTANT**: A one line bullet point is not sufficient!

### CONTACT DETAILS

Please insert name, organisation, website, address, telephone and e-mail details of the case authors AND interviewees AND any other relevant person involved in the study.
2.4.2 Survey guide

SECTORAL ANALYSIS OF THE LONG-TERM DYNAMICS OF BUSINESS R&D INTENSITY

Introducing the study

The survey you are about to undertake is part of the European Commission’s DG Research project 'Sectoral analysis of the long-term dynamics of business R&D intensity' in relation to (DG-RTD-2005-M-02-01): "Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators".

The background to the project is the need for the European Commission, in the framework of the discussions on the 3% R&D investment target and the policy tools to be used to achieve it, to better understand the drivers of business R&D intensity. The business R&D intensity of the EU has been stagnating for many years. However, the stagnation covers a diverse development in business R&D intensities and expenditures (BERD) at Member State level, some Member States having experienced impressive developments in business R&D intensities.

Activity VI (Phase II) of the project consists in a survey that would help in elaborating a more detailed analysis of 10 cases where BERD trends are particularly striking. The case studies will be delivered by the end of July 2009 to the Commission services.

The objective of the survey is to derive, extend and strengthen explanations for particular identified trends based on the data analysis. The cases will deepen the analysis of Phase 1 (statistical analysis) and examine trends and hypotheses derived from these analyses. Consequently, the cases will use the statistical analysis of Phase 1 to complement arguments (and provide an indication for the selection of case studies). The role of public policy in affecting the evolution of BERD intensities is of particular interest. Linking the case studies to different policy initiatives, such as the 3% Action Plan, is one of the key aims of the cases.

a. Preparing for the interview

Before starting case study:
- read carefully the annotated template and this guide
- conduct literature review of the publicly accessible materials related to BERD performance and intensities related to the sector/country of analysis
- draw up a list of five people to interview and submit them for approval to Technopolis.
- contact Technopolis help desk for a phone briefing and clarify any questions you may have on the study, or template

To arrange and prepare your interviews:
- contact the interviewees
  - send an email with key questions addressed by this study along with the mission letter from the Commission
o note that you should interview people having different perspective of the case who work in different organisations and at different level of planning and implementation
o be flexible and always suggest alternative dates for an interview

- inform Technopolis helpdesk about the date of your planned interviews as soon as you have them arranged.
- do not hesitate to contact the helpdesk with any other methodological problems or questions
- please keep in mind that different template sections are based on different information sources and require different analytical effort (see Table in section c of this guide)
- prepare key interview questions and structured notebook to take notes

b. Conducting interviews

The main questions your interview should be based are on the annotated template and on the survey guidelines, which are the main bases of your case study. Keep in mind that you SHOULD NOT feel obliged to ask all the questions. Ask selected questions and make sure that your respondent touches all relevant issues when answering them.

Keep in mind that your interview should be based on:

- open-ended questions
  o avoid asking very general, vague or yes/no questions; respondents should be encouraged to elaborate on the topic.

- semi-structured format
  o you should have some pre-planned questions for the interview, but the conversation should flow naturally based on information provided by the respondent. Do not insist on asking specific questions in a specific order. Be conversational and engaging. The interview should be conducted in a possibly informal way.

The responses should be recorded with structured written notes. This will help you to be more precise in your description and will allow for quoting your respondents should you want to do so.

Make sure you have complete contact details of all your respondents for future communication.

c. Preparing the analytical part of the exercise

- read again the annotated template
- contact the helpdesk should you still have any further methodological questions

- prepare a complete draft of the analysis and send it to the helpdesk
  o please keep in mind that different template sections require different level of analytical effort (see Table below)
  o remember that the material you are preparing will be published so use possibly clear language and style understandable for a wider public

- finalise the analysis following feedback from the core team
Main research methods for the survey case template

<table>
<thead>
<tr>
<th>Section</th>
<th>Research method</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data analysis</td>
<td>Desk research prior to field research</td>
<td>Interviews</td>
<td>Analysis and assessment during and after interviews</td>
</tr>
<tr>
<td>Synthesis</td>
<td>Based on all sections of description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BERD performance in selected sector/country</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analysis of drivers of BERD intensity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The role of public policies in determining BERD performance and BERD intensities</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lessons learned, case uniqueness and success factors</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- key element
- complementary element
- only if information is missing

**d. Contacting Technopolis help desk**

Technopolis established a dedicated helpdesk providing advice and support for field researchers throughout the survey phase. Please do not hesitate to contact the Help Desk whenever you have either methodological questions or have any important organisational communication e.g. unforeseen delays etc.

In order to contact the helpdesk please email, phone or Skype:

Lorena Rivera Leon
Technopolis Group, Belgium
lorena.rivera.leon@technopolis-group.com
Tel: +32 2 737 74 47
Fax: +32 2 737 74 49
Skype: lorena.rivera.leon
2.4.3 Survey guide

**Key to respondents:**
CM: Company manager (CEO, R&D director, etc.)
SR: representatives of sectoral business associations, etc.
AA: Analyst (academic, consultant, etc.)
PM: Policy-maker/manager

The survey questions are intended to act as a guide for interviews and are not expected to be "read-out verbatim" to interviewees. You are expected to tailor them to the interviewee based on your background reading on the country/sector/firm, using the key to respondents to select questions for specific interviewees. The survey questions are inspired by and adapted from the literature review prepared for the study.

As the interviews are conducted by telephone and the time available to complete the survey is limited (making follow-up difficult), please encourage the interviewee to comment on and justify your answers during the interview. Ask the interviewee to provide examples or reference to literature (including grey) wherever possible.

**Introductory questions: trends in BERD**

- How would you characterise your knowledge of recent (since 2000) trends in business expenditure on R&D? From 1 no knowledge, 2 some knowledge, 3 average 4 above-average, 5 in-depth knowledge
  - At corporate level (R&D investment strategies of one or more business enterprises). Where you have at least above average knowledge please for which enterprise(s)
  - At sectoral level (trends in R&D investment and factors underpinning such trends for a specific business sector, or ‘cluster’). Where you have at least above average knowledge please indicate for which sector(s)
  - At national (or eventually regional level for large Member States) level: Where you have at least above average knowledge please for which region(s)/country(ies)
    (CM/SR/AA/PM)

- What do you consider to have been the most significant change since 2000 in BERD intensity or patterns (which companies, which sectors, etc.) in your country/sector?
  (CM/SR/AA/PM)

- Do you consider that firms in ‘high-tech’ (technology content of products) sectors invest more intensively in R&D than firms from other sectors? If not, which other sectors/sub-sectors do you consider to be particularly important in driving R&D investment since 2000?
  (AA/PM)

**Role of enterprise-level strategies and structures**

- To what extent can BERD trends in your country/sector be attributed to the strategic decisions of one or more ‘major players’ (including if applicable groupings of smaller firms) to invest more (or less) in R&D?
  (SR/AA/PM)
Where you consider such individual firms and their strategies have played a role, please identify, which specific firms you consider are responsible for strongly influencing BERD trends? Please explain your choice.
(SR/AA/PM)

To what extent is the ownership structure (independent, publicly listed, part of national holding, subsidiary of multinational) of your firm (CM) / firms in your sector (SR) an influence on decisions to invest more (or less) in R&D?
(CM/SR)

To what extent do you consider each of the following possible factors have influenced R&D investment trends (in your firm/sector/country) since 2000:
   a. change in scale (size) of companies (access to human or financial resources)
   b. corporate strategies: strategic diversification of ownership and production (to access to complementary R&D resources) versus concentration;
   c. mergers and acquisitions (e.g. between technologically related enterprises) (including influence of foreign takeover of formally national firms);
   d. shifting organisational practices (knowledge management) influencing R&D productivity in enterprises.
(CM/SR/AA/PM)

Role of sectoral determinants

Since 2000, what are the key factors influencing decisions of your firm (CM) / firms in your sector (SR) to invest more (or less) in R&D?
To prompt the interviewee you may suggest factors such as: increased competition, specialisation in innovative activities, probability of being able to protect (IPR and appropriability issues) and exploit R&D results through marketable products/lowered production costs, product life-cycle trajectories; access to external financial resources, business cycle, etc.
(CM/SR)

To what extent is the possibility to carry out R&D in co-operation with other firms an important factor in influencing your firm (CM) / firms in your sector (SR) to invest in R&D? Has the importance of co-operation as a factor influencing R&D intensity changed over time (since 2000)? What factors influence the choice to co-operate for R&D (e.g. increasing scale/cost of R&D, need to access complementary technologies)?
(CM/SR)

To what extent does your firm (CM) / do firms in your sector (SR) contract out R&D (to R&D service firms, public or university based research organisations, etc.) as part of their investment in R&D? How important is access to such contract research organisations in influencing decisions on R&D investment; and has the importance increased or decreased over time (since 2000)? What factors (e.g. access to advanced equipment, knowledge on world leading research (basic), cost of contracting out versus internalising, etc.) influence the choice to internalise or externalise R&D?
(CM/SR)

To what extent does your firm (CM) / do firms in your sector interact with suppliers, customers or end-users in order to undertake R&D? How important an element is this type of ‘open-innovation’ process in influencing decisions on R&D investment; and has the importance increased or decreased over time (since 2000)?
What is the role of the framework conditions such as the regulatory environment, standardisation, intellectual property regimes, etc., in influencing the decision of your company (CM)/companies in your sector (SR) to invest in R&D?

Which (sub-)sectors (or eventually firms in specific sectors), in your country, do you consider to be amongst the most efficient in turning R&D investment into innovations (new products or processes); and why?

In your opinion, how much of the BERD intensity gap is caused by your country’s over- or under-specialisation in particular industries/sectors (some of which are more R&D-intensive than others)?

Do you consider that BERD trends have been influenced since 2000 by trends in the relative importance of manufacturing and services (or sub-sectors within these two groups)?

Are there specific trends in terms of foreign investment (outward/inward investment) or (re-)location of R&D labs, which you consider have influenced BERD performance in your country? If so, does this affect specific sectors more than others and what factors are driving this trend (e.g. relative cost of R&D staff, available HR for science and technology, locational advantages such as large public/academic R&D facilities, proximity to clusters of research-intensive firms, etc.).

In your opinion, are there specific public policy measures implemented since 2001 that you consider have significantly altered the propensity of businesses to invest in R&D (at national or sectoral levels)?

If yes, please identify which ones (please encourage the interviewee to talk about specific cases).

If no, do you consider what form of Government intervention is required, if any, in order to encourage businesses to invest in R&D.

Which of the following “policy-routes” to encourage higher BERD do you consider to be the most relevant for your firm/sector-specific sectors/businesses in general?

a. Promote establishment of new indigenous R&D-performing firms
b. Stimulate greater R&D investment in R&D-performing firms
c. Stimulate R&D investments in non-performing R&D firms
d. Attract R&D performing firms from abroad
e. Stimulating public-private collaboration in R&D
f. Increase R&D in public sector

If possible please ask the interviewee to rank the options and to comment on their priorities.
“Sectorial analysis of the long-term dynamics of business R&D intensity”

In relation to (DG-RTD-2005-M-02-01):

“Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators”

Final Report
Revised version

Annex 3: Country reports

Technopolis Group (assignment manager)
Idea Consult (coordinator)
SPRU, NIFU STEP

Brussels, 12 November 2009
# Table of contents

1 Country Reports: European Union  
1.1 Austria 95  
1.2 Belgium 102  
1.3 Bulgaria 109  
1.4 Cyprus 115  
1.5 Czech Republic 121  
1.6 Denmark 127  
1.7 Estonia 134  
1.8 Finland 140  
1.9 France 147  
1.10 Germany 154  
1.11 Greece 161  
1.12 Hungary 168  
1.13 Ireland 174  
1.14 Italy 181  
1.15 Latvia 188  
1.16 Lithuania 191  
1.17 Malta 194  
1.18 The Netherlands 197  
1.19 Poland 204  
1.20 Portugal 209  
1.21 Romania 217  
1.22 Slovakia 223  
1.23 Slovenia 228  
1.24 Spain 235  
1.25 Sweden 242  
1.26 United Kingdom 249  

2 Country Reports: Non-EU countries 256  
2.1 United States 256  
2.2 Japan 262  
2.3 Korea 268  
2.4 China 274  
2.5 Norway 276  
2.6 Iceland 282  

3 Calculating an European BERD aggregate 288  
3.1 BERD in Europe and its comparison with other third countries 298
Activity IV consisted of the collection of time series data and the construction of a series of country reports. All country reports can be found in Annex A3 (EU-27) and Annex A4 (United States, Japan, Korea and China).

The collection of country reports includes the EU27 Member States and other non-member states. Statistics from the non-member states (USA, Japan, and Korea) come from the 2009 OECD Analytical Business Enterprise Research and Development database (ANBERD) and OECD Stan database, but since many of the New Member States do not belong to the OECD, it was necessary to use other sources. New Member States included in the 2009 ANBERD database are the Czech Republic, Hungary, Poland, Slovakia, Slovenia and Romania. The first four countries are included in the 2009 OECD STAN database and preliminary STAN tables were used for Slovenia. Similar statistics are available in the EU KLEMS database, which made it possible to construct value-added for Estonia, Latvia, Lithuania, Cyprus and Malta. Eurostat R&D statistics collected through national surveys were used for Bulgaria, Estonia, Latvia, Lithuania, Cyprus and Malta. Finally, value-added data for Bulgaria and Romania come from the Eurostat Structural Business Statistics.

Each country report in this collection is organized in the same way except for the three countries where it was not possible to obtain a panel across a sufficient number of years. There are six sections in each report: (1) Background; (2) Top 10 industries performing BERD; (3) Changes in the distribution of BERD in the top 10 industries; (4) Trends in BERD intensity; (5) Trends in value-added by sector; and (6) Summary of the evolution of BERD. When possible, statistics were used from 1995 to 2006. To simplify the analysis, the 12-year period was averaged into two six-year periods covering 1995 to 2000 and 2001 to 2006. While such long periods softens some of the dynamics that took place over the 12 year period, it allows to make a distinction between before the Lisbon-driven reforms and policy agenda's and afterwards. Finally, in the last section there is a time series trend that includes all available data at the aggregate BERD level.
1 Country Reports: European Union

1.1 Austria

The analysis for Austria is based on data for 5 years as reported in ANBERD: 1998, 2002 to 2006. In terms of broad aggregates, around 72% of Business R&D (BERD) in this period is accounted for by Manufacturing industries (NACE 15-37) and 27% by Services (NACE 50-99). The main trend over the period 1998 to 2006 has been a decrease of the relative importance of the former (share declining from 76% in 1998 to 72% in 2002-2006) and an increase of the relative importance of the latter (share increasing from 22% to 27%). R&D intensity in manufacturing industries combined is 6.2% and in Services is 0.67%.

Concentration of BERD

The Austrian Business R&D is concentrated in 4 sectors accounting for almost 50% of the total in the period 1998 to 2006:
- Radio, TV and communication equipment
- Machinery and equipment
- R&D services
- Motor Vehicles

Moreover the 11 sectors shown in Figure 1 account for more than 80% of all industrial R&D.

Figure 1. Structure of BERD 2001-2006

<table>
<thead>
<tr>
<th>Sector</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio, TV and communication equipment</td>
<td>22%</td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td>9%</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>5%</td>
</tr>
<tr>
<td>Research &amp; development</td>
<td>10%</td>
</tr>
<tr>
<td>Other</td>
<td>18%</td>
</tr>
<tr>
<td>Wholesale &amp; retail</td>
<td>3%</td>
</tr>
<tr>
<td>Computer Services</td>
<td>4%</td>
</tr>
<tr>
<td>Chemicals less</td>
<td>3%</td>
</tr>
<tr>
<td>Instruments</td>
<td>3%</td>
</tr>
<tr>
<td>Electrical Equip.</td>
<td>4%</td>
</tr>
<tr>
<td>Machinery &amp; Equip.</td>
<td>11%</td>
</tr>
<tr>
<td>Other Business Services</td>
<td>8%</td>
</tr>
<tr>
<td>Oth. Business Services</td>
<td>4%</td>
</tr>
</tbody>
</table>

Changes in the structure of BERD

95
Figure 2 shows the evolution of BERD in Austria in the period since 1998. The main changes have been an increase in the share of R&D Services, Computer Services, and Machinery and equipment. At the same time, the largest decline has been in Radio, TV, and communication equipment. In most other sectors, the changes have been minimal.

**Figure 2. Winners and losers in the shares for BERD in Austria from 1998 to 2006**

**Trends in R&D Intensity**

Figures 3 and 4 report the changes in R&D intensity since 1998. We begin by mentioning a potential problem with the underlying data for R&D services (NACE 73) from ANBERD and STAN, which have been estimated by the OECD using national sources. However, the resulting R&D intensity exceeds far 100% for a number of years and hence the results below need to be treated with caution.

The first point to note from these Figures is that 6 out of the 11 sectors have increased their R&D intensity (this rises to 7 if we include R&D services). The largest proportionate increase has been for Computer services where the R&D intensity has more than doubled. The other industries to register increases have been Wholesale and Retail trade, Instruments, Machinery and Equipment, and Electrical Equipment. The only sector to show a slight decline is Chemicals.
Figure 3. Trends in Sectoral R&D intensity in Austria: 1998-2006

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1998 - 2006
Trends in shares of Value-added

In Figure 5 we report the changes in the share of value-added for the 11 sectors that are most important contributors to total BERD. The first point to note is that these 11 sectors together account for 27% of total value-added for Austria. This contrasts with their 80% share of total R&D. In other words the remaining sectors that account for 73% of GDP contribute less than 20% to industrial R&D. The other point to note is that there have been some small changes in the relative importance of most of these sectors over time. The only sector with a significant change is Business services which has increased from 4.7% to 5.9% of total value-added.

Figure 5. Trends in the shares of Value-added in Austria: 1998-2006
Summary of the evolution of BERD in Austria

This section presents a summary of the evolution of BERD in Austria. Figure 6 shows that aggregate BERD intensity has increased from 1.26% 1998 to 1.91% in 2006.

In Figure 7 a summary of the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity is presented. In Figure 8 we correlate the changes in BERD intensity (X axis) with the changes in the structure of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand indicates increasing BERD intensity and decreasing share of BERD.

Figures 7 and 8 show some contrasting trends in the 4 sectors that make up nearly half of BERD in Austria. In the largest sector, Radio, TV and Communications equipment, which represents more than 20% of total R&D, there has been a decline in its relative importance, but an increase in terms of intensity. On the other hand Computer services, Machinery and equipment, and Motor vehicles have increased in relative importance as well as in terms of R&D intensity.

Figure 6. Evolution of BERD intensity over time, 1998 to 2006

Note: Data for 1999 to 2001 are interpolated.
Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Austria: 1998-2006

<table>
<thead>
<tr>
<th>Research &amp; development</th>
<th>Change in R&amp;D Intensity</th>
<th>Change in Value Added</th>
<th>Change in BERD Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio, TV &amp; Telecomms</td>
<td>-0.22</td>
<td>0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>0.17</td>
<td>0.28</td>
<td>0.36</td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td>0.66</td>
<td>0.70</td>
<td>0.54</td>
</tr>
<tr>
<td>Instruments</td>
<td>0.67</td>
<td>0.97</td>
<td>0.67</td>
</tr>
<tr>
<td>Electrical Equip.</td>
<td>0.29</td>
<td>0.61</td>
<td>2.37</td>
</tr>
<tr>
<td>Machinery &amp; Equip.</td>
<td>0.09</td>
<td>0.05</td>
<td>-0.09</td>
</tr>
<tr>
<td>Chemicals less Pharma</td>
<td>-0.84</td>
<td>0.48</td>
<td>1.37</td>
</tr>
<tr>
<td>Computer Services</td>
<td>0.48</td>
<td>0.03</td>
<td>1.18</td>
</tr>
<tr>
<td>Oth. Business Services</td>
<td>0.57</td>
<td>1.18</td>
<td>2.44</td>
</tr>
<tr>
<td>Wholesale &amp; retail</td>
<td>0.51</td>
<td>0.82</td>
<td>0.69</td>
</tr>
</tbody>
</table>
Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Austria (Table 1).

Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• R&amp;D services</td>
<td>• Pharmaceuticals</td>
</tr>
<tr>
<td>• Radio, TV and Communications equipment</td>
<td>• Chemicals</td>
</tr>
<tr>
<td>• Motor Vehicles</td>
<td></td>
</tr>
<tr>
<td>• Instruments</td>
<td></td>
</tr>
<tr>
<td>• Electrical equipment</td>
<td></td>
</tr>
<tr>
<td>• Machinery &amp; Equipment</td>
<td></td>
</tr>
<tr>
<td>• Computer services</td>
<td></td>
</tr>
<tr>
<td>• Other Business services</td>
<td></td>
</tr>
<tr>
<td>• Wholesale &amp; Retail Trades</td>
<td></td>
</tr>
</tbody>
</table>
1.2 Belgium

In terms of broad aggregates, around 80% of the Business R&D (BERD) in Belgium is accounted for by Manufacturing industries (NACE 15-37) and 16% by Services (NACE 50-99). The main trend over the period 1995 to 2006 has been a slight decrease of the relative importance of the former and a slight increase of the relative importance of the latter. R&D intensity in manufacturing industries combined is 6.5% and in Services is 0.3%.

Concentration of BERD

Business R&D in Belgium is concentrated in 3 sectors, which account for almost 50% of the total in the period 1995 to 2006:

- Pharmaceuticals
- Chemicals (excluding pharmaceuticals)
- Radio, TV and communication equipment

The 12 sectors included in Figure 1 account for more than 80% of all Belgian industrial R&D.

Figure 1. Structure of BERD 2001-2006

Changes in the structure of BERD

Figure 2 shows the evolution of BERD in Belgium since the mid 1990s. The main changes over this period have been an increasing importance of Pharmaceuticals and Instruments and a decline in that of Other Chemicals and Radio, TV and Communications equipment.
Figure 2. Winners and losers in the shares for BERD in Belgium 1995-2006

Trends in R&D Intensity
Figures 3 and 4 report the levels and the trends in R&D intensities over the period 1995 to 2006. Figure 3 shows that the 3 sectors that dominate Belgium industrial R&D also have very high levels of R&D intensities: Radio, TV and Telecommunications equipment, Pharmaceuticals and Chemicals. The other sector with a high R&D intensity is Instruments.

Figure 3. Trends in Sectoral R&D intensity in Belgium: 1995-2006
The largest proportionate increase in R&D intensity since the mid-1990s has been for the Instruments sector (Figure 4), with R&D intensity increasing by more than 50%, from 14% to 21%. Electrical equipment, Food, Drink and Tobacco, and Radio, TV and Telecommunications equipment have also substantially increased the proportion of value-added devoted to R&D. In contrast there has been a proportionate decline in the R&D intensity in Computer services and Other business services. Most other sectors have changed little.

Figure 4. Top 5 winners and losers in R&D intensity by industry: 1995-2006
### Trends in shares of Value-added

Figure 5 reports the evolution of Value-added for the sectors that make the largest contributions to BERD. The first point to note is that although these sectors represent more than 80% of BERD in Belgium, they only account for 23% of value-added. The sector making the largest and increasing contribution to economic output is Other Business Services: it accounted for more than 10% of total Belgium value-added in 2001-2006. All other sectors make a very small contribution to output. The main trends to note are an increasing share of Computer Services and Pharmaceuticals and a declining share of Chemicals.

**Figure 5. Trends in the shares of Value-added in Belgium: 1995-2006**
Summary of the evolution of BERD in Belgium

This section summarizes the evolution of BERD in Belgium. Figure 6 shows that there have been two distinct phases in the terms of the trend in aggregate BERD intensity. From 1995 to 2001 there was a strong increase when the intensity climbed from 1.3% to 1.7%. However in the period from 2001 to 2005 there has been a decline.

Figure 6. Evolution of BERD intensity over time, 1995 to 2006
In Figure 7 we present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. In Figure 8 we correlate the proportionate changes in BERD intensity (X axis) with the changes in the structure of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand indicates increasing BERD intensity and decreasing share of BERD.

Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Belgium: 1995-2006

The analysis in Figures 7 and 8 shows very contrasting trends amongst each of the 3 sectors that make up nearly 50% of all Belgian industrial R&D. While the share of Pharmaceuticals which accounts for more than 20% all R&D has greatly increased (from 16% in the mid-1990s to 22% in 2001-06), its intensity remains unchanged. On the other hand Chemicals has seen a decline in both BERD share (from 19% to 13%) and in intensity. Finally in the case of Radio, TV and Telecommunications equipment, has seen a decline in the share of total R&D from 13% to 15% and an increase in R&D intensity from 37% to 45%.
Table 1 shows our assessment of the sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Belgium.

**Table 1. Typology of sectors in term of their contribution to the 3% target**

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Radio, TV and Telecommunications equip.</td>
<td>• Chemicals</td>
</tr>
<tr>
<td>• Pharmaceuticals</td>
<td>• Computer Services</td>
</tr>
<tr>
<td>• Instruments</td>
<td>• Basic Metals</td>
</tr>
<tr>
<td>• Machinery &amp; Equipment</td>
<td>• Motor Vehicles</td>
</tr>
<tr>
<td>• Electrical Equipment</td>
<td>• Other Business Services</td>
</tr>
<tr>
<td>• Rubber and Plastics</td>
<td></td>
</tr>
<tr>
<td>• Food, Drink and Tobacco</td>
<td></td>
</tr>
</tbody>
</table>
1.3 Bulgaria

In Bulgaria, manufacturing value added made up on average 43% of total value added from 1999-2000, and 37% from 2002 to 2006. By contrast services made up on average 51% of total value added from 1999-2000, but increased to more than 58% from 2002 to 2006. Averages for Bulgaria cover these periods because R&D statistics were not collected in every industry prior to 2002. The share of BERD in services is very high in Bulgaria, and it had increased from 38% to almost 60% over the two periods, while the share of BERD in manufacturing decreased from 50% to 42% over the same two periods. Average BERD intensity, measured as BERD over value added, fell from 0.72% in the first period to 0.59% in the second period. It should be noted that BERD and value added for Bulgaria were obtained from the Eurostat industrial database, and therefore based on the main activity of the firm. Both the statistics have additive problems. BERD at the industry level adds up to just over 50% of total BERD in the first period, particularly because of a lack of statistics for the service industries, and over 100% in the second period. Value added at the industry level adds up to over 100% of total value added in both periods.

**Distribution of BERD**

The top 10 industries performing R&D from 2002 to 2006 in Bulgaria account for 96% of total BERD, of which Transport and communications (60 to 64), Financial intermediation (65 to 67), and pharmaceuticals (2423) explain 51% of it. Figure 1 shows the structure of BERD for Bulgaria as an average between 2002 and 2006.

Figure 1. Structure of BERD 2002-2006
Changes in the distribution of BERD

Figure 2 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. The three top winners are other business activities (74), computer and related activities (73), and machinery and equipment (29). Rubber and plastic products (25), instruments, watches and clocks (33), and pharmaceuticals (2423) were the top three losers. Please keep in mind, however, that R&D statistics are not reported for all industries in Bulgaria.

Figure 2. Winners and losers in the shares for BERD in Bulgaria, 1999-2000 and 2002-2006

Trends in BERD Intensity

BERD intensity tripled in Bulgaria from the two year prior to 2001 and three years from 2004. Figure 3 shows the sectoral R&D intensity for the top 10 industries and figure 4 shows the top 5 industries and bottom five industries in terms of their dynamics, irrespective of their sectoral contribution to total BERD, over the two periods. Software services (72) and other business activities (74) were the biggest winners, whereas rubber and plastic products (25) was the biggest loser. R&D services (73) actually appeared to have the highest BERD intensity, but was left out because of suspected statistical anomalies.
Figure 3. Trends in sectoral R&D intensity in Bulgaria by industry, 1999-2000 and 2002-2006

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1999-2000 and 2002-2006
**Trends in Value-added by Sector**

Figure 5 shows the evolution of value-added for the top 10 industries. While these industries make up 86% of total BERD from 2004 to 2006, on average, they make up 61% of value added.

Figure 5. Trends in the shares of Value-added in Bulgaria: 1999-2000 and 2002-2006

---

**Summary of the evolution of BERD in Bulgaria**

Figure 6 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, Bulgaria is well below the target and falling further behind. Figure 7 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates increasing BERD intensity and decreasing share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand quadrant indicates decreasing R&D intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear losers.

Figures 7 and 8 show some contrasting trends in the top 3 sectors that make up about 50% of BERD in Bulgaria. However, there is not enough information to determine structural change over the 10-year period. Yet, software services (72) and other business activities (74) appear to be the clear winners, whereas rubber and plastic products (25) appears to be a clear loser.
Figure 6. Evolution of BERD intensity over time, 1998 to 2005

Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Bulgaria: 1998-2005
Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Bulgaria (Table 1).

**Table 1. Typology of sectors in term of their contribution to the 3% target**

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other business services</td>
<td>Rubber and plastics</td>
</tr>
<tr>
<td>Software services</td>
<td></td>
</tr>
<tr>
<td>Machinery and equipment</td>
<td></td>
</tr>
</tbody>
</table>
1.4 Cyprus

In Cyprus, manufacturing value added made up 9% of total value added on average during the entire period from 1998-2005, with a 3% decline in the 2000s. On average, total value added generated by services increased from 75% from 1998 to 2000 to 78% from 2001 to 2005, suggesting that agriculture and extractive industries maintained a fairly stable share. The share of BERD in services was high during this period, increasing from 42% in the first period to 60% in the second period. By contrast, the share of BERD in manufacturing decreased from 49% to 36% over the two periods. Average BERD intensity, measured as BERD over value added, increased from 0.09% in the first period to 0.13% in the second period. BERD intensity increased in manufacturing from 0.41% to 0.7% from one period to the next and in services it increased from 0.05% to 0.1% from one period to the next.

Distribution of BERD

The top 10 industries performing R&D from 2001 to 2005 in Cyprus account for 92% of total BERD, of which Computer and related activities (72), Pharmaceuticals (2423), and Other business activities (74) explain 60% of it. Figure 1 shows the structure of BERD for Cyprus as an average between 2001 and 2006.

Figure 1. Structure of BERD 2001-2005
Changes in the distribution of BERD

Figure 2 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. The three top winners are Computer and related activities (72), Pharmaceuticals (2423), and transport and communications (60 to 64); and the three biggest losers are Food and beverages (15 & 16), Electrical machinery and apparatus (31) and Community, social and personal services (75 to 99).

Figure 2. Winners and losers in the shares for BERD in Cyprus, 1998-2005

Trends in BERD Intensity

BERD intensity for BERD increased by 53% in Cyprus from the three year prior to 2001 and five years from 2001. Figure 4 shows the sectoral R&D intensity for the top 10 industries and figure 5 shows the top 5 industries and bottom five industries in terms of their dynamics, irrespective of there sectoral contribution to total BERD, over the two periods. Notable winners include, Pharmaceuticals (2423), Computer and related activities, and other chemicals (24-2423), of which pharmaceuticals had the highest R&D intensity in both periods.
Figure 3. Trends in sectoral R&D intensity in Cyprus by industry, 1998-2005

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1998-2005
**Trends in Value-added by Sector**

Figure 5 shows the evolution of value-added for the top 10 industries. While these industries make up more than 92% of total BERD from 2001 to 2006, on average, they made up less than 48% of value added, more than most of the new Member States because Community, social and personal services (75 to 99) are included in the top 10.

Figure 5. Trends in the shares of Value-added in Cyprus: 1985-2005

**Summary of the evolution of BERD in Cyprus**

Figure 6 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, Cyprus has shown some progress in moving toward the target, but is very far from the target. Figure 7 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing R&D intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing BERD intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) indicates increasing BERD intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear losers.

Figures 7 and 8 show some contrasting trends in the top 3 sectors that make up about 60% of BERD in Cyprus. The two largest sectors also appear to be the biggest winners. Pharmaceuticals (2423) and software services (72) show the largest increase in BERD intensity and increase in the share of BERD.
Figure 6. Evolution of BERD intensity over time, 1998 to 2005

Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Cyprus: 1998-2005
Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Cyprus (Table 1).

**Table 1. Typology of sectors in term of their contribution to the 3% target**

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software services</td>
<td>Social services</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>Machinery and equipment</td>
</tr>
</tbody>
</table>
1.5 **Czech Republic**

In the Czech Republic, manufacturing value added made up 26% of total value added on average during the entire period from 1995 to 2006. Value added generated by services increased from 56% total value added from 1995 to 2000 to 59% from 2001 to 2006, on average, suggesting that agriculture and extractive industries declined by 3% over the decade. The share of BERD in services also increased from 26% to 33% over the two periods, while the share of BERD in manufacturing declined from 72% to 65% over the two periods. Average BERD intensity, measured as BERD over value added, increased from 0.75% in the first period to 0.93% in the second period. BERD intensity was about 5 times higher in manufacturing than in services, but it increased in both industries. In manufacturing it increased from 2.07% to 2.30% from one period to the next and in services it increased from 0.34% to 0.51% from one period to the next.

**Top 10 industries performing BERD**

The top 10 industries performing R&D from 2001 to 2006 account for more than 80% of total BERD, of which, *Motor Vehicles* (34), *Research and Development* (73) and *Machinery and Equipment* (29) explains 53% of it. Figure 1 shows the structure of BERD for the Czech Republic as an average between 2001 and 2006.

Figure 1. Structure of BERD 2001-2006
Changes in the distribution of BERD in the top 10 industries

Figure 2 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. Computer and related activities (72) and pharmaceuticals (2423) were the biggest winners from the top 10 list, and aircraft and spacecraft (353), machinery and equipment (29), and other chemicals (24-2423) were the biggest losers from the top 10 list. R&D activity is relatively large because the Academy of Sciences in the Czech Republic remains an important institution with sixty research organizations under its umbrella doing a variety of different activities.

Figure 2. Top 5 Winners and top 5 losers in the shares for BERD in the Czech Republic, 1995-2006

Trends in BERD Intensity

BERD intensity for increased by almost 23% in the Czech Republic from the six year prior to 2001 and six years from 2001. Figure 3 shows the sectoral R&D intensity for the top 10 industries and Figure 4 shows the top 5 industries and bottom five industries in terms of their dynamics, irrespective of their sectoral contribution to total BERD, over the two periods. Pharmaceuticals (2423) and software (Computer and related activities) are notable winners in both figures. Motor vehicles (34) and other transport equipment (35) appear as notable losers.
Figure 3. Sectoral BERD intensity in the Czech Republic by industry, 1995-2006

Figure 4. Top 5 winners and losers in BERD intensity by industry, 1995-2006
Trends in Value-added by Sector

Figure 5 shows the evolution of value-added for the top 10 industries. While these industries make up more than 80% of total BERD from 2001 to 2006, on average, they only made up somewhat less than 28% of value added.

Summary of the evolution of BERD in the Czech Republic

Figure 6 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, then the Czech Republic has a long way to go. Nevertheless, BERD intensity increased from below 0.70% to over 1.1% over the 12-year period. Figure 7 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) indicates increasing BERD intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear losers.

Figures 7 and 8 show some contrasting trends in the top 3 sectors that make up more than 50% of BERD in the Czech Republic. None of these sectors were among the top winners. The three important winners are pharmaceuticals (2423), instruments, watches and clocks (33) and software services (72). Other transport (35-353) appears as a significant loser.
Figure 6. Evolution of BERD intensity over time, 1995 to 2006

Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in the Czech Republic: 1995-2006
Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in the Czech Republic (Table 1).

**Table 1. Typology of sectors in term of their contribution to the 3% target**

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmaceuticals</td>
<td>Motor Vehicles</td>
</tr>
<tr>
<td>Software services</td>
<td>Chemicals less pharma</td>
</tr>
<tr>
<td>Radio, TV and telecoms.</td>
<td>Machinery and equipment</td>
</tr>
<tr>
<td>Electrical machinery</td>
<td></td>
</tr>
<tr>
<td>Social services</td>
<td></td>
</tr>
</tbody>
</table>
1.6 Denmark

In terms of broad aggregates, around 64% of Business R&D (BERD) in Denmark is accounted for by Manufacturing industries (NACE 15-37) and 35% by Services (NACE 50-99). The main trend over the period 1995 to 2006 has been a slight decrease of the relative importance of both sectors. R&D intensity in manufacturing industries combined is 7.2% and in services is 0.9%.

Concentration of BERD

Danish Business R&D is highly concentrated with the following 4 sectors accounting for more than 55% of the total in the period 1995 to 2006:

- Pharmaceuticals
- Computer Services
- Machinery and equipment
- Other Business services

Twelve sectors, listed in Figure 1, account for more than 90% of all industrial R&D. In other words all the remaining sectors in the Danish economy account for less than 10% of the total R&D.

Figure 1. Structure of BERD 2001-2006
Changes in the structure of BERD

Figure 2 shows the evolution of BERD since 1995. The first point to emerge from the analysis of the structure of industrial R&D is that the service sectors are an important focus of R&D in Denmark: 5 out of the 12 sectors in Figure 1 are services. Moreover 4 out of these 5 sectors have increased in relative importance over time (Figure 2), and this includes two sectors that have seen the largest increases: Computer services (from 9.5% of the total in 1995-2000 to 16% in 2001-2006) and Financial services (from 1.7% to 5.3%). Other sectors that have increased in importance are Pharmaceuticals, Instruments and Food, Drink and Tobacco.

At the same time there has been a relative decline in following sectors: Wholesale and retail trade, Machinery and equipment, Radio, TV and communication equipment, Instruments, and Other Business services.

Figure 2. Winners and losers in the shares for BERD in Denmark 1995-2006

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Services</td>
<td>6.5</td>
<td>3.6</td>
<td>3.1</td>
</tr>
<tr>
<td>Financial Services</td>
<td>3.3</td>
<td>2.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>1.7</td>
<td>1.7</td>
<td>1.0</td>
</tr>
<tr>
<td>Instruments</td>
<td>-1.8</td>
<td>-4.9</td>
<td>-3.1</td>
</tr>
<tr>
<td>Other Business Services</td>
<td>-1.8</td>
<td>-4.9</td>
<td>-3.1</td>
</tr>
<tr>
<td>Radio, TV &amp; Telecomms</td>
<td>-4.9</td>
<td>-4.9</td>
<td>-4.9</td>
</tr>
<tr>
<td>Machinery &amp; Equip.</td>
<td>-4.9</td>
<td>-4.9</td>
<td>-4.9</td>
</tr>
<tr>
<td>Wholesale &amp; retail</td>
<td>-6.0</td>
<td>-6.0</td>
<td>-12.0</td>
</tr>
<tr>
<td>Food, Drink &amp; Tob.</td>
<td>-1.7</td>
<td>-4.9</td>
<td>-6.6</td>
</tr>
<tr>
<td>Trends in R&amp;D Intensity</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In terms of trends in R&D intensity, Figures 3 and 4 show that a major distinguishing feature for Denmark is that 10 out of the 12 sectors with the largest R&D expenditures have increased their R&D intensity in the period 1995 to 2006. The exceptions are Other Business services and Wholesale and Retail trade. The largest proportionate increase has been in Financial services, where the proportion of output devoted to R&D increased from 0.5% in 1995-2000 to 2% in 2001-2006. In the same period the intensity in Food, Drink and Tobacco has more than doubled (from 1.7% to 3.9%).
Figure 3. Trends in Sectoral R&D intensity in Denmark: 1995-2006

Figure 4. Top 5 winners and losers in R&D intensity by industry: 1995-2006

Trends in shares of Value-added

Figure 5 presents the trends in the contributions to value-added made by the 12 industries that are the largest in terms of R&D expenditures in Denmark. As
reported above these sectors account for more than 80% of total BERD but their share of total economic output is around 35%. As may be expected largest contributions to value-added are made by three service sectors: Wholesale and Retail trades, Other Business services and Financial services. Together these 3 account for nearly 23% of value-added and two out of the three have become increasing important to the Danish economy over time.

Figure 5. Trends in the shares of total Value-added in Denmark: 1995-2006
Summary of the evolution of BERD in Denmark

The section presents a summary of the evolution of BERD in Denmark. Overall industrial R&D intensity increased rapidly in the period 1995 to 2003: from 1.21% to 2.08% (see Figure 6). Since then there has been a slight decline, so that Danish industry was spending 1.97% of value-added on R&D by 2006.

In Figure 7 we present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. This analysis shows that there have been contrasting trends in the 4 sectors that account for more than 55% of BERD in Denmark. In the largest sector, Pharmaceuticals, the share of total BERD increased from 21% in the mid-1990s to 25% in 2001-06, and R&D intensity increased from 31% to 39%. On the other hand in Machinery and equipment, there has been a decline in the share of total R&D from 14% to 9% and the R&D intensity has remained virtually unchanged. Computer services follow a trend that is similar to Pharmaceuticals and Other Business services one that is similar to Machinery and Equipment.

In Figure 8 we correlate the proportionate changes in BERD intensity (X axis) with the changes in the structure of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand indicates increasing BERD intensity and decreasing share of BERD. This analysis shows that the most dynamic sector in terms of R&D in the Danish economy has been Financial Services and the least dynamic has been Wholesale and Retail Trade. Majority of sectors (8 out of the 12 sectors that make up 90% of BERD) have increased both their R&D intensity and their share of total R&D.
Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Denmark: 1995-2006

Figure 8. Correlation between the change in BERD intensity and the change in the share of BERD

Finally in Table 1 we present our assessment of the sectors in terms of their contribution to the progress towards a target of increasing overall R&D intensity in Denmark.
### Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pharmaceuticals</td>
<td>• Machinery and Equipment</td>
</tr>
<tr>
<td>• Radio, TV and Communications Equip.</td>
<td>• Other Business services</td>
</tr>
<tr>
<td>• Instruments</td>
<td>• Wholesale and Retail Trade</td>
</tr>
<tr>
<td>• Computer services</td>
<td></td>
</tr>
<tr>
<td>• Chemicals</td>
<td></td>
</tr>
<tr>
<td>• Electrical Equipment</td>
<td></td>
</tr>
<tr>
<td>• Food, Drink and Tobacco</td>
<td></td>
</tr>
<tr>
<td>• Telecommunications services</td>
<td></td>
</tr>
<tr>
<td>• Financial services</td>
<td></td>
</tr>
</tbody>
</table>
### 1.7 Estonia

In Estonia, manufacturing value added made up 17% of total value added on average during the entire period from 1998-2005, with only a slight increase in the 2000s. On average, total value added generated by services increased slightly from 66.9% total value added from 1998 to 2000 to 67.8% from 2001 to 2005. The share of BERD in services is high in Estonia, but it had decreased from 56.6% to 50.5% over the two periods, while the share of BERD in manufacturing increased from 41.6% to 44.1% over the two periods. Average BERD intensity, measured as BERD over value added, increased from 0.15% in the first period to 0.34% in the second period. BERD intensity was about 3 times higher in manufacturing than in services. It should be noted that BERD was obtained from the Eurostat industrial database, and therefore based on the main activity of the firm, and value added was obtained from the EU KLEMS database. The R&D statistics have some problems. Data were not collected for all industries during the first period and the industrial disaggregate added up to just over 100% in the second period.

#### Distribution of BERD

The top 10 industries performing R&D from 2001 to 2005 in Estonia account for 82% of total BERD, of which Computer and related activities (72), Pharmaceuticals (2423), Financial intermediation (65 to 67), and Petroleum (23) explain only 39% of it. Figure 1 shows the structure of BERD for Estonia as an average between 2001 and 2006.

Figure 1. Structure of BERD 2001-2005
Changes in the distribution of BERD

Figure 2 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. The three top winners are financial intermediation (65 to 67), Radio, TV and communication equipment (32), and Computer and related activities (72); and the top three losers are other business services (74), motor vehicles (34), and Transport, storage and communications (60 to 64).

Trends in R&D Intensity

BERD intensity for BERD increased by 122% in Estonia from the three year prior to 2001 and four years from 2001. Figure 3 shows the sectoral R&D intensity for the top 10 industries and figure 4 shows the top 5 industries and bottom five industries in terms of their dynamics, irrespective of their sectoral contribution to total BERD, over the two periods. Coke, and refined petrol production (23) made the greatest gains to become the industry with the highest R&D intensity. Radio, TV and communications equipment manufacturing (32), Instruments, watches and clocks (33), and software services (74) were the other big winners. There are no obvious losers in Estonia, but keep in mind, that R&D statistics were not collected from firms in industries.
Figure 3. Sectoral R&D intensity in Estonia by industry, 1998-2005

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995-2006
**Trends in Value-added by Sector**

Figure 5 shows the evolution of value-added for the top 10 industries. While these industries make up 82% of total BERD from 2001 to 2006, on average, they made somewhat more than 26% of value added.

Figure 5. Trends in the shares of Value-added in Estonia: 1995-2006

![Graph showing trends in value-added by sector](image)

**Summary of the evolution of BERD in Estonia**

Figure 6 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, Estonia has shown considerable progress in moving toward the target, but it still has a long way to go. Figure 7 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates increasing BERD intensity and decreasing share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left indicates decreasing BERD intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear losers.

Figures 7 and 8 show some contrasting trends in the top 10 sectors that make up more than 80% of BERD in Estonia. There are many winners in the Estonian economy and very few losers. The three most notable winners are Radio, TV and communication equipment (32), Instruments, watches and clocks (33), and software services (72). Other business services (74) is a notable loser from the point of view of decline share in BERD.
Figure 6. Evolution of BERD intensity over time, 1998 to 2005

Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in the Czech Republic: 1998-2005
Figure 8. Correlation between the change in BERD intensity and the change in the share of BERD

Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Estonia (Table 1).

Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software services</td>
<td>Other business services</td>
</tr>
<tr>
<td>Chemicals less pharma</td>
<td></td>
</tr>
<tr>
<td>Radio, TV and telecoms.</td>
<td></td>
</tr>
<tr>
<td>Instruments</td>
<td></td>
</tr>
</tbody>
</table>
1.8 Finland

In terms of broad aggregates, around 85% of Business R&D (BERD) in Finland is accounted for by Manufacturing industries (NACE 15-37) and 12% by Services (NACE 50-99). The main trend over the period 1995 to 2006 has been a decrease of the relative importance of the former and a slight increase of the relative importance of the latter. R&D intensity in manufacturing industries combined is 8.8% and in services is 0.5%.

Concentration of BERD

Business R&D in Finland is heavily concentrated, with Radio, TV and communication equipment accounting for 47% of the total in the period 1995 to 2006, followed by Machinery and Equipment, Transport and Telecommunications services and Pharmaceuticals. Together these 4 sectors account for 65% of total BERD. Moreover the 12 sectors shown in Figure 1 account for more than 90% of all industrial R&D. In other words the remaining sectors account for less than 10% of the total industrial R&D in Finland.

Figure 1. Structure of BERD 2001-2006

---

1 Although ANBERD does not disaggregate Telecommunications services (NACE 642) from Transport, storage and communications services (NACE 60-64), it is likely, given the importance of Nokia that majority of the R&D reported under the aggregate category is related to Telecommunications services.
Changes in the structure of BERD

Figure 2 shows the main trends in the structure of BERD for Finland in the period since 1995. Three out of the 4 sectors that dominate R&D have increased their share of the total over this period: Radio, TV and communication equipment, Computer services, and Pharmaceuticals. At the same time Machinery and Equipment has declined in relative importance, as have Chemicals, Rubber and Plastics, Electrical Machinery, Food, Drink and Tobacco, and Wood and Paper.

Figure 2. Winners and losers in the shares for BERD in Finland, 1995-2006.

Trends in R&D Intensity

Figures 3 and 4 show that there has been a dramatic change in the R&D intensity in the Pharmaceutical industry in Finland in the period 1995 to 2006. In the period up to the year 2000 this industry devoted 36% of value-added to R&D but this has increased to 64% in the period up to 2006. The other sectors showing a positive trend are Radio, TV and Communications equipment, Electrical equipment, Instruments, Computer services and Fabricated Metals. In the remaining sectors there has been very little change.
Figure 3. Trends in Sectoral R&D intensity in Finland: 1995-2006

Figure 4. Winners and losers in R&D intensity by industry, 1995-2006
Trends in shares of Value-added

Figure 5 reports the evolution of Value-added for the 12 sectors that make the largest contribution to BERD. The first point to note is that although these sectors represent more than 90% of industrial R&D in Finland, they only account for 32% of value-added. The sector making the largest contribution to economic output is Transport and Communications services, accounting for 10% of total Finnish value-added in 2001-2006. The other sectors with an important share of value-added are Wood and Paper that accounts for around 6% of the total and Radio, TV and Communications equipment that accounts for approx. 4%. However both these sectors show differing trends with the former decreasing in relative importance and the latter increasing. The other sector increasing its share of output is Computer services.

Figure 5. Trends in the shares of Value-added in Finland: 1995-2006
Summary of the evolution of BERD in Finland

In this section we present a summary of the evolution of BERD in Finland. At the aggregate level R&D intensity increased very rapidly in the period 1995 to 2000: from 1.64% to 2.7%. Since then there has been a levelling off so that in 2006 Finish industry as a whole spent 2.83% of value-added on R&D.

Figure 6. Evolution of BERD intensity over time, 1995 to 2006

In Figure 7 we present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. In Figure 8 we correlate the proportionate changes in BERD intensity (X axis) with the changes in the structure of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand indicates increasing BERD intensity and decreasing share of BERD.

The analysis shows that there have been contrasting trends in the 2 of the most important sectors in terms of BERD in Finland. In the largest sector, Radio, TV and Communications equipment, the share of total BERD increased from 43% in the mid-1990s to 50% in 2001-06, and the R&D intensity increased from 28% to 31%. On the other hand in the Machinery and Equipment sector, there has been a decline in the share of total R&D from 10% to 7% and slight decline in R&D intensity from 7.4% to 6.6%.

The Pharmaceuticals industry has shown an increase both in intensity and in its share. And a similar pattern can be observed in Computer services and Fabricated Metals. However in the other important sector, i.e., Transport and Communications services, there has been very little change in terms of either variable. Finally the Chemicals industry is another showing a decline in R&D intensity and BERD share.
Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Finland: 1995-2006

Figure 8. Correlation between the change in BERD intensity and the change in the share of BERD

Finally Table 1 presents our assessment of the sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Finland.
Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pharmaceuticals</td>
<td>• Machinery &amp; Equipment</td>
</tr>
<tr>
<td>• Radio, TV &amp; Communications equipment</td>
<td>• Instruments</td>
</tr>
<tr>
<td>• Electrical equipment</td>
<td>• Chemicals</td>
</tr>
<tr>
<td>• Computer services</td>
<td>• Food, Drink and Tobacco</td>
</tr>
<tr>
<td>• Fabricated Metals</td>
<td>• Wood and Paper</td>
</tr>
</tbody>
</table>
1.9 France

In terms of broad aggregates, around 86% of Business R&D (BERD) in France is accounted for by Manufacturing industries (NACE 15-37) and 9% by Services (NACE 50-99). The main trend over the period 1995 to 2006 has been a slight decrease of the relative importance of the former and a slight increase of the relative importance of the latter. R&D intensity in manufacturing industries combined is 8.6% and in services is 0.2%.

Concentration of BERD

French Business R&D is concentrated in the following 4 sectors that account for over 50% of the total in the period 1995 to 2006:

- Motor Vehicles
- Pharmaceuticals
- Radio, TV and communication equipment
- Aerospace

Moreover the 15 sectors shown in Figure 1 account for more than 90% of all industrial R&D. The remaining sectors in the economy account for less than 10% of total R&D.

Figure 1. Structure of BERD 2001-2006

Changes in the structure of BERD

One of the major changes in the structure of BERD in France over the period since 1995 (see Figure 2) has been an increase in the relative importance of
Motor Vehicles: its share has risen from 12.6% of the total in 1995-2000 to 15.4% in 2001-2006. The other sector to increase in importance has been Computer services (increasing from 2.4% to 4.2%). At the same time the sector with the steepest relative decline has been Instruments, which went from 8.3% of total French R&D to 5.3%. There has also been a decrease in the share of Office and Computing equipment. Most other sectors have shown very little change.

Figure 2. Winners and losers in the shares for BERD in France, 1995-2006

Trends in R&D Intensity

Figures 3 and 4 show the evolution of R&D intensity across industrial sectors in France in the period 1995 to 2006. The largest absolute increase has been in the Radio, TV and communication equipment sector, where the proportion of R&D devoted to value-added has risen from 35% in 1995-2000 to 45% in 2001-2006. Another important sector, Motor Vehicles has also increased its R&D intensity from 16% to 22%. At the same time there has been a steep decline in the R&D intensity for Office and Computer Machinery (from 33% to 23%). Instruments is another sector which has shown a decline. Other sectors with modest increases in R&D intensity have been Chemicals, Electrical Equipment and Rubber & Plastics.
Figure 3. Trends in Sectoral R&D intensity in France: 1995-2006

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995 to 2006

Trends in shares of Value-added
The changes in the shares of value-added for the 15 sectors that are most important in terms of R&D are reported in Figure 5. Together these sectors account for 24% of French economic output. At the same time they represent
more than 90% of total industrial R&D. In other words the remaining sectors account for less than 10% of BERD and around 76% of value-added.

There has been very little change in terms of the contribution of these sectors to value-added. The most important change has been the relative importance of Other Business services, which has increased its share from 8.5% to 9.9%. Most of the other sectors have seen very little change.

**Figure 5. Trends in the shares of Value-added in France: 1995-2006**
Summary of the evolution of BERD in France

In this section we present a summary of the evolution of BERD in France in the period 1995 to 2006. At the aggregate level there has been a small decline in R&D intensity: from 1.56% in 1995 to 1.48% in 2003.

Figure 6. Evolution of BERD intensity over time, 1995 to 2006

In Figure 7 we present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. This analysis shows that there have been some interesting patterns across sectors in the period from 1995 to 2006 as shown in Figure 4. The most important sector in terms of the volume of BERD, Motor Vehicles, has increased its share of the total from 13% to 15% at the same time as increasing its R&D intensity from 16% to 22%. On the other hand two other important sectors, Pharmaceuticals and Aerospace, have shown little change either in terms of BERD shares or R&D intensity. Radio, TV and communication equipment has increased in terms of R&D intensity but changed little in its contribution to total BERD.

In Figure 8 we correlate the proportionate changes in BERD intensity (X axis) with the changes in the structure of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand indicates increasing BERD intensity and decreasing share of BERD. Nearly half the 15 sectors that make up more than 90% of total R&D have increased both their share and their intensity. The most notable are Computer services and Motor Vehicles. Amongst the 5 sectors with declining shares and intensity is Aerospace, which accounts for over 10% of all BERD in France.
Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in France: 1995-2006

Figure 8. Correlation between the change in BERD intensity and the change in the share of BERD
Finally in Table 1 we present our assessment of the sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in France.

Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Motor Vehicles</td>
<td>• Aerospace</td>
</tr>
<tr>
<td>• Radio, TV and communication equipment</td>
<td>• Instruments</td>
</tr>
<tr>
<td>• Pharmaceuticals</td>
<td>• Chemicals</td>
</tr>
<tr>
<td>• Electrical Equipment</td>
<td>• Utilities</td>
</tr>
<tr>
<td>• Rubber and Plastics</td>
<td>• Other Business Services</td>
</tr>
<tr>
<td>• Computer services</td>
<td></td>
</tr>
<tr>
<td>• Food Drink and Tobacco</td>
<td></td>
</tr>
<tr>
<td>• Machinery and equipment (??)</td>
<td></td>
</tr>
<tr>
<td>• Telecommunications services (??)</td>
<td></td>
</tr>
</tbody>
</table>

(??) Indicates little change
1.10 Germany

In terms of broad aggregates, around 92% of Business R&D (BERD) in Germany is accounted for by Manufacturing industries (NACE 15-37) and 8% by Services (NACE 50-99). The main trend over the period 1995 to 2006 has been a slight decrease of the relative importance of the former and a slight increase of the relative importance of the latter. R&D intensity in manufacturing industries combined is 7.4% and in services is 0.2%.

Concentration of BERD

Business R&D in Germany is highly concentrated, with the following 5 sectors accounting for nearly two-thirds of the total in the period 1995 to 2006:

- Motor Vehicles
- Machinery and equipment
- Chemicals (less Pharmaceuticals)
- Radio, TV and Communication equipment
- Pharmaceuticals

Figure 1 lists the 12 sectors that account for more than 90% of all industrial R&D. The remaining sectors of the economy conduct 10% of R&D.

Figure 1. Structure of BERD 2001-2006

Changes in the structure of BERD
The biggest change in the structure of R&D in Germany over the period 1995 to 2006 has been the increasing relative importance of the Motor Vehicles sector (see Figure 2). Its share has increased from 25.9% of the total in 1995-2000 to 30.4% in 2001-2006. Pharmaceuticals, Instruments and Computer services also account for a greater share of total R&D over the period. At the same time there has been a decline in the relative importance of the following sectors: Chemicals (less Pharmaceuticals) Aerospace, Radio, TV and communication equipment, and Office machinery & Computers.

Figure 2. Winners and losers in the shares for BERD in Germany from 1995-2006

Trends in R&D Intensity
Figures 3 and 4 show that the biggest change in terms of R&D intensity in German industry has been in the Aerospace industry. The proportion of output devoted to R&D has declined from 54% in 1995-2000 to 31% in 2001-2006. Radio, TV and communication equipment and Office Machinery and Computers have also registered a decline in R&D intensity. On the other hand Computer Services, R&D services and Instruments have shown a strong positive trend. Pharmaceuticals and Motor Vehicles have also slightly increased their R&D intensity.
Figure 3. Trends in Sectoral R&D intensity in Germany: 1995-2006

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995-2006

Trends in shares of Value-added
Figure 5 presents the trends in the contributions to total value-added made by the 12 largest industries in terms of R&D expenditures in Germany. As reported above these sectors account for more than 90% of total BERD but their share of total economic output is around 15%. The two largest sectors are Motor vehicles and Machinery and Equipment. They are also the sectors that have increased in terms of their relative importance over time.

Figure 5. Trends in the shares of Value-added in Germany: 1995-2006

Summary of the evolution of BERD in Germany

In this section we present a summary of the evolution of BERD in Germany in the period 1995 to 2006. Overall R&D intensity in German industry rose from 1.60% in 1995 to 1.92% in 2000 (see Figure 6). However since then there has been stagnation followed by a slight increase in 2006.
In Figure 7 we present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. The analysis shows that there have been contrasting trends in the 5 sectors that account for more than two-thirds of BERD in Germany. In the largest sector, *Motor Vehicles*, the share of total BERD increased from 26% in the mid-1990s to 30% in 2001-06, and R&D intensity increased from 16.6% to 18.2%. On the other hand in *Chemicals* and *Radio, TV and communication equipment* there has been a decline in both the share of total R&D and R&D intensity. *Pharmaceuticals* shows a mild positive trend in both indicators, and the *Machinery and Equipment* sector shows little change.

In Figure 8 we correlate the proportionate changes in BERD intensity (X axis) with the changes in the structure of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand indicates increasing BERD intensity and decreasing share of BERD. Half of the 12 sectors that make up more than 90% of BERD in Germany have increased their share of the total as well as their R&D intensity. The most amongst these is *Computer services*. On the other hand 5 sectors show a decline in both indicators, the most notable being *Aerospace*. 
Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Germany: 1995-2006

![Diagram showing changes in the shares of BERD, Value-added and R&D intensity for different sectors]

Figure 8. Correlation between the change in BERD intensity and the change in the share of BERD

![Diagram showing the correlation between change in BERD intensity and share of BERD]

Finally in Table 1 we present our assessment of the sectors in terms of their contribution to the progress towards a target of increasing overall R&D intensity in Germany.
### Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pharmaceuticals</td>
<td>• Aerospace</td>
</tr>
<tr>
<td>• Motor vehicles</td>
<td>• Radio, TV &amp; communication equipment</td>
</tr>
<tr>
<td>• Instruments</td>
<td>• Office Machinery &amp; Computers</td>
</tr>
<tr>
<td>• R&amp;D services</td>
<td>• Chemicals</td>
</tr>
<tr>
<td>• Computer services</td>
<td>• Electrical equipment</td>
</tr>
</tbody>
</table>

The following sectors showed very little change: *Machinery & equipment* and *Rubber & Plastics*. 
1.11 Greece

In terms of broad aggregates, around 58% of Business R&D (BERD) in Greece is accounted for by Manufacturing industries (NACE 15-37) and 36% by Services (NACE 50-99). The main trend over the period 1995 to 2005 has been a slight increase of the relative importance of both sectors. R&D intensity in manufacturing industries combined is 0.9% and in services is 0.1%.

Concentration of BERD

Business R&D in Greece is concentrated in 4 sectors that account for over 51% of the total in the period 1995 to 2005:

- Radio, TV and communication equipment
- Computer services
- Chemicals (excluding Pharmaceuticals)
- Other business services

Figure 1 lists the 12 sectors that account for more than 80% of all industrial R&D.

Figure 1. Structure of BERD, 2001-2005

Changes in the structure of BERD

With the remaining 6% in Construction and Utilities
There have been major changes in the structure of industrial R&D in Greece for the period since 1995 (see Figure 2). For example the *Chemicals* sector has increased in its relative importance very rapidly, with its share increasing from 3.5% in 1995-2000 to 9.4% in 2001-2005. At the same time the *Construction* sector has declined in relative importance, with a decline in share from 6% to 0.6%. Nine out of the 12 sectors have increased their share since 1995, with notable increases in *Computer services, Radio, TV and Communications equipment*, and *Food, Drink and Tobacco*, and *Other Business services*. A sector that has declined in importance is *Machinery and Equipment*.

**Figure 2. Winners and losers in the shares for BERD in Greece, 1995-2005**

**Trends in R&D Intensity**

Figures and 4 present the main trends in R&D intensity by sector in Greece. It shows that there has been a rapid decline in the output devoted to R&D in the *Computer services* sector, going from 58% in 1995-2000 to 10.5% in 2001-2005. Most rapid increase in R&D intensity occurred in the *Chemicals* sector, from 1% to 3.5%. There have increases in *Pharmaceuticals* and *R&D services* and a decline in the *Machinery and Equipment* sector. Figure 4 shows that the biggest relative decline in R&D intensity has been in the *Construction* sector.
Figure 3. Trends in Sectoral R&D intensity in Greece: 1995-2005

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995 to 2005

Trends in shares of Value-added

Figure 5 shows the trends in the contributions to value-added made by the 12 industries that are the largest in terms of R&D expenditures in Greece. Together
these sectors account for around 33% of total output, but as discussed above they account for more than 80% of industrial R&D. The two largest sectors are Wholesale and Retail Trade and Construction.

Figure 5. Trends in the shares of Value-added in Greece: 1995-2005
Summary of the evolution of BERD in Greece

In this section we present a summary of the evolution of BERD in Greece since 1995. Figure 6 shows that at the aggregate level R&D intensity has increased from 0.14% in 1995 to 0.22% in 2001. Since then there has been a stagnation and decline.

Figure 6. Evolution of BERD intensity over time, 1995 to 2005

In Figure 7 we present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. The main message from Figure 4 is that in 3 out of the 4 sectors that are most important in terms of R&D in Greece the trends have been positive: Radio, TV and communication equipment, Chemicals (less Pharmaceuticals), and Other business services. The exception is Computer services where although there has been an increase in the share of BERD, there has been a steep decline in R&D intensity as noted above.

In Figure 8 we correlate the proportionate changes in BERD intensity (X axis) with the changes in the structure of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand indicates increasing BERD intensity and decreasing share of BERD. Eight out of the twelve sectors that account for 80% of BERD in Greece have increased their share of the total as well as increasing their R&D intensity. The most notable sector in this category is Chemicals (less Pharmaceuticals). On the other hand Construction and Machinery and Equipment have seen a decline in both indicators.
Finally in Table 1 we present our assessment of the sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Greece.
Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Radio, TV and Communications equipment</td>
<td>• Computer services</td>
</tr>
<tr>
<td>• R&amp;D services</td>
<td>• Machinery and Equipment</td>
</tr>
<tr>
<td>• Chemicals</td>
<td>• Construction</td>
</tr>
<tr>
<td>• Pharmaceuticals</td>
<td>• Wholesale and Retail Trade</td>
</tr>
<tr>
<td>• Other Business services</td>
<td></td>
</tr>
<tr>
<td>• Food, Drink and Tobacco</td>
<td></td>
</tr>
<tr>
<td>• Telecommunications services</td>
<td></td>
</tr>
</tbody>
</table>
1.12 Hungary

In Hungary, manufacturing value added made up 22% of total value added on average during the entire period from 1995-2006. On average, total value added generated by services increased from 62% from 1995 to 2000 to 65% from 2001 to 2006, suggesting that agriculture and extractive industries declined by 3% over the decade. The share of BERD in services also increased from 13% to 20% over the two periods, while the share of BERD in manufacturing declined only slightly from 79% to 78% over the two periods. Average BERD intensity, measured as BERD over value added, increased from 0.34% in the first period to 0.46% in the second period. BERD intensity was more than 10 times higher in manufacturing than in services, but it increased in both industries. In manufacturing it increased from 1.21% to 1.6% from one period to the next, and in services it increased from 0.07% to 0.14% from one period to the next.

**Distribution of BERD**

The top 10 industries performing R&D from 2001 to 2006 account for 87% of total BERD, of which Pharmaceuticals (2423), Wholesale and retail trade (50 to 52), and Radio, TV and communication equipment (32) explains 59% of it. Figure 1 shows the structure of BERD for Hungary as an average between 2001 and 2006.

**Figure 1. Structure of BERD 2001-2006**
Changes in the distribution of BERD

Figure 2 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. Wholesale and retail trade (50 to 52), radio, TV, and communications equipment (32), and motor vehicles (34) were notable winners in the top 10, and chemicals, excluding pharmaceuticals (24-2423) and machinery and equipment (29) were notable losers from the top 10.

Figure 2. Top 5 Winners and top 5 losers in the shares for BERD Hungary, 1995-2006

Trends in BERD Intensity

BERD intensity increased by almost 34% in Hungary from the six year prior to 2001 and six years from 2001. Figure 3 shows the sectoral R&D intensity for the top 10 industries and figure 4 shows the top 5 industries and bottom five industries in terms of their dynamics, irrespective of there sectoral contribution to total BERD, over the two periods. Both pharmaceuticals (2423) and Motor vehicles (34) are notable winners. R&D activity also appears as a winner in these figures, but it is small in comparison to the other industries, mainly because the country had reformed this sector early in the transformation process.
Figure 3. Trends in sectoral BERD intensity in Hungary by industry, 1995-2006.

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995-2006
Trends in Value-added by Sector

Figure 5 shows the evolution of value-added for the top 10 industries. While these industries make up more than 87% of total BERD from 2001 to 2006, on average, they only made up slightly more than 29% of value added.

Figure 5. Trends in the shares of Value-added in Hungary: 1995-2006

Summary of the evolution of BERD in Hungary

Figure 6 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress towards the 2% target for BERD envisaged by the Barcelona objectives, then Hungary has a long way to go. Nevertheless, BERD intensity almost doubled from about 0.30% to 0.56% over the 12-year period. Figure 7 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing BERD intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing R&D intensity and increasing share of BERD; and (4) indicates increasing BERD intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear losers.

Pharmaceuticals (2423) and Wholesale and retail trade (50 to 52) make up about 50% of total BERD in the Hungarian economy. The important winners are Wholesale and retail trade (50 to 52), Radio, TV and communication equipment (32), and motor vehicles (34). Pharmaceuticals (2423) appears to have experienced very little growth. But only wholesale and retail trade (50 to 52) show any significant growth in BERD intensity.
Figure 6. Evolution of BERD intensity over time, 1995 to 2006

Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Hungary: 1995-2006

- Change in share of BERD
- Change in share of value added
- Change in BERD intensity
Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Hungary (Table 1).

**Table 1. Typology of sectors in term of their contribution to the 3% target**

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmaceuticals</td>
<td>Machinery and equipment</td>
</tr>
<tr>
<td>Wholesale &amp; retail trade</td>
<td>Chemicals less pharma</td>
</tr>
<tr>
<td>Radio, TV and telecoms.</td>
<td></td>
</tr>
<tr>
<td>Electrical machinery</td>
<td></td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td></td>
</tr>
<tr>
<td>Other business services</td>
<td></td>
</tr>
<tr>
<td>Software services</td>
<td></td>
</tr>
<tr>
<td>Instruments</td>
<td></td>
</tr>
</tbody>
</table>
1.13 Ireland

In terms of broad aggregates, around 71% of Business R&D (BERD) in Ireland is accounted for by Manufacturing industries (NACE 15-37) and 28% by Services (NACE 50-99). The main trend over the period 1995 to 2005 has been a substantial decrease of the relative importance of the former (with a decline in share from 79% in 1995-2000 to 65% in 2001-2005) and a substantial increase in that of the latter (increase in share from 20% to 34%). R&D intensity in manufacturing industries combined is 2.2% and in services is 0.5%.

Concentration of BERD

Business R&D in Ireland is highly concentrated in the following 4 sectors that account for over 65% of the total in the period 1995 to 2005:

- Computer services
- Radio, TV and communication equipment
- Pharmaceuticals
- Instruments

Eleven sectors listed in Figure 1 account for more than 90% of all industrial R&D. The remaining sectors of the economy in Ireland account for less than 10% of the total.

Figure 1. Structure of BERD 2001-2005
Changes in the structure of BERD

There has been considerable change in the structure of business R&D in Ireland over the period 1995 to 2005 (Figure 1). There has been a major decline in the relative importance of Radio, TV and communications equipment, with its share of total R&D declining from 30% in the period 1995-2000 to 15% in 2001-2005. At the same time the share of Computer services has increased from 11% to 31%. Pharmaceuticals, Instruments, and Electrical equipment have all become relatively more important contributors to total BERD. On the other hand the relative importance of Transport and Telecommunications services, Food, Drink and Tobacco and Chemicals has declined.

Figure 2. Winners and losers in the shares for BERD in Ireland from 1995-2005

Trends in R&D Intensity

Figures 3 and 4 show the evolution of R&D intensity by sector since 1995. The first point to note from this analysis is that 7 out of the 11 sectors that make up the bulk of R&D have increased their R&D intensity. The most rapid increase has been in Computer services where the proportion of value-added devoted to R&D has gone from 6% in 1995-2000 to nearly 10% in 2001-2005. During the same period R&D intensity in Radio, TV and communications equipment has declined rapidly from 14.6% to 8.6%. Sectors with increasing intensity include Pharmaceuticals, Electrical equipment, Office Machinery and Computers, Instruments and Non-Metallic Minerals. In Transport and Telecommunications services, Food, Drink and Tobacco and Chemicals there have been declines in R&D intensity.
Figure 3. Trends in Sectoral R&D intensity in Ireland: 1995-2005

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995-2005

Trends in shares of Value-added
Figure 5 presents the trends in the contributions to value-added made by the 11 largest industries in terms of R&D expenditures in Ireland. As reported above these sectors account for more than 90% of total BERD but their share of total economic output is around 31%. The three largest sectors in terms of economic output are Chemicals, Transport and Telecommunications services and Food, Drink and Tobacco. Amongst the important changes have been the increasing relative importance of Computer services and a decreasing importance of Office Machinery.

**Figure 5. Trends in the shares of Value-added in Ireland: 1995-2005**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio, TV &amp; Telecomms</td>
<td>1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Computer Services</td>
<td>1.7</td>
<td>1.9</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Electrical Equip.</td>
<td>0.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Machinery &amp; Equip.</td>
<td>0.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Instruments</td>
<td>0.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Office &amp; comp mach</td>
<td>0.1</td>
<td>1.3</td>
</tr>
<tr>
<td>Oth. non-metallic Minerals</td>
<td>0.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Food, Drink, &amp; Tob.</td>
<td>4.4</td>
<td>5.1</td>
</tr>
<tr>
<td>Transport &amp; Telecom Services</td>
<td>5.3</td>
<td>6.0</td>
</tr>
<tr>
<td>Chemicals less Pharma</td>
<td>7.9</td>
<td>8.0</td>
</tr>
</tbody>
</table>

![Graph showing trends in the shares of Value-added in Ireland: 1995-2005](image-url)
Summary of the evolution of BERD in Ireland

In this section we present a summary of the evolution of BERD in Ireland since 1995. Figure 6 shows that at the aggregate level R&D intensity has declined slightly, going from 0.99% in 1995 to 0.93% in 2005.

Figure 6. Evolution of BERD intensity over time, 1995 to 2005

In Figure 7 we present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. Figure 4 shows that of the 4 sectors that account for more than 65% of BERD in Ireland, 3 have shown a positive trend in terms of R&D share and intensity: Computer services, Pharmaceuticals and Instruments. The exception is Radio, TV and Communications equipment where as discussed above there has been a steep decline in R&D intensity and BERD share.

In Figure 8 we correlate the proportionate changes in BERD intensity (X axis) with the changes in the structure of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand indicates increasing BERD intensity and decreasing share of BERD. Only 4 out of the 11 sectors that make up 80% of BERD in Ireland increased their share of BERD as well as their R&D intensity. As already discussed above the most notable amongst these was Computer services. At the other end of the spectrum are Radio, TV and Communications equipment, Office Machinery and Computers, Food, Drink and Tobacco, Transport and Telecommunications services and Chemicals (less Pharmaceuticals), which declined in terms of both indicators.
Finally in Table 1 we present our assessment of the sectors in terms of their contribution to the progress towards a target of increasing overall R&D intensity in Ireland.
Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Computer services</td>
<td>• Radio, TV &amp; Communications equipment</td>
</tr>
<tr>
<td>• Pharmaceuticals</td>
<td>• Office Machinery and Computers</td>
</tr>
<tr>
<td>• Instruments</td>
<td>• Food, Drink and Tobacco</td>
</tr>
<tr>
<td>• Electrical equipment</td>
<td>• Transport &amp; Telecommunications services</td>
</tr>
<tr>
<td>• Machinery &amp; equipment</td>
<td>• Chemicals</td>
</tr>
<tr>
<td>• Non-Metallic Minerals</td>
<td></td>
</tr>
</tbody>
</table>
1.14 Italy

In terms of broad aggregates, around 76% of the Italian Business R&D (BERD) is accounted for by Manufacturing industries (NACE 15-37) and 21% by Services (NACE 50-99). The main trend over the period 1995 to 2006 has been a decrease of the relative importance of the former (shown by a decline in the share from 81% in 1995-2000 to 73% in 2001-2006) and an increase in that of the latter (shown by an increase in share from 16% to 25%). R&D intensity in Manufacturing industries combined is 2.3% and in services is 0.2%.

Concentration of BERD

Business R&D in Italy is concentrated in the following 5 sectors that account for over 55% of the total in the period 1995 to 2006:

- Radio, TV and communication equipment
- Motor Vehicles
- R&D Services
- Aerospace
- Machinery and equipment

Figure 1 lists the 11 sectors account for more than 80% of all industrial R&D. All the remaining sectors of the Italian economy undertake less than 20% of total BERD.

**Figure 1. Structure of BERD 2001-2006**
Changes in the structure of BERD

Figure 2 shows that there have been some changes in the structure of business R&D in the period 1995 to 2006. One of the biggest changes has been the increasing relative importance of the Machinery and Equipment sector. In 1995-2000 this sector accounted for 7.7% of total Italian BERD but in 2001-2006 this had risen to 10.8%. During the same period Radio, TV and Communications equipment has declined in importance, with its share going from 19% to 12%. The other sectors to show a declining share of BERD are Pharmaceuticals, Motor Vehicles, Chemicals and Electrical machinery. Two service sectors, Computer services and Other Business services, together with Instruments have become more important contributors to business R&D over time.

Figure 2. Winners and losers in the shares for BERD in Italy from 1995-2006

Trends in R&D Intensity

Figures 3 and 4 show the changes in sectoral R&D intensity for Italy in the period since 1995. The Aerospace industry has the highest intensity that has also increased over time. On the other hand there has been a steep decline in the R&D intensity for Radio, TV and Communications equipment. In the period 1995-2000 this industry devoted 20% of output to R&D but this has declined to 14% in 2001-2006. Other sectors with declining intensity are Pharmaceuticals, R&D services and Electrical equipment. On the other hand Other Business services, Instruments, Machinery, Computer services and Motor Vehicles have also increased their R&D intensity.
Figure 3. Trends in Sectoral R&D intensity in Italy: 1995-2006

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995 to 2006
Trends in shares of Value-added

Figure 5 reports the evolution of value added for the 11 sectors that make the largest contribution to BERD. The first point to note is that although these sectors represent more than 80% of industrial R&D in Italy they only account for 15% of value-added. Thus the remaining sectors account for 85% of economic output but less than 20% of R&D.

There have been some changes in the structure of output over time, notably a decline in Radio, TV and Communications equipment and an increase in Machinery and Equipment. Other sectors gaining in importance are Instruments, Computer services and Other Business services. Motor Vehicles and Pharmaceuticals have shown an opposite trend.

Figure 5. Trends in the shares of Value-added in Italy: 1995-2006
Summary of the evolution of BERD in Italy

In the section we present a summary of the evolution of BERD in Italy in the period 1995 to 2006. As shown in Figure 6, overall R&D intensity has changed a little during this period, increasing increased from 0.58% in 1995 to 0.62% in 2006.

In Figure 7 we present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. This analysis shows some contrasting trends some of which have already been discussed above. In particular Radio, TV and Communications equipment shows both a declining R&D intensity and a declining share of BERD. On the other hand Machinery and Equipment sector has a positive trend in terms of both indicators.

In Figure 8 we correlate the proportionate changes in BERD intensity (X axis) with the changes in the structure of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand indicates increasing BERD intensity and decreasing share of BERD. Out of the 11 sectors that make up more than 80% of BERD in Italy 4 show a positive trend in terms of both increasing share and increasing R&D intensity: Machinery and equipment, Instruments, Computer services, Other Business services. Three sectors show a declining trend: Pharmaceuticals, Radio, TV and Communications and Electrical Equipment.
Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Italy: 1995-2006

Figure 8. Correlation between the change in BERD intensity and the change in the share of BERD

Finally in Table 1 we present our assessment of these trends by highlighting sectors in terms of their contribution to the progress towards a target of increasing overall R&D intensity in Italy.
Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Aerospace</td>
<td>• Radio, TV &amp; Communications Equip.</td>
</tr>
<tr>
<td>• Machinery and equipment</td>
<td>• Motor Vehicles</td>
</tr>
<tr>
<td>• Instruments</td>
<td>• Pharmaceuticals</td>
</tr>
<tr>
<td>• Computer services</td>
<td>• Chemicals</td>
</tr>
<tr>
<td>• Other Business services</td>
<td>• Electrical equipment</td>
</tr>
<tr>
<td></td>
<td>• R&amp;D services</td>
</tr>
</tbody>
</table>
1.15 Latvia

In Latvia, manufacturing value added made up 13% of total value added and services 73% of value added in 2005. The share of BERD in services was more than 61% and the share of BERD in manufacturing was 33% during this time period. BERD intensity in 2005 measured as BERD over value added was 0.2% for the economy as a whole, 0.5% in manufacturing and 0.17% in services. There are too few R&D statistics to compare over the 10-year period.

Distribution of BERD

The top 10 industries performing R&D in 2005 in Latvia accounted for 84.5% of total BERD, of which Research and development (73), Other business activities (74), and Wood, paper, printing, publishing (20) explain 59% of it. Figure 1 shows the structure of BERD for Latvia in 2005.

Figure 1. Structure of BERD in 2005
**Trends in BERD Intensity**

Figure 2 shows the sectoral R&D intensity for the top 10 industries in Latvia. R&D (73), radio, TV and communication equipment (32), and pharmaceuticals (2423) have the highest BERD intensities.

**Trends in Value-added by Sector**

Figure 3 shows the structure of value added in Latvia in 2005. The top 10 sectors in terms of BERD share make up only 34% of the share in value added.
Summary of the evolution of BERD in Latvia

Figure 4 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress towards the 2% target for BERD envisaged by the Barcelona objectives, Latvia has shown little progress in moving toward the target, and stall has a long way to go.

Figure 4. Evolution of BERD intensity over time, 1995 to 2005
1.16 Lithuania

In Lithuania, manufacturing value added made up 22% of total value added and services 60% of value added in 2005. The share of BERD in services was 54.5% and the share of BERD in manufacturing was almost 43% in the same year. BERD intensity in 2005, measured as BERD over value added, was 0.17% for the economy as a whole, 0.42% in manufacturing and 0.12% in services. There are too few R&D statistics to compare over the 10-year period.

Distribution of BERD

The top 10 industries performing R&D in 2005 in Lithuania accounted for 70% of total BERD, of which financial intermediation (65 to 67), wholesale and retail trade (50 to 52), and chemicals (24) explain 30% of it. Figure 1 shows the structure of BERD for Lithuania as an in 2005.

Figure 1. Structure of BERD in 2005
Figure 2 shows the sectoral R&D intensity for the top 10 industries in Lithuania. R&D (73), Instruments, watches and clocks (33), and computer and related activities (72) have the highest BERD intensities. R&D (73), which has an BERD intensity of more than 36%, may be a statistical anomaly associated with the institutional arrangements present under central planning.

Figure 2. Sectoral R&D intensity in Lithuania by industry, 2005

Trends in Value-added by Sector

Figure 3 shows the structure of value added in Lithuania in 2005. The top 10 countries in terms of BERD share make up only 32% of the share in value added.

Figure 3. Structure of value added in 2005
Summary of the evolution of BERD in Lithuania

Figure 4 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, Lithuania has shown little progress in moving toward the target, and stall has a long way to go.

Figure 4. Evolution of BERD intensity over time, 1996 to 2005
1.17 Malta

In Malta, manufacturing value added made up 17% of total value added and services 74% of value added. By contrast, the share of BERD in services was almost 23% and the share of BERD in manufacturing was 77%. BERD intensity in 2005 measured as BERD over value added was 1.1% for the economy as a whole, with 5% in manufacturing and 0.34% in services.

Distribution of BERD

The top 10 industries performing R&D in 2005 in Malta accounted for more than 96% of total BERD, of which Pharmaceuticals (2423), Radio, TV and communication equipment (32), and Electrical machinery and apparatus (31) explain 65% of it. Figure 1 shows the structure of BERD for Malta as an average in 2005.

Figure 1. Structure of BERD in 2005
Trends in BERD Intensity
Figure 2 shows the sectoral R&D intensity for the top 10 industries in Malta in 2005. With the exception of R&D (73), which is left out because BERD does not match the statistics available for value added, Pharmaceuticals (2423) and Electrical machinery and apparatus (31) have the two highest R&D intensities.

Trends in Value-added by Sector
Figure 3 shows the structure of value added in Malta in 2005. The top 10 countries in terms of BERD share make up only 25% of the share in value added.
Summary of the evolution of BERD in Malta

Figure 5 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, Malta has shown considerable progress in moving toward the target, but stall has a long way to go. Anomalies in the statistics may explain the low BERD intensity in 2002 and 2003.

Figure 5. Evolution of BERD intensity over time, 2002 to 2005
1.18 The Netherlands

In terms of broad aggregates, around 77% Business R&D (BERD) in the Netherlands is accounted for by Manufacturing industries (NACE15-37) and 19% by Services (NACE50-99). The main trend over the period 1995 to 2006 has been a slight decrease of the relative importance of the former and a slight increase in that of the latter. R&D intensity in manufacturing industries combined is 5.9% and in services is 0.30%.

Concentration of BERD

Business R&D in the Netherlands is concentrated in the following 4 sectors that account for over 54% of the total in the period 1995 to 2006:

- Office Machinery and Computers
- Chemicals (excluding Pharmaceuticals)
- Pharmaceuticals
- Machinery and equipment

The 11 sectors listed in Figure 1 account for more than 80% of all industrial R&D in the period 1995-2000.

Figure 1. Structure of BERD 2001-2006

Changes in the structure of BERD

Figure 2 shows the changing structure of industrial R&D in the Netherlands since the mid-1990s. Six out of the 11 sectors reported in Figure 1 have increased in
relative importance. The biggest increases have been in Office machinery & Computers and Machinery. Two service sectors, R&D services and Computer services have also increased in relative importance. The former has increased its share of total BERD 1.1% in 1995-2000 to 3.7% in 2001-2006, and the latter from 3% to 5%. At the same time the following sectors have become relatively less important: Instruments, Chemicals, and Other Business services, and Food Drink and Tobacco.

**Figure 2. Winners and losers in the shares for BERD in the Netherlands from 1995-2006**

The biggest change has been in relation to R&D services, where the proportion of value-added devoted to R&D has risen from 3.1% in 1995-2000 to 9.9% in 2001-2006. The Machinery and equipment sector, together with Computer Services and Pharmaceuticals, have also seen an increase in R&D intensity. There has been a decline in the intensity for Instruments and Other Business Services.

**Trends in R&D Intensity**

Figures 3 and 4 report the changes in R&D intensity by sector for the period 1995 to 2006. We exclude one important sector in this analysis, Office Machinery and Computers (NACE 30), due to data problems in ANBERD and STAN data. The reported numbers for this sector are estimates provided by the OECD based on information from national sources. However the R&D intensity based on these estimates is well in excess of 100%. Hence this sector has been omitted in Figure 2.

The biggest change has been in relation to R&D services, where the proportion of value-added devoted to R&D has risen from 3.1% in 1995-2000 to 9.9% in 2001-2006. The Machinery and equipment sector, together with Computer Services and Pharmaceuticals, have also seen an increase in R&D intensity. There has been a decline in the intensity for Instruments and Other Business Services.
Figure 3. Trends in Sectoral R&D intensity in the Netherlands: 1995-2006

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995-2006
Trends in shares of Value-added

Figure 5 presents the changes in the structure of value-added for the 11 sectors most active in R&D in the Netherlands. As discussed above, although these sectors together account for more than 80% of BERD, they only represent 32% of output as measured by value-added. In other words, the other industries (not included in the analysis here) contribute 68% to GDP but less than 20% to industrial R&D.

There has been little change in the contributions of these 11 sectors to value-added in the period 1995 to 2006. The only small changes have been to the two service sectors: Computer services and Other Business services.

Figure 5. Trends in the shares of Value-added in the Netherlands: 1995-2006
Summary of the evolution of BERD in the Netherlands

The section presents a summary of the evolution of BERD in the Netherlands from 1995 to 2006. Figure 6 shows that although there have been some changes over the period, overall R&D intensity remains the same. Thus there was an increase in this intensity from 1.14% in 1995 to 1.24% in 1999, the period since then has seen a decline to 1.14% in 2006.

Figure 6. Evolution of BERD intensity over time, 1995 to 2006

In Figure 7 we present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. This analysis shows some interesting patterns amongst the most important sectors in relation to the volume of R&D in the Netherlands. On the one hand is the Chemicals (less Pharma) sector where both BERD share and R&D intensity have declined. On the other hand are Pharmaceuticals and Machinery and equipment, where both these indicators show a positive trend.

In Figure 8 we correlate the proportionate changes in BERD intensity (X axis) with the changes in the structure of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand indicates increasing BERD intensity and decreasing share of BERD. Of the 11 sectors that constitute more than 80% of BERD in the Netherlands, 5 have increased both their share of the total and their R&D intensity. The most notable of these is R&D services, showing a strong positive trend in both dimensions. On the other hand 4 sectors show a negative trend in both indicators: Chemicals, Instruments, Food, Drink and Tobacco, and Other Business services.
Finally Table 1 presents our assessment of these trends by highlighting sectors in terms of their contribution to the progress towards a target of increasing overall R&D intensity in the Netherlands.
Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pharmaceuticals</td>
<td>• Chemicals</td>
</tr>
<tr>
<td>• Machinery and Equipment</td>
<td>• Instruments</td>
</tr>
<tr>
<td>• R&amp;D services</td>
<td>• Food, Drink and Tobacco</td>
</tr>
<tr>
<td>• Computer services</td>
<td>• Other Business services</td>
</tr>
<tr>
<td>• Wholesale and Retail Trade</td>
<td></td>
</tr>
</tbody>
</table>
1.19 Poland

In Poland, manufacturing value added made up 19% of total value added on average during the entire period from 1995-2006, with only a slight decline in the 2000s. On average, total value added generated by services increased from 61% from 1995 to 2000 to 65% from 2001 to 2006, suggesting that agriculture and extractive industries declined by 4% over the decade. The share of BERD in services also increased from 16% to 22% over the two periods, while the share of BERD in manufacturing declined from 73% to 66% over the two periods. Average BERD intensity, measured as BERD over value added, was more than 10 times higher in manufacturing than in services, and it decreased in both industries. In manufacturing it decreased from 1.12% to 0.69% from one period to the next and in services it decreased from 0.08% to 0.06% from one period to the next.

**Distribution of BERD**

Unlike in the smaller eastern European countries, the top 10 industries performing R&D from 2001 to 2006 in Poland account for only 65% of total BERD, of which machinery and equipment (29), Pharmaceuticals (2423), and motor vehicles (34) explain only 28% of it. Figure 1 shows the structure of BERD for Poland as an average between 2001 and 2006.

Figure 1. Structure of BERD 2001-2006
Changes in the distribution of BERD

Figure 2 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. Pharmaceuticals (2423) was a notable winner in the top 10, while machinery and equipment (29) and chemicals, excluding pharmaceuticals (24-2423) were big losers.

Figure 2. Winners and losers in the shares for BERD in Poland, 1995-2006

Trends in R&D Intensity

BERD intensity declined by 36% in Poland from the six year prior to 2001 and six years from 2001. Figure 3 shows the sectoral R&D intensity for the top 10 industries and figure 4 shows the top 5 industries and bottom five industries in terms of their dynamics, irrespective of there sectoral contribution to total BERD, over the two periods. However, software services (72) was a notable winner. Pharmaceuticals (2423) and R&D activity (73) also appears as winners in these figures with relatively small gains. Notable losers included aerospace (353), motor vehicles (34) and Radio, TV and communication equipment (32), other transport (35) and electrical machinery (31).
Figure 3. Sectoral R&D intensity in Poland by industry, 1995-2006

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995-2006
Trends in Value-added by Sector

Figure 5 shows the evolution of value-added for the top 10 industries. While these industries make up more than 65% of total BERD from 2001 to 2006, on average, they only made up slightly more than 32.5% of value added.

Figure 5. Trends in the shares of Value-added in Poland: 1995-2006

Summary of the evolution of BERD in Poland

Figure 6 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, then Poland has a long way to go. Nevertheless, BERD intensity fell about 50% between 1999 and 2002 in Poland, but then began to rise to 0.20% in 2005. Figure 7 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing BERD intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) indicates increasing BERD intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear losers.

Partly because of the size of the Polish economy, the BERD is more evenly distributed across several sectors. The important winners are pharmaceuticals (2423), and Computer services (72). There are several significant losers, including motor vehicles (34) and other transport (35).
Figure 6. Evolution of BERD intensity over time, 1995 to 2006

Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Poland: 1995-2006
Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Poland (Table 1).

**Table 1. Typology of sectors in term of their contribution to the 3% target**

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software services</td>
<td>Motor Vehicles</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Transport &amp; communications</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>Aerospace</td>
</tr>
</tbody>
</table>

**1.20 Portugal**

In terms of broad aggregates, around 50% of Business R&D (BERD) in Portugal is accounted for by Manufacturing industries (NACE15-37) and 45% by Services (NACE50-99). The main trend over the period 1995 to 2005 has been a decrease of the relative importance of the former, going from 58% in 1995-2000 to 46% in 2001-2005, and an increase in that of the latter, from 38% to 49%. R&D intensity in manufacturing industries combined is 0.7% and in services is 0.2%.

**Concentration of BERD**
Business R&D in Portugal is concentrated in the following 6 sectors that account for over 54% of the total in the period 1995 to 2005:

- Other Business services
- Radio, TV and Communication equipment
- Financial services
- Computer services
- Pharmaceuticals
- Transport and Communications services

Figure 1 lists 13 sectors that account for more than 80% of all BERD. The remaining sectors of the economy in Portugal account for less than 20% of total R&D.

**Figure 1. Structure of BERD 2001-2005**

![Pie chart showing the distribution of BERD across sectors](image)

**Changes in the structure of BERD**

The main trends in the structure of industrial R&D since 1995 are reported in Figure 2. The main change has been the increasing relative importance of the two service sectors: Other Business services and Financial services. In the case of the former, the share of total BERD has risen from 8.6% in 1995-2000 to 16.4% in 2001-2005. At the same time there has been a big decrease in the relative importance of Electrical equipment, with its share declining from 2.1% to 4.8%. Two other service sectors have increased their share of R&D over time: Computer services and Wholesale and Retail Trade. On the other hand Transport and Communications services sector has shown an opposite trend, together with Wood, Paper and Publishing, Machinery and Equipment and Chemicals (less Pharma).


**Figure 2. Winners and losers in the shares for BERD in Portugal, 1995-2005**

![Diagram showing winners and losers in the shares for BERD in Portugal, 1995-2005](image)

**Trends in R&D Intensity**

Figures 3 and 4 show that 8 out of the 12 sectors have increased their R&D intensity since 1995. The biggest proportionate increases have been in Other Business Services and Radio, TV and Communication equipment and Pharmaceuticals. The Radio, TV and Communication equipment industry has gone from devoting 4.6% of value-added to R&D in 1995-2000 to 11.8% in 2001-2005. There have been substantial proportionate increases in the intensity in Financial services, Wholesale and Retail, Computer services and Motor Vehicles. The relative decline has been in Electrical equipment and Transport and Communications services.

**Figure 3. Trends in Sectoral R&D intensity in Portugal: 1995-2005**
Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995 to 2005

Cary Figure 5 reports the evolution of Value-added for the 12 sectors that make the largest contribution to BERD. The first point to note is that although these sectors represent more than 80% of industrial R&D in Portugal they only account for 40%
of value-added. Thus the remaining sectors contribute 60% to total GDP, but represent less than 20% of total R&D.

There has been little change in terms of shares of value-added of these sectors over time, with a slight decrease for Other Business services and a slight increase for Financial services.

**Figure 5. Trends in the shares of Value-added in Portugal: 1995-2005**
Summary of the evolution of BERD in Portugal

In this section we summarize the main trends in BERD in Portugal over the period 1995 to 2005. Figure 6 shows that overall BERD intensity increased substantially in Portugal, albeit from a low base. Thus in 1995 Portuguese industry as a whole was devoting 0.13% of value-added to R&D and this increased to 0.36% in 2006.

Figure 6. Evolution of BERD intensity over time, 1995 to 2005

In Figure 7 we present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. This analysis shows some interesting contrasts between the 4 services sectors that are amongst the most important contributors to industrial R&D in Portugal. While 3 of these, namely Other Business services, Financial services, and Computer services, show a positive trend both in terms of BERD share and R&D intensity, the same does not apply to Transport and Telecommunications services.

In Figure 8 we correlate the proportionate changes in BERD intensity (X axis) with the changes in the structure of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand indicates increasing BERD intensity and decreasing share of BERD. Six of the 13 most important sectors in terms of BERD in Portugal have shown a positive trend both in terms of their share of the total and their R&D intensity. As mentioned already Other Business services is the sector showing the most dynamic trend. Only 3 sectors are the opposite end of the spectrum showing decreases in both indicators: Transport and Telecommunications services, Electrical Equipment and Wood and Paper.
Finally Table 1 presents our assessment of these trends by categorizing sectors in terms of their contribution to the progress towards a target of increasing overall R&D intensity in Portugal.
Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Other Business services</td>
<td>• Transport and Communications services</td>
</tr>
<tr>
<td>• Radio, TV and Communication equipment</td>
<td>• Electrical equipment</td>
</tr>
<tr>
<td>• Financial services</td>
<td>• Wood and Paper</td>
</tr>
<tr>
<td>• Computer services</td>
<td></td>
</tr>
<tr>
<td>• Pharmaceuticals</td>
<td></td>
</tr>
<tr>
<td>• R&amp;D services</td>
<td></td>
</tr>
<tr>
<td>• Motor vehicles</td>
<td></td>
</tr>
<tr>
<td>• Chemicals</td>
<td></td>
</tr>
<tr>
<td>• Machinery and Equipment</td>
<td></td>
</tr>
<tr>
<td>• Wholesale and Retail Trade</td>
<td></td>
</tr>
</tbody>
</table>
1.21 Romania

In Romania, manufacturing value added made up on average 48% of total value added from 1997-2000, and 37% from 2003 to 2006. By contrast, services made up on average only 42% of total value added from 1997-2000, and 55% from 2003 to 2006. Averages for Romania cover these periods because R&D statistics were not collected in every industry prior to 2003. The share of BERD in services is very low in Romania, but it had increased from 0.03% to 0.14% over the two periods, while the share of BERD in manufacturing decreased from 66% to 58% over the two periods. Average BERD intensity, measured as BERD over value added, doubled from 1.2% in the first period to 2.5% in the second period. It should be noted that value added was obtained from the EU KLEMS database.

Distribution of BERD

The top 10 industries performing R&D from 2003 to 2006 in Romania account for 60% of total BERD, of which Motor vehicles (34), Machinery and equipment (29), and Petroleum (23) explain only 26% of it. Figure 1 shows the structure of BERD for Romania as an average between 2001 and 2006.

Figure 1. Structure of BERD 2003-2006
Changes in the distribution of BERD

Figure 2 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. The three top winners are the Coke and refined petroleum industry (23), R&D (73) and Computer and related activities (72); and the top three losers are other Electricity, water and gas (40 and 41), basic metals (27), and textiles and leather (17 to 19). Please keep in mind, however, that R&D statistics were not collected from firms in industries from 29 (machinery and equipment) to 35 (other transport equipment) prior to 2003.

Figure 3. Winners and losers in the shares for BERD in Romania, 1997-2006

Trends in BERD Intensity

BERD intensity for BERD doubled in Romania from the four year prior to 2001 and three years from 2003. Figure 3 shows the sectoral R&D intensity for the top 10 industries and figure 4 shows the top 5 industries and bottom five industries in terms of their dynamics, irrespective of there sectoral contribution to total BERD, over the two periods. R&D (73), Coke and refined petroleum industry (23), R&D services (73), and software (73) were the winners. There are no obvious losers in Romania, but keep in mind, that R&D statistics were not collected from firms in industries from 29 (machinery and equipment) to 35 (other transport equipment) prior to 2003.
Figure 3. Sectoral R&D intensity in Romania by industry, 1997-2006

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1997-2006
Trends in Value-added by Sector

Figure 5 shows the evolution of value-added for the top 10 industries. While these industries make up 82% of total BERD from 2001 to 2006, on average, they made somewhat more than 26% of value added.

Figure 5. Trends in the shares of Value-added in Romania: 1998-2000 and 2003-2006

Summary of the evolution of BERD in Romania

Figure 6 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, Romania has exceeded this target by a wide margin. However, accounting anomalies in the way R&D is collected suggest that they are far from the target. Figure 7 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates increasing BERD intensity and decreasing share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand quadrant indicates decreasing BERD intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear loser.

Partly because of the size of the Romanian economy, the BERD is more evenly distributed across several sectors. It is not possible to determine who is a winner or loser given that R&D statistics were not collected from firms in industries from 29 (machinery and equipment) to 35 (other transport equipment) prior to 2003. Nonetheless, given the statistics available, Coke and refined petroleum industry (23), R&D services (74) and software (73) are the clear winners.
Figure 6. Evolution of BERD intensity over time, 1998 to 2005

Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Romania: 1997-2006
Figure 8. Correlation between the change in the BERD intensity and the change in the share of BERD

Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Romania (Table 1).

Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrol</td>
<td></td>
</tr>
<tr>
<td>R&amp;D</td>
<td></td>
</tr>
<tr>
<td>Software services</td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td></td>
</tr>
</tbody>
</table>
1.22 Slovakia

In Slovakia, manufacturing value added made up 24% of total value added on average during the entire period from 1995-2006, with only a slight decline in the 2000s. On average, total value added generated by services increased from 59% from 1995 to 2000 to 60% from 2001 to 2006, suggesting that agriculture and extractive industries maintained a stable share over the 12 years. Unlike in most other countries the share of BERD in services is high, 59% of total BERD over the entire 12-month period, but it also declined from 62% in the first period to 56% in the second period. The share of BERD in manufacturing increased from 36% to 41% over the two periods. Average BERD intensity, measured as BERD over value added, did not appear significantly higher in manufacturing than in the services industry. The main reason for this statistical anomaly is that much of business related R&D activity is generally accounted for in R&D (73), which is a service industry. This may be due to the inability to distribute it to the appropriate industry, or that many R&D labs are still under public control. One alarming trend is that BERD intensity in manufacturing it decreased from 0.85% to 0.56% from one period to the next.

Distribution of BERD

The top 10 industries performing R&D from 2001 to 2006 in Slovakia account for 88% of total BERD, of which R&D (73), Rubber and plastics products (25), and Radio, TV and communication equipment (32) explain for 65% of it. Figure 1 shows the structure of BERD for Slovakia as an average between 2001 and 2006.

Figure 1. Structure of BERD 2001-2006
Changes in the distribution of BERD

Figure 2 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. R&D (73) is particularly notable as it was reformed during the period being considered.

Figure 2. Winners and losers in the shares for BERD in Slovakia: 1995-2006

Trends in BERD Intensity

BERD intensity declined by 44% in Slovakia from the six year prior to 2001 and six years from 2001. Figure 3 shows the sectoral R&D intensity for the top 10 industries and figure 4 shows the top 5 industries and bottom five industries in terms of their dynamics, irrespective of there sectoral contribution to total BERD, over the two periods. Notable winners included pharmaceuticals (2423) and other chemicals (34). Significant losers include machinery and equipment (29), Radio, TV and communication equipment (32) and other transport equipment (34).
Figure 3. Sectoral R&D intensity in Slovakia by industry, 1995-2006

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995-2006
Trends in Value-added by Sector

Figure 5 shows the evolution of value-added for the top 10 industries. While these industries make up more than 88% of total BERD from 2001 to 2006, on average, they only made up slightly more than 10.5% of value added.

Figure 5. Trends in the shares of Value-added in Slovakia: 1995-2006

Summary of the evolution of BERD in Slovakia

Figure 7 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, then Slovakia is moving further away from this objective as BERD intensity tumbled from 0.90% to 0.23% between 1997 and 2006. Figure 7 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing BERD intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) indicates increasing BERD intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear losers.

R&D services generate almost half of BERD in Slovakia. The most important winners, however, are pharmaceuticals (2423), which shows the largest increase in BERD intensity, but shows little change in the share of BERD, and chemicals excluding pharmaceuticals (24-2423), which shows some gains in both BERD intensity and BERD share. R&D services observed large declines in both BERD intensity and BERD share, but this may be due to changes in accounting methods and the slow reform of the National innovation system.
Figure 6. Evolution of BERD intensity over time, 1995 to 2006

Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Slovakia: 1995-2006

- Change in share of BERD
- Change in share of value added
- Change in BERD intensity
Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Slovakia (Table 1).

**Table 1. Typology of sectors in term of their contribution to the 3% target**

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmaceuticals</td>
<td>R&amp;D services</td>
</tr>
<tr>
<td>Chemicals less pharma</td>
<td>Rubber and plastics</td>
</tr>
<tr>
<td>Fabricated metal</td>
<td>Radio, TV and telecoms.</td>
</tr>
<tr>
<td>Non-metallic minerals</td>
<td>Electrical machinery</td>
</tr>
</tbody>
</table>

**1.23 Slovenia**

In Slovenia, manufacturing value added made up about 25% of total value added on average during the entire period from 1995-2006, with only a slight decline in the 2000s. On average, total value added generated by services increased from 60% from 1995 to 2000 to almost 63% from 2001 to 2006, suggesting that agriculture and extractive industries declined somewhat over the 12 years. Unlike many of the other eastern European countries, the share of BERD in services decreased from 19% to 9% over the two periods, while the share of BERD in
manufacturing increased from 78% to 89% over the two periods. Average BERD intensity, measured as BERD over value added, increased from 0.83% in the first period to just over 1% in the second period. BERD intensity was about 10 times higher in manufacturing than in services in the first period and diverged considerably during the second period. In manufacturing it increased from 2.5% to 3.8% from one period to the next and in services it decreased from 0.26% to 0.16% from one period to the next.

**Distribution of BERD**

The top 10 industries performing R&D from 2001 to 2006 in Slovenia account for 88% of total BERD, of which Pharmaceuticals (2423), Radio, TV and communication equipment (32), and machinery and equipment (29) explain for 60% of it. Figure 1 shows the structure of BERD for Slovenia as an average between 2001 and 2006.

**Figure 1. Structure of BERD 2001-2006**
Changes in the distribution of BERD

Figure 2 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. The three top winners are Pharmaceuticals (2423), machinery and equipment (29), and Fabricated metal products (28); and the three biggest losers are R&D (73), Community, social and personal services (75 to 99) and chemicals, excluding pharmaceuticals.

![Figure 2. Winners and losers in the shares for BERD in Slovenia, 1995-2006](image)

Trends in BERD Intensity

BERD intensity increased by 26% in Slovenia from the six year prior to 2001 and six years from 2001. Figure 3 shows the sectoral R&D intensity for the top 10 industries and figure 4 shows the top 5 industries and bottom five industries in terms of their dynamics, irrespective of there sectoral contribution to total BERD, over the two periods. Notable winners include TV and communications equipment (32), Pharmaceuticals (2423), machinery and equipment (29), fabricated metal manufacturing (28), and Instruments, watches and clocks (33). R&D (73) was the big loser.
Figure 3. Sectoral R&D intensity in Slovenia by industry, 1995-2006

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995-2006
**Trends in Value-added by Sector**

Figure 5 shows the evolution of value-added shares for the top 10 industries. While these industries make up more than 88% of total BERD from 2001 to 2006, on average, they only made up less than 22% of value added.

**Figure 5. Trends in the shares of Value-added in Slovenia: 1995-2006**

---

**Summary of the evolution of BERD in Slovenia**

Figure 6 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, Slovenia has shown some progress in moving toward the target, but has stayed near the halfway point through the early 2000s. Figure 7 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing R&D intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing BERD intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) indicates increasing BERD intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear losers.

The most important winners are pharmaceuticals (2423), which show the largest increase in BERD intensity, but show a large growth in the share of BERD, and machinery and equipment (29), which also shows some growth in both BERD intensity and BERD share. R&D activity (73) is significant loser with large declines in both R&D intensity and BERD share, but this may be due to changes in accounting methods.
Figure 6. Evolution of BERD intensity over time, 1995 to 2006

Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Slovenia: 1995-2006

- Change in share of BERD
- Change in share of value added
- Change in BERD intensity
Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Slovenia (Table 1).

**Table 1. Typology of sectors in term of their contribution to the 3% target**

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmaceuticals</td>
<td>Other business services</td>
</tr>
<tr>
<td>Machinery and equipment</td>
<td>R&amp;D services</td>
</tr>
<tr>
<td>Instruments</td>
<td></td>
</tr>
<tr>
<td>Fabricated metal</td>
<td></td>
</tr>
</tbody>
</table>
1.24 Spain

In terms of broad aggregates, around 69% of Spanish Business R&D (BERD) is accounted for by Manufacturing industries (NACE15-37) and 25% by Services (NACE:50-99). The main trend over the period 1995 to 2006 has been a decrease of the relative importance of the former, with its share of the total decreasing from 78% in 1995-2000 to 65% in 2001-2006, and an increase in that of the latter, with the share going from 17% to 29%. R&D intensity in manufacturing industries combined is 2.3% and in services is 0.2%.

Concentration of BERD

Business R&D in Spain is concentrated, with 7 sectors accounting for over 52% of the total in the period 1995 to 2006:

- Pharmaceuticals
- Motor Vehicles
- Telecommunications services
- Machinery and equipment
- Aerospace
- Computer services
- Other Business services

The 16 sectors listed in Figure 1 account for around 80% of all industrial R&D.

Figure 1. Structure of BERD 2001-2006

<table>
<thead>
<tr>
<th>Sector</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmaceuticals</td>
<td>12%</td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td>9%</td>
</tr>
<tr>
<td>Telecommunications services</td>
<td>7%</td>
</tr>
<tr>
<td>Machinery and equipment</td>
<td>7%</td>
</tr>
<tr>
<td>Aerospace</td>
<td>6%</td>
</tr>
<tr>
<td>Radio, TV &amp; Telecomms</td>
<td>5%</td>
</tr>
<tr>
<td>Pharmaceuticals less</td>
<td>4%</td>
</tr>
<tr>
<td>Food, Drink, &amp; Tob.</td>
<td>3%</td>
</tr>
<tr>
<td>Rubber &amp; plastics</td>
<td>2%</td>
</tr>
<tr>
<td>Telecom Services</td>
<td>2%</td>
</tr>
<tr>
<td>Fabricated Metals</td>
<td>2%</td>
</tr>
<tr>
<td>Financial Services</td>
<td>2%</td>
</tr>
<tr>
<td>Other Business Services</td>
<td>6%</td>
</tr>
<tr>
<td>Instruments</td>
<td>2%</td>
</tr>
<tr>
<td>Electrical Equip.</td>
<td>4%</td>
</tr>
</tbody>
</table>

Changes in the structure of BERD
The main changes in the structure of industrial R&D since 1995 are reported in Figure 2. The clearest trend has been an increase in the relative importance of the three service sectors listed above as being amongst the most important in terms the volume of R&D: Computer services, Other Business services, and Telecommunications services. The biggest change has been in the Computer services sector, which has increased its share from 4.1% of the total in 1995-2000 to 6.8% in 2001-2006. At the same time there has been a steep decline in the importance of Radio, TV and Communications equipment (from 10.3% of the total to 3.3%). A smaller decrease in the share of BERD can be seen for Aerospace and Other Transport. The only other trend to note is an increase in the relative importance of Pharmaceuticals.

**Figure 2. Winners and losers in the shares for BERD in Spain from 1995-2006**

**Trends in R&D Intensity**

Figures 3 and 4 present the main trends in R&D intensity by sector in Spain since 1995. The main point to note is that 15 out of the 16 sectors that account for more than 80% of BERD have increased their R&D intensity. The biggest increase has been in the case of Pharmaceuticals, where the proportion of value-added devoted to R&D rose from 9.3% in 1995-2000 to 16.8% in 2001-2006. The only sector to show a decline has been Radio, TV and Communications equipment.
that are most important contributors to total BERD. The first point to note is that

Figure 3. Trends in Sectoral R&D intensity in Spain: 1995-2006

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995 to 2006

Trends in shares of Value-added
In Figure 5 we report the changes in the share of value-added for the 16 sectors that are most important contributors to total BERD. The first point to note is that
these 16 sectors together account for 23% of total value-added for Spain. This contrasts with their 80% share of total R&D. In other words sectors that account for 77% of GDP contribute less than 20% of industrial R&D. The other point to note is that there have only been minor changes in the relative importance of these sectors over time.

**Figure 5. Trends in the shares of Value-added in Spain: 1995-2006**
Summary of the evolution of BERD in Spain

In this section we summarize the main trends in BERD in Spain in the period 1995 to 2006. As shown in Figure 6 the aggregate level R&D intensity has increased from 0.42% in 1995 to 0.75% in 2006.

Figure 6. Evolution of BERD intensity over time, 1995 to 2006

In Figure 7 we present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. The main message from this analysis is that the 3 service sectors that are amongst the most important contributors to industrial R&D in Spain, namely Telecommunications services, Computer services and Other Business services, show a positive trend both in terms of BERD share and R&D intensity. The only sector with a negative trend in terms of both indicators is Radio, TV and Communications equipment.

In Figure 8 we correlate the proportionate changes in BERD intensity (X axis) with the changes in the structure of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand indicates increasing BERD intensity and decreasing share of BERD. This analysis shows that 8 out of the 16 sectors that account for around 80% of the total industrial R&D have increased both in terms of shares and in terms of R&D intensity. Apart from the three sectors mentioned above, the most prominent amongst these are Pharmaceuticals, Motor Vehicles and Food, Drink and Tobacco.
Finally in Table 1 we present our assessment of the sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Spain.
<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pharmaceuticals</td>
<td>• Radio, TV and Communications Equipment</td>
</tr>
<tr>
<td>• Motor Vehicles</td>
<td></td>
</tr>
<tr>
<td>• Telecommunications services</td>
<td></td>
</tr>
<tr>
<td>• Machinery and equipment</td>
<td></td>
</tr>
<tr>
<td>• Aerospace</td>
<td></td>
</tr>
<tr>
<td>• Computer services</td>
<td></td>
</tr>
<tr>
<td>• Other Business services</td>
<td></td>
</tr>
<tr>
<td>• Instruments</td>
<td></td>
</tr>
<tr>
<td>• Electrical equipment</td>
<td></td>
</tr>
<tr>
<td>• Other Transport</td>
<td></td>
</tr>
<tr>
<td>• Machinery &amp; Equipment</td>
<td></td>
</tr>
<tr>
<td>• Food, Drink and Tobacco</td>
<td></td>
</tr>
<tr>
<td>• Fabricated Metals</td>
<td></td>
</tr>
<tr>
<td>• Financial Services</td>
<td></td>
</tr>
<tr>
<td>• Instruments</td>
<td></td>
</tr>
<tr>
<td>• Electrical equipment</td>
<td></td>
</tr>
<tr>
<td>• OtherTransport</td>
<td></td>
</tr>
<tr>
<td>• Machinery &amp; Equipment</td>
<td></td>
</tr>
<tr>
<td>• Food, Drink and Tobacco</td>
<td></td>
</tr>
<tr>
<td>• Fabricated Metals</td>
<td></td>
</tr>
<tr>
<td>• Financial Services</td>
<td></td>
</tr>
</tbody>
</table>
1.25 Sweden

In terms of broad aggregates, around 86% of Business R&D (BERD) in Sweden is accounted for by Manufacturing industries (NACE15-37) and 13% by Services (NACE50-99). The main trend over the period 1995 to 2006 has been a slight decrease in the relative importance of the former and a slight increase in that of the latter. R&D intensity in manufacturing industries combined is 13% and in services is 0.6%.

Concentration of BERD

Swedish Business R&D is highly concentrated with the following 4 sectors accounting for 65% of the total in the period 1995 to 2006:

- Radio, TV and communication equipment
- Motor Vehicles
- Pharmaceuticals
- Machinery & Equipment

Figure 1 lists 12 sectors that account for more than 90% of BERD. The remaining sectors in the economy account for less than 10% of total R&D.

Figure 1. Structure of BERD 2001-2006
Changes in the structure of BERD

Figure 2 shows the main trends in the structure of BERD since 1995. The main point to emerge from this analysis is that there has been very little change in terms of the relative importance of these 12 sectors for total R&D. The only changes worth noting are slight decreases in the shares of R&D services and Machinery & Equipment.

Figure 2. Winners and losers in the shares for BERD in from 1995-2006

<table>
<thead>
<tr>
<th>Sector</th>
<th>Change 1995-2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Services</td>
<td>0.7</td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td>0.7</td>
</tr>
<tr>
<td>Radio, TV &amp; Telecommms</td>
<td>0.6</td>
</tr>
<tr>
<td>Electrical Equip.</td>
<td>0.5</td>
</tr>
<tr>
<td>Chemicals &amp; Pharmaceuticals</td>
<td>-0.2</td>
</tr>
<tr>
<td>Aerospace</td>
<td>-0.3</td>
</tr>
<tr>
<td>Instruments</td>
<td>-0.4</td>
</tr>
<tr>
<td>Wood, paper &amp; publishing</td>
<td>-0.6</td>
</tr>
<tr>
<td>Research &amp; development</td>
<td>-1.0</td>
</tr>
<tr>
<td>Machinery &amp; Equip.</td>
<td>-1.5</td>
</tr>
</tbody>
</table>

Trends in R&D Intensity

Figures 3 and 4 present the trends in R&D intensity for industrial sectors in Sweden. We begin by mentioning a potential problem with the underlying data for Radio, TV and Communications equipment (NACE 32) from ANBERD and STAN. There is no “Official BERD” data for this sector from 2001 onwards, hence ANBERD contains estimates based on data from national sources. The main problem is that this results in R&D intensities well in excess of 100% for a number of years. Although we have included these estimates here they need to be treated with caution.

A number of sectors have increased their R&D intensity since 1995, most notably Radio, TV and Communications equipment, Chemicals (less Pharmaceuticals) Electrical equipment, and Motor vehicles. At the same time R&D services, Pharmaceuticals, and Aerospace have reduced the proportion of their value-added devoted to R&D.
Figure 3. Trends in Sectoral R&D intensity in Sweden: 1995-2006

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995 to 2006
Trends in shares of Value-added

In Figure 5 we report the changes in the share of value-added for the 16 sectors that are most important contributors to total BERD. The first point to note is that these 12 sectors together account for 19% of total value-added for Sweden. This contrasts with their 90% share of total R&D. In other words sectors that account for 81% of GDP contribute less than 10% to industrial R&D. The other point to note is that there have been some small changes in the relative importance of these sectors over time. Radio, TV and Communications equipment has slightly decreased its share of total value-added and Computer services has increased its share.

Figure 5. Trends in the shares of Value-added in Sweden: 1995-2006
Summary of the evolution of BERD in Sweden

In this section we summarize the main trends in BERD in Sweden since 1995. In terms of overall R&D intensity, Figure 6 shows that there have been two distinct trends. The period from 1995 to 2001 saw a spectacular increase from 2.7% to 3.7%. However since then there has been a decline in this intensity so that in 2006 this stands at 3.2%.

Figure 6. Evolution of BERD intensity over time, 1995 to 2006

In Figure 7 we present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. This analysis shows some contrasting trends amongst the 3 most important sectors in terms of the volume of R&D in Sweden. Radio, TV and Communications and Motor Vehicles have maintained their high share of BERD and increased their R&D intensity. However Pharmaceuticals has maintained its high share of R&D but decreased in terms of intensity.

In Figure 8 we correlate the proportionate changes in BERD intensity (X axis) with the changes in the structure of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand indicates increasing BERD intensity and decreasing share of BERD. It shows that apart from the two sectors mentioned above, Chemicals (less Pharmaceuticals) and Electrical equipment have shown increasing trend in both the share and R&D intensity. On the other end Aerospace and R&D services are at the other end of the spectrum with declines registered in both dimensions.
contribution to progress towards a target of increasing overall R&D intensity in Sweden.

Finally Table 1 contains our assessment of the sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Sweden.
Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Radio, TV &amp; Communications Equip.</td>
<td>• Aerospace</td>
</tr>
<tr>
<td>• Motor Vehicles</td>
<td>• Pharmaceuticals</td>
</tr>
<tr>
<td>• Electrical Equipment</td>
<td>• Instruments</td>
</tr>
<tr>
<td>• Chemicals (less Pharmaceuticals)</td>
<td>• R&amp;D services</td>
</tr>
<tr>
<td>• Computer services</td>
<td>• Machinery &amp; Equipment</td>
</tr>
<tr>
<td>• Telecommunication services</td>
<td>• Wood and Paper</td>
</tr>
</tbody>
</table>
1.26 United Kingdom

In terms of broad aggregates, around 79% of UK Business R&D (BERD) is accounted for by Manufacturing industries (NACE15-37) and 19% by Services (NACE50-99). The main trend over the period 1995 to 2006 has been a slight decrease in the relative importance of the former and a slight increase in that of the latter. R&D intensity in manufacturing industries combined is 6% and in services is 0.3%.

Concentration of BERD

UK Business R&D is highly concentrated with the following 4 sectors accounting for over 50% of the total in the period 1995 to 2006:

- Pharmaceuticals
- Aerospace
- Motor Vehicles
- Computer services

Moreover the 14 sectors shown in Figure 1 account for more than 90% of all industrial R&D. This means that the remaining sectors of the UK economy account for less than 10% of total R&D.

Figure 1. Structure of BERD 2001-2006
Changes in the structure of BERD

The main changes in the structure of BERD since 1995 (shown in Figure 2) have been an increase in the share of Pharmaceuticals, Aerospace, and three sectors within services: Computer services, Telecommunications services and Financial services. At the same time Motor vehicles, Chemicals, Electrical machinery, and R&D services and Radio, TV and Communications equipment have all declined in terms of their relative importance for total R&D.

Figure 2. Winners and losers in the shares for BERD in from 1995-2006

Trends in R&D Intensity

Figures 3 and 4 show the main trends in R&D intensity by sector in the period 1995-2006. The sector with the biggest change is Radio, TV and Communications equipment that has increased the proportion of value-added devoted to R&D from 12.8% in 1995-2000 to 23.4% in 2001-2006. Financial Services and Aerospace are the other sectors with a large increase in R&D intensity. There has been a decline in the intensity in R&D services from 10.4% to 7.1%.
Figure 3. Trends in Sectoral R&D intensity in the UK: 1995-2006

![Trends in Sectoral R&D intensity in the UK: 1995-2006](image)

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995 to 2006

![Top 5 winners and losers in R&D intensity by industry, 1995 to 2006](image)
Trends in shares of Value-added

Figure 5 presents the trends in the contributions to total value-added made by the 14 largest industries in terms of R&D expenditures in the UK. As reported above these sectors account for more than 90% of total BERD but their share of total economic output is only around 21%.

There have only been some small changes in the structure of value-added, with increases for Financial services and Computer services and a decline for Motor Vehicles, Coke & Petroleum, and Machinery & equipment.

Figure 5. Trends in the shares of Value-added in the UK: 1995-2006
Summary of the evolution of BERD in the UK

This section summarizes the main trends in BERD in the UK since 1995. Figure 6 shows that at the aggregate level there has been a steady decline in R&D intensity over time: from 1.39% in 1995 to 1.18% in 2004.

Figure 6. Evolution of BERD intensity over time, 1995 to 2006

In Figure 7 we present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. This analysis shows that there have been some contrasting trends in the 4 most important sectors in terms of the volume of R&D. Thus for example the Aerospace sector has increased both its BERD share and its R&D intensity. On the other hand Motor Vehicles has decreased its share of R&D while maintaining its R&D intensity.

In Figure 8 we correlate the proportionate changes in BERD intensity (X axis) with the changes in the structure of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left hand indicates increasing BERD intensity and decreasing share of BERD. Apart from Aerospace, three other sectors show a positive trend both in terms of increasing share and increasing intensity: Financial Services, Telecommunications services and Food, Drink and Tobacco. On the other hand R&D services is one sector showing a negative trend in both indicators.
Finally Table 1 presents our assessment of all 14 sectors in terms of their contribution to the progress towards a target of increasing overall R&D intensity in the UK.
### Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pharmaceuticals</td>
<td>• Motor Vehicles</td>
</tr>
<tr>
<td>• Aerospace</td>
<td>• R&amp;D services</td>
</tr>
<tr>
<td>• Radio, TV &amp; Communications equipment</td>
<td>• Electrical equipment</td>
</tr>
<tr>
<td>• Coke &amp; Petroleum</td>
<td>• Chemicals (less Pharma)</td>
</tr>
<tr>
<td>• Instruments</td>
<td></td>
</tr>
<tr>
<td>• Machinery &amp; Equipment</td>
<td></td>
</tr>
<tr>
<td>• Computer services</td>
<td></td>
</tr>
<tr>
<td>• Telecommunications services</td>
<td></td>
</tr>
<tr>
<td>• Food, Drink and Tobacco</td>
<td></td>
</tr>
<tr>
<td>• Financial services</td>
<td></td>
</tr>
</tbody>
</table>
2 Country Reports: Non-EU countries

2.1 United States

In the United States, manufacturing value added made up 15% of total value added on average during the entire period from 1995-2006, with a decline 2% from the six years before 2001 and the six years from then. Value added generated by services increased from 75% total value added from 1995 to 2000 to 77% from 2001 to 2006, on average. The share of BERD in services increased from 29% to 34% over the two periods, while the share of BERD in manufacturing decreased from 71% to 66% over the two periods. Average BERD intensity, measured as BERD over value added, decreased slightly from 1.93% in the first period to 1.86% in the second period. BERD intensity was about 10 times higher in manufacturing than in services. In manufacturing it increased from 8.3% to 9.0% in manufacturing from one period to the next and in services it increased from 0.74% to 0.81% from one period to the next.

Distribution of BERD

The top 10 industries performing R&D from 2001 to 2006 in the United States account for 80% of total BERD, of which Radio, TV and communication equipment (32), Computer and related activities (72), and Pharmaceuticals (2423) explain only 37% of it. Figure 1 shows the structure of BERD for the United States as an average between 2001 and 2006.

Figure 1. Structure of BERD 2001-2006
Changes in the distribution of BERD

Figure 2 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. The three top winners are pharmaceuticals (2423), Computer and related activities (72), and R&D (73); and the three biggest losers are Wholesale and retail trade (50 to 53), Aircraft and spacecraft (353), and Office, accounting and computing machinery (30).

Figure 3. Winners and losers in the shares for BERD in the United States, 1995-2006

Trends in BERD Intensity

BERD intensity declined by 3.6% in United States from the six year prior to 2001 and six years from 2001. Figure 3 shows the sectoral R&D intensity for the top 10 industries and figure 4 shows the top 5 industries and bottom five industries in terms of their dynamics, irrespective of there sectoral contribution to total BERD, over the two periods. Radio, TV and communication equipment (32), pharmaceuticals (2423) and Instruments, watches and clocks (33) were top winners that are also in the top 10. Aircraft and spacecraft (353), wholesale and retail (50-52), and chemicals minus pharmaceuticals (24-2423) were among the greatest losers.
Figure 3. Trends in sectoral R&D intensity in the United States by industry, 1995-2006.

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995-2006
**Trends in Value-added by Sector**

Figure 5 shows the evolution of value-added for the top 10 industries. While these industries make up 80% of total BERD from 2001 to 2006, on average, they slightly more than 19% of value added.

Figure 5. Trends in the shares of Value-added in the United States: 1995-2006

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio, TV and telecoms.</td>
<td>1.07</td>
<td>1.62</td>
</tr>
<tr>
<td>Software services</td>
<td>1.37</td>
<td>0.62</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>0.54</td>
<td>0.66</td>
</tr>
<tr>
<td>Instruments</td>
<td>0.44</td>
<td>0.36</td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td>1.25</td>
<td>0.94</td>
</tr>
<tr>
<td>Wholesale and retail trade</td>
<td>13.07</td>
<td>12.60</td>
</tr>
<tr>
<td>Aerospace</td>
<td>0.53</td>
<td>0.49</td>
</tr>
<tr>
<td>Chemicals less pharma</td>
<td>1.21</td>
<td>1.00</td>
</tr>
<tr>
<td>Machinery and equipment</td>
<td>1.18</td>
<td>0.91</td>
</tr>
<tr>
<td>Social services</td>
<td>22.78</td>
<td>23.74</td>
</tr>
</tbody>
</table>

**Summary of the evolution of BERD in the United States**

Figure 6 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, the United States does appear as a reasonable role model. Figure 7 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates increasing BERD intensity and decreasing share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left indicates decreasing BERD intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear losers.

Figures 7 and 8 show some contrasting trends in the top 10 sectors that make up about 80% of BERD in the United States. The US economic is one of the most dynamic economies in terms of changes in BERD intensity. Pharmaceuticals (2423) and software services (72) were the big winners, with the largest increase in R&D intensity and in the share of BERD. Several other industries were winners, including Radio, TV and communication equipment (32), and Instruments, watches and clocks (33). By contrast, Motor Vehicles (34), Aircraft and spacecraft (353), and wholesale and retail trade (50 to 52) were big losers.
Figure 7. Evolution of BERD intensity over time, 1995 to 2006

Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in the United States: 1995-2006

- Change in share of BERD
- Change in share of value added
- Change in BERD intensity

Radio, TV and telecoms: -0.46, 0.38, 0.74
Software services: 0.25, 0.18
Pharmaceuticals: 0.12, 0.26
Instruments: -0.08, 0.36, 0.23
Motor Vehicles: -2.31, -0.31, -0.02
Wholesale and retail trade: -3.27, -0.47, -0.33
R&D services: -0.04, 0.00
Aerospace: -3.14, -0.26, -0.31
Chemicals less pharma: -1.52, -0.27, -0.19
Machinery and equipment: -0.19, 0.13, 0.96
Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in the United States (Table 1).

**Table 1. Typology of sectors in term of their contribution to the 3% target**

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio, TV and telecoms.</td>
<td>Wholesale &amp; retail trade</td>
</tr>
<tr>
<td>Software services</td>
<td>Aerospace</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>Chemicals less pharma</td>
</tr>
<tr>
<td>Instruments</td>
<td>Motor vehicles</td>
</tr>
<tr>
<td>Machinery and equipment</td>
<td></td>
</tr>
</tbody>
</table>
2.2 Japan

In Japan, manufacturing value added made up on average 21% of total value added during the entire period from 1995-2006, with a decline 2% from the six years before 2001 and the six years from then. Value added generated by services also decreased from 65% total value added from 1995 to 2000 to 68% from 2001 to 2006, on average. The 1% increase in share of value added coming from the two sectors was made up by a corresponding decrease in agriculture and the extractive industries. The share of BERD in services increased from 2% to 8% over the two periods, while the share of BERD in manufacturing decreased from 95% to 90% over the same periods. Average BERD intensity, measured as BERD over value added, decreased slightly from 2% in the first period to 2.34% in the second period. BERD intensity was very small when compared with manufacturing. In manufacturing it increased from 8.6% to 10.4% in manufacturing from one period to the next and in services it increased from 0.06% to 0.27% from one period to the next.

Distribution of BERD

The top 10 industries performing R&D from 2001 to 2006 in Japan account for 82% of total BERD, of which Motor Vehicles (34), Radio, TV and communication equipment (32) and Office, accounting and computing machinery (30) explain 42% of it. Figure 1 shows the structure of BERD for Japan as an average between 2001 and 2006.

Figure 1. Structure of BERD in Japan, 2001-2006
Changes in the distribution of BERD

Figure 2 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. The three top winners are Office, accounting and computing machinery (30), motor vehicles (34), and Pharmaceuticals (2423); and the three biggest losers are Radio, TV and communication equipment (32), Electrical machinery and apparatus (31) and Chemicals (24-2423).

Trends in BERD Intensity

BERD intensity increased by almost 18% in Japan from the six year prior to 2001 and six years from 2001. Figure 3 shows the sectoral R&D intensity for the top 10 industries and figure 4 shows the top 5 industries and bottom five industries in terms of their dynamics, irrespective of there sectoral contribution to total BERD, over the two periods. Office, accounting and computing machinery (30), Pharmaceuticals (2423), and Instruments, watches and clocks (33) were the top 3 winners.
Figure 3. Trends in sectoral R&D intensity in Japan by industry, 1995-2006.

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995-2006
**Trends in Value-added by Sector**

Figure 5 shows the evolution of value-added for the top 10 industries. While these industries make up more than 82% of total BERD from 2001 to 2006, on average, they slightly more than 13.5% of value added.

Figure 5. Trends in the shares of Value-added in Japan: 1995-2006

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Vehicles</td>
<td>3.04</td>
<td>2.30</td>
</tr>
<tr>
<td>Radio, TV and telecoms.</td>
<td>1.92</td>
<td>1.24</td>
</tr>
<tr>
<td>Office and computing equip.</td>
<td>0.55</td>
<td>0.31</td>
</tr>
<tr>
<td>Electrical machinery</td>
<td>1.14</td>
<td>0.94</td>
</tr>
<tr>
<td>Machinery and equipment</td>
<td>2.26</td>
<td>2.17</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>1.19</td>
<td>0.88</td>
</tr>
<tr>
<td>Chemicals less pharma</td>
<td>1.00</td>
<td>0.74</td>
</tr>
<tr>
<td>R&amp;D services</td>
<td>0.38</td>
<td>0.34</td>
</tr>
<tr>
<td>Instruments</td>
<td>0.33</td>
<td>0.31</td>
</tr>
<tr>
<td>Food, drink and tobacco</td>
<td>2.61</td>
<td>2.62</td>
</tr>
</tbody>
</table>

**Summary of the evolution of BERD in the Japan**

Figure 6 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, Japan has gone well beyond the target, making it something of a moving target for the European countries. Figure 7 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates increasing BERD intensity and decreasing share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left indicates decreasing BERD intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear losers.

Figures 7 and 8 show some contrasting trends in the top 4 sectors that make up almost 50% of BERD in Japan. The big winner was Office, accounting and computing machinery (30). Pharmaceuticals (2423), motor vehicles (34), and Instruments (33) were also winners with more modest gains in both BERD intensity and in the share of BERD. There were few losers in Japan, but Radio, TV and telecoms (32) experienced the greatest decline among the top 10 industries.
Figure 6: Evolution of BERD intensity over time, 1995 to 2006

Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Japan: 1995-2006

<table>
<thead>
<tr>
<th>Industry</th>
<th>Change in share of BERD</th>
<th>Change in share of value added</th>
<th>Change in BERD intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Vehicles</td>
<td>-3.81</td>
<td>0.39</td>
<td>2.63</td>
</tr>
<tr>
<td>Radio, TV and telecoms.</td>
<td>-0.12</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>Office and computing equip.</td>
<td>-0.29</td>
<td>0.16</td>
<td>2.86</td>
</tr>
<tr>
<td>Electrical machinery</td>
<td>-0.20</td>
<td>0.14</td>
<td>2.21</td>
</tr>
<tr>
<td>Machinery and equipment</td>
<td>-0.09</td>
<td>0.12</td>
<td>1.44</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>-0.20</td>
<td>0.16</td>
<td>0.64</td>
</tr>
<tr>
<td>Chemicals less pharma</td>
<td>-0.14</td>
<td>0.06</td>
<td>0.34</td>
</tr>
<tr>
<td>Instruments</td>
<td>-0.12</td>
<td>0.00</td>
<td>0.29</td>
</tr>
<tr>
<td>Food, drink and tobacco</td>
<td>-0.02</td>
<td>0.00</td>
<td>0.12</td>
</tr>
<tr>
<td>Rubber and plastics</td>
<td>-0.14</td>
<td>0.00</td>
<td>0.12</td>
</tr>
</tbody>
</table>
Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Japan (Table 1).

**Table 1. Typology of sectors in term of their contribution to the 3% target**

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Vehicles</td>
<td>Radio, TV and telecoms.</td>
</tr>
<tr>
<td>Office &amp; computing equip.</td>
<td></td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td></td>
</tr>
<tr>
<td>Instruments</td>
<td></td>
</tr>
</tbody>
</table>
2.3 Korea

In Korea, manufacturing value added made up on average 28% of total value added during the entire period from 1995-2006. Value added generated by services also increased from 54% total value added from 1995 to 2000 to 57% from 2001 to 2006, on average. This increase was marked by a corresponding decline in agriculture and the extractive industries. The share of BERD in services declined from 10% to 8% over the two periods, while the share of BERD in manufacturing increased from 83% to 87% over the same periods. Average BERD intensity, measured as BERD over value added, decreased slightly from 1.9% in the first period to 2.4% in the second period. BERD intensity was very small when compared with manufacturing. In manufacturing it increased from 5.8% to 7.7% in manufacturing from one period to the next remained around 0.03% in the service industries.

Distribution of BERD

The top 10 industries performing R&D from 2001 to 2006 in Korea account for 85% of total BERD, of which Radio, TV and communication equipment (32), motor vehicles (34) and chemicals (24-2423) explain 65% of it. Figure 1 shows the structure of BERD for Korea as an average between 2001 and 2006.

Figure 1. Structure of BERD 2001-2006
Changes in the distribution of BERD

Figure 2 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. The three top winners are Radio, TV and communication equipment (32), Machinery and equipment (29), and Computer and related activities (72); and the three biggest losers are motor vehicles (34), Transport, storage and communications (60 to 64), and Office, accounting and computing machinery (30).

Figure 3. Winners and losers in the shares for BERD in Korea, 1995-2006

BERD intensity increased by almost 27% in Korea from the six year prior to 2001 and six years from 2001. Figure 3 shows the sectoral R&D intensity for the top 10 industries and figure 4 shows the top 5 industries and bottom five industries in terms of their dynamics, irrespective of there sectoral contribution to total BERD, over the two periods. Instruments, watches and clocks (33), Radio, TV and communication equipment (32), and Aircraft and spacecraft (353) were the top winners, of which Aircraft and spacecraft (353) had the highest R&D intensity in both periods. Motor vehicles (34), Transport, storage and communications (60 to 64), and Electricity, gas & water (40 & 41) were the furthermost losers.
Figure 3. Trends in sectoral R&D intensity in Korea by industry, 1995-2006

Figure 4. Top 5 winners and losers in R&D intensity by industry, 1995-2006
**Trends in Value-added by Sector**

Figure 5 shows the evolution of value-added for the top 10 industries. While these industries make up more than 95% of total BERD from 2001 to 2006, on average, they were a little more than 30% of value added.

**Figure 5. Trends in the shares of Value-added in Korea: 1995-2006**

**Summary of the evolution of BERD in Korea**

Figure 6 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, Korea has gone well beyond the target, making it something of a moving target for the European countries. Figure 7 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates increasing BERD intensity and decreasing share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left indicates decreasing BERD intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear losers.

Figures 7 and 8 show some contrasting trends in the top 2 sectors that make up almost 60% of BERD in Korea. The largest sector, Radio, TV and communication equipment (32) was also the biggest winner with the largest increases in BERD intensity and in the share of BERD. By contrast motor vehicles (34) and Transport, storage and communications (60 to 64) were the biggest losers in both categories.
Figure 6. Evolution of BERD intensity over time, 1995 to 2006

Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Korea: 1995-2006
Figure 8. Correlation between the change in the BERD intensity and the change in the share of BERD

Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Korea (Table 1).

<table>
<thead>
<tr>
<th>Table 1. Typology of sectors in term of their contribution to the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sectors making good progress towards the 3% target</strong></td>
</tr>
<tr>
<td>Radio, TV and telecoms.</td>
</tr>
<tr>
<td>Machinery and equipment</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
</tr>
</tbody>
</table>
2.4 China

In China, manufacturing contributed more than 41% of total value added and the service industries contributed a little 36.6% of value added in 2000. Agriculture, mining, electricity, water and gas, and construction generated the rest. The share of BERD in services was almost 6.6%, while the share of BERD in manufacturing decreased 84.6% in 2000. Average BERD intensity, measured as BERD over value added, was 0.58%. In manufacturing it was almost 1.2% and in the services it 0.10%.

Distribution of BERD

The top 10 industries performing R&D in 2005 in China for a little more than 70% of total BERD, of which Radio, TV and communication equipment (32), machinery and equipment (29), and chemicals minus pharmaceuticals (3402423) explain 35% of it. Figure 1 shows the structure of BERD for China for 2000, but includes only the top 10 industries. R&D data were obtained from the 2009 OECD ANBERD database and value added data were obtained from the OECD 2000 input-output table for China. Definitions are included in the appendix.

Figure 1. Structure of BERD in 2000

Trends in BERD Intensity

Figure 2 shows the sectoral R&D intensity for the top 10 industries in China. Radio, TV and communication equipment (32) has the highest BERD intensity, followed by Instruments, watches, and clocks (33), which is not in the top 10, but has an intensity of 5.7%, and office, accounting and computing machinery, which is also not in the top 10, but has an intensity of just over 3%. Of the top ten, pharmaceuticals (2423), machinery and equipment (29), motor vehicles (34) and other transport (35) are over 2%.
Trends in Value-added by Sector

Figure 3 shows the structure of value added in China for 2000. The top 10 industries in terms of BERD share make up less than 75% of the share in value added.

Figure 3. Structure of value added in 2005
2.5 Norway

In Norway, manufacturing value added made up 11% of total value added on average during the entire period from 1995-2006, with a decline 2% from the six years before 2001 and the six years from then. Value added generated by services also decreased from 61% total value added from 1995 to 2000 to 57% from 2001 to 2006, on average. The 6% decline in share of value added coming from the two sectors was mainly made up by increases in the production of oil and natural gas. The share of BERD in services increased from 34% to 36% over the two periods, while the share of BERD in manufacturing increased from 51% to 48% over the two periods. Average BERD intensity, measured as BERD over value added, decreased slightly from 1.06% in the first period to 1.01% in the second period. BERD intensity was about 8 times higher in manufacturing than in services. In manufacturing it increased from 4.4% to 4.7% in manufacturing from one period to the next and in services it increased from 0.60% to 0.64% from one period to the next.

Distribution of BERD

The top 10 industries performing R&D from 2001 to 2006 in Norway account for 61% of total BERD, of which Computer and related activities (72), Machinery and equipment (29), and Radio, TV and communication equipment (32) explain only 28% of it. Figure 1 shows the structure of BERD for Norway as an average between 2001 and 2006, but includes only the top 10 industries. Definitions are included in the appendix.

Figure 1. Structure of BERD 2001-2006
Distribution of BERD in the top 10 industries

Figure 2 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. The three top winners are financial intermediation (65 to 67), Computer and related activities (72), and R&D (73); and the three biggest losers are Transport, storage and communications (60 to 64), Radio, TV and communication equipment (32) and Pharmaceuticals (2423).

Trends in BERD Intensity

R&D intensity for BERD decreased by more than 5% in Norway from the six year prior to 2001 and six years from 2001. Figure 3 shows the sectoral R&D intensity for the top 10 industries and figure 4 shows the top 5 industries and bottom five industries in terms of their dynamics, irrespective of there sectoral contribution to total BERD, over the two periods. R&D services (73) and financial intermediation (65 to 67) made the greatest gains in R&D intensity. Radio, TV and communication equipment (32) had the highest R&D intensity and also made gains between the two periods. Software services (73), other business services (74), and transport and communications (60 to 64) experienced the greatest declines in R&D intensity.
Figure 3: Trends in sectoral R&D intensity in Norway by industry, 1995-2006.

Figure 4: Top 5 winners and losers in R&D intensity by industry, 1995-2006.
Trends in Value-added by Sector.

Figure 5 shows the evolution of value-added for the top 10 industries. While these industries make up 61% of total BERD from 2001 to 2006, on average, they made up less than 22% of value added. “Other” is mainly made up of the extractive (oil and natural gas sector).

Figure 5: Trends in the shares of Value-added in Norway: 1995-2006

6. Summary of the evolution of BERD in Norway

Figure 6 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, Norway has shown some progress in moving toward the target, but has stayed near the halfway point through the early 2000s. Figure 7 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing R&D intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing R&D intensity and increasing share of BERD; and (4) indicates increasing R&D intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear winners.

Figures 7 and 8 show some contrasting trends in the top 10 sectors that make up about 60% of BERD in Norway. The most significant winners were R&D services (73), Financial intermediation (65 to 67), Machinery and equipment (29), and Food, drink and tobacco (15 to 16). Other business services (74) and transport & communications (60 to 64) were the greatest losers.
Figure 6: Evolution of BERD over time, 1995 to 2006

Figure 7. Changes in the shares of BERD, Value-added and R&D intensity in Norway: 1995-2006
Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Norway (Table 1).

**Table 1. Typology of sectors in term of their contribution to the 3% target**

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery and equipment</td>
<td>Software services</td>
</tr>
<tr>
<td>Food, drink and tobacco</td>
<td>Other business services</td>
</tr>
<tr>
<td>Finance</td>
<td>Transport &amp; communications</td>
</tr>
<tr>
<td>R&amp;D</td>
<td></td>
</tr>
</tbody>
</table>
2.6 Iceland

In Iceland, manufacturing value added declined from 16% of total value added in the six years before 2001 to 13% in the five years from then. Value added generated by services increased from 62% total value added from 1995 to 2000 to 68% from 2001 to 2006, on average. The share of BERD in services increased from 63% to 70% over the two periods, while the share of BERD in manufacturing decreased from 32% to 26% over the two periods. Average BERD intensity, measured as BERD over value added, increased quite dramatically from 1.08% in the first period to 1.79% in the second period. In manufacturing it increased from 2.16% to 3.71% in manufacturing from one period to the next and in services it increased from 1.08% to 1.85% from one period to the next.

**Distribution of BERD**

The top 10 industries performing R&D from 2001 to 2005 in Iceland account for 91% of total BERD, of which R&D (73), computers and related activities (72), and pharmaceuticals (2423) explain only 71% of it. Figure 1 shows the structure of BERD for Iceland as an average between 2001 and 2005, but includes only the top 10 industries. Definitions are included in the appendix.

Figure 1: Structure of BERD 2001-2005
Distribution of BERD in the top 10 industries

Figure 2 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. The three top winners are R&D (73), pharmaceuticals (2423), and machinery and equipment (29); and the three biggest losers are food and beverages (15 and 16), Electrical machinery (31) and other business services (74).

Figure 2: Winners and losers in the shares for BERD in Iceland, 1995-2005

Trends in R&D Intensity

R&D intensity for BERD increased 67% in Iceland from the six year prior to 2001 and six years from 2001. Figure 3 shows the sectoral R&D intensity for the top 10 industries and figure 4 shows the top 5 industries and bottom five industries in terms of their dynamics, irrespective of there sectoral contribution to total BERD, over the two periods. R&D services (73) made the greatest gains, followed by machinery and equipment (29) and pharmaceuticals (2423). Other business services (74) was the greatest loser.
Figure 3: Trends in sectoral R&D intensity in Iceland by industry, 1995-2005.

Figure 4: Top 5 winners and losers in R&D intensity by industry, 1995-2005.
Trends in Value-added by Sector.

Figure 5 shows the evolution of value-added for the top 10 industries. While these industries make up 91% of total BERD from 2001 to 2006, on average, they made up less than 28% of value added.

Figure 5: Trends in the shares of Value-added in Iceland: 1995-2006

Summary of the evolution of BERD in Iceland

Figure 6 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, Iceland has done very well. Figure 7 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing R&D intensity and share of BERD; (2) the lower right hand quadrant indicates decreasing R&D intensity and share of BERD; (3) the upper left hand quadrant indicates decreasing R&D intensity and increasing share of BERD; and (4) indicates increasing R&D intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear winners.

More than 60% of BERD was carried out in R&D services (73) and software services (72). R&D services (73) and pharmaceuticals (2423) were the biggest winners, but both industries are relatively small in terms of value added. Food, drink and tobacco (14 to 15), and other business services (74) were the biggest losers.
Figure 6: Evolution of BERD over time, 1995 to 2005

![Graph showing the evolution of BERD over time from 1995 to 2005.]

Figure 7: Changes in the shares of BERD, Value-added and R&D intensity in Iceland: 1995-2005.

![Bar chart showing changes in shares of BERD, value-added, and R&D intensity across different industries.]
Figure 8: Correlation between the change in the R&D intensity and the change in the share of BERD.

Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Iceland (Table 1).

Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D</td>
<td>Other business services</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>Finance</td>
</tr>
<tr>
<td>Instruments</td>
<td></td>
</tr>
<tr>
<td>Machinery and equipment</td>
<td></td>
</tr>
</tbody>
</table>
Calculating BERD for Europe as a whole is a difficult, if not, impossible task, especially if the data are to be comparable and these data are used together with another data source such as the OECD STAN database. Nevertheless, in 2005, 90% of total BERD for the 27 countries of the European Union was carried out in only 9 countries. Figure 1 shows all of the European countries that are included in the 2009 OECD ANBERD database calculated in terms of current USD purchasing power parities (PPPs). This was done to insure the greatest comparability. The year 2005 was chosen because it had statistics for every country, including Luxembourg. Six Member States are not included in the ANBERD database, but they would be included in the small circle, which only includes countries with less than 1% share in total BERD, which consists of between 1% and 2% of total BERD.

Figure 1 shows that the top 3 countries, Germany, France and the United Kingdom make up 63% of total BERD in Europe as a whole. The inclusion of Italy, Sweden, Spain, the Netherlands, Austria and Belgium would bring the cumulative total to 90% of total BERD. Differences in the structure of BERD in the small countries would have a negligible effect on the structure of BERD for Europe as a whole.

Figure 1: Total BERD in Europe, 2005

Figures 2 and 3 illustrates the manufacturing and service industries in 2005 for all of the European countries that are included in the 2009 OECD ANBERD database calculated in terms of current USD purchasing power parities (PPPs). The distribution shifts somewhat, but the order of the countries remains basically the same.
Toward a European structural analysis

The best way to do an analysis in a similar way as in the individual country reports is to include the eight countries that represent the top 90% of BERD and express this in Euros. Since statistics for Austria is not complete, Austria would need to be dropped, but this country only represents 3% of the total. Finland, Denmark and Ireland can be added to bring the total well over 90%. The European total comprise of 11 countries: Germany, France, UK, Italy, Sweden, Spain, the Netherlands, Belgium, Finland, Denmark, and Ireland. We estimate the European average in the same way as the country studies: a six-year average from 1995 to 2001 and a six-year average from 2002 to 2006.
Certain problems appear when aggregating the different countries together. Differences in accounting methods make it difficult to make such an aggregation fully compatible. Missing information will also make it difficult to estimate a European average. Even the top 3 countries have missing values. In particular, there is no reliable statistics for recycling (37) and hotels and restaurants (55). In a few instances there were missing data, which was estimated by assuming constant BERD intensities between the two periods. It was an issue for social services (79 to 99) in Denmark and France, R&D (73) in France and Ireland, Financial intermediation (65 to 67) in Sweden, wholesale and retail (50 to 52) and transport and communications (60 to 64) in the UK and electricity gas and water (40 and 41) and construction (45) for Ireland. In a few instances, we put zeros in both the BERD and value-added for countries where there were no statistics in one or the other and they were relatively insignificant. One example of this is coke and petrol (23) for Ireland and Denmark.

**Background to a European structural analysis**

In Europe, manufacturing value added made up 20% of total value added on average from 1995 to 2000, and about 18% of total value added on average from 2001 to 2006. The services industries generated about 55% of total value added during the first period and about 57% during the second period. Agriculture, mining, electricity, water and gas, and construction generated the rest. The share of BERD in services was just over 12% in the first period, increasing to almost 15% in the second period, while the share of BERD in manufacturing decreased from 86% to 83% over the two periods. Average BERD intensity, measured as BERD over value added, increased slightly from 1.36% in the first period to 1.41% in the second period. In manufacturing it increased from 5.8% to 6.5% and in the services it increased from 0.31% to 0.37% over the two periods.

**Distribution of BERD**

The top 10 industries performing R&D from 2001 to 2006 in Europe account for 80% of total BERD, of which motor vehicles (34), pharmaceuticals (2423) and Radio, TV and communication equipment (32), explain more than 41% of it. Figure 4 shows the structure of BERD for Europe as an average between 2001 and 2006.
Changes in the distribution of BERD

Figure 5 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. The three top winners are software services (72), pharmaceuticals (2423), software services (72), and motor vehicles (34); and the three biggest losers are chemicals, excluding pharmaceuticals (24-2423), Radio, TV and communication equipment (32), and aircraft and spacecraft (353).
Figure 5. Winners and losers in the shares for BERD in Europe, 1995-2006

**Trends in BERD Intensity**

BERD intensity increased by a very small percentage in Europe from the six year prior to 2001 and six years from 2001. Figure 6 shows the sectoral R&D intensity for the top 10 industries and figure 4 shows the top 7 industries and bottom five industries in terms of their dynamics, irrespective of their sectoral contribution to total BERD, over the two periods. Software services (72), motor vehicles (34), and transport and communications (60 to 64) were the top 3 winners, and Aircraft and spacecraft (353), chemicals minus pharmaceuticals (24-2423), and electrical machinery (31) were among the greatest losers.
Figure 6. Trends in sectoral R&D intensity in Europe by industry, 1995-2006.

Figure 7. Top 5 winners and losers in R&D intensity by industry, 1995-2006.
**Trends in Value-added by Sector**

Figure 8 shows the evolution of value-added for the top 10 industries. While these industries make up 80% of total BERD from 2001 to 2006, on average, they make up slightly less than 17% of value added.

Figure 8. Trends in the shares of Value-added in the United States: 1995-2006.

Figure 9 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, Europe remains far from the target. Figure 10 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 11 summarizes the main changes in the structure of industrial R&D and value-added as well as proportionate changes in R&D intensity. Figure 8 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates increasing BERD intensity and decreasing share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left indicates decreasing BERD intensity and decreasing share of BERD. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear losers.
Figures 10 and 11 show some contrasting trends in the 10 industries that make up about 80% of BERD in Europe. Software services (72), software services (72), motor vehicles (34), pharmaceuticals (2423) and Instruments, watches and clocks (33) were the top winners. By contrast, aerospace (353), and chemicals minus pharmaceuticals (24-2423) were the biggest losers. Machinery and equipment (29), and electronic equipment (32) increased BERD intensity, but decreased their contribution to total BERD.

Software services (72) and pharmaceuticals (24-2423) were also winners in the United States as was pharmaceuticals (24-2423) in Japan. Other transport (35-353), Radio, TV and communication equipment (32), and Instruments, watches and clocks (33) also showed rapid growth in BERD intensity in the United States, whereas they experienced declines or little change in Europe. Aircraft and spacecraft (353) and Chemicals minus pharmaceuticals were also among the biggest losers in the United States.
Figure 9. Evolution of BERD intensity over time, 1995 to 2006

Figure 10. Changes in the shares of BERD, Value-added and R&D intensity in Europe, 1995-2006.
Finally we use all this information to present our assessment of the 11 sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Europe (Table 1).

Table 1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Vehicles</td>
<td>Pharmaceuticals</td>
</tr>
<tr>
<td>Instruments</td>
<td>Aerospace</td>
</tr>
<tr>
<td>Software services</td>
<td>Chemicals less pharma</td>
</tr>
<tr>
<td>Transport &amp; comm.</td>
<td></td>
</tr>
</tbody>
</table>
Some preliminary conclusions on EU aggregate

Both 'pharmaceuticals' and 'motor vehicles' play a key role in Europe due to both their large share of BERD and their increase in BERD share and BERD intensity since 1995. Another important sectoral cluster to be considered is the ICT-driven one, partly manufacturing, partly services.

Regarding 'pharmaceuticals', interesting cases are definitely the UK, BE, SE, DK (SI is interesting but it is mainly driven by one company). This sector has shown a tremendous increase in R&D expenses over the past 15 years, but this went together with a decrease in measurable outputs of R&D (R&D productivity slowdown, less drugs patented, less drugs getting through clinical trials, compared to increasing R&D cost, etc).

For 'motor vehicles', interesting cases are Germany and the countries around it (in particular CZ and SK, PL), into which the German automotive sector has moved part of its value chain. The increase in BERD intensity in the German automotive sector may be due to the fact that the lower-end segments of the value-added chain has been moved out to CZ and SK, leaving in DE the parts with a higher R&D component.

Finally, the ICT-driven sectoral cluster is less prominent in terms of share in BERD, but it is an important player in terms of (growth of) valued added, and in terms of switch to services. Here, interesting country cases are IE, SE, FI, and HU.

3.1 BERD in Europe and its comparison with other third countries

The evolution of BERD in Europe and comparison with the United States

Figure 4.2.1 shows the total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, Europe remains far from the target. Figure 4.2.2 illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates increasing BERD intensity and decreasing share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left indicates decreasing BERD intensity and decreasing share of BERD. The least dynamic industries will appear within the large cluster in the centre of the scatter diagram (with unreadable industry codes), whereas the most dynamic industries appear clearly in the different quadrants. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear losers.

The US is one of the most dynamic economies in terms of changes in BERD intensity. Computer and related activities (72) was the biggest winner, with the largest increase in BERD intensity and in the share of BERD. Several other industries were winners, including pharmaceuticals (24-2423), and transport, storage and communications (60 to 64), which mainly contains telecommunications (R&D activity). Chemicals minus pharmaceuticals were the biggest loser (24-2423). Other losing industries include radio, TV and communication equipment (32), electrical machinery (31), and Office, accounting and computing machinery (30). Aircraft and spacecraft (353) was a clear loser in terms of BERD share, but maintained the same intensity, automotive vehicles (34) increased it share in BERD, but did not increase its intensity and other
business activities (74) increased its BERD intensity, but did not increase its share in BERD.

In comparison with the United States, pharmaceuticals (24-2423) and Computer and related activities (72) were also winners in this country, but their intensity increased much more rapidly there. Other transport (35-353), Radio, TV and communication equipment (32), and Instruments, watches and clocks (33) also showed rapid growth in BERD intensity in the United States, whereas they experienced declines or little change in Europe. Aircraft and spacecraft (353) and Chemicals minus pharmaceuticals (24-2423) declined in the US and Europe.

Figure 4.2.1. Evolution of BERD intensity over time, 1995 to 2006

Figure 4.2.2. Correlation between the change in the BERD intensity and the change in the share of BERD
“Sectorial analysis of the long-term dynamics of business R&D intensity”

In relation to (DG-RTD-2005-M-02-01):

"Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators“

Final Report
Revised version

Annex 4: Survey-based case studies

Technopolis Group (assignment manager)
Idea Consult (coordinator)
SPRU, NIFU STEP

Brussels, 12 November 2009
“Sectorial analysis of the long-term dynamics of business R&D intensity”

In relation to (DG-RTD-2005-M-02-01):

“Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators”

Case study
Business Expenditures in R&D in the Belgian Pharmaceutical Industry

Dr Vincent Duchene and Eveline Durinck
IDEA Consult

Coordinated by

Brussels, 30 September 2009
Table of contents

1 Synthesis 303

2 BERD intensity performance in Belgium and the Belgian pharmaceutical industry 304
   2.1 The pharmaceutical industry in the EU 304
   2.2 The pharmaceutical industry in Belgium 307

3 Analysis of BERD drivers in the Belgian pharmaceutical industry 313

4 The role of public policies in determining BERD performance and BERD intensity in Belgium 318

5 Lessons learned, case uniqueness and success factors 321

Bibliography 325
Business Expenditures in R&D in the Belgian Pharmaceutical Industry

1 Synthesis

The pharmaceutical sector in Belgium represents an interesting case study in the context of the sectoral analysis of business R&D intensity: the pharmaceutical industry in Belgium accounts for more than 22 percent of total industrial R&D for the period 2001-2006 and it has an increased importance in terms of shares of total BERD and shares of value added since the mid 1990s. Moreover, in Belgium, the pharmaceutical industry represents 56% of total high-tech R&D, which is the highest percentage in the whole EU-25. These figures underline the importance of pharmaceutical R&D within the high-tech sector in Belgium.

The drivers of R&D spending in the Belgian Pharmaceutical sector exceed the Belgian-specific setting and are mostly determined by the global context in which the pharmaceutical companies are operating. We have identified the following four types of R&D spending drivers: (1) evolution towards the open innovation model; (2) increased costs of R&D; (3) more stringent and complex regulation with regard to market authorizations, price setting and reimbursement and (4) Belgium-specific drivers. The increased R&D costs associated with the development of a new drug have the logical upward effect on business R&D expenditures in the pharmaceutical sector in Belgium. However, especially the more rigorous price setting and reimbursement regulatory framework is an important but negative driver for business R&D expenditures: the stricter regulatory environment induces extra costs to the pharmaceutical industry and poses delays in the market access of a new drug, thus shortening the time span to regain initial R&D investments and therefore dis-incentivising R&D spending. Finally, the Belgium-specific drivers have a positive effect on R&D spending and refer to the high concentration of highly educated people, the world-level standard of biomedical research and the top-level hospital infrastructure available in Belgium to perform clinical trials.

As mentioned above, the drivers for R&D spending in the Belgium pharmaceutical industry go beyond national boundaries and are shaped at the EU and worldwide levels. Therefore Belgian national and regional policies only have a limited impact on the BERD performance and intensity of the pharmaceutical industry. We have identified three policy initiatives in Belgium that do have an influence on the R&D spending of the pharmaceutical industry: (1) fiscal policies, (2) science and education policies and (3) regulation policies. Whereas the fiscal environment and science and education policies stimulate R&D spending, the slow regulatory decision-making in Belgium clearly curbs the R&D investment spending.

In order to further stimulate R&D spending in the pharmaceutical sector in Belgium, policies oriented towards “horizontal convergence” should be pursued through harmonisation in the pricing and reimbursement decision process across different countries in the EU. Belgium could participate in this already initiated horizontal convergence process by for example benchmarking the methodologies and procedures it uses with regard to pricing and reimbursement against those of its neighbouring countries to see what are “the best practices”, so that the methods and standards applied in the Belgian pricing and reimbursement decisions can be improved and can become horizontally aligned with those of its neighbouring countries. Finally, the way forward for the Belgian government with regard to its public policies in favour of the pharmaceutical industry, should focus on (a) a further strengthening of the fiscal stimuli for the pharmaceutical industry, and (b) the additional expansion and improvement of the knowledge base and clinical infrastructure via affirmative scientific and innovation policies.
2 BERD intensity performance in Belgium and the Belgian pharmaceutical industry

2.1 The pharmaceutical industry in the EU

The importance of the pharmaceutical sector for Europe’s Innovation performance

In spite of the increased commitments in Europe at both the national and Community levels to increase the level and quality of investment in research and innovation, recent evidence shows that the EU is still lagging well behind the US and other major economies. R&D expenditure, for instance, especially in the private sector, remains low and is stagnating as compared to other main world economies such as the US, Japan or China.

In this context, the debate on the extent, origin and nature of the relative underinvestment in research and innovation in Europe has gained importance over recent years. Among the most recent contributions to this debate, the latest European Commission’s “Key Figures on Science, Technology and Competitiveness 2009” shows that the higher level of business R&D intensity in the US compared to the EU is due to two factors (see Figure 1 and Figure 2 below):

1. High-tech industries represent a larger share of the economy in the US than in the EU (they account for 18% of total manufacturing value added in the US against 12% in the EU);

2. High-tech industries are on average about 20% more research-intensive in the US than in the EU (their R&D intensity, expressed as business R&D expenditure in % of sectoral value added, amounts up to 25% in the EU against 30% in the US)

On the other hand, medium-high-tech and medium-low-tech industries are as research-intensive in the EU as in the US, but they are significantly bigger in the EU than in the US. Obviously, research and technological innovation in the EU tend to be more concentrated in medium-tech sectors than in the US (European Commission, 2009).

---

1 High-tech manufacturing industries consist of the following five NACE sectors: ‘pharmaceuticals, medicinal chemicals and botanical products’ (24.4); ‘office machinery and computers’ (30), ‘radio, television and communication equipment and apparatus’ (32), ‘medical, precision and optical instruments, watches and clocks’ (33), ‘aircraft and spacecraft’ (35.3).
Although not fully comparable with the previous data, the European Commission’s EU Industrial R&D investment scoreboard confirms these insights (see Figure 3 below): the cumulated R&D investment by the top-1000 EU and US R&D spenders was in 2005 to a larger extent concentrated in high-tech sectors in the US as compared to the EU. The pharmaceutical industry represents an important sub-set of these high-tech industries in both economies.

However, the EU pharmaceutical sector accounts for a much higher share of total R&D investment by big European high-tech, research-intensive companies than its US counterpart (50% of the cumulated R&D investment against one-third in the US). Data from the OECD Anberd database confirm this higher importance of pharma R&D in the EU: in the US, Business R&D expenditure in the pharmaceutical sector (Pharma BERD) represented in 2003 only 19% of total R&D expenditure (BERD) in all high-tech sectors. In the EU, the pharmaceutical sector concentrated in the same year 33% of total high-tech R&D expenditure (OECD, Anberd April 2008). Clearly, given these differences in industrial structures and in the structural distribution of R&D, the pharmaceutical sector is a crucial sector with regard to Europe’s attempt to reduce the R&D- and the innovation gap with its main competitors.
The period considered.

doubled, the pharmaceutical sector is the EU high-tech sector which recorded the fastest growing R&D-intensity over the period considered.

**Figure 3: Sectoral composition of R&D investment by EU and US companies, 2005**

![Sectoral composition of R&D investment by EU and US companies, 2005](image)

**Source: The 2006 EU Industrial R&D Investment Scoreboard**

**R&D intensity grows faster in the pharmaceutical sector than in other high-tech sectors**

Figure 4 below shows those manufacturing sectors that experienced a positive growth in the EU-27 economy (in terms of real value added, ordinate axis) between 1995 and 2003 and those sectors that have been declining over this period. They also compare growth in value added to growth in R&D expenditure (abscissa) for each sector. Sectors in which R&D expenditure has grown in real terms at a more rapid pace than value added have become more research-intensive (the research intensity of a sector is defined here as R&D expenditure as a % of value added) and are located below the bisector (dotted line). The size of the symbols is related to the size of the sectors in terms of total value added over the period 1995-2003 in the EU-27 economy.

Strikingly, the pharmaceutical sector is the EU high-tech sector which has experienced by far the highest increase of real business R&D expenditure over the past decade. The sector also shows the second highest increase in real value added among all sectors considered. Furthermore, since the BERD increase was twice as high as the increase in value added, the pharmaceutical sector is the high-tech sector in the EU which recorded the fastest growing R&D-intensity over the period considered.
2.2 The pharmaceutical industry in Belgium

Belgium: concentration and structure of BERD, trends in R&D intensity and Value Added

In terms of broad aggregates, around 80% of the Business R&D (BERD) in Belgium is accounted for by Manufacturing industries (NACE 15-37) and 16% by Services (NACE 50-99). The main trend over the period 1995 to 2006 has been a slight decrease of the relative importance of the former and a slight increase of the relative importance of the latter. R&D intensity in manufacturing industries combined is 6.5% and in Services is 0.3%.
Concentration of BERD
Business R&D in Belgium is concentrated in 3 sectors, which account for almost 50% of the total in the period 1995 to 2006:

- Pharmaceuticals
- Chemicals (excluding pharmaceuticals)
- Radio, TV and communication equipment

Figure 5 shows the 12 sectors that account for more than 80% of all Belgian industrial R&D. In other words, the remaining sectors in the economy account for less than 20% of all R&D.

Changes in the structure of BERD
Figure 5 shows the evolution of BERD in Belgium since the mid 1990s. The main changes over this period have been an increasing importance of Pharmaceuticals and Instruments and a decline in that of Chemicals (less Pharmaceuticals) and Radio, TV and Communications equipment.

Trends in R&D Intensity
In terms of changing R&D intensities over the period 1995 to 2006, Figure 6 shows that the largest increases have been for Radio, TV and Communications equipment and Instruments and Electrical equipment. The largest decline has been for Computer Services. Most other sectors have seen little change.

Figure 5: Trends in the shares for BERD in Belgium: 1995-2006

Source: Rindicate, 2009
Figure 6: Trends in Sectoral R&D intensity in Belgium: 1995-2006

![Figure 6: Trends in Sectoral R&D intensity in Belgium: 1995-2006](chart.png)

Source: Rindicate, 2009

Trends in shares of Value-added

Figure 7 reports the evolution of Value-added for the sectors that make the largest contributions to BERD. The first point to note is that although these sectors represent more than 80% of BERD in Belgium, they only account for 23% of value-added. The sector making the largest and increasing contribution to economic output is Other Business Services: it accounted for more than 10% of total Belgium value-added in 2001-2006. All other sectors make a very small contribution to output. The main trends to note are an increasing share of Computer Services and Pharmaceuticals and a declining share of Chemicals.
**Summary of the evolution of BERD in Belgium**

In Figure 8 and Table 1 we present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. Figure 8 shows that there have been contrasting trends in the 3 sectors that account for more than 50% of BERD in Belgium. In the largest sector, Pharmaceuticals, the share of total BERD increased from 16% in the mid-1990s to 22% in 2000-06. However, the R&D intensity in this sector remained unchanged. On the other hand in Radio, TV and Telecommunications equipment, there has been a decline in the share of total R&D from 15% to 13% and an increase in R&D intensity from 37% to 45%. The pattern in Chemicals is yet again different, with a declining BERD share and intensity.
**Figure 8:** Changes in the shares of BERD, Value-added and R&D intensity in Belgium: 1995-2006

```
Table 1 shows our assessment of the sectors in terms of their contribution to progress towards a target of increasing overall R&D intensity in Belgium.

**Table 1:** Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio, TV and Telecommunications equip.</td>
<td>Chemicals</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>Computer Services</td>
</tr>
<tr>
<td>Instruments</td>
<td>Basic Metals</td>
</tr>
<tr>
<td>Machinery &amp; Equipment</td>
<td>Motor Vehicles</td>
</tr>
<tr>
<td>Computer Services</td>
<td>Other Business Services</td>
</tr>
<tr>
<td>Electrical Equip.</td>
<td></td>
</tr>
<tr>
<td>Rubber &amp; plastics</td>
<td></td>
</tr>
<tr>
<td>Basic metals</td>
<td></td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td></td>
</tr>
<tr>
<td>Food, Drink, &amp; Tob.</td>
<td></td>
</tr>
<tr>
<td>Oth. Business Services</td>
<td></td>
</tr>
</tbody>
</table>

Source: Rindicate, 2009
```
**Importance of high-tech and pharmaceutical R&D in Belgium**

From the data description above, it is clear that the pharmaceutical sector in Belgium represents an interesting case study in the context of the sectorial analysis of business R&D intensity: the pharmaceutical industry accounts for more than 22 percent of total industrial R&D for the period 2001-2006 and it has an increased importance in terms of shares of total BERD and shares of value added since the mid 1990s. Moreover the following figures underline the importance of high-tech R&D and -within the high-tech sector- pharmaceutical R&D in Belgium:

1. Belgium is among the 8 countries in which 95% of the EU-25’s high-tech R&D is concentrated (these eight countries are DE, FR, UK, SE, IT, FIN, NL, BE).

2. In Belgium, the pharmaceutical industry represents 56% of total high-tech R&D (OECD, Anberd 2008), which is the highest percentage in the whole EU-25.

These two characteristics add to the relevance of examining the drivers of R&D business spending in the pharmaceutical sector in Belgium.
3 Analysis of BERD drivers in the Belgian pharmaceutical industry

In this section, we discuss the drivers of R&D spending in the Belgian Pharmaceutical sector. It should be borne in mind, however, that most of these drivers largely exceed the Belgian-specific setting and are determined by the global context in which the pharmaceutical companies are operating. In what follows, we will discuss the following four types of R&D spending drivers: (1) evolution towards the open innovation model; (2) increased costs of R&D; (3) more stringent and complex regulation with regard to market authorizations, price setting and reimbursement and (4) Belgium-specific drivers.

Open innovation model

The knowledge growth in the pharmaceutical industry is expansive, making it impossible for the pharmaceutical companies to have all the required know-how in house. This “knowledge boom” leads the pharmaceutical companies towards cooperation with external high-technological third parties. Companies perform only those processes and products in which they excel themselves, while outsourcing the remaining processes and products to other parties that can handle these better and/or cheaper. The outsourcing occurs mostly vertically, towards smaller companies; horizontal cooperation is much less prevalent. Competition issues may play a role here.

This model of open innovation described by interviewees has been also confirmed in the literature by Pammolli and Ricaboni (2007), who describe that a process of division of innovative labour started at the end of the 1970s lead to an increased organisational complexity (and associated cost) of R&D activities in pharmaceuticals. The relevant scientific knowledge and organisational skills are now more than ever dispersed across a wide range of locations and organisations. R&D in the pharmaceutical sector is more than ever heavily relying on intense collaboration between actors, including large and small firms, public research institutes, and universities. The number of researchers and research teams involved in any single R&D project has also increased. R&D licensing agreements, or the average number of assignee or inventors per patent, have also increased substantially over the past 2 decades (Pammolli et al., 2007).

However, the effect of this evolution towards open innovation on the R&D costs of the pharmaceutical industry remains ambiguous. From the interviews we conducted, it seems that the effect on R&D costs is positive, in the sense that outsourcing allows a rationalisation of the R&D costs, by increasing the efficiency of the R&D processes. This greater efficiency through outsourcing can be explained by the following two factors: (1) as mentioned above, R&D is outsourced to those partners that are better and/or more cost-efficient in performing a specific R&D activity and (2) because these outsourced R&D projects are often carried out by small(er) (biotech) companies, where the consequences of a failure are much more visible, these projects are better monitored. This incentivises the partners to perform good work.

Another interviewee however mentioned that 10 years ago, it was predicted that the pharmaceutical industry would move away from the dominance of a few large multinationals. However, he remarked that up to this day, the multinationals still have a leading role to play in the sector. This might indicate that not only business models have been changing significantly but also that here is a diversification in the business models used.
The knowledge boom described above is also a consequence of the fact that the most straightforward diseases have already been tackled (by the most straightforward therapies), increasing the focus on complex pathologies, which requires a more extensive knowledge base. This intensified attention towards more complex diseases and treatments also leads to a significant increase in the costs related to R&D in the pharmaceutical sector. The reasons for these R&D cost increases are discussed in the next section.

**Increased R&D costs**

A second driver behind the increased R&D spending in the pharmaceutical sector in Belgium consists of the increased R&D costs for the development of new drugs. The R&D costs in the pharmaceutical industry have grown dramatically and already amount to 1 Billion Euro per drug that effectively makes it to the market. This cost expansion is due to two reasons.

The first reason lies in the scientific domain: only the complex pathologies are left in the disease-spectrum (mostly diseases to the central nervous system), making it more difficult and thus expensive to develop new drugs. This fact is confirmed in the literature by Pammolli and Ricaboni (2007), who has analysed the evolution of R&D portfolios of pharmaceutical companies worldwide in the period prior to 1995 and during the period 1995-2005. By comparing the rate of activity and the probability of success of the different R&D projects between these two periods, they found out that R&D projects are increasingly targeting more complex pathologies (i.e. pathologies with a lower average probability of successful development). Interesting to note in this context is the evolution towards customized therapies.

The second reason relates to regulatory factors: higher demands by the marketing authorization agencies with regard to the number of patients and tests per patient in clinical trials increase the costs significantly.

These increased R&D costs considerably affect the R&D model of the pharmaceutical companies, directing them towards holding a broader portfolio of products (with less sales per product, but also with a broader spread of risks) instead of focussing only on the development of so-called “blockbusters”. This expansion of the product portfolio is realized via the acquisition of e.g. bio-tech companies or other pharmaceutical companies that are more specialized in complex pathologies. Furthermore, the increase in R&D costs makes that the R&D processes are geared towards “failing early”, which means that a much stricter and shorter monitoring process is elaborated and applied at each stage of the R&D trajectory, aiming to detect as early as possible potential failures. The fact that R&D processes are geared towards failing early in turn leads also to the broader product portfolio mentioned above. Another consequence of the amplified R&D costs is that pharmaceutical companies are focussing their R&D efforts towards “small indications” (i.e. focus on specific niches within particular diseases). First of all, because the R&D costs in these areas are lower. Secondly because it is easier to prove the value added of new drugs in these areas – due to e.g. the fact that there are no other drugs available yet in this area or that clinical trials can be conducted on a smaller scale - thus leading to faster market access of the new drug and a longer period to regain the R&D investments.

As mentioned above, the regulatory environment plays a very important role in the increase of R&D costs in the pharmaceutical industry. Moreover, the stricter regulation rules with regard to price setting and reimbursement mechanisms are a

---

2 These are the EMEA (European Medicines Agency) in the EU and the FDA (Food and Drug Administration) in the USA.
negative driver for R&D spending, as they pose a serious obstacle to innovation. This is discussed in the next section.

**Stringent marketing authorization regulation and complex pricing setting and reimbursement mechanisms**

The regulatory framework in the pharmaceutical industry is multifaceted, spanning multiple stages in the R&D time-line that characterizes the development of a new drug. Here we focus on two important regulation "hurdles": (1) the marketing authorization of a new drug; (2) the pricing and reimbursement decisions determining the market access of a new product. Figure 9 gives an overview of the route from discovery of a new drug to the final consumer access of the new drug.

**Figure 9: Route from discovery to consumer access**

![Route from discovery to consumer access](image)

*Source: World Health Organisation, 2006; The pharmaceutical industry in Europe, key data, PowerPoint*

The marketing authorization decision is taken by the EMEA in the EU, thus allowing for one application for the whole EU. In the US, the FDA is responsible for the marketing authorization. The main trend in this "regulation hurdle" is that the requirements that a new drug has to satisfy in order to have a positive evaluation by the EMEA and/or FDA are becoming more and more stringent and complex: this is a worldwide phenomenon and not only applicable to the EU. These stringent demands have increased the time-line for product development substantially: before, 12-18 months of treatment were sufficient for clinical trials, now "outcome trials" are required which have to include survival and mortality rates\(^3\). Moreover, recently the approval procedure has also been extended by one month. This increase in the development time-line of new drugs has two negative effects on the R&D spending by the pharmaceutical industry. First of all, the time to regain the investment costs (which is limited by the fixed duration of patent protection) is shortened, thus decreasing the incentive for pharmaceutical companies to

\(^3\) Also, the clinical trials have to include more patients and are much more stringent with regard to the side effects of certain drugs.
innovate. Secondly, in the business model of the pharmaceutical industry, the R&D costs are financed by current sales. These sales also diminish due to the amplified development time of a new drug, leading to less money being available to invest in R&D. Finally, we would like to note that although the US are evolving in the same direction as the EU (stricter regulation), in the US, the focus lies on the improvement of a product once it is on the market: e.g. if it is a life-saving drug, it will already be able to access the market after phase IIb of the clinical trials.

Pricing and reimbursement decisions are taken by the national and/or local authorities within the EU. These decisions can be based on several mechanisms, differing from country to country. In ESMT, 2009, the three mechanisms that are the most prevalent in the EU are described: (1) external price benchmarking; (2) internal reference pricing and (3) pharmaco-economic assessments. In external price benchmarking, the price of a drug in a country is compared to and determined by the price of the same drug in a reference country or in a basket of reference countries. Internal reference pricing determines the price of a new drug on the basis of a similar drug in the same country. Pharmaco-economic assessments fix the price of a new drug according to its cost-effectiveness.

Throughout the interviews performed for this study, it became clear that each of these mechanisms induces extra costs to the pharmaceutical industry and poses delays in the market access of a new drug, thus again shortening the time span to regain R&D investment costs, leading to the above mentioned negative impacts on R&D spending. Especially the pharmaco-economic assessments are subject to intense criticism: health technology assessments of a new drug tend to disadvantage “later-in-class” drugs (i.e. drugs within a certain therapeutic class that are not the first in this class to be launched; ESMT, 2009) because even if the “later-in-class” drug has better characteristics than the “first-in-class” drug, it is very difficult for the pharmaceutical companies to prove that the “later-in-class” drug has a therapeutic and socio-economic added value over and above the “first-in-class” drug. One example was given of a life-saving drug against AIDS, which was very expensive and was therefore valued not to have enough value added when compared to existing medication. It was then decided by some national authorities that the new drug would only be made available on the market as a “third-line therapy” (i.e. only if all other medication does not work, this product can be prescribed and reimbursed). Thus, the pharmaceutical company could charge a high price for this new drug but did not have any market for its product, even though it had gone successfully through all the marketing authorization procedures. This example shows how the pricing and reimbursement decisions can dis-incentivize the drive to innovate.

Again, this stricter regulatory framework forces pharmaceutical companies (1) to target a broader portfolio, minimizing risk by spreading it over more products, and (2) to focus their attention on areas where there is still a higher unmet need such as oncology, vaccines and biologics. In these areas, it is easier for the pharmaceutical companies to prove improvement relative to already existing drugs. This shift towards other areas and a broader portfolio is also enhanced by the fact that patents worth nearly 30 Billion USD per year are loosing their exclusivity, which is also a regulatory issue that we will not further discuss here.

Finally, we would like to note that there are some large differences between countries in the EU with regard to the regulatory burdens that we discussed above. For example, the UK is regarded by our interviewees as a very “favourable” country when it comes down to pricing and reimbursement decisions, as it has one of the fastest procedures in this area in the EU leading to quick market launches of new drugs. When looking at the drugs that had received

---

4 E.g. the new drug only has to be taken once a week instead of every day.
market authorization between January 2003 and December 2006, in the UK all of these authorized drugs were already launched on the market in June 2007 (IMS, 2007). However, in Belgium, 42% of the authorized drugs was not yet accessible to patients in 2007: in Belgium, considering the reference period described above, the average time to access the market for a new drug was 478 days (IMS, 2007). This delay in market access significantly shortens the period for pharmaceutical companies to regain their R&D costs, leading to less cash-flow being available for current R&D spending and bringing about negative incentives to invest in R&D in Belgium: one of the interviewees noted that it is not interesting to invest in e.g. clinical trials in countries where you know in advance that the market access of a new drug will be very difficult. Clinical trials will be conducted in countries with a favourable but most of all a clear and transparent regulatory environment: predictable hurdles for market access are very important in this regard.

**Belgium-specific drivers for the pharmaceutical industry**

Throughout the interviews that we conducted, the interviewees noted some Belgium-specific factors that are positive drivers for R&D spending in the Belgian pharmaceutical industry. The first factor is the high concentration of highly educated people in Belgium. The second factor relates to the world-level standard of biomedical research in Belgium. Finally, the third factor points to the top-level hospital infrastructure available in Belgium to perform clinical trials. The first and second factors have a positive influence on the spending for basic research on new molecules/compounds. Again the first factor, taken together with the third factor, positively influences the spending on the development (i.e. clinical trials) of a new drug.
4 The role of public policies in determining BERD performance and BERD intensity in Belgium

In this section, we describe the policy initiatives in Belgium that have an influence on the R&D spending of the pharmaceutical industry. We distinguish three kinds of public policy drivers: (1) fiscal policies, (2) science and education policies and (3) regulation policies, more in particular the implementation of the regulatory framework in Belgium. The first two drivers have a positive effect on the pharmaceutical R&D spending in Belgium, whereas the third driver has a negative impact on R&D investments.

Fiscal Policies

The favourable fiscal policies in Belgium positively affect the R&D spending in the pharmaceutical industry. We can distinguish five kinds of measures that create a positive fiscal environment for the pharmaceutical industry in Belgium. These policies are not solely targeting the pharmaceutical industry and are thus generic in their nature, but they do impact positively on the R&D activities of science-intensive companies such as pharmaceutical firms.

1. The fiscal deduction of
   a. Own R&D investment costs,
   b. Costs related to IPR.

2. The “notional interest” regime, through which companies can fiscally deduct the investments they financed by internal (own) funding.

3. The exemption of a part of the advance tax payment for researchers. This exemption amounts to 65% for the following categories of researchers (IWT, 2008):
   a. Researchers in companies that work on research projects in cooperation with universities and/or research institutes,
   b. Scientific personnel that is employed by “Young Innovative Companies” (i.e. an SME that is less than 10 years old and for which a minimum of 15% of the costs are related to R&D),
   c. Researchers that have obtained a PhD in applied sciences, exact sciences, animal medicine, pharmaceutical sciences or civil engineering and that are employed in a research and development programme,
   d. Researchers with a Master’s degree that are employed in a research and development programme.

4. The decrease in taxes on revenues generated by royalties: 80% of these revenues is exempted from taxes, corresponding to a decrease in the corporate tax rate from 34% to 6.5%. The patents from which the royalties are generated can be linked to a Belgian company as well as to a Belgian subsidiary of a foreign pharmaceutical company. The tax reduction not only applies to patents developed by the company itself but also to acquired and in-licensed patents that were further improved (IWT, 2008).

5. The tax exemption of a premium of up to 2000 Euro that researchers can receive as a compensation for producing a “novel idea”. A special cell within the Ministry of Economic affairs decides whether or not the idea can
be regarded as "novel" and the premium to compensate the idea can be exempted from taxes.

All interviewees agreed that this combination of measures is very important to attract pharmaceutical R&D investments in Belgium.

**Science and education policies**

The science and education policies of the Belgian federal and regional governments have a stimulating effect on the R&D spending of the Belgian pharmaceutical industry. We can give some examples of how the science and technology policies are oriented towards creating a positive environment for the Belgian pharmaceutical industry:

- The establishment of the Centre of Translational Medicine, in which universities and pharmaceutical companies cooperate to facilitate the transfer from "Bench" to "Bedside".
- The "Odysseus" and "Methusalem" programmes (Pharma.be, 2007):
  - The Odysseus programme offers top-researchers upon their return to Flanders the financial means to establish and extend their research in Flanders,
  - The Methusalem programme gives structural funding to Flemish top-researchers.
- The "Biowin" collaboration programme was indicated by the biopharmaceutical sector as one of the main competitive axes in Wallonia (Pharma.be, 2007). The programme stimulates the collaboration between the academic and business environments in domains such as cancer and diseases to the brain.
- The IWT in Flanders (the regional scientific funding agency for Flanders) supports companies to perform R&D by granting financial support for "R&D company projects". The funding covers 40% of research costs or 15% of development costs (European Commission Erawatch, 2009).
- The creation by the Flemish government of "Strategic Research Centres", such as the Institute for Biotechnology (VIB). This institute receives together with three other Strategic Research Centres 100 million Euro per year (European Commission Erawatch, 2009) and has as main goal to generate new knowledge in the field of life-sciences and bio-technology that can be used to generate and reinforce the local economic development (VIB, 2009).

Those various initiatives all contribute to providing the pharmaceutical companies in Belgium with large numbers of high-quality human capital, including attracting top-research staff from abroad. Interestingly, various interviewees pointed also at the high standard of living, quality of life and well-developed 'welfare state' as key elements for the attractiveness of highly-skilled people to Belgium.

**Regulatory environment**

As mentioned above, the regulatory environment in the pharmaceutical industry surpasses the national/regional levels and can be better looked at from a EU or even worldwide perspective. However, specifically for Belgium, the slow administrative handling of the pricing and reimbursement decisions has a very negative effect on the R&D spending of the Belgian pharmaceutical industry.

We described above that the national authorities are responsible for the pricing and reimbursement decisions. However, at European level, there exists the
“Transparency Directive” (European Directive 89/105/EEC) that aims to ensure a transparent pricing and reimbursement procedure in each of the Members States by requiring among others, that these decisions must be adopted within a limited time-frame (European Commission, 2008), where a time span of 180 days is considered reasonable. As we mentioned above, the average pricing and reimbursement procedure in Belgium lasts 478 days, therefore this does not comply with the EU’s Transparency Directive. According to the interviewees, the Belgian administration brings out an automatic negative advice after 180 days, forcing the pharmaceutical applicant company to re-submit its pricing and reimbursement application. In this way, the Belgian state complies with the Transparency Directive, but stalls the procedure by giving a negative evaluation to the application. As all interviewees agreed that the fiscal environment stimulated R&D spending, they confirmed that the slow regulatory decision-making curbed their R&D investment spending.
5 Lessons learned, case uniqueness and success factors

Belgium, at both the federal and the regional levels, has implemented ambitious research and innovation policies over the past ten years, relaying at the national and regional levels the overall concern for more innovation-enhancing policies. The new fiscal incentives put in place, the high quality of the supply of human capital in the corresponding scientific disciplines, as well as the world-class level of research infrastructures were key success factors to explain the importance of pharmaceutical R&D in Belgium and its continued growth over the recent past.

Therefore, the way forward for the Belgian governments should focus on (a) a further strengthening of the fiscal stimuli for the pharmaceutical industry, and (b) the additional expansion and improvement of the knowledge base and clinical infrastructure via affirmative scientific and innovation policies. Moreover, the attachment of the pharmaceutical industry to Belgium is based on the presence of a strong industrial base, which should not be lost out of sight in the design of future public policies. More in particular, Belgium is encouraged to further stimulate R&D in the areas in which it has relative specialisation strengths, such as in vaccination and neurotic diseases.

But as it clearly appeared from the analysis and the interviews, Belgium should progress towards making its regulatory framework more flexible and more aligned with evolutions at the EU level. A large progress has been made over the past 10 years in terms of ‘horizontal’ harmonisation at EU-level with regard to the authorization procedures, but there remains a large room for progress. More horizontal convergence could be achieved through harmonisation in the pricing and reimbursement decision process across different countries in the EU. Belgium should be encouraged to participate in this already initiated horizontal convergence process by for example accepting the results from EMEA without requiring supplementary studies or data from the pharmaceutical industry. Also, Belgium could benchmark the methodologies and procedures it uses with regard to pricing and reimbursement against those of its neighbouring countries to see which are “the best practices”, so that the methods and standards applied in the Belgian pricing and reimbursement decisions can be improved and can become horizontally aligned with those of its neighbouring countries. Besides, the different institutions involved in the pricing and reimbursement decisions should be well aligned to speed up the decision-making process.
CONTACT DETAILS

Case study authors:
Dr Vincent Duchêne and Eveline Durinck
IDEA Consult
Kunstlaan 1-2, Box 16
Brussels
Belgium
T: 0032 (0) 2 282 17 76
Vincent.Duchene@ideaconsult.be,
Eveline.Durinck@ideaconsult.be
www.ideaconsult.be

Experts taking part of the study group as interviewees:

Janssens Pharmaceutica
Stephane Gijssels
Vice President Communication and Public Affairs
Turnhoutseweg 30
2340 Beerse
Belgium
T: 0032 (0) 14 60 30 30
sgijssel@janbe.jnj.com
www.janssenpharmaceutica.be

GSK Biologicals
Pascal Lizin
Director External and Public Affairs
Avenue Pascale 2-4-6
1300 Wavre
Belgium
T: 0032 (0)10 85 31 11
pascal.lizin@gskbio.com
www.gsk.be

UCB Pharma
Didier Malherbe
Vice President Public Affairs
Allée de la Recherche
1070 Brussels
Belgium
T: 0032 (0)2 559 95 85
didier.malherbe@ucb.com
www.ucb.com

Pfizer
Jens Grueger
Head of Global Market Access
Walton Oaks, KT20 7 NS
UK
T: 0044 1737 330023
Jens.Grueger@pfizer.com
www.pfizer.com

David Gillen
Head of Medical Teams, Primary Care BU Europe Canada Australia and NZ
Walton Oaks, KT20 7 NS
UK
T: 00 44 1737 330899
David.Gillen@pfizer.com
www.pfizer.com

Novartis
Eric Cornu
Head of Region Europe
CH-4002 Basel
Switzerland
T: +32 2 246 19 70
meni.styliadou@novartis.com
www.novartis.com

Schering-Plough Research Institute
André Broeckmans
VP EU Regulatory Policy & Intelligence
Molenstraat 110
5342 CC Oss
Netherlands
T: +0031 412 669106
andre.broekmans@spcorp.com
www.schering-plough.com

Movetis
Dirk Reyn
CEO
Veedijk 58
2300 Turnhout
Belgium
T: 0032 (0)14 404 350
Griet.VanHoudt@movetis.com
www.movetis.com

Pharma.be
Leo Neels
Managing Director
Terhulpsesteenweg 166
1170 Brussels
Belgium
T: 0032 (0) 2 661 91 00
ln@pharma.be
www.pharma.be

IWT
Dirk Veelaert and Mia Callens
Scientific Advisors
Bischoffsheimlaan 25
1000 Brussels
Belgium
T: 0032 (0)2 209 09 27
Mia.callens@iwt.be
Dirk.Veelaert@iwt.be
www.iwt.be
Vlaams Instituut voor de Biotechnologie (VIB)
Rudy Dekeyser
Managing Director
Rijvisschestraat 120
9052 Zwijnaarde
Belgium
T: 0032 0 (9) 244 66 11
rudy.dekeyser@vib.be
www.vib.be
Bibliography

Ecorys NI (2009), General welfare analysis of the pharmaceutical market in the European Union

ESMT (European School of Management and Technology) (2009), An economic assessment of the relationship between price regulation and incentives to innovate in the pharmaceutical industry, ESMT Competition Analysis

European Commission (2006), Monitoring Industrial Research: The 2006 EU industrial R&D investment score board


European Commission Erawatch (2009), Erawatch country report Belgium 2009: analysis of policy mixes to foster R&D investment and to contribute to the ERA, DG Research


IWT (2008), Overzicht van de belangrijkste O&O stimuli in België

Mertens G (2005), Beyond the blockbuster drug: strategies for nichebuster drugs, targeted therapies and personalized medicine, Business Insights Limited

OECD Anberd Database (2008)

OECD Anberd Database (2009)


Rindicate (2009), Sectorial analysis of long-term dynamics of business R&D intensity

World Health Organisation (2006), The pharmaceutical industry in Europe, key data, PowerPoint
“Sectorial analysis of the long-term dynamics of business R&D intensity”

In relation to (DG-RTD-2005-M-02-01):

“Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators”

Case study
The German Automotive Industry

Hannes Leo
Associated Consultant to Technopolis Group Belgium

Study coordinated by
Technopolis Group

Brussels, 14 September 2009
# Table of contents

1  Synthesis ................................................................. 329

2  BERD intensity performance in Germany and the German automotive industry 330
   2.1  Business spending on R&D: Germany’s role in Europe .................. 330
   2.2  The automotive industry in Germany .................................... 333

3  Analysis of BERD drivers in the Germany automotive industry – at sectoral level 335

4  The role of public policies in determining BERD performance and BERD intensity in the Germany ........................................ 341

5  Lessons learned, case uniqueness and success factors ......................... 343

6  References  ..................................................................... 345

7  Contact Details ................................................................ 346
1 Synthesis

German business expenditure on R&D (BERD) accounts for 31% of all business R&D expenditures in the European Union. About 30% of the German spending comes out of the automotive sector which is not only larger but also more research intensive than in most other countries. Additionally about half of the German increase in BERD in the 1995 – 2006 period was realised by this sector. Other German sectors which made progress towards Barcelona 3% target are aerospace, pharmaceuticals, instruments, R&D services and Computer services. Radio, TV and communications equipment, office machinery and computing, chemicals and electrical equipment were clearly losing ground on the way to the 3% target.

The increasing R&D investments in the automotive industry are partly due to the premium car strategy of the German industry, national and European regulations and climate change – as the most pressing environmental issue – together with (at least long term) rising costs and scarcity of fossil fuels and the substantial external costs of individual mobility and transport.

The German automotive industry has reacted to these challenges by increasing R&D investment to reduce fuel consumption and pollution, to increase car safety and to introduce electronics and communications systems.

R&D is strongly influenced by regulation which impacts both on the supply side (motor vehicle production) and the demand side (use of motor vehicles). Regulation can thus have a strong impact on the level of R&D spending at the firm level when enforcing innovations that make cars more environmental friendly and safer.

Climate change and rallying raw material prices have led to an intensified search for alternative ways to satisfy the huge demands for (individual) mobility and transport services within the given environmental constraints. The dominant view that emerged in the expert interviews is a gradual increase of cars with alternative power trains. By 2020 about 20% of the car fleet would be powered by alternatives power trains: hybrid power trains (i.e. various combination or electric and combustion engines fuelled by electricity stored in batteries or produced by fuel cells, bio fuels, natural gas, diesel, etc.) and electric power trains, which are in the research lab or in a preproduction phase nowadays. This offer will most likely be enriched by new variants in the years to come. The innovation efforts will not stop at the development of new power trains but will entail the development of new mobility concepts.

The search for the dominant design of the car of the future and for new mobility concepts will create a high level of variation in the automotive sector. The dynamics in such an environment are similar to the early phase of an industrial sector in a life cycle perspective (see Geroski, 2002) in which substantial entry and exit can be observed before the dominant design evolves and the market consolidates. While these are difficult times for incumbents, the German producers seem to be well aware of the challenges and invest – notwithstanding the financial and economic crisis – more or at least keep their level of investment to secure their market share and to catch-up technologically in some areas.

There are some formidable technological challenges associated with the development of the car of the future and of appropriate mobility concepts. This might increase demand for research co-operation in the already existing global networks but may also stimulate co-operation with German high-tech sectors which are being a main target of German innovation policy measures. The German High-tech Strategy and the National Reform Programme developed measures to bring industrial dynamism in current high-tech fields on par with their counterparts in the USA, Japan, the UK or the Nordic Countries.
While the liaison between the automotive sector and some high-tech industries seems appropriate it would intensify the German “dependency” on developments around the automotive sector. There the mixture of increasing environmental constraints and the insecurities about price developments and access to fossil fuels has substantial potential for disruptive or at least cyclical developments.

2 BERD intensity performance in Germany and the German automotive industry

2.1 Business spending on R&D: Germany’s role in Europe

Spending on R&D is not only highly concentrated among companies but also among the member states of the European Union (EU). The huge size difference of EU member state’s economies, their respective development levels and their sector compositions result in a highly skewed distribution of R&D activities throughout the European Union: about 90% of total business expenditures on research and development (BERD) for the EU’s 27 countries was carried out in only nine countries in 2005. Out of this group, the three largest countries - Germany, France and the UK – accounted for almost two thirds of total spending. Within this group, Germany is clearly the single most important R&D performer financing 31% of all BERD and thus almost equalling the spending of France and the United Kingdom together.

Figure 1: Total BERD in Europe, 2005

Source: 2009 OECD ANBERD database, current USD purchasing power parities (PPPs) – Rindicate 2009.

Strong in manufacturing – lagging in services

Germany’s role in the European R&D concert is strongly rooted in the larger than average (in terms of value added) manufacturing sector which performs 34% of European manufacturing R&D expenditures. The corresponding figure for the service sector is 19% and thus just slightly larger than the UK’s contribution (18%).

330
92% of German business R&D activities are performed in the manufacturing sector (NACE 15 – 37). The remaining 8% of the service sector (NACE 50 – 99) is well below the EU average. The main trend over the period 1995 to 2006 has been a slight decrease of the relative importance of the former and a slight increase of the relative importance of the latter. R&D intensity (R&D as a percentage of turnover) in manufacturing industries combined is 7.4% and in services is 0.2%.

**Two thirds of BERD in concentrated in just five sectors**

Business R&D in Germany is highly concentrated, with the following five sectors accounting for nearly two-thirds of the total in the period 1995 to 2006 (share in parenthesis, see Figure 2):

- Motor Vehicles (30.4%)
- Machinery and equipment (10.8%)
- Chemicals less Pharmaceuticals, (8.7%)
- Radio, TV and Communication equipment (10.7%)
- Pharmaceuticals (7.8%)

The biggest change in the structure of R&D in Germany over the period 1995 to 2006 has been the increasing relative importance of the Motor Vehicles sector (see Figure 2). Its share has increased from 26% of the total in 1995-2000 to 30.4% in 2001-2006. Instruments and Computer services also accounted for a greater share of total R&D over the period. At the same time there has been a decline in the relative importance of the following sectors: Aerospace, Radio, TV and communication equipment, Pharmaceuticals, Office machinery & Computers, and Chemicals.

Figure 3 shows that the biggest change in terms of R&D intensity (R&D as percentage of value added) in German industry has been in the Aerospace industry. The proportion of value added devoted to R&D has declined from 54% in 1995-2000 to 31% in 2001-2006. Radio, TV and communication equipment and Office Machinery and Computers have also registered a decline in R&D intensity. On the other hand Instruments and R&D services have shown a strong positive trend. Pharmaceuticals and Motor Vehicles have also slightly increased their R&D intensity.
Figure 2: Trends in the shares for BERD in Germany: 1995-2006

Source: Rindicate, 2009

Figure 3: Trends in sectoral R&D intensity (R&D as a percentage of value added) in Germany: 1995-2006

Source: Rindicate, 2009
Summary of the evolution of BERD in Germany

Figure 2 and 3 present a summary of the main changes in the structure of industrial R&D and value-added as well as the changes in R&D intensity. There have been contrasting trends in the five sectors that account for more than two-thirds of BERD in Germany. In the largest sector, Motor Vehicles, the share of total BERD increased from 26% in the mid-1990s to 30% in 2000-06, and R&D intensity as a percentage of value added increased from 16.6% to 18.2%. On the other hand in Chemicals (less Pharmaceuticals) and Radio, TV and communication equipment there has been a decline in both the share of total R&D and R&D intensity. Pharmaceuticals shows a slightly positive trend in both indicators and the Machinery and Equipment sector shows little change.

2.2 The automotive industry in Germany

The innovation premium

The German automotive industry has positioned itself as "premium car" manufacturers: Audi, BMW, Mercedes, Porsche, VW, and the likes are well established global brands which come with a reputation for producing well engineered, high quality cars which sell with a premium. Premium cars or brand are most of all associated with the high end segment, i.e. powerful, luxurious and expensive cars, but the concept has been diffused to other car segments as well. While the components of the "premium car" concept are somewhat fuzzy, it can nonetheless be taken quite literally: buyers are willing to pay a premium on cars “made in Germany” and are compensated by a bundle of features which boost the "prestige" of the car holder (see NIW – ZEW, 2009). Calculations, based on hedonic price indices, estimate substantial premiums for the German manufacturers when taking Toyota as the benchmark car producer (see Table 1): A Mini fetches a 50% premium – the coefficients can be interpreted as a percent premium - over a similarly equipped Toyota. In the case of the other premium brands, the premium is less but still substantial: Mercedes 37%, BMW 31%, Audi 22% (NIW – ZEW, 2009).
Of course, the German automotive sector encompasses not only the premium segment but a diversified range of products which include, in a statistical sense, the manufacture of motor vehicles (including cars, truck and buses) and motor vehicle engines (NACE 34.1), manufacture of coachwork for motor vehicles, trailers and semi-trailers (NACE 34.2), and manufacture of parts and accessories for motor vehicles and engines (NACE 34.3).

The success of the German automotive industry can be clearly seen in industrial structures as well. The growth of this industry in Germany was not only stronger than that of manufacturing and GDP – resulting in an increasing share in total output and employment over time – but also more rapid than in most industrialised countries. The German automotive industry accounted for more than 4% of GDP in 2005; about double the size of other developed industrial countries (1.8%, NIW–ZEW, 2009). The automotive sector in Germany thus produces about 14% of total manufacturing output (against about 8% in the EU27) which amounts to slightly less than half of the European total value added in this industry according to the Competitiveness Report 2004 (EC, 2004). In absolute term this equates to a gross production value of €387.3 billion, value added of €79.2 billion, employment of 848,200 people and an export share of roughly 70% (NIW – ZEW, 2009).

As the automotive industry is built upon layers of suppliers out of different industries and countries, the figures for the automotive industry are only the tip of the iceberg if its

---

**Figure 4:** Average premium or deduction for car producers (Benchmark: Toyota)

<table>
<thead>
<tr>
<th>Marke</th>
<th>Koeffizient</th>
<th>Standardabweichung</th>
<th>t-Wert</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>0.310</td>
<td>0.010</td>
<td>32.49</td>
</tr>
<tr>
<td>Saab</td>
<td>0.405</td>
<td>0.013</td>
<td>30.67</td>
</tr>
<tr>
<td>Mercedes</td>
<td>0.370</td>
<td>0.012</td>
<td>30.13</td>
</tr>
<tr>
<td>Mini</td>
<td>0.498</td>
<td>0.017</td>
<td>29.86</td>
</tr>
<tr>
<td>Alfa Romeo</td>
<td>0.182</td>
<td>0.010</td>
<td>18.15</td>
</tr>
<tr>
<td>Audi</td>
<td>0.224</td>
<td>0.012</td>
<td>17.92</td>
</tr>
<tr>
<td>Land Rover</td>
<td>0.279</td>
<td>0.026</td>
<td>10.63</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>0.154</td>
<td>0.022</td>
<td>7.04</td>
</tr>
<tr>
<td>Honda</td>
<td>0.050</td>
<td>0.008</td>
<td>5.96</td>
</tr>
<tr>
<td>Citroen</td>
<td>0.040</td>
<td>0.013</td>
<td>3.07</td>
</tr>
<tr>
<td>Volvo</td>
<td>0.042</td>
<td>0.014</td>
<td>3.00</td>
</tr>
<tr>
<td>Renault</td>
<td>0.022</td>
<td>0.010</td>
<td>2.18</td>
</tr>
<tr>
<td>Peugeot</td>
<td>0.002</td>
<td>0.009</td>
<td>0.20</td>
</tr>
<tr>
<td>Lancia</td>
<td>-0.043</td>
<td>0.019</td>
<td>-2.29</td>
</tr>
<tr>
<td>Ford</td>
<td>-0.023</td>
<td>0.010</td>
<td>-2.44</td>
</tr>
<tr>
<td>Nissan</td>
<td>-0.040</td>
<td>0.012</td>
<td>-3.35</td>
</tr>
<tr>
<td>Mazda</td>
<td>-0.053</td>
<td>0.010</td>
<td>-5.22</td>
</tr>
<tr>
<td>Opel/Vauxhall</td>
<td>-0.042</td>
<td>0.008</td>
<td>-6.40</td>
</tr>
<tr>
<td>Fiat</td>
<td>-0.075</td>
<td>0.012</td>
<td>-6.13</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>-0.066</td>
<td>0.009</td>
<td>-7.22</td>
</tr>
<tr>
<td>Kia</td>
<td>-0.140</td>
<td>0.013</td>
<td>-10.84</td>
</tr>
<tr>
<td>Suzuki</td>
<td>-0.144</td>
<td>0.011</td>
<td>-13.10</td>
</tr>
<tr>
<td>Hyundai</td>
<td>-0.259</td>
<td>0.019</td>
<td>-13.47</td>
</tr>
<tr>
<td>Skoda</td>
<td>-0.274</td>
<td>0.010</td>
<td>-26.60</td>
</tr>
<tr>
<td>Seat</td>
<td>-0.296</td>
<td>0.011</td>
<td>-27.91</td>
</tr>
</tbody>
</table>

Source: NIW – ZEW, 2009
economic significance is to be evaluated. The German automotive sector has increasingly “distributed labour” and presently produces about 25% of the production value of the final output that was around 40% in 1980. (NIW–ZEW, 2009). Compared to other car producing companies, German and Japanese automotive companies have retained the largest in house production capacity.

The success of the German automotive industry has been based equally on

• cost-cutting strategies after a “cost crisis” at the end of the 1980s which led to increased productivity;
• rapidly increasing R&D investments and innovation efforts which produced “new to the market” innovation;
• an enlarged market within Germany and substantial volume increases on export markets (NIW – ZEW, 2009).

The German automotive industries absorbs a large share of people with tertiary education: 19.1% of employees with a tertiary education and 20.9% of employees with an education in natural sciences and engineering working in manufacturing are employed in the automotive industry. Based on total employment, the share of people with tertiary education working in the automotive sector is 13.8%. This is again substantially above the EU-15 average of 10.8% (NIW – ZEW, 2009).

3 Analysis of BERD drivers in the Germany automotive industry – at sectoral level

The German automotive industry has increased R&D spending substantially and in a more pronounced manner than the remainder of the German economy over the past two decades. The R&D spending of the automotive industry now accounts for 30% of total R&D spending in Germany. The automotive industry has contributed about half of the total increase in R&D spending in Germany. Latest statistics show that the industry remains on course and there is no observable impact of the ongoing financial and economic crisis (see VDA, 2009 and Rammer, 2009).

In 2007, the R&D intensity (R&D as percentage of turnover) of the automotive industry returned to its 1995 level (around 6% of turnover) after spending substantially more in the years in between. R&D expenditures peaked in 2003 when 7.5% of turnover was invested. The German automotive companies are thus amongst the most R&D intensive worldwide.
**Figure 5:** R&D spending of the automotive industry

Source: NIW-ZEW, 2009

**Figure 6:** R&D intensity as a percentage of turnover

Source: NIW-ZEW, 2009
**Lead market as a driver for innovation**

The strong R&D and innovation orientation of German car producers is a facet of the already mentioned premium car strategy. Innovations are an important selling proposition in this concept and will be first introduced into up market cars and will likely trickle down to the medium and small cars segment later on. Such a strategy is only feasible if it serves corresponding customer preferences. This “personality trait” – which of course is a precondition for most premium car customers – seems to be vastly present in the German market. According to Beise et al. (2002), Germany overall qualifies as a lead market for automobiles. This assessment is according to the authors supported by the following (German) specificities:

- A comparatively high valuation of automobiles by consumers coupled with an inclination to search, examine and select new products. This fosters the perception of product innovations by consumers
- High fuel prices which have stimulated the diffusion of new fuel efficient engine at an early date
- The established image of German car producers as first movers in terms of innovations which has reduced the reluctance of consumers to buy German cars with innovative features
- The competitive home market with a large number of competent suppliers
- The well maintained and developed infrastructure and strict regulations (dense motorways network, no speed limit, taxation) which reinforce customer demand for driving qualities at high speed and safety features.

**Tech-savvy customers and innovation expenditures are complimentary**

The favourable home (lead) market – which was substantially enlarged in the course of the German unification – is the basis of the excellent innovation performance of German car producers and contains the major elements which drive R&D and innovation performance of German automotive producers: consumer preferences (e.g. open to innovation, environmentally concerned), regulation or missing regulation (e.g. speed limits, fuel efficiency, taxation of fuels), competition and supportive infrastructure.

In the years since 2000 three issues have driven the research expenditures of the German automotive industry:

**Creating more environmental friendly cars.** Driven by European legislation (EURO 3,4,5; that sets limits for particle emissions and other gaseous pollutants for light duty vehicles) the car emissions have been reduced substantially. This process is ongoing as EURO 6 is just around the corner. Improving fuel consumption has also been high on the agenda of the automotive industry as this has been a major selling proposition for German cars. The development of alternative power trains has also been allocated substantial amount of resources.

**Car electronics and modern communications technologies.** Electronics, sensors and computer systems have been integrated in almost all car components. Similarly modern communications technologies have been and will increasingly be an integral part of automotive vehicles.

**Improving car safety and reducing the impact on persons involved in accidents.** The number of people injured in car accidents has been reduced by 80% since 1970 in Germany. Presently, the EU has set the ambitious targets to reduce the number of people killed in accidents by 50% by 2015 and by 75% by 2020. This strategy includes not only car passenger safety (e.g. by improving crash security) but also the safety of other persons involved in accidents (e.g. pedestrians) and has to be achieved either by car design or by active safety systems (e.g. cameras monitoring person movements, driver assistance systems). In general, a substantial number of innovative safety equipment has been introduced early - if not even been pioneered – by German
automobile producers (e.g. airbags, intelligent wheel brakes or ABS, Electronic Stability Programme or ESP, equipment to reduce vehicle related crime including car theft) or is currently under development (e.g. night vision driving, steered headlights, driver assistance systems).

While the lead market characteristics and the factors just mentioned are likely to remain important building blocks for the German “autosphere”, global developments since 2007 have altered the environment of car producers and related industries substantially:

- The general failure to reduce or at least contain greenhouse gases on a global scale and the resulting, increasingly dramatic, levels of CO2 already in the atmosphere, have not only created more momentum and determination on the side of policymakers but have changed the attitudes of buyers alike.
- The rally of raw material prices including fossil fuel and the discussions about "peak oil" highlighted the scarcity of resources and the resulting competition for access to raw materials and energy.

Both developments have led to an increased search for alternative ways to satisfy the huge demands for (individual) mobility and transport services within the given environmental constraints. Overall, the mixture of increasing environmental constraints and the insecurities about price development and access to fossil fuels has substantial potential for disruptive developments with could impact on the automotive sector as well.

Individual mobility and road transport accounts for about 30% of CO2 emissions in European countries. The Kyoto protocol – with the USA and China as likely late additions among signatory countries - and the resulting CO2 emission targets request more environmental friendly cars and trucks in general and – in some countries – a non negligible contribution to the reduction of CO2 emission from the transport sector. This necessity is further strengthened by the rising individual mobility and the strongly increasing number of cars in use around the globe. Even in industrialised countries – where the latest vintage of low emission cars is introduced first – the increase in the number of cars has outweighed the emission reduction of new cars in many countries. As many European markets are now close to their saturation levels, future improvements in fuel consumption and CO2 emissions might actually lead to an overall improvement in greenhouse gas emissions out of individual mobility and transport services.

The new impetus for the reduction of greenhouse gases comes on top of long lasting efforts to reduce negative external effects of transport and mobility. The European Union and the European Automobile Manufacturers Association (ACEA), for example, have fixed a voluntary target of 120g/km CO2 for new car fleet average in 2012 or the Euro 5 and 6 directives which mandate pollutant levels for diesel and gasoline engines. European and national regulation have thus provided incentives to lower the emissions of traditional internal combustion engines but have not motivated European producers to introduce alternative power trains (Leitner, 2009) on the market.

**Moving along existing trajectories**

German automotive producers have traditionally invested early on in alternative power train technologies and have experimented with fuel cells and hydrogen powered cars, to mention just two examples. While – and this is the dominant scenario of car producers – the eventual transition to these new power train technologies will be gradual, the actual market introduction was frequently postponed. Technological difficulties, lacking infrastructure investments and the remarkable improvements of the internal combustion engine may have reduced the perceived necessity to really introduce alternatively powered cars onto the market.

A substantial part of the success in reducing fuel consumption and pollutants was due to reengineered and optimized diesel engines which were the favoured development paradigm of the European car producers. The diesel technology – nonetheless – has
remained a European phenomenon and was not adopted in other parts of the world. Thus, the still available potential of diesel engines can only be developed for the European market while other technologies to curb fuel consumption and emissions have to be used outside Europe (e.g. hybrid power trains).

**Hybrid investments: The customer is king**

The introduction of hybrid cars by Toyota and Honda was the first major challenge to this development paradigm. While German car producers do still “insist” on the larger saving potential of diesel engines compared to hybrid engines, consumers increasingly opt for hybrid cars and have triggered substantial innovation investments to develop this sort of cars in Germany. The sluggish reaction of German producers to the hybrid challenge has created the impression that companies like BMW and Daimler are least suited – in the view of customers – to develop hybrid or electric drive technologies (Landmann et al. 2009 as cited in Leitner, 2009).

The success of hybrid cars indicates stronger and more precise demand from consumers. The automotive industry so far has often rather created new market needs and seldom responded just to customer demands, hence innovations were rather technology driven (push innovations). However, consumer preferences have changed and will change and may have a stronger impact on the business policy and product portfolio of companies in the future (Leitner, 2009).

**The search for the next dominant design**

The mounting pressure to develop alternatives to internal combustion engine (ICE) has created a new race for the dominant design of the car of the future. The dominant view that emerged in the interviews performed for this study is a gradual increase of cars with alternative power trains: in 2020 about 20% of the car fleet could be powered by alternatives power trains. The internal combustion engine is expected to remain "competitive" at least up to the year 2020 by further reducing fuel consumption through downsizing of engines, higher compression, lightweight construction, etc. Investment in second generation bio fuels (i.e. not using crops for the production of bio fuels) might further improve the CO2 balance of the ICE.

The race for the dominant design of the car of the future unfolds in the segment of “alternatively” powered vehicles: hybrid power trains (i.e. various combination of electric and combustion engines, fuelled by electricity stored in batteries or produced by fuel cells, bio fuels, natural gas, diesel, etc.) and electric power trains are being researched in laboratories or are currently in a preproduction phase. The present variety will definitely be enriched by new variants in the years to come.

The innovation effort will most likely not stop at the development of new power trains but will entail the development of new mobility concepts to satisfy the huge demand for individual mobility.

The search for the dominant design of the car of the future and for new mobility concepts will create a high level of variation in the automotive sector. The dynamics in such an environment are similar to the early phase of an industrial sector in a life cycle perspective (Geroski, 2002) in which substantial entry and exit can be observed before the dominant design evolves and the market consolidates. The automotive sector may thus again enter into a phase with market entry after a long consolidation phase in which the number of independent producers shrunk from 36 in the seventies to 14 in 2003 (see Competitiveness Report, 2004). If there is no or little successful market entry, the race for the next dominant design may at least bring market shares into the flux by increased competition among existing car producers.

The difficulties of the German car industry to adopt to the hybrid challenge is just one indication that large producers experience substantial lock-in effects which may reduce their willingness to innovate in areas which would devaluate their knowledge base, investments or distribution systems when there is little to gain in the short run. The
resulting strategy might be to “wait and see” what dominant design evolves and to invest once this decision is taken. This approach would create room for manoeuvre for new entrants with less or no restrictions in this context and would thus support a highly dynamic market environment.

This situation is a particular challenge for premium car producers and their research departments in particular. A substantial part of the portfolio of premium producers is not considered as blueprints for the environmental friendly cars of the future. Efforts to reduce fuel consumption and the emission of greenhouse gases in this segment are thus pivotal to reduce maintenance costs and to secure societal acceptance of this segment. While this challenge is important for all car producers it has to be at the core of R&D and innovation efforts of premium car producers as they are operating in segments which will be hit most severely by a change in the current paradigm and a resulting change in the business model.

**Lessons learned?**

One indication of a “wait and see” strategy of German car producers would be a reduction of R&D spending. This is not in line with actual developments: R&D spending of the German automotive sector has increased in 2008 (VDA, 2009) and also in the first quarter of 2009 (Rammer, 2009). There are no indications that there will be a substantial reduction in the near future – at least not in projects of strategic importance.

The interviews developed for this study, give the impression that German car producers are well aware of the challenges ahead and have responded accordingly. They have been working hard to come up with appropriate technological solutions and to close technological gaps wherever they exist: German producers do have lower patent shares in electronics and chemicals (NIW–ZEW, 2009). The industry claims to have already developed a substantial amount of “new to the market” innovations that will be introduced into the market in the near future. Producing premium cars comes with the advantage of having customers that expect innovations and are willing to pay for them. Thus, advanced technological solutions that address the existing challenges would seem to be an appropriate answer.

These challenges are major drivers of R&D activities in the German automotive industry. In doing so, they can rely on specialised suppliers which carry out about half of the R&D activities according to the Competitiveness Report 2004 (EC, 2004) and a vast network of research and innovation partners at universities and research institutions in Germany and around the globe. The automotive industry spends about 27% of total R&D expenditures on collaborative R&D ventures that is considerably higher than in total manufacturing equalling 20% (NIW–ZEW, 2009).

The automotive industry has not only developed joint development capacities with their suppliers but also the ability to manage large distribution and maintenance networks and a complex production process. These competences give established car producers a substantial advantage over new entrants if they are actively tackling the challenges ahead.

**Regulating success?**

The car industry has been subject to a large body of regulation which impact on various parts of the value chain (e.g. procurement, construction, production, distribution of services and R&D, (see Competitiveness Report, 2004). A part of these regulations focus on the supply side (block exemption regulating the distribution of cars vehicle services, industrial design protection and design patents, registration, evaluation, authorisation and restriction of chemicals (REACH), end-of-live vehicle directive, CO2 voluntary commitment, Mobile Air conditioning (MAC), EURO 3, 4, 5, 6 regulations set limits for particle emissions and other gaseous pollutants for light duty vehicles, pedestrian protection directive) or affect consumer behaviour and the use of motor vehicles at the demand side (charging for external costs of transportation, taxation, bio-fuels,
harmonisation of rules and penalties, common limits on lorry drivers’ working hours, harmonisation of weekend bans for lorries, driver certificate, etc.).

This increasingly harmonised European regulatory framework creates similar conditions for all automotive producers within this area and thus limits the role of indigenous regulations at national level. The impact on R&D and innovation expenditures out of these regulations is sometimes considerable and a decisive factor in directing innovation activities. A well designed regulatory framework thus sets the framework conditions for future innovation activities without restricting the creativity of market participants (technology neutrality) but is at the same time a precondition for radical innovation (Sofka et al., 2008).

Missing consensus on core issues and thus missing regulation might prevent radical innovations by creating a “chicken or egg” problem. This might apply to the complementary large-scale infrastructure for refuelling the cars of the future if other than fossil fuels are to be used. Regulation and standardization will thus be a substantial driver of future development together with the preferences of consumers, their willingness to accept new mobility concepts and to develop social innovations. Whatever the future concept for individual mobility will be, the innovations will only materialise if the necessary complementary infrastructure can be developed at reasonable cost and be based on a regulatory fundament that reduces (wasted) costs of system competition.

4 The role of public policies in determining BERD performance and BERD intensity in the Germany

Germany has developed a complex but well organised governance system with clear roles for Ministries and administrative agencies. The present division of labour anchors strategy formulation, development of new instruments and responses to new challenges and co-ordination with other policy actors at the ministerial level. Administering agencies manage programmes, communicate with potential beneficiaries, monitor programmes and provides feedback to Ministries on programme success, potential needs for adjustments and changing challenges within the policy portfolio. The model is operational both at federal level and in the majority of the States.

The German innovation governance system is strongly affected by the institutional and legal setting. Both the Federal Government and the 16 Länder (Federal States) governments are important players and share a number of policy responsibilities for financing education, research and innovation policy programmes and initiatives. The Federal Government takes up a variety of activities in research and innovation policy and may be regarded as the main actor in the German innovation system.

German companies have specialised in the development of complex innovations along established technology trajectories. The car industry is a perfect example for this approach which is also emulated in mechanical and electrical engineering and chemical (except pharmaceuticals). This is complemented by a strong position in some non-high-tech sectors like plastics, textiles and metals.

The automotive industry has become the main driver for R&D and innovation in Germany in recent years. The dynamics of this sector have lured other industries to enlarge or adopt their product range to cater for the needs of the automotive sector. This development, which was not the outcome of deliberate strategies, has created dynamic advantages for the German innovation system but has made the system vulnerable for cyclical changes in the demand for automotive products.

---

1 This section is largely based on Rammer (2009) who presents a broad and well-informed overview of the German innovation system and ongoing reform efforts.
In recent years, concerns have grown that Germany is not coping with the challenges of the information society and new developments in the field of biotechnology. In other words, industrial dynamism in current high-tech fields is not as pronounced as in the USA, Japan, the UK or the Nordic Countries. One indicator of this development mode is the low share of value added created by high-tech manufacturing industries and the sluggish performance in knowledge intensive services. This structure reduces the growth potential of the economy overall as the expansion of high-tech sector is most likely above average.

A strong position in high-tech-industries may also be favourable for the challenges in the automotive industry itself which demands both a sophisticated research system and increasingly cross sectoral co-operation and input from high-tech industries.

Germany has reacted to this situation by drafting the High-tech Strategy and by developing policies and measures in the National Reform Plan. The High-tech Strategy is a sort of White Paper that lays down the government’s priorities in research and innovation for the period 2006 to 2009. The total funding amounts to €14.6 billion. The government was innovative itself when designing this strategy: for the first time horizontal coordination between ministries and policy areas was implemented to adequately address the challenges ahead. The strategy contains a large number of measures which concentrate on 17 thematic areas and the following generic measures: strengthening research and innovation capacities in science and industry, improving framework conditions for high tech start-ups, accelerating the diffusion of new technologies, strengthening international co-operation and developing the education system in the field of vocational education and training.

The High-tech strategy is the major vehicle of the Federal Government to increase R&D spending to 3% of GDP. The German National Reform Programme is another building block that lays out measures to address the challenges of the German research and innovation system. The 2008 version proposes steps to develop the information society and innovation, to open markets and to boost competition, to strengthen the framework for entrepreneurial activity, to make public finances sustainable, to secure sustainable growth and to protect social security, to use ecological innovation as a competitive advantage, securing energy supply and combating climate change, and to gear the labour market for new challenges countering demographic change. Both strategies do not only exist on paper but have been successfully implemented by either building on existing measures, by introducing new ones or by changing the framework conditions.

A major requirement for the success of both strategies and the future growth path of the German economy are adjustments in the education system. The education system in Germany tends to perform worse than that of many other countries, and adjusting the system to a changing and dynamic world seems to be particularly demanding. As the supply of well-trained graduates is stagnant a lack of qualified labour is likely to become one of the most important barriers for innovation when the economy returns on a growth path. A number of policy initiatives with limited effectiveness have been launched in the past years. The divided responsibilities between the Federal level (responsible for vocational training and education) and the State level (responsible for primary, secondary and tertiary education including Universities), are cited as a reason for reform inertia.

The above average growth of the automotive sector is not due to sector specific support programmes. Rather on the contrary, automotive firms received only 0.4% of their R&D expenditures by way of public support. The corresponding figure for total manufacturing is 3.0%. This low number is the result of meagre participation in horizontal innovation promotion programmes and in thematic programmes but does not take into consideration the public support “embodied” in the components developed by suppliers.
This public support along the value chain is considered to be far more substantial than in the core of the automotive sectors – the big producers. Furthermore, this figure does not reflect the support given through financing automotive centred scientific infrastructure: Germany supports a number of highly sector specific research institutions which are important for the industry.

The recently launched Innovation Alliance programme, which again is not sector specific but supports alliances of companies and scientific institutions, has seen substantial participation from the automotive industry. Currently, the following innovation alliances with intensive participation from the automotive sector are up and running: Green Car Body Technologies, Automotive Electronics, Lithium-Ion Batteries and Virtual Techniques for Real Produkts receive support from the Federal Ministry of Education and Research.

Of course, - and this is not surprising given the size of the sector - the German government supports positions favourable to the sector in international discussions and in the European legislative processes. The present regulations on short-term work are also an important support (?) for automotive companies to master the effects of the crisis. The swift reaction of the government in the Opel crisis – which is part of the insolvency of GM – is another indication of the importance of the automotive sector in the German system.

5 Lessons learned, case uniqueness and success factors

Climate change and rallying raw material prices have led to an intensified search for alternative ways to satisfy the huge demands for (individual) mobility and transport services within the given environmental constraints. The search for the dominant design of the car of the future and for new mobility concepts will create a high level of variation in the automotive sector. The dynamics in such an environment are similar to the early phase of an industrial sector in a life cycle perspective (Geroski, 2002) in which substantial entry and exit can be observed before the dominant design evolves and the market consolidates.

While these are difficult times for incumbent, the German producers seem to be well aware of the challenges and invest – notwithstanding the financial and economic crisis – and stick to their long term R&D investment strategies to at least keep their level of investment to secure their market share and to catch-up technologically in some areas.

The success of German automotive producers has increased the sector’s weight and the German dependency on developments in this industry. The mixture of increasing environmental constraints and the insecurities about price developments and access to fossil fuels has substantial potential for disruptive or at least cyclical developments which would impact on the overall economic performance of the country.

Thus policymakers will be confronted with substantial restructuring of the sector in the years to come – a process where incumbents are not necessarily on the winning side as a deviation from the technological path may change “fortunes” considerably. The industry has been an autonomous player, acting independently from most public support mechanisms and deciding based on idiosyncratic decision based on views and perceptions formed within the sector. Policymakers in this situation may consider the following:

• If policymakers do have the impression that the industry fails to live up to societal needs or take decisions which undermine long-term competitiveness then strict regulations may be the step to take. While it seems that the industry is well able and willing to exploit the potential of ICE and alternative fuels, the sluggish response to hybrid power trains at least illustrates that some opportunities can be
missed even by an industry that is heavily investing in R&D. Should this happen in other areas then policymakers might step in, give the lead market concept another twist, and demand more pronounced development efforts by setting advanced regulations.

- The German automotive industry has established global and intense links to scientific institutions and is well able to tap these sources. Thus better scientific support for the industry in Germany can only be achieved by increasing the quality of scientific institutions which might form co-operations with the industry. Co-operative research programmes and horizontal alliances for the development of large pre-competitive technology fields might also be stimuli that could be further developed.

- The automotive sector has developed into an integrator of high-tech components from a number of high-tech industries and research institutions. Its innovation potential is thus also constrained by the capabilities and performance of these sectors (ICT, biotechnology, satellite technologies, etc.). This horizontal co-operation structures have to be actively reflected when designing research and innovation policies for this sector.

- An obvious area for public intervention is the creation of an environment that holistically supports e-mobility and includes the development of supporting infrastructures and research on social innovations to cope with the restructuring of industries triggered by rallying raw material prices (including oil) and increasing global efforts to reduce CO2 emissions.

- The German automotive industry has been very successful in attracting substantial quantities of science and engineering graduates almost at the expense of other industries. Lifting the level of tertiary educated people would not only allow a more balanced growth of the economy but would lift already existing shortages of scientists and engineers. This suggestion, of course, rests on the successful introduction of reforms to primary and secondary education in Germany.

While the times ahead may bring more variation in the industry, the German producers seem overall well aware of the challenges ahead and have invested more or have at least kept their level of investment to secure their market share and to catch-up technologically in some areas. The established networks, the achieved technological sophistication and the changed strategic orientation put them in a good position to come up with solutions and business models for individual mobility and transport that are environmentally and societal sustainable.
6 References


Rindicate (2009), Sectoral analysis of the long-term dynamics of business R&D Intensity, Brussels.


VDA (2009), F&E-Leistungen auf Rekordniveau, Politikbrief 01/2009.
7 Contact Details

Author
Hannes Leo
Associate Consultant to Technopolis Belgium
T: +43 664 3520812
Hannes@leo.on.at

Experts taking part of the study group as interviewees:

Jochen Otterbach
BMW Group
Head Innovation and Technology Management
80788 München
T: +49-89-382-61983
Jochen.Otterbach@bmw.de

Birgit Hofmann
Consultant (Referentin) in the Automotive Industry department - IVA5
Federal Ministry for Economy and Technology
Scharnhorststr. 34-37
10115 Berlin
T: +49 30-2014-7203
Birgit.Hofmann@bmwi.bund.de

Dr. Friedrich Preißer
Head Research Association for Automotive Technology
VDA
Westendstraße 61
60325 Frankfurt
T: +49 69 9 75 07-247
preisser@vda.de

Prof. Dr. Joachim Axmann
Future Research and Trend Transfer
VW
Brieffach 1252
D-38436 Wolfsburg
T: +49 531 948497
joachim.axmann@volkswagen.de

Hans-Georg Kusznir
External Relations, Science and Technology (K-GK-A2)
Brieffach 1252
D-38436 Wolfsburg

Dr. Georg Licht
Head Industrial Economics and International Management
ZEW
Postfach 103443
68034 Mannheim
T: +49 6211235177
licht@zew.de
“Sectorial analysis of the long-term dynamics of business R&D intensity”

In relation to (DG-RTD-2005-M-02-01):

“Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators”

Case study
Business Expenditures in R&D in Sweden: the case of the ICT industry and the Radio, TV and communications equipment sector

Dr Rurik Holmberg
Technopolis Group

Coordinated by

Brussels, 12 November 2009
# Table of contents

1. **Synthesis** 350
2. **Business expenditures in R&D in Sweden** 351
   2.1 The context 351
   2.2 The ICT industry in Sweden 353
   2.3 Developments of the ICT industry 355
3. **Analysis of BERD drivers in the ICT industry and the Radio, TV and telecommunications equipment sector in Sweden** 357
4. **The role of public policies in determining BERD performance and BERD intensities in Sweden** 360
5. **Conclusions, lessons learned and policy options** 362

Bibliography 364
Business Expenditures in R&D in Sweden: the case of the ICT industry and the Radio, TV and communications equipment sector

1. Synthesis

Swedish business enterprise research and development (BERD) is remarkably high in relative terms in an international context. Approximately one-fourth of Swedish BERD takes place in the ICT sector, with telecom giant Ericsson as the key player. Thus, developments in the Swedish ICT sector are of interest well beyond Sweden.

Because of the dominant role of Ericsson in the Swedish ICT industry, the development of Swedish BERD is analysed mainly through the prism of Ericsson. By and large, the rest of Swedish BERD in the ICT sector has to take into consideration or even adjust to decisions made by Ericsson.

In the late 1970s, Ericsson, together with the Swedish Telecom Agency, developed the first analogue mobile telephone standard. When the European telecom markets were deregulated soon afterwards, Ericsson turned out to be well-prepared for the introduction of the digital standard, the GSM.

The business environment in the ICT sector has changed profoundly since the early 2000s. Rapid technological development has spread ICT to several other sectors, especially other technologies. To keep up with the pace of the changes is a fundamental challenge for companies in the traditional “core ICT”. Therefore, it has become crucial to understand several sectors and to cooperate with companies possessing specific knowledge. Increasingly, the ICT sector is shaped by demand in other sectors.

In parallel with this development business is increasingly specialised. There is increasingly less scope for the production of general-purpose hardware, but instead several niches have emerged for producers of solutions including software. Also subcontractors are increasingly required to produce entire solutions instead of single parts.

The profound changes mentioned above have caused a shift in R&D from research towards development and innovation. At present, conducting basic or even applied research appears to be too far away from the market and these segments are increasingly the responsibility of governmental agencies (such as VINNOVA in Sweden). Furthermore, R&D in the ICT sector is characterised by many small steps, but taken at a very rapid pace.

A result of the changes is that major companies tend to look for cooperation instead of outright competition. The relatively few government regulations in the sector have caused a certain degree of internal consolidation within the industry.
2. Business expenditures in R&D in Sweden

2.1 The context

On a European level, the share of Swedish business research and development (BERD) is clearly exceeding the size of the country, with a population just exceeding nine million. From figure 1 below, it can be seen that the Swedish share of European BERD is of similar magnitude than that of several bigger countries. The reasons for this are manifold, but to a large extent the figures illustrate the fact that Sweden over a long period of time has successfully developed numerous industries in both manufacturing and services, which at least partially have been able to maintain their knowledge-intensity up to this date.

Figure 1. Total BERD in Europe, 2005

Source: Rindicate-2009

It is worth noticing that in contrary to many other countries, Sweden’s share of BERD remains the same for both manufacturing industries and services (i.e. 5%). However, this might only be a temporary phenomenon, as Swedish business is increasingly moving towards becoming more service-intense. This development has been rather slow, though. Manufacturing industries (NACE15-37) account for 86% of BERD, while services (NACE50-99) stand for 13%. R&D intensity (R&D expenditure as a proportion of sales) in manufacturing industries combined is 13% and in services 0.6%. As will be seen below, this average figure for the manufacturing industries contains significant sectoral variations.

Four sectors dominate Swedish BERD, namely:

- Radio, TV and communication equipment
- Motor Vehicles
- Pharmaceuticals
- Machinery & Equipment

Taken together, these sectors accounted for almost two-thirds of Swedish BERD between 1995 and 2006. Moreover, with an additional eight sectors (see figure 2) more than 90% of Swedish BERD is included.

**Figure 2.** Trends in the shares for BERD in Sweden: 1995-2006

![Bar chart showing trends in R&D intensity for various Swedish industrial sectors.](chart)

Source: Rindicate, 2009

Only minor shifts in the BERD structure took place between 1995 and 2006, the most important of which was the decrease in the importance (in R&D terms) of R&D services and Machinery & Equipment. This might look different in the near future because the present crisis seems to have hit the Swedish motor vehicle industry particularly hard. On the other hand there are some signs that the automation industry, on the contrary would have gained ground, which might be reflected in future R&D statistics. The very high share of the ICT industry has even slightly increased.

In figure 3 the trends in R&D intensity for various Swedish industrial sectors are presented.¹ Sectors where an increase has taken place are in particular motor vehicles and electronic equipment, while a decrease has taken place in aerospace and pharmaceuticals. Concerning the aerospace industry, there is basically only one Swedish producer, SAAB, and at least partially the decrease has to be attributed to the complications of selling a fighter aircraft, in particular as a consequence of a changing international environment, where neutrality of the producer is no longer necessarily a

---

¹ The category Radio, TV and Communications equipment (NACE 32) consists of estimates only from 2001 onwards, which raises questions on reliability.
decisive argument. In the case of pharmaceuticals, the merger of Astra with British Zeneca might have caused some R&D to move away from Sweden.

**Figure 3. Trends in Sectoral R&D intensity in Sweden: 1995-2006**

Despite the possible inaccuracies concerning the category Radio, TV and communications equipment in Figure 3, it is obvious that this sector has increased its R&D content dramatically over the last 15 years as reflected in the figure. The reasons for this will be described in detail below, but by and large it is an issue of a rapidly and profoundly changing global market. Put differently, if there would have been no intensification of R&D, the entire industry would not have been competitive any longer.

### 2.2 The ICT industry in Sweden

For further analytical purposes in this report, the Radio, TV and Telecom equipment sector will be treated as corresponding to the ICT sector. Despite the fact that the two concepts are not synonymous, both ‘sectors’ are dominated by the telecom giant Ericsson, which justifies the simplification. More than 70% of Swedish BERD in ICT is conducted by Ericsson while the corresponding share of Ericsson in Radio, TV and Telecom equipment is approximately 80%. Ericsson’s share of total Swedish BERD (of all sectors) is 18%. This dominance of Ericsson in BERD in ICT implies that a study of BERD in ICT in Sweden will almost by necessity have to put focus on Ericsson.

Sweden is relative to its size one of the global top performers in most aspects of ICT. The Connectivity Scorecard 2009 puts Sweden in 2nd place after the USA, although with a

---

2 For instance both, Finland and Norway, had at various occasions declined to purchase the aircraft.  
3 According to Figure 2, TV, radio and telecom accounts for 23.4 % of Swedish BERD. The category ICT (see below) accounts for 26%. The concept of ICT includes in addition to the actual production of equipment also a number services, but with the notable exception of "content industries". Thus it is slightly broader than the category "TV, Radio, and Telecom".  
Source [www.itps.se](http://www.itps.se) (Institutet för tillväxtpolitiska studier)
small difference margin. According to the Connectivity Scorecard, Sweden shows no weaknesses in the indicators measured and has "the most balanced and best-rounded performance of any country on the Scorecard". Moreover, Sweden "has the highest proportion of individuals employed in ICT specialist skill occupations" and "ICT investment as a share of total investment is higher in Sweden than in all OECD member countries barring the USA. Sweden is one of the leading investors in knowledge in the OECD, along with the USA and Finland". However, despite such praise, there are underlying issues that Sweden has to tackle if it wants to maintain its position, one of which is the decreasing level of general education. It also seems that at present Sweden is undergoing a process of industrial restructuring, from manufacturing to services. How this process is managed is crucial for Sweden's future industrial and thus overall economic performance. Despite the fact that Sweden is ranked very high on the Scorecard and other lists in terms of ICT performance, Sweden has a tendency to be better at reaching high averages than being an outstanding performer in particular sectors.

The ICT sector accounted for 26% of Swedish BERD in 2007. Total Swedish BERD in 2007 was SEK 81 billion (approximately EUR 8 billion), out of which 82% was carried out by large companies, with more than 250 employees (Statistics Sweden 2008). One particular complication arises when analysing a genuinely global sector like ICT in national terms, namely how to count for R&D conducted abroad. For instance approximately only 50% of Ericsson's R&D is done in Sweden, but taking into consideration that Ericsson’s total R&D expenses (in 2008) were close to SEK 30 billion (EUR 3 billion) means that a significant part of Swedish R&D is still stemming directly from Ericsson (Ericsson Annual Report 2008). Because the R&D carried out by Ericsson in Sweden is a part of a global structure, analysing it within a national framework will not produce a complete picture.

Total employment in Swedish ICT firms was 160,000 in 2006, out of which 100,000 were working in Sweden. Total number of ICT staff in the Stockholm region only was 86,000. A third of all R&D-researchers in Sweden were employed in the ICT sector in 2006. BERD in manufacturing ICT in 2005 was 0.7% of GDP while the corresponding figure for ICT services was 0.3 (OECD 2008).

The telecom industry in Sweden consists of three major players; Ericsson, Sony Ericsson and TeliaSonera. In addition to these, there are of course numerous smaller actors. It should be mentioned that Skype was founded in Sweden.

TeliaSonera, the result of a merger between the once national monopolies in Sweden and Finland, is today a leading provider of telecom services in the Nordic region as well as in Spain, Russia, and Turkey. The number of employees is 32,000.

Ericsson is a global provider of telecom equipment and services to mobile and fixed network operators. Ericsson is operating in 175 countries and has approximately 60,000 employees worldwide. Ericsson’s core business areas are: networks (68% of total sales), professional services (23%) and multimedia (9%).

Sony Ericsson was founded in 2001 as a joint company (owned 50-50 by Sony and Ericsson) producing multimedia devices, in particular mobile telephones. The company headquarters are located outside Sweden. The number of employees is approximately 50,000.

---

4 The performance of the Swedish education system has been one of the major political issues for at least a few years in Sweden. In this context it should suffice to mention that there have been several reports from the institutions of higher education claiming that the level of especially mathematics among new students is alarmingly low.

5 There might be an illusion of discrepancy here: R&D in ICT appears to be altogether 1% of GDP, which would make its share of BERD far higher than 26%, as mentioned above. However, these figures also include R&D conducted abroad, which explains the otherwise inexplicably high figure.
Huawei opened its “R&D institute” in Stockholm in 2001. Currently it employs 80 persons in R&D. Press reports from 2008 and 2009 paint a picture of competition for qualified staff between Ericsson and Huawei. For instance, in October 2009, Huawei employed 15 engineers made redundant by Sony Ericsson in Kista. Other reasons for Huawei to invest in R&D in Stockholm include the existence of qualified consultancy services, low total costs, and transparent authorities.

Other companies conducting R&D in Sweden (mainly Stockholm Kista) include Hewlett-Packard, IBM, and Tieto.

2.3 Developments of the ICT industry

As was explained above, given the heavy impact Ericsson has on Swedish BERD in general and its almost dominant share in BERD in the ICT industry, it becomes fruitful to put Ericsson in the foreground when analysing changes and BERD drivers in the Swedish ICT sector.

One of the major changes in ICT-BERD in the last two decades is the deregulation of the European telecom market. Before the liberalisation, during the era of national monopolies, each company was obliged to perform its own R&D in order to be able to respond to demands by the respective governments. The consequence was a less innovative environment, because the individual national telecom companies were actually doing similar things with relatively small resources. In some cases one crucial task was to maintain a level of R&D just high enough to be able to utilise developments abroad. This requirement to maintain domestic R&D disappeared in connection with the liberalisation process and most national monopolies almost completely abandoned not only their R&D activities, but also their infrastructure and equipment and turned into service providers exclusively. The abandoning of small R&D efforts opened a niche for major European players.

This development opened up a broad niche for Ericsson, which already back in the late 1970s had been one of the original developers, together with the Swedish Telecom Agency, of the analogue mobile telephone standard, NMT. At this time the first steps to coordinate action with other national telecom agencies were taken in order to develop the digital system, which was to be called GSM. In the 1980s the basics of digital technology were already known and it was obvious at Ericsson that if the company would venture into this field, it would already possess the knowledge needed. It was not even considered particularly visionary any longer. The fact that the engineers of Ericsson actually possessed the skills was a consequence of the Swedish universities having been engaged in the mobile communications’ field already before. If this had not been the case, it is likely that Ericsson could not have taken the lead in the digital development. In the early 1990s, NMT was replaced by GSM. This has had a decisive impact on the European telecom market, not the least because it created a common standard throughout Europe. In the USA, where the government attempted to be technology neutral, the telecom industry more or less fell apart. These experiences point at the need for policies to be involved in major trends in ICT.

From the early successes with the NMT a virtuous circle would develop a few years later. In 1987, STU (a predecessor of today’s VINNOVA – the Swedish governmental agency for innovation systems) launched a major programme for digital communication, which doubled research funding, which in turn led to a major increase of researchers, who could

---

6 See e.g. Sydsvenska Dagbladet 20.10.2009 and NyTeknik 12.3.2008 and 31.10.2007
7 www.stockholmbusinessregion.se/templates/page_39231.aspx
8 It should be noted that the successor of the Swedish Telecom Agency, TeliaSonera, no longer focuses on research and development to the same extent and consequently employs less qualified R&D staff (Arnold, Good & Segerpalm 2008).
be employed by Ericsson just in time for the major breakthrough of the GSM system. Had it not been for this and other subsequent programmes by VINNOVA, it is unlikely that Ericsson would have had access to the qualified staff needed. Another important aspect behind the success was the smooth cooperation between research carried out at universities and the industry, mainly Ericsson (Arnold, Good & Segerpalm 2008)9.

These developments gave Ericsson a significant lead in the future developments. By and large, the Swedish telecom industry BERD (and thus ICT in general) came to lie on the shoulders of Ericsson. But the development in BERD has not been smooth; Ericsson’s R&D expenditures as a percentage of turnover have followed a rather unstable path; until 1989, R&D remained below 10% of turnover, but jumped to above 15% in the following years. In the aftermath of the severe crisis in Sweden in the early 1990s, this ratio dropped for several subsequent years only to hike dramatically around the turn of the millennium, reaching 25% in 2001–2002. The following years this figure dropped back to around 15 (Arnold, Good & Segerpalm 2008: p.20).

One important element for Ericsson was that it had already for a long time been export-oriented. The Swedish market was too small to provide any “big-country-advantages” and thus the prevailing insight was that in the end the public sector could not come to Ericsson’s assistance. The biggest threat to Ericsson was that other, bigger European countries would allow state intervention in the development of the new digital technology GSM and thereby providing direct support to their own telecom companies. This threat was never materialized and Ericsson was able to reap the rewards from its preparedness. The developments in the USA were of particular interest, because despite the fact that no telecom policy had been formulated, the market had been liberalized and operators put orders with Ericsson.

Today Ericsson puts less focus on mobile telephones, the development of which has been transferred to Sony Ericsson (where Ericsson holds a 50% stake). Instead Ericsson’s core business is in base stations and structures. This opens up significant market potential especially in the developing countries. The advantage of this strategy is that demand is less trend-sensitive than with mobile telephones. This also puts Ericsson in a more favourable position in the value chain.

Ericsson has concentrated its R&D activities to Kista outside Stockholm. It has been followed by a number of other companies and currently Kista is considered one of the leading European centres for various ICT areas, such as wireless technology and services, broadband development, applied ICT in finance, media, automation and life science.10

9 In their study Arnold, Good & Segerpalm (2008) identified the numbers of “mobile-relevant” PhD graduates between 1973 and 2006. There were approximately ten PhDs produced in this field between 1973 and 1980. This figure jumped to around 20 for the periods 1981 – 85 and 1986-90. Between 1991 and 1995 a total of 40 PhDs were produced, between 1996 and 2000 the number was 60 and between 2001 and 2005 a total of 70 relevant PhDs were produced. This increase has been followed by a dramatic increase of “mobile-relevant” PhD-holders employed by other companies than Ericsson (but neither employed by universities), p.18.
10 www.stockholmbusinessregion.se/templates/page_21496.aspx
3. Analysis of BERD drivers in the ICT industry and the Radio, TV and telecommunications equipment sector in Sweden

When discussing R&D in the ICT industry one crucial aspect that has to be emphasised, is the spread of ICT to other sectors of industry. Important developments in ICT are increasingly reflected also in for instance the automobile industry (operational systems, security, and production), medical technology (analyses, processes and new materials) and the biotechnology sector. This of course also applies in both directions, i.e. that demand from other sectors shape the ICT industry and define its priorities. The direction and focus of R&D are thus to an increasing extent determined outside the ICT industry itself, which requires actors in the ICT industry to be able to thoroughly understand the needs of a vast number of other industries.

Another trend is that the ICT companies themselves are increasingly specialized. Being a broad producer in ICT is close to impossible today. When in 2000 Swedish ICT was very much centred on telephones and mobile systems as broad, separate activities, today technology and its applications are welded together in a narrower niche. In this respect the Swedish ICT industry faces a threat; although Swedish R&D in the “core ICT” remains strong, the fact that ICT has increasingly spilled over to other sectors puts new demands on R&D. For this reason, unless R&D in Sweden becomes more focused, there will be a risk of lagging behind on a broad scale, i.e. not only in ICT itself. This threat has been counteracted by Swedish companies through e.g. participation in transnational research clusters, but also by locating R&D to several countries in order to gain from local areas of strength. Ericsson manifests this development. Approximately 50% of Ericsson’s R&D takes place in Sweden, followed by China and the USA. The focus on Sweden is simply a result of Ericsson being originally a Swedish company, but otherwise the fact that a decisive share of R&D located in Sweden is not the result of any particular policy decisions. However, there is a climate in Sweden supporting work with complicated products, which supports maintaining R&D in Sweden. Such a climate cannot be ordered through hierarchical structures, but instead a sense of cooperation is required. This is more a cultural issue than a political one. However, the fact that Huawei and Nokia are performing R&D in Sweden (literally next door to Ericsson) indicates that these companies too are specialising by utilising specific skills present in the Stockholm region.

At present, Ericsson has R&D activities in 17 countries, which however might be too many in terms of efficiency. On the other hand, once a particular competence has been developed, it cannot simply be shut down. Another important aspect is the need to be present in relevant clusters. The existence of excellent universities in a particular place is not sufficient; when Ericsson acquired Redback Networks in California in 2007, it also acquired a strong base in the dynamic Californian ICT sector. As was mentioned above, in Kista outside Stockholm where Ericsson has its headquarters, an ICT cluster of global importance has emerged. It is a political challenge to pay sufficient attention to the formation of clusters, because they significantly contribute to keeping skilled workforce in the country, while at the same time the clusters support universities through interaction (and by providing a labour market for the graduates). In 2007, a joint research centre under the auspices of the Royal Institute of Technology was created through support from Ericsson, Huawei, Telia Sonera, Saab Communications and the Swedish Governmental Agency for Innovation Systems, VINNOVA.

---

11 Ericsson has R&D in Spain, Italy, United Kingdom, Hungary, Finland, Sweden, Denmark, Germany, Ireland, Norway, Canada, USA, Japan, China, Brazil, and India.
12 NyTeknik 12 december 2007. The research centre is called Wireless@KTH
In general it can be said that very few start-up companies ever grow really big. Instead large companies attract small sub-contractors, not vice versa. However, as a consequence of the great downturn in the early years of the 2000s, Ericsson closed between 25 and 30 design centres, which were partially a remnant from the times of the monopolies acquired by Ericsson. From these cuts, in terms of employees, some 50% took place in Sweden. In the ensuing years, a profound globalisation of the ICT sector has taken place and R&D is increasingly located where competitive advantages are identified.

Ericsson’s R&D decisions are also affected by the fact that new products need to be compatible with older equipment, in contrary to e.g. start-up internet companies. Moreover, the demands from operators have become increasingly tough and informal networks are often a prerequisite to be able to do business. For instance, the R&D centre in Hungary stems by and large from the experience of several earlier business agreements. Of course, low costs and the presence of skilled labour force were important, too, but not by any particular decisions coming from the Hungarian government.

In ICT the focus of RD&I has dramatically shifted from research towards development and innovation. The creation of the NMT was heavily based on research and a number of ensuing major scientific and technological breakthroughs. Today, the R&D contents of ICT products remain high, but the individual steps taken in R&D are actually rather small. Because these small steps are taken at a tremendous pace, products are renewed constantly while old R&D has no value in the market. From the consumers’ perspective this pace is manifested in ever better products. Also in non-ICT sectors spillover from this rapid development can be felt, usually in terms of embedded ICT solutions.

Another trend is the “servicification” of inputs by subcontractors. Sub-contractors are only decreasingly producing something in strictly technological terms, but rather complete service packages, or complete sub-systems. This trend has produced several layers of subcontractors focused on particular sub-systems, which causes further specialization of R&D.

At present, the ICT industry has been searching for cooperation instead of competition. This is particularly important in developing technology standards and platforms. This in turn allows for faster development and therefore the amount of R&D increases when initial uncertainty about future standards is removed. In mobile communication, the broad acceptance of GSM was the key to reduced uncertainty.\(^{13}\)

There are often concerns voiced that with foreign acquisitions of Swedish companies that R&D will move abroad. At a first glance, there appears to be an abundance of concrete examples, such as when Ericsson sold its production unit for semiconductors to Infineon, which soon afterwards moved the production abroad. There was no qualified production of semiconductors left in Sweden. Such developments should be interpreted in terms of business dynamics, and maybe even in positive terms, because developments like this have led to increased focus in Swedish R&D. Semiconductor production is not a necessary part of this. So far nothing in the ICT sector has actually left Sweden, because gains from rationalizations appear in other parts of the industry. However, a prerequisite for such dynamics is that there is an ICT industry in Sweden, which in turn is completely dependent on the access to skilled workforce. Contrary to the ICT sector, the development in the automobile industry has an effect on society on a broader scale.

\(^{13}\) But what if the standard is somehow wrong? Competition occurs to a large degree between technologies (and of course in this respect also between companies). For instance, Blue ray recently pushed HD DVD from the market and the main producers of the latter simply informed that they would switch to the victorious technology.
because of the structure of subcontractors’ networks. The structure of the ICT industry is more flat (and more globalised) and thus the network as such will remain regardless of where some nodes are located.

Today, the global scene has changed dramatically and there is now more outward than inward movement of Swedish R&D in ICT. Nevertheless, strong local clusters have emerged, such as Kista discussed above, Stockholm’s “Wireless Valley”. Sweden’s strengths in attracting foreign investment in R&D are highly qualified researchers, openness towards new ideas, and strong cooperative patterns. This latter aspect is well illustrated by the actions of VINNOVA (and its predecessors) in the 1970s and 1980s, especially in connection with the development of the NMT standard.

Ownership structure appears to have little impact on R&D intensity. However, in the case of the Swedish ICT industry the sample is simply too small (and with too little diversity in ownership structure) for drawing other than highly cautious conclusions. The fact that the first mobile telephone standard, (the NMT) was created by Ericsson in cooperation with the Swedish Telecom Agency – a government body – indicates that there have been no obvious differences whether the actor is a joint stock company or a government agency.

However, when there is international ownership involved, the market is more often perceived as global, which in turn tends to strengthen overall R&D, while national ownership tends to imply focus on the domestic market. This trend can also be identified in those cases when there is a Swedish subsidiary to an international company. The subsidiary tends to try to be successful within the company in order to get more demanding tasks in R&D.

There is one Swedish macroeconomic development that might have contributed to the persistence of R&D in Sweden. For decades, Sweden kept up its industrial competitiveness through a series of devaluations. Together with the compressed salaries, which have been a cornerstone of the Swedish labour market (i.e. small difference between low and high wages), this has probably led to more investment in Swedish R&D staff, which thus has been perceived cheap in comparison to foreign R&D staff. In comparison to Germany with a rather similar industrial structure, it can be observed that there is more R&D in Sweden in relative terms.\footnote{It should be clarified that this does not imply that overall salaries, or labour costs as such, would be low in Sweden. However, the fact that salaries on the higher end of the scale appear to have been lower in Sweden than abroad has stimulated investment in knowledge-intensive activities (while activities not requiring particular skills have fared worse than abroad).}
4. The role of public policies in determining BERD performance and BERD intensities in Sweden

In the 1970s and 1980s, the contribution of academic research to the development of ICT in Sweden was crucial. But as a consequence of the fundamental changes in the industry described earlier (i.e. that R&D takes place closer to the market, with emphasis more on product development and less on research) the picture has become less clear. Therefore there is a risk of research and development entering parallel roads, which would hamper the so far successful cooperation that laid the foundations for the success of the Swedish ICT industry. However, public policy can have the function of signalling that some particular developments are considered important. Such developments have taken place before, for instance with safety issues in the automobile industry, which gave Swedish producers a competitive advantage.

Major Swedish companies such as ABB, Ericsson, the automobile industry, the medical technology industry and parts of the process industry are well aware of the risk of not having sufficient numbers of top researchers in Sweden in the future, especially against the above-mentioned background that ICT proliferates into several other industries. The Swedish Governmental Agency for Innovation Systems, VINNOVA, has been trying to counteract this potential threat by launching support programmes for R&D in the ICT sector. The first programmes for R&D support for the ICT sector date back to the 1970s, and several programmes, the latest of which was launched in 2008, have followed them (Arnold, Good & Segerpalm 2008). The results from the previous highly successful interaction between publicly funded research and the rise of Ericsson as a global actor in mobile telephony serve as an encouraging example. Nevertheless, there are concerns that this is not enough for the promotion of innovations and for counteracting the so-called “Swedish paradox”, according to which Swedish innovative ideas turn into marketable products only abroad.

Swedish ICT needs earlier financing. In Finland for example, TEKES, the counterpart of VINNOVA, has twice the total resources despite Finland being significantly smaller. A long-term perspective is needed for international competitiveness, especially in ICT where the turnover pace of innovations is very high. Many policy-makers in Sweden perhaps not properly understand this.

The focus of Swedish policy measures is usually in basic research and despite the VINNOVA programmes, it remains rather difficult to find support for high-risk priorities. R&D is also a question of foresight, which is crucial for Sweden if it wants to maintain its global position in ICT. VINNOVA has started financing researchers conducting R&D for small companies, which otherwise would probably not dare to invest in R&D. However, in these cases the companies themselves define their priorities.

An issue perceived to be typical for Sweden is that of employee mobility. It has often been claimed that due to particular designs in the Swedish social safety net, many employees are reluctant to change employers. This becomes evident in the low mobility amongst researchers in academia, for whom both academic traditions and the social safety net counteract changes of workplace. It can be asked whether some support system for researcher mobility could be created. Also the rest of the labour market would need increased mobility, but at present this is not stimulated and this in turn is an obstacle to radical product development, which more often tends to take place in start-up firms.

15 VINNOVA is financing two Centres of Excellence in the ICT field; “ICT-the next generation” (at the Royal Institute of Technology) and “The Linköping-Lund Initiative on IT and Mobile Communication”, which aims at developing capacity for new telecom systems and platforms. Source: www.vinnova.se
**Cooperation patterns of R&D within the EU** and with support from EU structures have perhaps not lived up to the expectations. On the one hand, common standard setting has been important, but on the other hand the slowness of the EU structures and the ensuing poor capability to react to the sometimes extremely rapid changes in the ICT sector makes big companies reluctant to participate whole-heartedly (in particular because the funding of joint projects goes to the universities directly), while SMEs lack the resources to cover the transaction costs for participation.

Another potential problem is that in high-tech **many other countries have strong political commitments** to reach the top. This attitude is nowadays almost completely absent in Sweden, which seems to have taken a more liberal approach than others. Previously the public sector strongly supported Swedish industry and perhaps the time has come to review the practices and focus on being excellent.
5. Conclusions, lessons learned and policy options

The performance of the Swedish ICT industry has so far been extraordinary, but the industry relies on a small number of companies. In particular one company, Ericsson, is in many cases almost synonymous to the Swedish ICT industry. However, the cornerstone of the Swedish performance in the ICT sector was initially the cooperation between the public sector and Ericsson. The role of academic research and the universities’ role in training skilled engineers are of crucial importance in the development.

The key factors and developments behind R&D decisions identified in this report are:

- The internationalisation of R&D
- The spread of ICT to several industrial sectors
- The increasing specialisation among ICT companies
- The need for (some) new products to be compatible with older equipment
- The shifting of focus from research towards development and innovation due to the very high pace of developments
- The cooperation patterns partially replacing competition

In the last decade, R&D in the ICT sector has been characterized by the rapid change towards a global market. National boundaries have lost their meaning for the ICT industry and R&D activities are increasingly concentrated where they are most productive. Also the rapid pace of renewal in the ICT industry requires constant product improvement, often as a sequence of a large number of small steps, but at an extraordinary speed. In order not to split resources, companies have to focus. This in turn favours the creation of alliances around some particular technology.

The spread of ICT to other industries puts pressure on the Swedish ICT skills to be able to meet the needs emerging in e.g. the automation industry or the automobile industry, where R&D cannot perhaps be separated from production to the extent that has taken place in the ICT industry itself.

Another major trend is the movement from the production of purely hardware towards the development of software, i.e. providing products with contents and thus facing increasing specialisation. A particular case of specialisation occurs when some particular branch of R&D is moved from Sweden to locations abroad. This is often perceived as a loss. Instead such developments can also be interpreted as a step towards increased focus in R&D in Sweden.

These trends have forced ICT companies to put much more emphasis on development than research; the latter broadly speaking being left to the public sector and universities to conduct. However, from a Swedish perspective, it is an issue whether the universities are interested and/or capable of making the same strategic choices as the ICT industry.

Cooperation between companies in ICT is commonplace today. This generates a certain safety when standards and platforms are agreed upon. This in turn has contributed to the high pace of technological development.

Sweden has neither been highly successful nor unsuccessful in attracting foreign investment in R&D. There are strong milieus, however, with Kista outside Stockholm as the most outstanding example.

Swedish industrial policy in the last decade has been rather indifferent (not only towards ICT). Industry has been assumed to take care of itself. In many respects this has been a successful path, but now there are concerns that competing with companies from countries with strong policy support for industry may prove too much of a challenge.
After two decades of policies favouring liberalisation and deregulation, many analysts both, within and outside the Swedish ICT industry, call for the return of public sector involvement.
CONTACT DETAILS

Case study author:

Dr Rurik Holmberg
Technopolis Group in Estonia
Harju 6 - 411
10130 Tallinn,
Estonia
T: +37 2 631 0525
rurik.holmberg@technopolis-group.com
www.technopolis-group.com

Experts taking part of the study group as interviewees:

Johan Ancker
Director R&D and Education
The Association of Swedish Engineering Industries
Storgatan 5
Box 5510
114 85 Stockholm
T: +46-8-782 08 00
johan.anker@teknikforetagen.se
www.teknikforetagen.se

Olof Ejermo
Researcher
Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE),
Lund University
LUCIE-huset, Sölvegatan 16
P.O. Box 117
221 00 Lund
T: +46-46-222 9650
Olof.ejermo@circle.lu.se
www.lu.se

Jan-Erik Stjernvall
Head of HR&O Group Function Technology and Portfolio Management, Ericsson
Torshamnsgatan 23, Kista
164 83 Stockholm
T: +46-10-719 00 00
Jan-erik.stjernvall@ericsson.com
www.ericsson.com

Jonas Wallberg
Head of Information and Communications Technology Department
The Swedish Governmental Agency for Innovation Systems (VINNOVA)
Mäster Samuelsgatan 56
101 58 Stockholm
T: +46-8-473 30 00
Jonas.wallberg@vinnova.se
www.vinnova.se

Bibliography

Ericsson Annual Report 2008

OECD (2008), OECD Information Technology Outlook 2008

Rindicate (2009), Sectorial analysis of the long-term dynamics of business R&D intensity. Interim progress report n°2: Results of Phase 1 activities


Internet sources

www.connectivityscorecard.org
www.ericsson.com
www.itps.se
www.sonyericsson.com
www.teliasonera.com
www.vinnova.se
“Sectorial analysis of the long-term dynamics of business R&D intensity”

In relation to (DG-RTD-2005-M-02-01):

“Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators”

Case study

Business Expenditures in R&D in Finland

Dr Rurik Holmberg
Technopolis Group

Coordinated by

Brussels, 13 November 2009
# Table of contents

1. Synthesis 368
2. BERD performance in Finland 369
3. BERD drivers in Finland 374
4. The role of public policies in determining BERD performance and BERD intensities in Finland 380
5. Conclusion, lessons learned, and policy options 383

Bibliography 386
Business Expenditures in R&D in Finland

1. Synthesis

The Finnish Business Expenditure on R&D (BERD) is dominated by telecom giant Nokia, which accounts for approximately 50% of total BERD in Finland. Within the ICT sector this dominance becomes almost complete. Thus any analysis of BERD trends in the Finnish ICT sector will at the same time by necessity need to focus on the strategic actions taken by Nokia.

Since 2000, the ICT sector in Finland has been characterised by rapid internationalisation, and consequently the Finnish ICT sector has become adjusted to a global field of activity. The domestic market is no longer decisive. The ICT sector is also characterised by increased technological convergence, i.e. that various technologies tend to become intertwined. This has forced ICT companies to step up their R&D in several sectors, often through acquisitions, mergers, and alliances. Another characteristic of the ICT sector is the pace of development; new or significantly improved products and services replace existing ones within a very short time span.

The very rapid development in the ICT sector has a profound impact on R&D. First, there is a shift from research to development. Second, the way R&D is conducted changes. Open innovation is increasingly a part of R&D in the ICT sector. In particular this implies that users have a bigger part in the development of technology and as a result R&D is increasingly sensitive to demands by the users. Another new development is the creation of "lablets", which are institutionalised cooperation between firms and universities. Nokia has located part of its R&D to renowned universities worldwide.

The success of Nokia has not been followed by neither a general upswing in ICT-related R&D in Finland nor significant FDI in R&D. This is perceived a major problem, because a big influx of foreign R&D would likely intensify the R&D efforts of ICT firms, which tend to be below expectations despite Nokia’s success. Foreign FDI in ICT R&D would also contribute to a diversification and consequently less reliance on Nokia only.

The Finnish public sector has recently stepped up its activities for promoting R&D, especially in sectors not directly related to Nokia. However, because of Nokia’s growth in especially the ICT service sector, it becomes justified to ask whether the present pattern – the giant Nokia surrounded by by several subcontractors - will instead reproduce itself, leaving Nokia deciding the direction of R&D in ICT.
2. BERD performance in Finland

Any analysis of Finnish R&D has to address the fact that the telecom giant Nokia stands for roughly one-third of Finnish gross expenditure on R&D (GERD). The remaining two-thirds are more or less equally divided between the public sector and all other enterprises. Indeed, Nokia’s R&D expenditure accounts for approximately 50% of BERD in Finland. In pecuniary terms, Nokia’s R&D expenditure is in the range of 2-3 billion EUR while the following places in the national ranking of BERD are taken by (Metso (pulp and paper), ABB (engineering), Wärtsilä (engineering), Orion (pharmaceuticals), LM Ericsson(ICT)), which have individually R&D expenditures only somewhat in excess of €100m. This extreme weight of Nokia has left its mark on universities, for example, which (perhaps hesitantly) tend to adjust their research activities towards the interests of Nokia. By and large, the entire Finnish R&D agenda in ICT is set by Nokia, and therefore any study of Finnish BERD – not to mention the specific category Radio, TV and telecommunication - has to focus on Nokia. Moreover, because of Nokia’s dominant role, separating Nokia and overall developments in Finnish R&D is not always possible and therefore these issues are discussed in parallel throughout this study. It should go without saying that the share of Finnish ICT industry profoundly independent from Nokia is insignificant. It also has to be pointed out that Nokia has undergone a process of change from an equipment producer towards a provider of Internet-related services and therefore it is increasingly difficult to fit Nokia into traditional categories, especially after the creation of Nokia Siemens Networks.

The sector ‘Radio, TV and telecommunications equipment’ is not synonymous of the ICT industry. However the overlapping, especially due to the dominant role of Nokia within both is big enough to treat them simultaneously. Radio, TV and telecommunications account for just below 50% of BERD, while ICT R&D is just above 50%. These figures coincide with the share of Nokia in BERD. According to the OECD’s definition, ICT is the “combination of manufacturing and services industries that capture, transmit and display data and information electronically”. A key feature in this definition is, according to the OECD, that it breaks the dichotomy between manufacturing and services, a dichotomy which, as will be seen in the case of Nokia, is becoming increasingly obsolete. Source: www.oecd.org/dataoecd

---

1 With Nokia Siemens Networks included the amount is roughly EUR 6 bn, being the largest R&D expenditures of any European company, see www.teknikkatalous.fi
2 The sector ‘Radio, TV and telecommunications equipment’ is not synonymous of the ICT industry. However the overlapping, especially due to the dominant role of Nokia within both is big enough to treat them simultaneously. Radio, TV and telecommunications account for just below 50% of BERD, while ICT R&D is just above 50%. These figures coincide with the share of Nokia in BERD. According to the OECD’s definition, ICT is the “combination of manufacturing and services industries that capture, transmit and display data and information electronically”. A key feature in this definition is, according to the OECD, that it breaks the dichotomy between manufacturing and services, a dichotomy which, as will be seen in the case of Nokia, is becoming increasingly obsolete. Source: www.oecd.org/dataoecd
In terms of broad aggregates, around 85% of Business R&D (BERD) in Finland is accounted for by manufacturing industries (NACE 15-37) and 12% by services (NACE 50-99). In the period 1995 to 2006 the relative importance of the former has decreased somewhat while the latter has increased correspondingly. R&D intensity in industries combined is 8.8% and in services is 0.5% (Rindicate, 2009).

Concentration of BERD

In terms of statistical classification, BERD in Finland is concentrated into Radio, TV and communication equipment, which accounted for 47% of total BERD in the period 1995 to 2006. The sub-category Radio and TV is almost insignificant in comparison; 10 million EUR or 0.2% of total Finnish BERD, which is less than 0.5% of the combined category Radio, TV and communication equipment (Statistics Finland 2007). Consequently, this category is completely biased towards telecommunications. The sectors Machinery and Equipment; Transport and Telecommunications services; and Pharmaceuticals follow this category in terms of expenditure. Together these 4 sectors account for 65% of total BERD. Moreover the 12 sectors shown in Figure 1 account for more than 90% of all industrial R&D.

Figure 1 shows the main trends in the structure of BERD in Finland since 1995. Three out of the four dominant sectors in R&D-terms have increased their share of the total: Radio, TV and communication equipment, Computer services, and Pharmaceuticals. At the same time Machinery and Equipment has declined in relative importance, as has among others Wood and Paper.

---

3 The category “Electronic components, telecom equipment and telecommunications” in Finnish statistics accounts for 2.45 billion EUR, or slightly more than 50% of total BERD. Moreover, the category “IT services” accounts for an additional 310 million EUR.

4 For the sake of clarity it should be mentioned that not all of Nokia’s R&D is carried out in Finland, and neither is all of Nokia’s R&D to be found in this category.

5 According to “common wisdom” in Finland, Finnish industry stands on three legs – paper, machinery and communication technology (the addition of communication technology is recent. Earlier the catchphrase was that Finnish industry was standing on two legs). It should also be pointed out that figures for R&D in wood and paper usually underestimate the actual R&D, which is of systemic character, i.e. the combination of machinery and a learning process. For a discussion on this topic (in a Swedish context) see Laestadius (1996).
Figure 1. Trends in the shares for BERD in Finland: 1995-2006

Trends in R&D Intensity

Figure 2 below shows that there has been a dramatic change in the R&D intensity in the pharmaceutical industry in Finland in the period 1995 to 2006. Before 2000, the R&D intensity was 36%, but this figure increased to 64% in the period up to 2006. The other sectors showing a positive trend are Radio, TV and Communications equipment, Electrical equipment, Instruments, Computer services and Fabricated Metals. In the remaining sectors there has been very little change.

Whether other sectors besides high-tech are important in R&D investments is a matter of definitions, because for example, the OECD defines high-tech as based on the share of R&D. The issue at hands is rather at the level of statistics, because there is only ambiguous information on what actually is accounted as R&D. One tendency observed is that too much focus is put on explicit high-tech R&D at the expense of incremental and tacit knowledge. The shipbuilding industry in Finland may serve as a good example of this. Statistically, the industry contains only little R&D, but in reality R&D is done elsewhere, mainly by subcontractors statistically active in other sectors: 25 years ago, 80% of R&D in connection with the construction of a new cruise ship was conducted by the shipbuilding industry; today 80% of R&D is done outside the sector. Software development, on the other hand, is a rather standardized activity, but it is statistically reflected as R&D-intensive.

---

It should be noted that the Finnish pharmaceutical industry is rather small on a global scale. There is one major company in Finland, Orion, which globally ranks as 70th in terms of size. Therefore decisions made by this company have a profound impact on statistics in this field for Finland. See www.orion.fi
Figure 2. Trends in Sectoral R&D intensity in Finland: 1995-2006

Source: Rinndicate, 2009

It is worth mentioning that contrasting trends can be observed for the two most important sectors in terms of BERD in Finland. In the largest sector, Radio, TV and Communications equipment, the share of total BERD increased from 43% in the mid-1990s to 50% in 2000-06, and the R&D intensity increased from 28% to 31%. On the other hand in the Machinery and Equipment sector, there has been a decline in the share of total R&D from 10% to 7% and a slight decline in R&D intensity from 7.4% to 6.6%. The pattern in Pharmaceuticals is similar to that in Radio, TV and Communications equipment.

According to the OECD Information Technology Outlook 2008 (OECD 2008), in 2004 ICT manufacturing comprised more than 25% of total manufacturing BERD in the OECD. In Finland the corresponding number was 63%. Moreover, in 2005 BERD in Finland in ICT manufacturing as a share of GDP was just below 1.4% and thereby the highest in the world. BERD in ICT services was 0.3% of GDP, which put Finland on a second place globally. In terms of R&D employees in ICT (full time equivalents), Finland was in the 9th place, which has to be related to the fact that Finland has a population only slightly exceeding five million. Among individual companies, in 2006 Nokia was in 6th place worldwide in terms of ICT R&D expenditures. But taken together, Nokia-Siemens would be in the 1st place globally (OECD 2008).

Against this background, it may come as a surprise that according to the Connectivity Scorecard, an international research programme linking increased national connectivity with socio-economic transformation, Finland reaches only the 11th position
internationally\textsuperscript{7}. Given its potential, Finland therefore becomes almost an under-performer in total ICT application, although a number of individual indicators are well above average\textsuperscript{8}. In consumer infrastructure, Finland has excellent tele-density and mobile penetration, high broadband speeds with good penetration in comparison to other countries surveyed, and comprehensive Internet usage. PC penetration is extensive and ICT skills are excellently distributed in the population. However, weaknesses are to be found in business using the Internet to buy and sell, SMS and voice activity, and FTTP (fiber-to-the-premises) deployment. The latter indicator might indicate significant regional discrepancies.

\textsuperscript{7} The Connectivity Scorecard is a cooperation between London Business School, the consulting firm LECG, and Nokia-Siemens Networks, see www.connectivityscorecard.org

\textsuperscript{8} In 2003/04 more than 25\% of Finnish investment was in the ICT sector, rendering it 3\textsuperscript{rd} place of countries measured (and most likely globally). ConnectivityReport2009 p. 37.
3. BERD drivers in Finland

The broad innovation system

Finland has not been outstandingly successful in generating big innovations, but instead been remarkably able to apply R&D-results from elsewhere. Thus, it is the absorption capacity in Finland that has made the crucial difference. Nokia, for example, has to a significant extent successfully drawn upon technology developed elsewhere. GSM is the perfect illustration of this.

The dominant sector in Finnish BERD, i.e. Radio, TV and telecommunication, (in practice, as was mentioned above, only telecommunication counts in this case) is characterized by relatively few radical innovations, because the very dynamics of the sector at present dictate gradual (instead of revolutionary) change, and thus radical innovation is not a prerequisite for developing successful applications. This can be contrasted to for instance the pharmaceutical industry, where radical innovation is more common, but where the risks for costly but unsuccessful R&D efforts are much greater. Innovations in medicine also require more than only consumer preferences to become accepted. Moreover, the rather smooth standardization process in the ICT sector can be seen in contrast to continuous heated debates over progress in biotechnology. Following this reasoning, Nokia rose to global prominence due to its capacity to adjust to the environment in the ICT sector based on gradual albeit rapid development. Also in the ICT sector the market mechanisms have rewarded those who successfully apply results from elsewhere, while public sector involvement in standard-setting has been limited.

The human resources in Finland are most likely sufficient for maintaining and edge in ICT; not only the absolute numbers of skilled personnel justify this claim, but also the specific cooperation culture\textsuperscript{9} and competitive universities, which is the only way to develop R&D strengths in the long-term. In order to maintain the present level of human resources, the Finnish university sector, albeit having produced very good results so far, will have to constantly review its progress. Also new types of universities are needed which have a profound understanding of the R&D-needs of the enterprise sector. In 2010 the new Aalto University in Helsinki will become operational. This university is the result of a merger between the Helsinki School of Economics, the University of Art and Design and the Helsinki University of Technology. High hopes are put to this new combination of traditional institutions of higher learning, which might produce new combinations of art, technology, and business, i.e. what Finland would need in order to maintain its overall industrial strength.

Nevertheless, a big company like Nokia cannot solely rely on Finnish domestic supply of human resources, not even for R&D conducted in Finland. It is evident that despite

\textsuperscript{9} The Finnish cooperation culture is frequently mentioned in various studies, but providing a definition is rather complicated. Because this concept is referred to in this study, too, and because this culture definitely has a bearing on the topic under discussion, a few words on the topic might be required. In brief, there is a remarkably strong sense in Finland of “pulling in the same direction”, especially after an initial discussion when opinions may still differ. Deviation from what has been agreed upon is usually not accepted. This culture may be efficient in some situations, but one should ask the question whether an important explanation to the poor performance of Finland in attracting FDI (see below) could be found in the conformity pressure stemming from this culture.
Nokia’s resources, keeping foreign experts in Finland has proven difficult. From Nokia’s viewpoint there are three issues that are needed in connection with attracting foreign experts and FDI in R&D:

1) To create and maintain good circumstances in general for business activity is a continuous process, which requires uninterrupted attention.

2) Taxation of income is important for attracting R&D professionals to any country. Nokia has observed that the Finnish system with tax preferences for foreign specialists for a period of two years does not work. The specialists leave after these two years. The aim should be trying to attract those who would like to stay longer. There exists an entrenched thinking in Finland that R&D is strictly project-based, and that foreign specialists anyway will leave after these two years. This might be the biggest obstacle for companies like Nokia when trying to attract foreign specialists in R&D.

3) General infrastructure when trying to attract internationally recognized specialists: “Where would those people like to live who can choose where to live?” is a question frequently asked by Nokia. Therefore there is a need to generate R&D units where foreigners would like to stay longer.

**(Changes since 2000)**

The entire landscape for BERD in the ICT sector has changed dramatically since 2000. First of all, from a Finnish viewpoint, there is the realization that the world is full of competitors and consequently every company has to work hard to find its own customers. This in turn has led to an increasingly customer-oriented approach whereby not only physical devices are marketed, but increasingly complete solutions and services. This development appears to have come almost as a surprise for those companies that were in business already in 2000.

In Finland it can be observed that in particular the software industry has grown rapidly, while the production of equipment has been slower and will probably be increasingly specialized. For software producers, the distributions channels are not dependent on particular equipment and therefore they have more flexibility with respect to their customers. This development points at increased role for services throughout the ICT sector, while general equipment production will decline, at least in relative terms.

Another major change has been the growing importance of open-innovation in RD&I. By this is meant cooperation with a rather free flow of knowledge and information. Not participating, on the other hand, would hamper the possibility to follow general developments in the branch. Being able to utilize this flow of information and knowledge requires personnel that are able to assess innovations and new information emerging in such processes. Furthermore, open innovation puts more focus on users and thus there is no development without the users, of both equipment and services. The customers are naturally assumed to have the ultimate expertise especially in the area of services. In brief, the agenda is increasingly set outside the companies performing R&D, which thereby tend to respond to demand instead of creating or steering it.

Specifically for Nokia, the very company philosophy has changed towards an open innovation environment. R&D is conducted with several partners and the aim is common
results, not so much intellectual property rights. In the last four years, Nokia has increasingly taken the initiative to so called “lablets”, i.e. research units at university campuses (MIT, Hollywood, Cambridge, Zürich, Lausanne, Tampere, and Helsinki/Espoo). There is also intensifying cooperation with Beijing. The trend towards increased public-private joint R&D is strong throughout the ICT industry. This development can be seen against the background that the very field of activity has undergone changes for Nokia. It was still a traditional telecom equipment company in 2000, but during the last three years Nokia has seen a movement towards Internet services. The broadening of the field of activity has emphasised the capacity to adopt new results from a wide range of fields, while at the same time the distinction between public and private, goods and services has become more obscure.

Open innovation becomes particularly important when taking into consideration the process of convergence in the ICT sector, i.e. that several new branches enter the sector through the increasing number of applications embedded in mobile communications equipment (games, cameras, and GPS - only to mention the most obvious). This forces ICT companies to increased cooperation with R&D performers beyond their traditional field of activity. This development is one of the most important reasons for the constantly increasing R&D expenditures in the ICT industry. A conspicuous example of such cooperation is the Nokia-Siemens-Nortel chain, which covers almost the whole value chain, becoming a “full-service department store”.

**Consequences of strategic decisions**

Traditionally Finnish SMEs have not been particularly active exporters, maybe for purely geographical reasons (in countries where physical distances to export markets have been smaller, a tradition of exports by SMEs has often developed over time). In Finland, on the contrary, SMEs have been serving the big industry, which in turn have been the locomotives for exports, and therefore SMEs have less often encountered end-users. This has continued in the 2000s as well, and thus the large firms in Finland still play a crucial role in Finnish export performance. It is remarkable that this pattern has been reproduced in such a young sector as ICT, where Nokia is the exporting hub for a cluster of SMEs. Consequently, Nokia has the final say on R&D targets of these companies.

A number of features appear to be common for all BERD in Finland, whether ICT or other sectors:

- There appears to be no major difference regarding R&D investment between public and private ownership. What on the other hand makes a big difference is whether or not the company headquarters are located in Finland. This has become particularly clear with the national SHOK programmes (on which more below),

---

10 A partial explanation to this phenomenon might be the barter trade arrangements between Finland and the Soviet Union until 1991. In exchange for oil and some other raw materials, the Finnish authorities supplied the Soviet Union with some industrial goods that were purchased from privately owned suppliers in Finland. The result was a fairly lucrative trade (for Finland) in the short and medium-term, but highly problematic in the long-term. Many Finnish producers became accustomed to exporting without marketing and without investment in R&D. Attitudes from this not-too-distant era might still linger on, but today the big companies have completely replaced the authorities.
which have been launched to promote R&D in some particular fields for a period of 3-7 years. In those cases when there have been company headquarters in Finland, participation has been rather common, but when not, there seem to have more difficulties in persuading the headquarters to participate. The reason for this may be sought for insufficient understanding for particular Finnish cooperation practices, e.g. cooperating with a de facto competitor.

- Ownership structure is sometimes crucial, especially in those cases when there is external or especially foreign financing involved. Foreign investors usually have high demands on R&D in Finland, and in those rather few cases when foreign investments are actually made in Finland, it is mainly through the acquisition of Finnish R&D-performing firms. Foreign investment in for instance marketing is close to non-existent.

- Finnish companies without external (and in particular foreign) financing tend to be far less prone to be involved in R&D activities. Concerning big companies, it is especially changes in ownership structures that have a bearing on changes in R&D. Also when a big company buys a small one with R&D, the time horizon often shifts, i.e. the big company might have the resources and therefore time to expect returns in the longer run, while smaller companies usually have to get returns sooner.

Mergers, acquisitions, and alliances

Mergers, acquisitions, and alliances are of significant importance in deciding the direction and capacity of big company R&D. In particular a failure to acquire necessary R&D can seriously impede further development. In the case of Nokia, at least the following aspects can be identified:

- Many acquisitions made by Nokia have been large in terms of new R&D capacity acquired. They have often aimed at gaining entirely new competence areas. The same applies to alliances, which ultimately aim at diversifying competences within the alliance. However, any cooperation is an evolutionary process that often starts from joint projects. Therefore these processes are usually not particularly rapid. For example, the alliance Nokia-Siemens (now also Nortel) added powerful extra capacity for all participants.

- The ICT industry increasingly consists of elements of other industries and thus mergers tend to create complementary advantages. This is particularly important in customer-oriented activities. A specific form of competences sought after is the knowledge of the various standards developed within the technology branches nowadays combined in e.g. mobile communications. Thus, a producer of mobile telephones needs to have perfect knowledge of standards in for example the camera or GPS industries. This also applies to regulations, business models, and even pricing.

- But mergers and acquisitions take place for other reasons, too. When Nokia’s global position strengthened in the 2000s, it turned out that R&D presence in the BRIC countries was of utmost importance for cultural and geographic reasons – and eventually for the corporate image. The determinant is the characteristics of the
market being entered. This is however not an aspect within the EU, where basically only suitable partners are sought for R&D.

No success in FDI

The sustained heavy reliance on Nokia in Finnish BERD has prompted a discussion whether foreign investment could be a way to generate either completely new or otherwise strengthen existing BERD beside Nokia. A significant influx of foreign know-how would probably have an enhancing effect on Finnish BERD. However, Finland has been remarkably unsuccessful in attracting FDI in R&D. There are relatively few foreign companies that would start R&D activities in Finland\(^\text{11}\). Foreign companies have bought a small number of Finnish companies, nevertheless. This issue is clearly taken seriously in Finland.\(^\text{12}\) However, it seems that the ICT sector has attracted even less FDI in R&D than other sectors, but in general the issues are the same for all sectors.

It has proven very complicated to explain this lack of interest in investing in R&D in Finland, and this problem has so far eluded Finnish decision-makers. Finland can provide a stable, wealthy society with relatively low rates of corruption and other crime. The education level is very high, the communications are good, English is widely spoken and the culture is technology-friendly\(^\text{13}\).

Most likely the explanation to the poor attractiveness of Finland for FDI in R&D is highly complex. It might partially be an issue of tax policies not favouring outstanding foreign experts to settle down in Finland, but also a number of cultural aspects might play a role. Also the size of the country (5 million inhabitants) may be too small to generate widespread interest\(^\text{14}\).

It is important to add that basically no public sector programmes have been created to remedy the situation. The Finnish public sector offers some incentives, but so does the EU, which easily overshadows Finnish national efforts. There is no outright Finnish investment support. The success of Nokia should at least in theory have brought FDI in R&D to Finland, but it is possible that during the years of extraordinary growth of Nokia, all attention was paid to this fact and consequently the opportunity to attract FDI was lost. Finland may simply have not been good enough in marketing itself. Now it might be too late to rely on Nokia, a global player, and FDI in R&D has to be attracted by other means.

\(^{11}\) According to OECD (2008), a total of 38 cross-border deals with Finland as target country took place in 2001. The corresponding figure for 2008 was 38. In absolute terms these figures are not extremely low, but given Finland’s role in the ICT sector, significantly higher figures could have been expected. Between 1997 and 2007, in terms of total number of being target for mergers and acquisition, Finland was in 18\(^{\text{th}}\) position globally. As an acquirer, Finland was 13\(^{\text{th}}\).

\(^{12}\) All interviewees for this study dwelled long on this particular question, sharing the view that this is a major shortcoming with respect to the future of BERD in Finland.

\(^{13}\) This problem description was more or less shared by all interviewees, although with slightly different emphasis.

\(^{14}\) Some superficial explanations often heard in Finland include the climate and the language unrelated to most other European languages. If the climate would be decisive, this trend should be observed globally. If on the other hand lingual relatedness would be decisive to a degree that it shadows all the positive aspects listed above, it would be truly difficult to explain trends in global FDI.
A number of Finnish R&D intensive companies have been bought by foreign companies – in forestry, engineering, and to some extent ICT. Since 2003, an average of 20 Finnish companies performing R&D in the ICT sector have been bought annually by foreigners. The corresponding figures for Sweden – the probably most adequate country to compare with regarding ICT – are more than twice as high. In terms of cumulative value of the deals since 2004, Sweden has attracted more than four times as much FDI in the ICT sector (OECD 2008).\(^\text{15}\) Usually the very reason for buying Finnish R&D intensive companies is the aim to enter the Finnish innovation system only, because the market itself is rather small. Therefore foreign investors tend to cut down on all other but the core R&D. Finnish marketing companies in the ICT sector are only rarely being bought. Also there are relatively few “greenfield” R&D intensive foreign investments in Finland in the ICT sector, with the exception of a small number of companies clustered around Nokia.

\(^\text{15}\) Going back to 2002 would strengthen the accumulative Finnish figure relative to that of Sweden, while going even further back would again increase the discrepancy.
4. The role of public policies in determining BERD performance and BERD intensities in Finland

The two public bodies with the most important direct impact on BERD developments in Finland are the Academy of Finland, subordinated to the Ministry of Education and the Technology Funding Agency, TEKES, subordinated to the Ministry of Employment and the Economy. The former has a budget of EUR 309 million for competitive research funding while the latter has a budget of EUR 575 million. TEKES is mainly responsible for the support of increased R&D in SMEs.

The Policy Mix Project identified three main challenges for enhancing BERD in Finland. First, the scope of R&D performing companies needs to be diversified. The competitive advantage Finnish R&D performing companies in the ICT sector had a decade ago is diminishing. Therefore public sector policy needs to stimulate BERD by involving SMEs more efficiently, support the creation of high tech start-ups, to improve the capacity of the innovation system to absorb current R&D and to promote innovative growth-oriented business. Second, public policy has to ensure the existence of high-level competence in research, and third it should facilitate job creation in high productivity sectors (ERAWATCH, 2009).

In the “Policy Mix Project” the following six routes to stimulate R&D were specified:

1. promoting the establishment of new indigenous R&D performing firms;
2. stimulating greater R&D investment in R&D performing firms;
3. stimulating firms that do not perform R&D yet;
4. attracting R&D-performing firms from abroad;
5. increasing extramural R&D carried out in cooperation with the public sector or other firms;
6. increasing R&D in the public sector.

In Finland the policy instruments developed tend to cover several routes simultaneously. This allows for greater flexibility to change key policies. Regarding route 1, the Finnish policy mix has been favouring the development of framework conditions, for example promoting entrepreneurship, providing access to venture capital and creating incubators. Since 2008, TEKES has a particular programme for young innovative companies. The second route is covered by schemes for grants and loans and to encourage companies to either develop their own R&D or to participate in joint R&D projects. The third route is a main challenge for Finnish public policy, because the number of R&D performing firms has remained low, in particular in non-manufacturing sectors. This indicates a serious shortcoming in for instance software development. As has been discussed before, Finland has not been particularly successful in attracting FDI in R&D. Some programmes have been launched to remedy the situation, e.g. a regional initiative whereby individual regions, instead of Finland as a whole, will be presented as target areas for FDI. The newly established Strategic Centres for Science, Technology and Innovation (SHOK –see below) are partially designed to intensify R&D collaboration between firms and between firms and the public sector, but the broader aim is to create new dynamics in Finnish
business R&D. The sixth route is mentioned here only for the sake of completeness and it has little bearing on BERD (ERAWATCH, 2009).

For a global company like Nokia, Finnish policy measures are only marginally important, but they might have a decisive impact on small businesses planning to increase their R&D-efforts. Many small R&D-intensive companies have been created as sub-contractors to Nokia, some of them as clear-cut cases of spillover. One of the big challenges for Finnish innovation policy today is to facilitate a change whereby a number of these companies would be able to distance themselves from this complete dependence on Nokia and to find new customers. There remain several areas into which R&D-intensive SMEs can still successfully venture. Following route three above, development potential can be found in e.g. in software solutions for the banking system and wireless information traffic. SMEs could specialise in measuring, following-up, and monitoring the state of networks.

The role and potential of policy measures should not be exaggerated. As was mentioned in connection with route one above, the Technology Funding Agency TEKES has defined priority areas, but in the end, individual companies make the investments. Thus, TEKES can create a context, but this is not necessarily decisive for firm behaviour. However, the role of TEKES is important for promoting the use of ICT in the public sector, which can have a stimulating effect on R&D in SMEs. TEKES is also increasingly focusing on embedded ICT, i.e. the fact that ICT can no longer be considered distinct from other areas of technology, but often instead a core component. As is the case with Nokia’s venturing into other areas of technology, TEKES seems to follow suit (which perhaps could be interpreted as yet another example of Nokia ultimately setting the agenda in Finnish R&D). This may open up new possibilities for firms managing to combine R&D from different fields of technology.

A recent major development in Finland is the creation of Strategic Centres for Science, Technology and Innovation (SHOK). In 2006, the Government’s Research and Innovation Council called for the creation of specific programmes to promote R&D in certain areas. The Council identified a number of broad areas in which to invest extra research resources (ICT, forest, health, built environment, metals and mechanical engineering, and energy and the environment)\textsuperscript{16}. When the SHOK programmes were launched in 2008 they received enormous attention, especially because of their inclination towards companies actually conducting the R&D. The SHOK programmes are based on public sector initiative by which the concrete formulation of R&D needs is handed over to companies, which in turn are expected to react and thereby realise the advantage of mutual cooperation.

The aim of the ICT SHOK is to bring back long-term perspectives into R&D in the ICT sector. At present R&D in the sector is, according to TEKES, characterised by fragmentation, short-term perspectives and a lack of vision for the future. The ICT component is present in other SHOK concentrations, too (www.tekes.fi). At the same time, however, TEKES is not particularly interested in basic or applied research. Instead the aim is to identify those companies which have the potential to commercialise, i.e.

\textsuperscript{16} For details in English, see http://www.aka.fi/en-gb/A/Science-in-society/Strategic-Centres-for-Science-Technology-and-Innovation/Operational-CSTIs/
companies that are good at not only developing products, but also at marketing. This might, after all, imply a medium-term instead of a long-term perspective.

As a consequence of its relatively small size, Finland has to prioritise, which perhaps is one of the key explanations to the R&D focus on ICT, and Nokia in particular. There may simply be only little room in terms of R&D capacity for yet another similar area of strength. However, the gradual transformation of Nokia into a broad service producer may have a profound impact on R&D in Finland. The promotion of ICT services by the public sector programmes combined with Nokia’s changing priorities might restructure the entire R&D landscape in Finland.
5. Conclusion, lessons learned, and policy options

Finnish R&D in the ICT sector is completely dominated by Nokia. Thus strategic decisions made by Nokia profoundly affect all ICT-related R&D conducted in Finland. This fact has caused some concerns in Finland.

In general, Finnish R&D in the ICT sector has not been characterised by radical innovation, but rather by the capacity to adjust and to utilise R&D conducted elsewhere. Partially this can be attributed to the limited human resources – an issue observed closely in Finland and which has prompted rethinking in the higher education structure.

Important developments since 2000 include above all the rapid internationalisation of the ICT sector. In addition to this, the ICT sector is characterised by increasing convergence, by which is meant that several technologies are becoming intertwined. This development has forced companies like Nokia to create new alliances in order to develop competence in those technologies where it has little prior experience.

Another important trend since 2000 is the growing role of open innovation, i.e. that knowledge and information flow rather freely between companies and between producers and users instead of being strictly held on to as for example IPR. As a result of the more conspicuous role of the users, R&D in the ICT sector has become increasingly sensitive to customer demands.

Mergers, acquisitions, and alliances have become increasingly important in order to gain competence in the entire ICT sector, and even beyond, when other technologies are incorporated into ICT equipment or vice versa when ICT has become a component of other technologies. Another reason for acquisitions is the need to be physically present in some major emerging markets, often for reasons of corporate image.

Ownership structure appears to have only minor impact on R&D-intensity. In the Finnish context, it is rather the size of the company that is decisive. In this respect, Finland has unutilized potential with a great number of SMEs not actually conducting any significant R&D.

One of the absolutely biggest concerns in connection with Finnish R&D is the poor capacity to attract foreign investment. Foreign R&D related investment is expected to bring new know-how to Finland, while at the same time it can be observed that it has an intensifying effect on R&D performance in Finland. The reasons behind the absence of significant influx of foreign R&D are manifold, complex, and somewhat obscure. It nevertheless appears that chances have been lost due to insufficient efforts from the side of the entire innovation system.

The international standardisation process in the ICT industry has by and large been self-regulating (contrary to some other sectors) and it has not required the active intervention of authorities. Broadly speaking, consumer preferences are decisive. Nevertheless, there are regulations in nearby sectors, which affect the ICT industry, too, such as environmental legislation.
Nokia is surrounded by a number of subcontractors, which are completely dependent on it. This is actually not a new phenomenon in Finland, but the sheer size of Nokia has given rise to some concerns in Finland leading to efforts by the public sector to encourage more independence from Nokia.

In 2008, a programme for Strategic Centres for Science, Technology and Innovation (SHOK) was launched. This is a large-scale effort to concentrate R&D to those sectors where it is assumed to produce important results within a relatively short time-span. The programme can also be seen as an attempt to remedy the profound dependence on Nokia.
Case study author:

Dr Rurik Holmberg
Technopolis Group in Estonia
Harju 6 - 411
10130 Tallinn,
Estonia
T: +37 2 631 0525
rurik.holmberg@technopolis-group.com
www.technopolis-group.com

Experts taking part of the study group as interviewees:

Kimmo Ahola
Director of the National Programme UBICOM – embedded ICT
The Finnish Funding Agency for Technology and Innovation, TEKES
PL 69
Kyllikinportti 2
00101 Helsinki
T: +358-10-60 55 756
Kimmo.ahola@tekes.fi
www.tekes.fi

Erkki Ormala
Vice President, Technology Policy
Nokia
Keilalahdentie 4
02150 Espoo
T: +358-0-7180 34412
erkki.ormala@nokia.com
www.nokia.com

Christopher Palmberg
Senior Researcher
The Research Institute of the Finnish Economy (ETLA)
Lönnrothinkatu 4 B
00120 Helsinki
T: +358-9-609900
christopher.palmberg@etla.fi
www.etla.fi

Juha Ylä-Jääski
Director of the Innovation Environment Division
Federation of Finnish Technology Industries
Eteläranta 10
P.O. Box 10
00131 Helsinki
T:+358-9-192 31
Juha.yla-jaaski@teknologiateollisuus.fi
www.teknologiateollisuus.fi
Bibliography


Connectivity Scorecard, www.connectivityscorecard.org

ERAWATCH country report 2009: Finland. Analysis of policy mixes to foster and R&D investment and to contribute to the ERA, ERAWATCH Network and Advansis Oy

Laestadius, Staffan (1996) Vid ”lägteknologins” frontlinjer – konsten att tillverka 14000m² papper per minut och tekniken och industrin bakom den Forskningsrapport, Institutionen för industriell ekonomi och organisation, Kungliga tekniska högskolan

IPTS (2008) Mapping R&D investment by the European ICT business sector,

Monitoring and analysis of policies and public financing instruments conductive to higher levels of R&D investments: The “Policy Mix” roject. Case study Finland 2007. Technolpolis

Nokia, www.nokia.com

OECD, www.oecd.org/dataoecd

OECD Information Technology Outlook 2008

Orion, www.orion.fi

Rindicate (2009) Sectorial analysis of the long-term dynamics of business R&D intensity. Interim progress report n°2: Results of Phase 1 activities

Statistics Finland, www.tilastokeskus.fi, data from:


Tekniikka ja Talous, www.tekniikkatalous.fi

The Technical Research Centre of Finland, www.vtt.fi
“Sectorial analysis of the long-term dynamics of business R&D intensity”

In relation to (DG-RTD-2005-M-02-01):

“Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators”

Case study
Business Expenditures in R&D in Aerospace Industry in France

Lorena Rivera Leon
Technopolis Group

Brussels, 12 October 2009
# Table of contents

1  Synthesis                                           389

2  BERD intensity performance in France and the French Aerospace Industry 390
   2.1 Business expenditures on R&D in France   390
   2.2 The aerospace industry in France         392

3  Analysis of BERD drivers in the French aerospace industry 395

4  The role of public policies in determining BERD performance and BERD intensities in the French aerospace industry 400

5  Conclusion, lessons learned, and policy options 403

Bibliography                                          406
The Aerospace Industry in France

1 Synthesis

The Aerospace industry explained 7% of total BERD in the EU during the period 2001-2006, and it is one of the top 5 sectors in terms of shares. The Aerospace industry is mainly concentrated in five countries in the EU: France, the United Kingdom, Germany, Italy and Spain. France is the second largest contributor to the sector in terms of value-added accounting for a share of approximately 22% of EU-25 value added; and it is the top contributor in terms of turnover, accounting for 41% of total. Geographically, the French aerospace industry is highly concentrated in 3 regions that account for 68% of total workforce: Ile-de-France (32%), Midi-Pyrénées (26%) and Aquitaine (10%). The US is Europe’s main competitor and both, the US and the EU dominate the global Aerospace market. France is running on a trade surplus in the industry. Intermediate consumption stands for 85% of production value reflecting the concentration of assembly activities in the country.

The main characteristics of the Aerospace industry are long product cycles, high levels of capital and R&D intensity, and strong competition from the US. The Aerospace industry is not a homogenous industry since it consists of several sub-industries that face different industrial structures, innovation systems and challenges. Notable differences are between military and civil aeronautics; and between space and aeronautics. The major difference being that space is subsidised, whereas aeronautical companies are not, which impacts on their R&D performance. Aerospace is a high-tech and capitalistic industry, whose well-structured supply chain has a tendency towards globalisation. The industry is extremely consolidated with a few large players that set the rules and rhythm of the industry. Barriers to entry are high.

BERD drivers in the aerospace industry are mainly environmental issues and sustainable development, and implications stemming from the globalisation of industry. Other important drivers are security issues, international and national regulations, IPRs and R&D collaboration between industry stakeholders. R&D drivers in the space sub-industry are institutional programmes, international regulations (mainly related to climate change) and EU specific research frameworks (i.e. the Galileo global navigation satellite system). R&D efforts in the military side of the industry have been decreasing, mainly because of rather static military budgets. Public funds and Programmes are strong drivers of BERD. France has a long history of strong involvement of the government in the aerospace industry. The main indirect innovation policy measures influencing BERD in the aerospace industry are: the Research tax credit, the Carnot institutes, the financing of academic laboratories concerning the offer of fundamental research; and the CIFRE conventions. The most relevant direct innovation policy measures influencing BERD is the support to competitiveness clusters, part of the Company Competitiveness Fund.
2 BERD intensity performance in France and the French Aerospace Industry

2.1 Business expenditures on R&D in France

R&D in the European Union is highly concentrated at the sectoral level and the country level. France accounted for 17% of total BERD of the EU in 2005 (18% of total BERD in manufacturing, and 10% of total BERD in services) and together with Germany and the United Kingdom the three countries accounted for more than 60% of total BERD. Around 86% of business R&D (BERD) in France is performed in the manufacturing industries (NACE 15-57), and 9% in services (NACE 50-99), slightly above the EU average in manufacturing and considerably below the average in services. R&D intensity in manufacturing combined is 8.6% and in services is 0.2%.

Half of BERD is concentrated in just four manufacturing sectors

French Business R&D is concentrated in four sectors that account for over 50% of the total for the period 1995 to 2006 (see Figure 1):

- Motor Vehicles (16%)
- Pharmaceuticals (13%)
- Radio, TV and communication equipment (12%)
- Aerospace (11%)

One of the major changes in the structure of BERD in France over the period since 1995 was an increase in the relative importance of Motor Vehicles: its share has risen from 12.6% of the total in 1995-2000 to 15.4% in 2001-2006. The Computer services sector also increased in importance (shares going from 2.4% to 4.2% of total). At the same time the sector with the steepest relative decline was Instruments, which went from 8.3% of total French R&D to 5.3%. Most other sectors had shown very little change in terms of shares, including the aerospace industry. In terms of value added, the 15 sectors that represent more than 90% of total BERD account for 24% of French economic output.

Figure 2 shows the evolution of R&D intensity across industrial sectors in France for the period 1995 to 2006. The largest increase was in the Radio, TV and communication equipment sector, where the proportion of R&D devoted to value-added had risen from 35% in 1995-2000 to 45% in 2001-2006. The Motor Vehicles sector also increased its R&D intensity from 16% to 22%. At the same time, there was a steep decline in the R&D intensity for Office and Computer Machinery (from 33% to 23%).

Summary of the evolution of sectoral BERD in France

There have been some interesting patterns across sectors in France in the period 1995 to 2006. The most important sector in terms of the volume of BERD, Motor Vehicles, has increased its share from 13% to 15% at the same time as increasing its R&D intensity from 16% to 22%. On the other hand two other important sectors, Pharmaceuticals and Aerospace, have shown little change either in terms of BERD shares or R&D intensity. Radio, TV and communication equipment has increased in terms of R&D intensity but changed little in its contribution to total BERD.
**Figure 1. Structure of BERD: 2001-2006**

![Structure of BERD: 2001-2006](image)

Source: Rindicate, 2009

**Figure 2. Trends in Sectoral R&D intensity in France: 1995-2006**

![Trends in Sectoral R&D intensity in France: 1995-2006](image)

Source: Rindicate, 2009
2.2 The aerospace industry in France

In statistical terms, the industry is defined as ISIC Rev.3 35.3 or the ‘manufacture of aircraft and spacecraft’\(^1\), consisting of mainly three sub industries: the civilian aerospace industry, the defence or military aerospace industry and the space industry.

The Aerospace industry explained 7% of total BERD in the EU during the period 2001-2006, and it is one of the top 5 sectors in terms of shares. The sector has lost a bit less than 1% of total shares in the EU for the period 1995 to 2006\(^2\). It has also lost on its sectoral R&D intensity, passing from 37.3 to 33.4, and making the sector the greater loser (in absolute terms) in terms of intensity in the EU. Its value added has been steady since 1995, making up slightly less than 0.3% of value added. In France, the sector has followed similar patterns. It lost 1% of share between 1995 and 2006, it lost its R&D intensity, passing from 44.4 to 41.1, (although proportionally the lost was equal to less than 0.10) and stood steady in terms of value added (accounting for 0.4%). This steadiness and decline requires further analysis considering that the sector accounts for more than 10% of total BERD in France.

The Aerospace industry is mainly concentrated in five countries in the EU: France, the United Kingdom, Germany, Italy and Spain. France is the second largest contributor to the sector in terms of value-added accounting for a share of approximately 22% of EU-25 value added (Vekeman, 2006 based on Eurostat); and it is the top contributor in terms of turnover, accounting for 41% of total.

According to GIFAS, the French Association of Aerospace Industries\(^3\) (GIFAS, 2008), total revenues from the aerospace industry were €33.5 billion in 2007\(^4\), of which the civil aeronautics sector represented 73% of total and the defence aerospace sector 27%. The industry employed about 134,000 people by the end of 2008, 76% of which were skilled jobs (including managerial staff, technicians, administrative and supervisory staff). Although the industry direct economic weight is relatively small, accounting for under 1% of value added and 0.6% of total employment in 2006 (Vekeman, 2006), the industry is an important generator of high-skilled jobs, makes an important positive contribution to French industrial employment (GIFAS, 2009), and is a powerful driver of innovation.

Total revenues before inflation adjustments in the sector have increased since 1998. The total value of orders booked has been unstable, with a considerable drop in 2002 that started to increase again since then. In 2007, orders booked went down 22% compared with 2006. The relative size of the military side of the Aerospace industry has been slightly decreasing in terms of revenues accounting for 27% of total in 2007; and has decreased considerably in terms of total value of orders accounting for 15% of total for the same year (GIFAS, 2008). Aeronautics (civil and military)

---
\(^1\) The sector principally covers equipment, parts and accessories used in the production of aircraft and spacecraft used for the transport of passengers and freight, as well as military applications.
\(^2\) The EU aggregate level considers 11 countries that account for more than 90% of total BERD: Germany, France, the United Kingdom, Italy, Sweden, Spain, the Netherlands, Belgium, Finland, Denmark and Ireland. The EU average changes are estimated using a six-year average from 1995 to 2001 and a six-year average from 2002 to 2006.
\(^3\) GIFAS (Groupement des industries Françaises Aéronautiques et Spatiales) is a trade organisation comprising more than 260 members, from major primer contractors and system suppliers to SMEs specialising in the design, development, production, marketing and maintenance of all aerospace programs and equipment.
\(^4\) Before adjustment for inflation.
makes up for 71% of the industry turnover at European level (ASD, 2007), with the remaining turnover coming from land and naval defence (22%) and space (7%). The figures follow the same pattern in terms of employment breakdown. Similar trends are seen for the French industry (GIFAS, 2008).

Geographically, the French aerospace industry is highly concentrated in 3 regions that account for 68% of total workforce: Ile-de-France (32%), Midi-Pyrénées (26%) and Aquitaine (10%) (GIFAS, 2009). The French industry employed the 23% of total workforce for the sector in the EU25 in 2006. Apparent labour productivity amounted to EUR 77 600 value added per person employed in 2002, well above the average of manufacturing of EUR 51 500 (Vekeman, 2006 based in Eurostat). The industry’s size distribution differs from that of total manufacturing with large firms playing a more dominant role. The average enterprise size was of 210 persons employed in 2002, while employment in enterprises with 1-19 persons only accounted for 1% of employment in the industry.

The US is Europe’s main competitor and both, the US and the EU dominate the global Aerospace market. France has a fundamental role in Europe and it is an essential player in the restructuring taking place within the European industry (GIFAS, 2009). Of the 20 largest companies in the global Aerospace industry in 2000 (based on aerospace related turnover), 4 were French companies (Thales, SNECMA, Alcatel and Dassault Aviation), and one more being the giant EADS (German, French, Spanish partnership, and third largest world company) (EC, 2003).

France is running on a trade surplus in the aerospace industry. Both exports and imports have increased in the period 1998-2007 by 1.6 and 1.4 times respectively. About 61% of total revenues and 74% of total orders are destined to export (GIFAS, 2008). The main exports market for the French aerospace industry is the EU (43%), North America (31%), East Asia (9%) and the Middle East (6.5%) (GIFAS, 2008). Intermediate consumption⁵ stands for 85% of production value reflecting the concentration of assembly activities in the country (Vekeman, 2006 based in Eurostat).

Business data from the Industrial R&D Investment Scoreboard confirms the central role of the French aerospace industry⁶. In 2008, EADS ranked first in the EU within the aerospace and defence sector (overall rank 12), followed by Finmeccanica (Italy, rank 16), SAFRAN (France, rank 30), Rolls-Royce (United Kingdom, rank 40), Thales (France, rank 43), Dassault Aviation (France, rank 72), and BAE Systems (United Kingdom, rank 78). Out of these R&D performing companies, EADS and Finmeccanica spent more than 1 billion euro on R&D financed by own funds in 2007. Of the largest non-EU companies, only Boeing and United Technologies, both US companies, came close to the R&D spending levels of the top European companies in the sector. Furthermore, globally the sector shows mixed developments: while EADS reduced R&D investment by 6% in 2007 respectively from the previous year; Boeing increased it by 18% (EC JRC, 2008).

---

⁵ Intermediate consumption is defined as the purchases of goods and services, corrected for changes in stocks and for purchases of goods for resale (if any). It reflects the total consumption of goods and services for the production process (Vekeman, 2006 based in Eurostat).

⁶ The R&D Investment Scoreboard presents information on 2000 companies from around the world reporting major investments in R&D. It covers the top 1000 R&D European investors and the top 1000 R&D foreign investors (EC JRC, 2008). Data provided in the Scoreboard only include R&D financed by a company’s own funds. Government funded spending is not included, which makes it particularly difficult to compare French and US companies given the larger share of government funded R&D in the US.
There are strategic firms that drive innovation performance in the sector and thus dominate the French aerospace industry. EADS (European Aeronautic Defence and Space Company) is a German-French-Spanish merger developing civil and military aircraft, communications systems, missiles, space rockets, satellites and related systems. Headquartered in the Netherlands, it holds the subsidiary Airbus, based in Toulouse, and that is responsible for the production of around half of the world’s commercial aircrafts. Safran is specialised in defense, aerospace propulsion and equipment, communications and security. The Thales Group’s expertise relies on information systems and services; while Dassault Aviation specialises in the manufacturing of military, regional and business jets.

According to the ASD (2008), the European Aeronautic industry generated around 70% of R&D expenditure, while the remaining 30% came from public funding. The source of funding differed between civil and military aeronautics, with the funding coming from industry as for 85% for civil aeronautics, and 44% of total expenditures for military aeronautics. In the case of the French aerospace industry, R&D funded directly from cash flow accounted for 54% of total R&D spending and 8% of total revenues in 2007 (GIFAS, 2008).
3 Analysis of BERD drivers in the French aerospace industry

The Aerospace industry is not a homogenous industry since it consists of several subindustries that face different industrial structures, innovation systems and challenges. Notable differences are between military and civil aeronautics; and between space and aeronautics.

Despite this, the aerospace industry has very specific characteristics. Aerospace is a high-tech and capitalistic industry, whose well-structured supply chain has a tendency towards globalisation. R&D projects are characterised for their long cycles and processes (i.e. in aeronautics, 10 to 15 years for developing an airplane that has an average life of 40 years) and high complexity. Thus, R&D investments taken today have an impact in the long-term. France also has a long history of strong involvement of the central government in the industry. It is commonly said among government experts that the industry is a market failure and that letting it function in an open market is risky considering the social and environmental implications. Thus, there is high-level of public intervention in strategic corporate investment decisions. The industry is also considered a strategic industry since it is a large contributor to the French trade balance. Innovation in the aerospace industry has also spillover effects over other economic sectors, thus inducing innovation in other sectors and clusters less technology intensive. Finally, the industry is extremely consolidated with a few large players that set the rules and rhythm of the industry. Barriers to entry are high. The main players have been consolidated through international partnerships of parent and joint companies that have implications for BERD since they had resulted in mergers and collaboration in terms of maximisation of R&D efforts.

Experts have mixed opinions on the effects of the global financial crisis on BERD. The industry has not been severely touched so far. This is mainly because budgets are long-term and ordered in Research Programmes over long periods of time. Nevertheless, government experts expressed their concerns on how the industry will react in the medium-long term due to decreasing or static financial and budgetary resources.

The space sub-industry remains a special case. Despite being the smallest share of the industry (estimated at 7% of the European industry turnover in 2007 according to ASD (2008)), it is the one that receives the most of public intervention in terms of corporate strategies not only at national level, but also notably at EU level. For example, R&D strategies and investment policies of the space branch of Thales, Thales Alenia Space, are strongly influenced by the European Space Agency, and the company holds limited scope for action in terms of defining R&D investment priorities. Experts signalled that in the space sub-industry the main R&D drivers are mainly institutional programmes; international regulations and priorities related to

---

7 See Hollanders, et.al. (2008) for a discussion on the consolidation process in the European Aerospace industry.

8 Thales Alenia Space is a joint venture between Thales (France, 67%) and Finmeccanica (Italy, 33%). It is a European leader for satellite systems and orbital infrastructures. It is a worldwide reference in telecommunications, radar and optical Earth observation, defense and security, navigation and science. It is the leading EU supplier of satellite-based solutions for Defense and Security.
climate change; and EU specific research frameworks (i.e. the Galileo global navigation satellite system\(^9\)).

R&D efforts in the military side of the industry have been decreasing in the last years, mainly because the deployment of military programmes is costly financially and politically.

In such a large and differentiated industry, the drivers influencing R&D expenditures in enterprises are hard to isolate and attribute to one specific reason due to interdependencies.

The main drivers of BERD identified in this study for the industry as a whole are: environmental issues and sustainable development, and implications stemming from the globalisation of industry (i.e. global competitive pressures). Other relevant drivers are security issues, international and national regulations, Intellectual Property Rights (IPRs) and R&D collaboration between industry and academia.

**Environmental issues and sustainable development**

The so called "*grenelle de l'environnement*" became an important driver of BERD since it took place in October 2007. The *grenelle* gathered decision makers for the formulation of long-term strategies on issues related to the environment and sustainable development, inclusive of society and represented by the government, the syndicates, and industry and civil associations. The main three priorities are climate change, biodiversity protection and the reduction of pollution. The *grenelle* set clear quantifiable objectives relevant to the aerospace industry (issued and transposed from the European Research Programme "Clean Sky"). The objectives for 2020 are to: reduce by 50% CO2 emissions in air transport, reduce by 80% nitrogen oxidize emissions (NOx), and reduce by 50% noise produced by aircrafts. These objectives are very ambitious and they became drivers of R&D in order to prevent technological crashes and enhance the development of future technologies for aircrafts. These objectives also call for organisational changes and efficient management tools.

Regarding the space sub-industry, the National Centre for Meteorological Research\(^10\) has been setting the environment as a priority, notably by the implementation of meteorological satellites for monitoring carbon emissions and enhancing R&D related to climate change\(^11\). R&D investments are driven by international priorities and research programmes, notably those by the International Geosphere-Biosphere Programme, the World Meteorological Organisation, and the EU R&D Framework Programmes. The European Space Agency (ESA) has also been following similar trends, notably onto using the International Space Station (ISI) as a platform for global climate change research\(^12\).

Diminishing oil resources and high aircraft engine emissions have also set new challenges to the aerospace industry. For instance, the International Air Transport

---

\(^9\) Galileo is the EU initiative for a state-of-the-art global navigation satellite system. It will be interoperable with GPS and GLONASS. The fully deployed Galileo system will consist of 30 satellites and the associated ground infrastructure.

\(^10\) The National Centre for Meteorological Research (CNRM or *Centre National de Recherches Météorologiques*) is the research service of *Météo-France*, the French public organisation for meteorology. The CNRM is in charge of all R&D related to meteorological issues.

\(^11\) The research priorities of the CNRM are meteorological forecasting, studies on the atmosphere, knowledge on climate, and the interactions between climate, the atmosphere and the mankind.

\(^12\) A "Call for Ideas" is to be launched in October 2009 for monitoring interest in deploying remote-sensing instruments for global change studies on the ISS. Depending on industry interest, the Call would be followed by a specific Announcement of Opportunity for instruments or multi-user payloads.
Association (IATA) has set a voluntary fuel efficiency goal consisting in the reduction of fuel consumption and CO2 emissions by 25% by 2020 in order to arrive to “zero emission” planes within 50 years. R&D efforts are focusing in developing second-generation biofuels that are sustainable. Airbus (in partnership) started investigating, developing and testing renewable-energy technologies to convert bio-feedstocks into commercial aviation fuel since 2008.

**Better coordination, communication and action for better and more efficient R&D**

Industry collaboration at all levels has been promoted since 2001 with the launch of the Advisory Council for Aeronautics Research in Europe (ACARE), the most advanced of the European Technology Platforms, whose mission is to establish and carry forward a Strategic Research Agenda (SRA) for aeronautics research that influences all European stakeholders in the planning of research programmes. Following this initiative, the Council for Civil Aeronautics Research (CORAC, or in French “Conseil pour la Recherche Aéronautique Civile”, commonly called the “French ACARE”) was established in mid 2008 with the objectives of defining and implementing research and technological actions to reach the European environmental objectives at 2020 horizon. The Council is a consequence of a convention signed at the beginning of 2008 by aerospace stakeholders during the grenelle de l’environnement.

The CORAC reunites the main industry stakeholders, including GIFAS, Airbus, EADS, SAFRAN, Thales, ADP, Air France, the Union of French Airports (UAF), the National Federation of commercial aviation (FNAM) and the Ministries of Research, Industry and Defence. It facilitates and promotes coordinated action between industry and government. Industry experts signalled the Council as being efficient in coordinating and optimising R&D efforts; i.e. through its monthly Steering Committee that designs research priorities and suggests technology programmes. Government experts said the Council is an excellent tool for developing joint R&D projects and help in the maturity of emerging technologies.

**The globalisation of industry: “Innovating or dying” in a global competitive industry**

The aerospace industry is more global and more competitive than ever. The industry’s main driver is the market pull of competition push. Industry’s players are forced to follow the market trends in order to remain competitive.

The French industry has gone through a strong consolidation process that started in the 1990s. Nowadays, it involves a complex network of companies, joint ventures, international consortia and partnerships. Airbus is the leading manufacturer of commercial aircraft, based in Toulouse, and subsidiary of EADS (a German-French-Spanish merger that has 15 cross holdings (Hollanders et.al, 2008)). In 2008, Airbus

---

13 The partnership is formed of Airbus, JetBlue Airways, International Aero Engines, UOP and Honeywell Aerospace.

14 The Steering Committee is presided by Airbus’s Director General, and coordinated jointly by the Directorate General for civil aeronautics and the GIFAS.

15 On the basis of preparatory meetings that took place in the beginning of 2008, the Ministry of Ecology, Energy, Sustainable Development and Sea set four priorities: the introduction of a strategic Programme on research and technology; the reinforcement of (public and private) support to research; the development and introduction of a new generation of airplanes with much better environmental performance; and the development of an international research policy for the industry.

16 EADS is a global leader in aerospace, defence and related services. The Group includes Airbus, Airbus Military (tanker, transport and mission aircraft), Eurocopter (the world’s largest helicopter supplier), and EADS Astrium (EU leader in space programmes).
booked 777 aircraft orders, valued at US$100 billion at list prices, and representing 54% market share for commercial aircraft, and thus moving beyond its US rival Boeing to become the world’s largest commercial aircraft maker. Competition between Airbus and Boeing, commonly referred as the "Airliner Wars", has become a strong driver of innovation and BERD in the last years. Between 1999 and 2008 Airbus received more orders than Boeing (6378 and 6140 orders respectively), but it had less deliveries in comparison (3606 and 4089 respectively)\(^\text{17}\). Competition is intense and there are recurrent discussions on the role of public intervention in driving innovation and R&D in the US industry vs. the EU industry. Experts signalled that public intervention and public expenditures in R&D in the US are usually mixed between civil and military aerospace, whereas in France public intervention is mostly influencing the military and defence sub-sector of the industry, and thus not intervening in the civil aircraft sub-industry.

Competitive pressures from the fast-growing developing economies have also been rising in the last years, notably those from the BRICs (Brazil, Russia, India and China), and particularly China\(^\text{18}\). The country is a major importer in the global aircraft industry (aircrafts and engines). Its role as an exporter of aircraft components is expected to grow in the next years due to major investments in component manufacturing by Airbus and Boeing. Although wages in the industry are not competitive if compared with other Chinese high-tech sectors, the industry has grown in efficiency since 2000 (Hollanders et.al., 2008)\(^\text{19}\).

In terms of corporate strategies, industry experts signalled that R&D champions are characterised for having clear strategic plans, roadmaps of products and technology maps that they use in order to optimise R&D investments at a point in time and achieve competitive advantages in the global industry\(^\text{20}\).

Technology-push remains a limited driver because of restrictions set by to international and national standards (i.e. related to security and environmental issues).

Finally, the aerospace industry carries a historical “heritage” and it is often considered as strategic in terms of “economic sovereignty”. Thus, there are international pressures among large and industrialised countries to develop a powerful and stable aerospace industry that gives “visibility” to the country worldwide. This explains public intervention and the strong government efforts for concentrating R&D activities in the country (despite some assembly activities from Airbus taking place in fast-growing developing countries like China since 2009).

**R&D collaboration between industry and universities**

Experts underlined the importance of collaboration between industry and universities as a driver for BERD. In the industry’s view, applied R&D is mostly the responsibility of industry, whereas fundamental research is to be undertaken by academics in

\(^{17}\) Airbus faced major complications in 2005 and 2006 connected to its new 550-seat A380 plane.

\(^{18}\) China’s aerospace industry consists of two major conglomerates of Aviation Industries China (AVIC I and II) grouping around 200 firms.

\(^{19}\) According to the Chinese National Bureau of Statistics, there was a 35% decrease in the total number of employees since 2000.

\(^{20}\) The Cost Readiness Levels (CRL)s scale is commonly used in order to evaluate planned R&D expenditures and determine investment priorities. They are designed to communicate the quality of the cost estimate to stakeholders. It is based on the model “Technology readiness level” developed by the NASA used to assess the maturity of evolving technologies prior to incorporating that technology into a system. See the Program Analysis and Evaluation Office of the NASA here: [http://www.nasa.gov/offices/pae/organization/cost_analysis_division.html](http://www.nasa.gov/offices/pae/organization/cost_analysis_division.html)
universities or research labs. Some large companies (i.e. Thales Alenia Space, Airbus) had signed cooperation agreements with universities and engineering schools (écoles d’ingénieurs) on PhD programmes and special scholarships. In this extent a recent reform related to freedom and responsibilities of universities, the loi d’autonomie des universités (or LRU: loi relative aux libertés et responsabilités des universités), was signalled as a factor hindering collaboration, and thus BERD, since the role of universities and research labs in R&D is less clear. The law, adopted in 2007, expects that by 2013, all universities achieve complete budgetary and financial autonomy and management of their human resources, including the right to become owners of their real state. The financial autonomy is said to favour financial criterion when choosing research priorities (i.e. profitability of R&D), and thus risking the quality and quantity of fundamental research, and long-term applied research.

The above also has implications for Intellectual Property Rights (IPR). Universities and research centres have increasing pressures towards strong IPRs and patenting (i.e. in order to guarantee future financial profitability of R&D investments). Industry experts expressed IPRs to be increasingly a burden of collaboration among stakeholders in the industry, since short-term valorisation processes are being preferred to long-term strategic visions.
4 The role of public policies in determining BERD performance and BERD intensities in the French aerospace industry

France has a long history of strong involvement of the government in the industry, mainly justified by arguments on market failures and the industry being strategic in terms of innovation, highly qualified employment, trade and economic sovereignty. In terms of policy measures, the industry can be separated in two distinctive sub-industries: aeronautics and space. Both sub-industries have differentiated policy measures.

Policy design falls within the responsibility of the government’s ministries. Most R&D and innovation policy choices are made in the context of the annual vote on the law related to R&D, the Mission of Research and Higher Education (MIRES). After major changes over the last years due to the modernisation of the state budget management, the implementation aspects of the policies increasingly fall into the agencies’ responsibilities.

The National Agency for Research (ANR or Agence Nationale de la Recherche) was primarily designed to finance research projects but since 2008 it deals with innovation. Its responsibilities developed to include the management of R&D related programmes relevant to the aerospace industry, such as the Carnot institutes (FR_68) and the competitiveness clusters (FR_62) (INNO-Policy, 2008). The Agency for Industrial Innovation (AII), absorbed by the OSEO agency since 2008, was created in 2006 to support and subsidise large programmes for industrial innovation. The rationale for the creation of the AII was to support new structuring industrial programmes such as Airbus, with the aim of increasing BERD notably among large enterprises. These large-scale programmes were based on multi-disciplinary R&D and involved pre-competitive development activities. Finally, a new institutional actor emerged, the Ministry in charge of Ecology, Energy, Sustainable Development and Land Management that resulted of the institutional merger between the Ministry in charge of Transport and Energy and the Ministry of the Environment. This Ministry is in charge of regulating and managing the environmental stringent objectives for the aerospace industry described in the previous section.

The European Space Agency (ESA) sets the priorities for the space sub-industry and funds most of its R&D. It draws up the European space programme and carries it through. ESA is an international organisation composed of 18 Member States, including France. ESA’s budget comes from the contributions of its members that are calculated as a function of each country’s GDP. Its headquarters are in Paris.

R&D public support to the French aerospace industry is in charge and monitored by the Ministry of Defence concerning military R&D and; the Ministry in charge of Ecology, Energy, Sustainable Development and Land Management (MEEDDM), concerning civil aeronautics R&D.

There are other relevant institutional actors that influence BERD priorities in the aerospace industry. The French Civil Aviation Authority (DGAC or Direction Générale de l’Aviation Civile) is a department of the Ministry of Ecology and sustainable development, responsible notably for safety and security. It supervises mainly the

21 The OSEO agency is strongly oriented towards SME and enterprise’s innovative projects support through a large set of support measures sometimes co-financed by the regional councils. Since 2008, the agency evolved towards larger enterprises and developing enterprises.
security control of companies active in the aircraft industry, aircraft operations and crew.

Government experts highlighted four indirect innovation policy measures under the responsibility of the Ministry of Research as being particularly relevant for the aerospace industry: the Research tax credit (FR_5, or Crédit d’Impôt Recherche), the Carnot institutes (FR_68 or Labellisation Carnot); the financing of academic labs concerning the offer of fundamental research; and the CIFRE conventions (Industrial contracts for training through research, or Conventions Industrielles de Formation par la Recherche).

The Research tax credit (CIR) is one of the central pieces of French innovation policies. The CIR was created to promote BERD across sectors. After modifications in 2004, 2006 and 2008, the current scheme is simpler and it applies to the volume of R&D expenditures: 30% of R&D expenses, 50% the first year and 40% the second year, with a EUR 100 million ceiling compared to a previous ceiling of EUR 16 million (INNO-policy, 2008). Government experts signalled the CIR to be extremely efficient, and a world reference, in pushing enterprises to invest in R&D.

The Carnot Institutes were created in order to promote the activity of public research institutes engaged in active research partnerships and socio-economic actors, including private enterprises. The institutes are managed by the ANR. So far, there are 33 Carnot institutes that gather 12% of public research staff and make up to 50% of contract research in France (INNO-policy, 2008). Labelled in 2007, ONERA is the Carnot Institute on aerospace systems. The Institute is the second most important in France in terms of volume of research in partnership (16% of all Carnot Institutes).

The CIFRE Conventions offer a subvention to any French enterprise that hires a PhD student for placement on research collaboration with a public research laboratory, thus promoting public-private partnerships on R&D. The CIFRE process started in 1981 by the French Ministry of Higher Education and Research. It has been successful in bringing together over 6000 enterprises and 4000 academic research laboratories involving around 12000 PhDs. From the students point of view it is an excellent opportunity to access to a diploma-based first job. The support has proven successful in terms of thesis defence for students and access to the job market. In 2008, around 6% of total CIFRE conventions were related to the arms industry (naval and aeronautical) (CIFRE, 2008).

Regarding direct innovation policy measures with a view to increase innovation and competitiveness, there is the inter-ministerial fund named the Company Competitiveness Fund (FCE or Fonds de Compétitivité des Entreprises). The fund belongs to the Ministry of Economy, Finance and Employment and gathers credits from the Ministries of Defence, Transport, Health, Agriculture and the Home Ministry. The FCE supports competitiveness clusters (pôles de compétitivité) and industrial R&D. Within the FCE, the FUI (Single Interministerial Funds or Fond Unique Interministérielle) finances R&D projects within the competitiveness clusters through two calls for projects every year. Consequence of a call for projects in December 2004, the Association Aerospace Valley (AAV) was created in July 2005 in order to develop at the national, European and International level the competitiveness of the Aeronautical pole and space embarked systems of the Midi-Pyrenees and Aquitaine (notably in the cities of Toulouse and Bordeaux). It is formed of companies, research centres, training centres and other relevant institutions concerned with the aerospace industry. The cluster received about EUR 1.5 billion of funding for the period 2006-2008. The AAV employs around 94000 people in industry and services, of which around 9% are research positions. It groups

22 The ONERA (Office national d’études et recherches aérospatiales) was created in 1946 and is the main actor on aerospace, space and defence R&T. It has around 2000 employees, and 1500 researches located in 8 sites around France.
relevant industry players such as Airbus, AirFrance Industries, Alstom, Dassault Aviation, EADS Space Transportation, EADS Socata, ONERA, Snecma Propulsion Solide and Thales. The cluster is a world leader in civil aircraft of over 100 seats, luxury business aircraft, low-and medium-power gas turbines for helicopters, landing gear and aircraft batteries.

At the EU level, the Community framework for state aid for research and innovation argues for State Aid focusing on activities that have the most sustainable impact on competitiveness, jobs and growth in the EU, such as R&D. Government experts signalled it as being relevant for boosting R&D (not exclusively in the aerospace industry but cross-sectoral). In 2005, around EUR 5.4 billion was devoted to R&D (around 12% of total State Aid). Recent impact studies (see Technopolis, 2008) had found the framework to have different effects across sectors and countries. In the case of France, the impacts were not only different depending on the sectors but also related to specific clauses of the framework (i.e. the matching clause).

Industry experts signalled the EU funds and Programmes to be complementary to the national initiatives and being more related to applied research than to fundamental research. According to industry experts, the main benefits of the EU R&D Framework Programmes is the possibility of collaborating in partnerships with different countries, and thus preventing double-investments and improving the efficiency of R&D investments.

In relation to education related policies, there are mixed conclusions on experts. Government experts signalled the importance of training through research schemes in order to boost BERD. They signalled that for the aerospace industry there is a good match between supply and demand of highly qualified workers. On the other side, industry experts signalled the employment market for the industry as being slightly in deficit (i.e. demand is higher than supply).
5 Conclusion, lessons learned, and policy options

To summarise key points in this case study report are:

• The Aerospace Industry is a high-tech industry and a powerful driver of R&D. The industry is geographically highly concentrated and dominated by large firms, both in economic terms and in R&D performance. The industry is not homogeneous and performance and behaviour in aeronautics and space are quite different.

• BERD drivers in the aerospace industry are mainly environmental issues and sustainable development, and implications stemming from the globalisation of industry. Other important drivers are security issues, international and national regulations, IPRs and R&D collaboration between industry stakeholders. R&D drivers in the space sub-industry are institutional programmes, international regulations (mainly related to climate change) and EU specific research frameworks (i.e. the Galileo global navigation satellite system). R&D efforts in the military side of the industry have been decreasing, mainly because of rather static military budgets.

• Competition drives BERD in the Aerospace industry. The US is France’s main competitor on aircrafts, and the so-called ‘Airliner Wars’ between Airbus and Boeing are driving R&D performance. China is emerging as potential competitor in the near future and most notably as an important exporter of aircraft components.

• R&D collaboration between industry stakeholders is a driver of BERD. Increased collaboration and transparency within a vision and roadmap shared by all stakeholders is desirable. The Council for Civil Aeronautics Research seems efficient and the appropriate institutional body for achieving this objective.

• Public funds and Programmes are strong drivers of BERD. France has a long history of strong involvement of the government in the aerospace industry. The main indirect innovation policy measures influencing BERD in the aerospace industry are: the Research tax credit, the Carnot institutes, the financing of academic laboratories concerning the offer of fundamental research; and the CIFRE conventions. The most relevant direct innovation policy measures supporting BERD is the support to competitiveness clusters, part of the Company Competitiveness Fund.
Case study author:
Lorena Rivera León
Technopolis Group Belgium
Avenue de Tervuren, 12
B-1040 Brussels
Belgium
T: +32 2 734 7440
lorena.rivera.leon@technopolis-group.com
www.technopolis-group.com

Experts taking part of the study group as interviewees:
Michel Andrau
R&D and Product Policy Director
Thales Alenia Space
100 Boulevard du Midi,
PO Box 99 F-06156 Cannes-la-Bocca
France
T: +334 9292 3233
michel.andrau@thalesaleniaspace.com
www.thalesgroup.com/space

Marc Belloeil
Ministère de l’Enseignement Supérieur et de la Recherche
1, rue Descartes
75231 Paris Cedex 05
France
T: +331 5555 8733
marc.belloeil@recherche.gouv.fr
www.enseignementsup-recherche.gouv.fr

Anne Bondiou-Clergerie
Directeur des Affaires R&D et Space
Groupement des Industries Françaises Aéronautiques et Spatiales (GIFAS)
8, rue Galilee
75116 Paris
France
T: +331 4443 1770
anne.bondiou-clergerie@gifas.asso.fr
www.gifas.asso.fr

Patrice Desvallees
Sous-Directeur adjoint de la construction Aéronautique
Direction des programmes aéronautiques civils (DPAC), Direction Générale de l’Aviation Civile
9, rue de Champagne
91200 Athis Mons
France
T: +331 5809 3583
Joseph Prieur
International Affairs Directorate
Office National d’Etudes et de Recherche Aérospatiales (ONERA)
CLORA Club des Organismes de Recherche Associes
8 Avenue des Arts
B-1210 Brussels
Belgium
T: +32 2 506 88 41
prieur@clora.eu
Bibliography

ASD (2007), Facts and Figures 2007, Aerospace and Defence Industries Association of Europe, Brussels

CIFRE (2008), CIFRE Conventions, Scientific thinking, Business thinking, Association national recherche technologie, Ministère de l'enseignement supérieur et de la recherche


Technopolis (2008), Impact de l’encadrement communautaire des aides d’état a la recherche et développement et innovation sur la compétitivité de l’Union européenne, Programme National d’Assistance Technique, Direction Générale des Entreprises, European Commission

Vekeman, Guy (2006), Manufacture of aerospace equipment in the European Union, Eurostat, Statistics in focus; Industry, Trade and Services

Other sources

Centre d’analyse stratégique: www.strategie.gouv.fr
The European Space Agency: www.esa.int
Centre National de Recherches Météorologiques: www.cnrm.meteo.fr
European Aeronautic Defence and Space Company: www.eads.com
Airbus: www.airbus.com
International Air Transport Association: www.iata.org
Agence Nationale de la Recherche: www.agence-nationale-recherche.fr
Association Aerospace Valley: www.aerospace-valley.com
“Sectorial analysis of the long-term dynamics of business R&D intensity”

In relation to (DG-RTD-2005-M-02-01):

“Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators”

Case study
Business Expenditures in R&D in Ireland

John Clark
Technopolis Group

Coordinated by

Brussels, 22 September 2009
Business Expenditures in R&D in Ireland

1. Synthesis

This case study of recent trends in business expenditure on research and development (BERD) in Ireland, at the industrial sector level, includes a summary of Irish BERD performance at the national/sectoral level, and attempts to identify the main drivers behind recent trends, the pattern of public policy and its role.

Ireland has been involved in a ‘catching up’ process of investment in research and development (R&D) from very low levels in the 1980s to a BERD intensity still below, but approaching, that of the average for the OECD countries. This has been accompanied by large inputs of public support to R&D in higher education and in business itself, which have helped pull R&D in the desired directions of higher BERD and, at least until recently, increased concentration in particular sectors, notably information and communication technologies (ICT) and biotechnology.

The extent to which overall and sectoral trends in BERD have been driven by ‘external’ factors on the one had, and are attributable to public policy on the other, is (as always) difficult to delineate. A major external factor was the large and unexpected influx of (mainly US) multinational corporations in the 1990s, attracted by a low-wage, low-tax economy. These conditions made Ireland an attractive base for production but not, initially at least, for R&D. Irish R&D policy since the late 1990s can be seen as an attempt to capitalise and consolidate this trend by establishing Ireland as an international base for R&D by supporting the development of facilities to attract researchers from abroad, efforts to increase the stock of domestically-trained researchers, grants to companies and promotion of their collaboration with higher education institutes (HEIs) particularly targeted to ICT and biotechnology, and (later) R&D tax incentives, representing a form of more general support for R&D applicable to all sectors.

BERD in Ireland has increased very rapidly over the last 20 years. It is now (2008) at about 1% of gross domestic product (GDP), compared with an OECD average of about 1.3%. The rise in BERD intensity over the period has arguably, and somewhat perversely, been constrained by the exceptionally high rate of economic growth. Rapid growth in GDP and BERD has been accompanied by certain unevenness in development, with overseas-based multinationals rather than indigenous companies contributing most of the increase in BERD. There is still some way to go to establish R&D within the business culture in many sectors, and to develop widespread interaction between the science base in HEIs and business oriented research, whereby the former can contribute novel ideas of practical benefit to industry, which the latter are able to absorb and apply.
2. BERD performance in Ireland

2.1 Overall levels and intensity of BERD

Business expenditure on R&D (BERD) was at a very low level in the 1980s, averaging around 0.5% of GDP. Strong economic growth in Ireland in the 1990s was accompanied by strong growth in BERD, which roughly trebled in real terms during the 1990s. Over 1996-1999, BERD growth of about 14% per annum matched the growth of the overall economy (Forfas, 2007). By 1999, BERD had reached nearly €0.8 bn, around 0.9% of GDP, compared with a EU average of about 1.2%. Over 1999-2001, BERD (in constant prices) remained steady, while continuing strong economic growth saw BERD intensity drop to around 0.8%.

BERD continued to rise at a healthy rate during 2001-2007, rather more rapidly than GDP, signifying an overall rise in intensity; the recent economic downturn is expected to be accompanied by a further rise in BERD intensity. Methodological changes in data collection, however, mean that results need to be interpreted with caution (CSO, 2009).

In 2001, one-third of foreign firms in Ireland (300) was R&D-active, and accounted for two-thirds of BERD; just 19 of these firms accounted for nearly half of total Irish BERD. Expenditure in the HEI and public research sectors together accounted for €422m in 2002. Of Government funding for R&D, 56% was allocated to HEIs, 32% to public research organisations and 12% to support R&D in firms. Government support to business accounted for 4.5% of total business R&D, well below the EU average of 8% (Interdepartmental Committee on STI, 2004).

Growth in BERD since the turn of the century (Forfas, 2007) has been accounted for mainly by foreign-owned firms, whose BERD share rose from under 65% in 1999 to over 70% in 2006; BERD in indigenous firms rose by less than 10%, or little over 1% per annum, in constant prices.

2.2 Sectoral composition of BERD

The sectoral focus of BERD in Ireland has been strongly on biotechnology and ICTs. In 2001, 40% of indigenous firms’ R&D, and 22% of foreign affiliates expenditure, was in software and computer-related activities, while the respective figures for electrical/electronic equipment were 17% and nearly 50%. The ICT and electrical/electronic sectors account for well over half of all research personnel in Ireland (Forfas, 2007).

The other major R&D areas for indigenous firms were food, drink and tobacco (around 10% each), while pharmaceuticals and instruments accounted or most of the remaining foreign affiliates’ R&D.

1 It is often suggested (e.g. Martin, 2009) that, for Ireland, GNP is a more appropriate measure of economic activity than GDP, since GNP excludes the large outgoing flows of profits from multinational corporations (and other net income flows) which are very large for the country. GNP is some 19% lower than GDP, resulting in BERD intensity on the GNP basis (BERD/GNP) being around 0.15 of a percentage point higher than intensity on the GDP basis. However, for consistency with other case studies, the GDP intensity measure is used here.
Figure 1 shows the average sectoral composition of BERD over the two periods 1995-2000 and 2001-2006 (blue lines), compared with EU11\(^2\) averages (red). Overall, the five sectors accounting for the highest share of BERD are:

- Radio, TV and communication equipment
- Computer and related activities
- Pharmaceuticals
- Instruments, watches and clocks
- Electrical machinery

Together, these sectors accounted for a little over 60% of BERD 1995-2000 and nearly 75% 2001-2006, indicating increased sectoral BERD concentration. The outstanding changes between the periods are the trebling in the BERD share of computer and related activities (and a smaller increase in the share of pharmaceuticals), accompanied by a halving of the radio, TV and communication equipment share. Several sectors with initially low levels of BERD (motor vehicles, chemicals excluding pharmaceuticals, rubber and plastics) showed relative declines between the periods. Compared with Europe (EU11) overall, the outstanding feature of BERD composition is the high share of Irish BERD in the ICT area.

Figure 1. BERD shares 1995-2000 and 2001-2006 (averages) comparisons with EU-11

The increase in the sectoral concentration of BERD is further demonstrated in Figure 2, showing ‘snapshots’ of BERD shares in 1995 and 2005. The combined shares of just two sectors, software/computing and pharmaceuticals, grew from 32% to 51%, while both Food, Drink and Tobacco and chemicals saw falls in BERD share of one-half, to just 5% and 2% of national BERD, respectively.

2 The countries included are Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden and the UK.
BERD in pharmaceuticals is conducted almost exclusively by FDI multinationals, while indigenous companies carry out around two-fifths of software/computing BERD.

**Figure 2: BERD shares 1995 and 2005**

Source: Forfas, 2007

### 2.3 Value-added and BERD intensity

In terms of their relative contributions to the Irish economy (i.e. value added), ICT and pharmaceuticals, together contributing around 5% of GDP, are far smaller than, for example, food manufacturing and non-pharmaceutical chemicals. The former are therefore far more R&D intensive – this is of course generally the case in industrialised countries, but (as discussed later) BERD in ICT and biotechnology in particular has received particular encouragement in Ireland through Government policy. ‘Computer and related activities’ is notable as the sector where Irish BERD intensity, as well as BERD share, is significantly higher than that of EU11. Irish BERD intensity in most other sectors (including pharmaceuticals) is below the EU11 average.

BERD intensity in both ICT and pharmaceuticals has increased significantly in Ireland since the mid-1990s. For ICT, value-added has also increased significantly – sectoral growth and higher BERD intensity have contributed to the overall growth of BERD in broadly equal measure. The relative size of the multinational-dominated pharmaceutical sector, in contrast, has remained almost constant, the increase in BERD being reflected in a proportionate increase in R&D intensity.

Falls in total BERD over 1995-2005 in the radio, TV and telecommunications and food, drink and tobacco sectors have been accompanied by reductions in BERD intensity, most notably in the former. There are some indications of a recovery in R&D in the food sector from the early-to-mid 2000s.
3. **Drivers of BERD intensity**

In the 1990s, the overwhelming driver of BERD intensity was foreign direct investment (FDI), by high-tech multinational firms based overseas. During the late 1980s and throughout the 1990s, there were very high levels of FDI into the country, with FDI inflows measuring 2.7% of GDP in 1997 (O'Doherty, 2002), the great majority of the investment being by US companies. Unlike most OECD countries with high FDI, most of the investments were in the form of greenfield sites rather than through mergers and acquisitions, foreign firms being attracted to develop new facilities in the country by low corporate tax rates, relatively low wages and a young well-educated workforce.

This FDI inflow led to the significant increases in BERD during the 1990s, as indicated in Section 2. By the mid-to-late 1990s, more than two-thirds of Irish BERD was contributed by foreign-owned companies located in Ireland, a situation very unusual among OECD countries.

Most investment was concentrated in electronics, software and pharmaceuticals, but with little of the resulting production being sold in the Irish market. In addition, the large US-based multinationals generally did not move large proportions of their R&D activities or facilities into Ireland – the high share of foreign contributions to Irish BERD, and its rapid growth, are indicative, rather, of the very low indigenous base. A significant factor here is the low corporate tax rate – while making Ireland an attractive location for production and profit generation, there was less incentive to carry out R&D in a country without tax offsets against R&D expenditures. Unlike most OECD countries, Ireland had no R&D tax credit scheme before 2004.

Hence, while the FDI was beneficial for Irish employment and exports, involving significant transfers of existing technology and know-how into the economy in general, it did not itself lead to a process of significant diffusion of technologies and knowledge embodied in them into the wider industrial base (O'Doherty, 2002). The low transfer of R&D resources from the multinationals’ home countries was exacerbated by a lack of absorptive capacity in the predominantly low-tech, traditional Irish manufacturing sector, which severely restricted the extent of technological ‘spillovers’ to the wider economy.

At the turn of the century, R&D was seen by the Government not to be solidly embedded in the structure of the economy. Rapid economic growth, rising wages and increased international competition in many areas were becoming powerful drivers for a move up the ‘value chain’ involving research-based improvements in product and process technologies. Large-scale initiatives were launched by the government to improve the country’s stocks of both physical and human capital, primarily oriented towards basic or ‘strategic’ research, principally through support to the universities.

R&D has been stimulated in the last few years by support from public funds, the areas of ICT and biotechnology being the prime beneficiaries. Research talent has been attracted from abroad, and the flow of domestically trained researchers increased. Traditional sectors have benefited to some extent also – for example, the food sector has moved from basic primary commodities to higher value products such as probiotics, with support from Enterprise Ireland, and the R&D in the

---

3 Measures taken by the Irish authorities to increase R&D are discussed in Section 4.
‘instruments’ sector has been stimulated by development of an industrial cluster specialising in medical devices. Such developments were driven to a considerable extent by a combination of FDI and government-aided support.

A potentially important driver of BERD, of general rather than sector-specific importance, has been the introduction and development of tax-credit schemes since 2004. These, considered in more detail in the next section, appear not yet to have had major impacts. They, and other policy measures, are largely intended to reduce the tendency of multinationals to leave their major R&D activities and resources at home, an important constraint on Irish BERD. Another constraint on BERD intensity, relevant particularly to indigenous firms and to more traditional sectors, is the lack of a history of innovative behaviour in Irish businesses, as evidenced by the very low levels of BERD prior to the major influx of foreign multinationals (e.g. Forfas, 2007). Changing cultural attitudes is a slow process.

An aspect of R&D activity increasingly recognised as important is absorptive capacity – ‘the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends’ (Cohen and Levinthal, 1990). This depends on skills and processes typically built up over years or decades. It requires the ability to recognise opportunities presented to the firm by external knowledge, and is fostered by strong external links such as with other companies and with academia. A 2005 study (Forfas 2005a) provided a strong endorsement of the importance of absorptive capacity, in particular through appropriate human resources and of the benefits of deliberate management of innovation within firms and the wider innovation system, including the building of links with higher education institutions. It recognised, however, that realisation of the benefits of the huge increases in national R&D investment, and building on the great progress of previous years across the whole economy, required renewed policy measures to build absorptive capacity.

A recent ERAWATCH report (Martin, 2009) identifies weak absorptive capacity in indigenous Irish industry as an ongoing problem, and cautions that ‘weak higher-education - industry linkages may dissipate the returns from Ireland’s foresight investment in biotechnology and ICT’. The report points out that national infrastructure is not ideal in this respect, with ‘no specialist or sector-based research institutes in Ireland which, in other countries, play a major role in assisting SMEs to source and utilise knowledge produced in the higher education or public research sectors’. The report acknowledges, however, official recognition of the problem and initiatives to ameliorate it.

Ireland, which has experienced uneven development with many sectors lagging in R&D, has a particular need to benefit from improved absorptive capacity, where the rich supply of multinationals provides opportunities for others to reap externalities.
4. The role of public policies in determining BERD performance and BERD intensities

4.1 Policy framework for R&D and technological progress

Division of responsibility for RTDI policy in Ireland is quite complex, although overall responsibility lies with the Department of Education and Science (DES) and the Department of Enterprise, Trade and Employment (DTE). Within the latter, development of RTDI policy lies with the office of Science and Technology (OST). DTE is also responsible for policy development and implementation bodies, in particular:

- Enterprise Ireland, established in 1988, has a team of advisors working closely with Irish firms. It manages a variety of RTD and general business support programmes, and programmes to promote industry/academic links for technological development;
- IDA (Industrial Development Authority) Ireland, the body with national responsibility for attracting overseas investment to Ireland as well as working with existing multinationals to increase their R&D and other activities in Ireland;
- Forfas, the policy advisory and co-ordination board for industrial development and S&T, with legal powers for technology promotion, and through which powers are delegated to Enterprise Ireland and IDA Ireland.

In addition, the Irish Council for Science, Technology and Innovation was set up in 1997 to advise Government on S&T matters. One of its initial focuses was on Technology Foresight, an exercise that led to the inception of another new institution, Science Foundation Ireland (SFI), tasked with establishing a world class capability in niche areas of ICT and biotechnology, including underlying scientific disciplines. There was a perceived need to build up a strategic research capability in these areas, involving longer-term rather than applied research. This was complemented in more recent years by the appointment of a Chief Scientific Advisor to the Government.

In Ireland, the Higher Education Authority funds the HEI research infrastructure, with expertise at the sectoral level supported by SFI funding. Enterprise Ireland is concerned with the promotion of academic-industry collaboration and commercialisation. Technology programmes sponsored by Enterprise Ireland have been more successful in some areas than others, one constraining factor to increased R&D being the large number of non-innovative SMEs in the country.

4.2 R&D policy and National Development Plans

2000-2006

The National Development Plan (NDP) 2000-2006 set aside nearly €2.5bn for research, technological development and innovation (RDTI). For comparison, this sum corresponds to between one-half and one-third of total Irish BERD over the period. NDP finance was focussed primarily on basic or strategic research; €1.1bn of this was to be for fundamental research, of which €560m was to be administered by Science Foundation Ireland, and €550m to be channelled to HEIs.
The expansion of the RTDI institutional framework, and increases in funding, reflected concern regarding the levels and structure of R&D investment in Ireland. The increases during the 1990s still did not pull Irish BERD/GDP intensity up to those of most EC countries, and its dependence on FDI was seen to render the gains vulnerable to strategic decisions by the overseas companies. There was a perceived need (articulated in a report by the National Competitiveness Council (2000) and the Technology Foresight exercise) to entrench competitive advantage within the country, through fundamental enablers such as experienced researchers and R&D facilities that were seen to be largely located abroad.

The NDP was designed to promote ‘a major accelerated increase in RTDI investment’, with the objectives in particular of strengthening the capacity of Irish third level institutions and other research establishments to conduct research relevant to the needs of the Irish economy, and strengthening the capacity of Irish firms to assimilate the results of R&D into their products and processes.

There was therefore considerable emphasis on basic research in HEIs, and, sectorally, emphasis on ICT and biotechnology.

A major capital investment programme was incorporated in the plan, to develop the R&D physical infrastructure of HEIs to increase research potential and to facilitate, in turn, collaborative R&D efforts with industry and foster industrial exploitation of the improved research base. An additional policy/research-management objective was to develop the Programme for Research in Third Level Institutions (PRTLI) 1999-2001, which involved a system of competitive bidding between HEIs for research support for national strategic priorities, and to provide postgraduate and post-doctoral support.

A review of supports provided for R&D in the business sector (Evaltec, 2004), specifically those operated by IDA Ireland, noted, among other things, limited success with policies for fostering collaborative research networks, key success factors for which were technological capability within industry and an HEI culture conducive to such collaborations.

A survey of business opinion on the activities of the Science Foundation Ireland found that the SFI-funded Centres for Science, Engineering and Technology (CSETS) had resulted in useful increases in industry/academic networking (Forfas, 2005b). While broadly supportive, some business opinion was that SFI’s funding had tended to favour basic science at the expense of strategic applied research, with most support given in research grants to academics and smaller amounts awarded to CSETs. They also considered that real skill shortages existed in Ireland and expressed doubts that SFI funding would produce the right type of people for industry – up-to-date skill sets with a degree of industry exposure, rather than PhDs with a purely academic background, were required. As indicated earlier, interactions between SMEs and academia appear to be very low. Overall, businesses considered SFI to have been more successful in raising the level and quality of HEI research than in fostering industrial exploitation of it.

In 2004, the Inter-Departmental Committee on STI produced an Action Plan for Promoting Investment in R&D to 2010, by which the vision of an Ireland ‘internationally renowned for the excellence of its research and at the forefront in generating and using new knowledge for economic and social progress within an innovation driven culture’ was seen to depend, among other things, on:

- BERD increasing from €917m (2001, 0.9% of GNP) to €2.5bn (1.7% of GNP) by 2010;
• A doubling of indigenous companies performing ‘minimum’ (at least €100,000 per annum) R&D;

• A quadrupling of indigenous enterprises performing R&D in excess of €2m per annum;

• Total R&D increasing to 2.5% of GNP by 2010 (1.4% in 2001, compared with an EU average of 1.9%).

The means of achieving the enterprise sector targets were seen to be:

• A reorientation of the enterprise support budget towards R&D from other forms of business support;

• To support development of strategic research competencies (technology platforms) based on enterprise needs;

• To develop seed capital markets for early stage ventures.

Ireland introduced a 20% tax credit against corporation tax for incremental R&D in the Finance Act 2004, rather late and (initially at least) not generous in comparison with tax credit schemes in other EU and OECD countries. A separate credit was introduced for capital spending on R&D facilities. Tax credits apply to R&D in general, rather than providing sectorally focussed R&D, as with previous initiatives. In 2008, the benefits were increased, with the rate being raised to 25% and the base year against which incremental increases in R&D were to be measured remained as 2003. It appears that the scheme is only just beginning to be effective, although no impact assessment is yet available. Such assessments are difficult, as are attempts to attribute increases in R&D to any specific factor, although studies do suggest a substantial R&D response to tax credit schemes (e.g. Griffith et al. 1996).

2007-2013

The National Development Plan 2007-2013 includes investment of €6.1bn in Science, Technology and Innovation (STI). This includes a €2.3 million Enterprise Ireland supported research programme for the biopharmaceutical sector, details of which were announced in June 2009. The emphasis on ICT and biotechnology evidenced in the previous NDP remains, with some broadening into other areas.

The STI Programme operates through the following major cross-sectoral sub-programmes:

• World Class Research — €3.5bn, mainly for funding channelled through SFI, focusing again on biotechnology and ICT, although the SFI’s remit was amended in May 2008 to include the broad thematic area of sustainable energy and energy-efficient technologies (DETE 2008).

• Enterprise — €1.3bn, administered mainly by Enterprise Ireland.

Other (sector-specific) sub-programmes are agri-food (€641m), energy (€149m), marine (€141m), geoscience (€33m), health (€301m), environment (€93m).
4.3 International private-public R&D collaboration: Irish participation in EU Framework Programmes

Irish participation in the EU’s Fourth Framework Programme (FP4, 1994-1998) was high, but this performance was not maintained in the subsequent FP5 (1998-2002), when the number of participations fell by 40% and the total funding received by 55%. A complex of reasons, mainly concerned with broad economic conditions, are thought to explain this, and a number of hypotheses have been put forward (Technopolis, 2005).

Ireland’s share of total funding remained largely unchanged between FP5 and FP6 (Technopolis, 2009). Participation levels in FP6 were slightly down on those of FP5, but success rates within the competition were well above those for applicants from all countries, although industry success rates were much lower than those of other types of applicant. The recent ERAWATCH report (Martin, 2009) also draws attention to declining numbers of Irish private-sector participants in Framework Programmes. It appears that national funding issued by SFI and other agencies has to some extent ‘crowded out’ FP6 participation (Technopolis, 2009).

A policy of encouraging greater Irish participation in Framework Programmes as a means of promoting international linkages and Irish BERD seems appropriate in the light of these trends.

4.4 Trends and effects of policy

There are indications that developments in Irish R&D have been moving positively, and that efforts to embed R&D in the national economic system are paying off. The recent Government report on progress in developing the ‘smart’ economy (DETE, 2009) notes the following:

• Some apparent success in start-ups and spinouts, with support from Enterprise Ireland for 430 ‘high potential’ start-up (HPSU) companies between 2000 and 2006, investing €219m in these companies. 40% of this was for R&D, and leveraged a further €262m from the companies themselves. A further 140 HPSUs were supported in 2007-2008, 21% of which were created by people previously employed in multinationals – although there appears to be a lack of independent evidence on the impact of the support. Spinouts from HEI appear to be low (but possibly improving); 13 in 2007, 7 in 2008, 14 in the first half of 2009.
• There was a rather modest 20% increase in researchers in business 2001-2007, but a 183% increase in PhD researchers, to around 14% of all business researchers.
• Ireland’s bibliometric output is now above the EU average, having been well below in 2003, and its overall global ranking has risen from 27th in 2003 to 17th in 2008. There have also been gains in the more commercially relevant areas of patenting and licensing.

The main outstanding issues required to achieve a higher level and greater sectoral balance in BERD in Ireland appear to be improved flows of knowledge from the science base to industry, and the establishment of an innovative and entrepreneurial attitude in the latter, especially among low-BERD indigenous firms.
5. Conclusions, lessons learned and policy options

To summarise key points in the report:

- Irish BERD has been increasing rapidly during the 1990s and 2000s, from a previously very low base to an intensity (BERD/GDP) still below, but approaching, that of comparable developed nations. Sectorally, there has been an increasing concentration of BERD in ICT and pharmaceuticals (rising to 75% in these sectors combined), prompted both by the arrival of hi-tech multinationals and (later) by Government policy.

- FDI was the major BERD driver in the 1990s, with low company taxes and low wages encouraging production facilities by multinationals. While this increased the level of BERD in high-tech sectors, most of the R&D base of the incoming companies remained at home. There was a perceived need to embed R&D in Ireland to retain investments and sustain growth.

- Government policy was designed to facilitate this, and was involved particularly in raising the science base in niche ICT and biotech areas. Policy since the late 1990s has been successful in raising the HEI science base, and BERD has continued to increase rapidly, still mainly among the foreign-owned firms.

- The ability of indigenous firms in particular to take advantage of developments in the science base, and to benefit from knowledge spillovers from their foreign-owned counterparts, remains limited, and an increase in the absorptive capacity of these firms might be expected to lead to Ireland being well up in the ranks of mainstream innovative economies.

- Similar conclusions apply to gains from interaction with foreign companies and research organisations, which could be stimulated through greater involvement with EU Framework Programmes.

- The recent Indecon (2008) review of Science Foundation Ireland finds that significant collaborative, research and commercial outputs have emerged since the establishment of SFI. While recognising attribution difficulties, it concludes that ‘in light of the significant funding allocations made by SFI which outweigh all other sources, we feel it reasonable to attribute most of these gains to the increased incidence of SFI funding’.

- Overall, evidence suggests the relatively long-term view adopted for government R&D policy in the past has been successful. There are many case-study examples of successes (e.g. IDA Ireland (2009), but most evidence to date is anecdotal. While (as Indecon (2008) suggest) it is early to assess the impact of Government support programmes, there is now a need for ongoing, rigorous independent evaluation studies to assess the absolute and relative efficacies of the various Governmental initiatives to increase BERD, including tax incentives.
CONTACT DETAILS

John Clark
Technopolis Group Limited
3 Pavilion Buildings,
Brighton BN1 1EE
United Kingdom
T: +44 (0)1273 204320
john.clark@technopolis-group.com
www.technopolis-group.com

Experts taking part of the study group as interviewees:

Helena Acheson
Division Manager
Science, Technology & Innovation Policy and STI Awareness Programmes
Forfas
Wilton Park House
Wilton place
Dublin 2
T: +353 1 607 3019
helena.acheson@forfas.ie
www.forfas.ie

Marcus Breathnach
Senior Policy Advisor
Science, Technology and Human Capital Division
Forfas
Wilton Park House
Wilton place
Dublin 2
T: +353 1 607 3241
www.forfas.ie

Neil Cooney
Policy and Corporate development
Enterprise Ireland
T: +353 1 727 2378
Neil.cooney@enterprise-ireland.com
www.enterprise-ireland.com

Dick Kavanagh
Managing director
Industry research and development Group Ltd
Pembroke House
28-32 Upper Pembroke Street
Dublin 2
Ireland
T: +353 1 237 4671
Dick_kavanagh@irdg.ie
www.irdg.ie
Pat Nolan
Principal Officer
Cross-departmental STI Policy, Governance and Awareness
Department of Enterprise, Trade and Employment
23 Kildare St.
Dublin 2
Ireland
T: +353 1 631 2466
pat_e_nolan@entemp.ie
www.entemp.ie

Dermot O’Doherty
PMPGenesis Consulting
T: +353 87909 2491
dermot@genesisconsult.com
www.genesisconsult.com

John Smith, Enterprise Ireland
Manager - R&D and Technology Transfer
Enterprise Ireland
The Plaza
East Point Business Park
Dublin 3
T: +353 1 727 2206
John.Smith@enterprise-ireland.com
www.enterprise-ireland.com

Andrew Stockman
Manager, Tax, Finance and Surveys Department
Enterprise Division
Forfas
T: +353 1 607 3224
Andrew.stockman@forfas.ie
www.forfas.ie
Bibliography

CSO (Central Statistics Office, 2009), Business Expenditure on Research and Development 2007/2008


Department of Enterprise, Trade & Employment (2009), Delivering the Smart Economy

Enterprise Ireland (2009), Annual Report and Accounts 2008


Forfas (2005a), Making Technological Knowledge Work: A Study of the Absorptive Capacity of Irish SMEs

Forfas (2005b), Science Foundation Ireland: The First Years 2001-2005

Forfas (2007), Research and Development Performance in the Business Sector Ireland 2005/6

Government of Ireland (2005), Strategy for Science, Technology and Innovation


IDA Ireland (2009), Ireland – A Winning Proposition for Research, Development and Innovation

Indecon (2008), Value for Money Review of Science Foundation Ireland

Interdepartmental Committee on STI (2004), Building Ireland’s Knowledge Economy – the Irish Action Plan for Promoting Investment in R&D to 2010

Irish Central Statistics office (2009), Business Expenditure on Research and Development 2007/2008


National Competitiveness Council (2000), The Competitive Challenge, Forfas

Technopolis (2005), *Evaluation of the Impacts and Operation in Ireland of the European Union’s Fifth Framework Programme for Research, Technological Development and Demonstration*

Technopolis (2009), *Evaluation of Framework Programme 6 in Ireland*
“Sectorial analysis of the long-term dynamics of business R&D intensity”

In relation to (DG-RTD-2005-M-02-01):

“Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators”

**Case study**

A comparative study between the Aerospace industry and the Radio, TV and communications equipment sector in Italy

Alessandro Muscio
Universita Luiss Guido Carli

Coordinated by
Technopolis Group

**Brussels, 13 November 2009**
# Table of contents

1. Synthesis 427

2. BERD performance in studied sectors 428

3. Drivers of BERD intensity 431
   3.1 BERD intensity in the Aerospace and in the Radio, TV and communication equipment sectors: a tale of two companies 431
   3.2 Drivers of BERD intensity in the Aerospace Industry 433
   3.3 Drivers of BERD intensity in the Radio, TV and communication equipment industry 435

4. The role of public policies in determining BERD performance and BERD intensities 438

5. Conclusions, lessons learned and policy options 442

Bibliography 444
A comparison between the Aerospace Industry and the Radio, TV and communications equipment sector in Italy

1 Synthesis

Business R&D in Italy is concentrated in just 5 sectors: Radio, TV and communication equipment, Motor Vehicles, R&D Services, Aircraft, Machinery and equipment. Over the period 1995-2006 there were some substantial changes in sectoral R&D intensity: which increased in the Aircraft industry and steeply declined in the Radio, TV and Communications equipment industry. Despite starting from the same country framework conditions and characteristics, different drivers at the sectoral level increased performance in the former industry and decrease it in the latter.

BERD investment in these two sectors can be attributed to the strategic decisions and to changes occurred to two leading companies: Finmeccanica, a leading manufacturer in Europe in the aerospace industry, and Telecom Italia, the national Italian telephone company.

Since 1995 the Italian government dismissed much of its participation in Finmeccanica (retaining only one third of the capital) and liberalised the telecommunication industry, privatising Telecom Italia.

Finmeccanica then started acquiring important aerospace companies and signing joint ventures, accumulating critical mass and competences in several key areas of the aerospace and defence industry. Large business orders for aircrafts, helicopters and other equipment allowed substantial investments in R&D and the expansion of the Group.

On the other hand, the privatisation of telecommunications in Italy, drastically increased competition between Telecom Italia and other service operators, bringing down investments in the equipment sector as well. Telecom Italia drastically reduced its R&D activity and the number of companies in the equipment sector decreased sharply. At present the highest investor in R&D in the Radio, TV and communication equipment sector is Italtel a company also participated by Telecom Italia.

The Italian government sector did not implement relevant policy initiatives in support of high-tech industries. However, whilst R&D activity in the aerospace and defense industry was still able to thrive because of large business orders that permitted to Finmeccanica to readjust its strategy in the international scenario, the sudden increase in competition brought by market liberalisation of telecommunication had devastating effects on the whole industry.
2 BERD performance in studied sectors

Over the last five years the rate of economic growth in Italy has been below the EU27 average. Real GDP growth peaked to 1.9% in 2007 and then slowed down to 1.5% in 2008 after few years of very modest growth rates.

Business confidence in 2008, before the world financial crisis, was low but the superior economic performance of other countries sustained exports. In fact, Italy has always performed relatively well in terms of exports, even if since 2004 the trade balance has been negative (-8.6 M€ in 2007).\(^1\)

Innovation performance has been modest. According to the Growth Competitiveness Index estimated by the World Economic Forum, Italy underperformed other EU large countries like France, Germany and the UK. The European Innovation Scoreboard (EIS) rates Italy as a “moderate innovator”, where the rate of improvement of innovation performance has been below the EU27 average (EC, 2009). Over the past 5 years, the EIS found that strong growth in Italy’s innovation performance had come from improvements in “Human resources”, “Finance and support”, “Throughputs” and the “Summary Innovation Index (SII)”.\(^2\) Performance in Firm investments has not improved and performance in Innovators and Economic effects has worsened, in particular due to a decrease in New-to-market sales (-7.8%) and New-to-firm sales (-5.3%). The EC (2008) identifies the main weaknesses of the Italian innovation system via the analysis of the EIS indicators. The EIS indicators identify as the main challenges for Italy improving performance in the following areas:

- Science & Engineering (S&E) graduates and population with tertiary education;
- Business R&D;
- Skills acquisition and educational attainment.

These weaknesses in the innovation system constrain R&D performance and innovation activity. Istituto Nazionale di Statistica (ISTAT) monitors R&D activity in Italy measuring R&D expenditure in firms, not-for-profit organisations and public institutions (ISTAT, 2008). Between 2005 and 2006, R&D expenditures grew 6.1% in real terms, accounting for 1.14% in terms of the country’s GDP. The largest contribution to R&D growth is provided by BERD that grew 4.5% over the period considered.\(^3\) In 2006, the business sector invested 8,210 M€ in R&D (48.8% of total expenditure), universities invested 5,098 M€ (30.3%), public institutions 2,897 M€ and not-for-profit institutions 630 M€ (3.7%). Over the period considered there has been no drastic changes in the expenditure distribution, with BERD representing around 50% of total R&D expenditure and therefore well below the targets set by the EC (66%).

The central government introduced in 2005 a tax credit for the remuneration of internal or external staff assigned to R&D tasks. The introduction of this policy initiative inevitably had some effects on the distribution of R&D expenditure across sectors, increasing R&D investments especially in the business sector and in not-for-profit institutions.

---

1 Source: ICE (2009).
2 The SII gives an “at a glance” overview of aggregate national innovation performance.
3 However, this change in the composition of R&D expenditure was partially due to the change in status of some large private research institutions (from private to public and from public to not-for-profit).
According to ISTAT (2008b), innovation expenditure in 2006 in Italy was highest in the following three sectors: Aircraft & aerospace; TV, Radio TV & telecommunications; office equipment. These sectors also derive some of the highest shares of turnover from innovative products. There is a direct relationship between expenditure per employee and firms’ size. In fact, large enterprises invest around € 9000 per employee, whilst medium and small enterprises invest respectively € 5000 and € 2400.

### Table 1. Innovation expenditure in Italy

<table>
<thead>
<tr>
<th>Sector</th>
<th>Total (x € 1000)</th>
<th>Per employee (total enterprises)</th>
<th>Per employee (total innovative enterprises)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft &amp; aerospace</td>
<td>732,299</td>
<td>22.0</td>
<td>23.7</td>
</tr>
<tr>
<td>Radio, TV and communication equipment</td>
<td>1,324,246</td>
<td>19.7</td>
<td>24.6</td>
</tr>
<tr>
<td>Office equipment</td>
<td>179,746</td>
<td>16.7</td>
<td>20.3</td>
</tr>
<tr>
<td>Pharmaceutical products</td>
<td>864,342</td>
<td>12.5</td>
<td>14.7</td>
</tr>
<tr>
<td>Manufacture of other transport equipment</td>
<td>1,134,119</td>
<td>11.7</td>
<td>15.1</td>
</tr>
<tr>
<td>Other industries</td>
<td>15,731,574</td>
<td>4.8</td>
<td>8.2</td>
</tr>
</tbody>
</table>

Source: ISTAT (2008b)

OECD data confirm that Business R&D in Italy is concentrated in the following 5 sectors that account for over 55% of the total in the period 1995 to 2006:

- Radio, TV and communication equipment
- Motor Vehicles
- R&D Services
• Aerospace
• Machinery and equipment

Since 1995, the Aerospace industry has gained the highest intensity in R&D expenditure that has also increased over time. On the other hand there has been a steep decline in the R&D intensity for Radio, TV and Communications equipment. Business data from the Industrial R&D Investment Scoreboard (EC-JRC, 2008) confirm this trend. This Scoreboard presents information on 2000 companies from around the world reporting major investments in R&D. The set of companies it covers comprises the top 1000 R&D European investors and the top 1000 R&D foreign investors. The rankings include 51 top investors in Italy. In 2007 Finmeccanica ranked first in Italy in terms of R&D investments. The Group operates primarily in the aerospace and defence sector but has interests in several other industries such as telecommunications. Other relevant sectors present in the Industrial Scoreboard are Automobiles and parts, and Telecommunications. R&D expenditure is concentrated in very few sectors. Aerospace and defence, and Automobiles and parts, account for 74% of total expenditures of Italian investors included in the Scoreboard. Only 1 company in the rankings, Italtel, belongs to the Telecommunication equipment sector (Ranking No. 6) and only Telecom Italia belongs to the Fixed line telecommunications sector (Ranking No. 6).

### Table 2. Industrial R&D Investment Scoreboard 2007: Italy

<table>
<thead>
<tr>
<th>No</th>
<th>Company</th>
<th>Rank</th>
<th>ICD Sector</th>
<th>NACE Sector Code</th>
<th>R&amp;D Investment 2007 (MC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Finmeccanica</td>
<td>16</td>
<td>Aerospace &amp; defence (271)</td>
<td>7522</td>
<td>1,985.00</td>
</tr>
<tr>
<td>2</td>
<td>Fiat</td>
<td>17</td>
<td>Automobiles &amp; parts (335)</td>
<td>3410</td>
<td>1,741.00</td>
</tr>
<tr>
<td>3</td>
<td>Eni</td>
<td>87</td>
<td>Oil &amp; gas producers (53)</td>
<td>1110</td>
<td>208.00</td>
</tr>
<tr>
<td>4</td>
<td>Pirelli</td>
<td>95</td>
<td>Automobiles &amp; parts (335)</td>
<td>2511</td>
<td>173.00</td>
</tr>
<tr>
<td>5</td>
<td>Intesa-Sanpaolo</td>
<td>98</td>
<td>Banks (835)</td>
<td>6511</td>
<td>167.00</td>
</tr>
<tr>
<td>6</td>
<td>Telecom Italia</td>
<td>133</td>
<td>Fixed line telecommunications (653)</td>
<td>6420</td>
<td>122.00</td>
</tr>
<tr>
<td>7</td>
<td>Daniele</td>
<td>135</td>
<td>Industrial machinery (2757)</td>
<td>2924</td>
<td>120.50</td>
</tr>
<tr>
<td>8</td>
<td>Italtel</td>
<td>156</td>
<td>Telecommunications equipment (9578)</td>
<td>3220</td>
<td>103.41</td>
</tr>
<tr>
<td>9</td>
<td>IFMSSI</td>
<td>203</td>
<td>Automobiles &amp; parts (335)</td>
<td>3410</td>
<td>71.70</td>
</tr>
<tr>
<td>10</td>
<td>Sorin</td>
<td>226</td>
<td>Health care equipment &amp; services (453)</td>
<td>3310</td>
<td>63.51</td>
</tr>
</tbody>
</table>

Source: EC, 2009
3 Drivers of BERD intensity

3.1 BERD intensity in the Aerospace and in the Radio, TV and communication equipment sectors: a tale of two companies

BERD investment trends in the Aerospace and Radio, TV and communication equipment can be attributed to the strategic decisions and to changes occurred to two leading companies in these sectors: Finmeccanica, for the aerospace sector, and Telecom Italia, for the Radio, TV and communication equipment sector.

The Italian aerospace industry comprises a small number of large firms and a much larger number of smaller businesses. The industry is considered to be world class in helicopters, propulsion and trainers (civil and military). The industry plays a leading international role in several specific areas of competence and market niches, with full system capability in helicopters, missiles and ATM and system integration capabilities across the complete process: design, testing, full qualification and support. Most of the major Italian aerospace companies such as Alenia Aeronautica, Agusta Westland and Galileo Avionica are part of the Finmeccanica group or have merged with foreign partners (Collins et al., 2004).

Finmeccanica is Italy's second-largest manufacturing conglomerate and a leading high-tech business. The group operates primarily in the aerospace and defence sectors, but also has significant know-how and manufacturing assets in rail transport, energy, telecommunications and IT. Finmeccanica's aerospace and defence activities account for around 70% of consolidated sales, and employ around 60,000 staff. The Group ranks as number one in Italy in terms of its expenditure on R&D, investing around 16% of turnover in this area.

In the past Finmeccanica was fully owned by the Government, but has been partially privatised, with the Government retaining a 'golden share' which allows control. In 2000, the Italian Ministry of Finance participation in Finmeccanica was reduced to one third of the capital. In recent years the Finmeccanica Group has acquired important aerospace companies in order to build a common strategy and to achieve critical mass (e.g. it acquired Marconi and Westland to integrate Finmeccanica's competencies in the radar and helicopter industry and strengthened its role as one of the leading manufacturers in Europe in aeronautics acquiring Aermacchi and a 30% share in Fiat Avio - now the Avio Group). The group is now organised into homogeneous operating companies in

---

4 There are three major geographical clusters of aeronautics companies, and their associated supply chains. The industry is concentrated in the north-east (Piemonte-Lombardia-Liguria), in two southern regions (Campania and Puglia), and around the city of Rome, in central Italy. This distribution is the result of both economic processes and policy. The aerospace industry’s presence in the north of the country dates back to the beginning of the 20th century. The presence of the aerospace industry in southern Italy (e.g. Fiat Aviation, Alfa Romeo Avio that became Fiat Avio, Air Italia and CIRA) is due to post-Second World War regional development policies in support of the less developed south, which promoted the localisation of companies in Southern Italy. The clustering of companies and major research institutions around Rome is due to the strong relationship with the government and government research institutions.

5 Alenia Spazio and Agusta were set up in 2000, Galileo Avionica and Oto Melara in 2001, Alenia Aeronautica in 2002. In 2001, the transport sector expanded with the creation of AnsaldoBreda and Ansaldo Trasporti Sistemi Ferroviari. In 2002, acquisitions included Marconi Mobile (now SELEX Communications), OTE and Telespazio.
line with a strategy of international development, leaving Finmeccanica with the task of strategic and industrial control.\(^6\)

The Radio, TV and communication equipment sector in Italy counted 9,155 enterprises in the year 2000\(^7\) but the number of companies diminished by 39% in 2007. The industry underwent some major changes as a consequence of the liberalisation of postal and telecommunications services that took place in 1996 and that increased drastically competition in the communication equipment sector. The industry saw the gradual separation between communication services and manufacturing of communication equipment in the telephone industry as part of a world trend. Telecom Italia played a key role in the evolution of the industry.

Telecom Italia is the leading telecommunications company in Italy, providing mobile and fixed line phone services, Internet and IPTV. All services are provided via different companies and brands: Telecom, Tim and Alice. Telecom was one of the largest investors in R&D in the telecommunication industry. The Telecom Group was born in 1994 from the merger between 5 different companies of the IRI-STET Group, all operating in the telephone industry: SIP, Iritel, Italcable, Telespazio and SIRM. The Italian government controlled the Group, but it was privatised in 1997. Between 1996 and 1997 one of the biggest reforms in the Italian economic history took place: the liberalisation of postal and telecommunications services.\(^8\) In 1997, the Italian government sold 35.26% of Telecom shares privatising the group (the government preserved 3.5% of shares and the “golden share”). The Government was looking for large buyers that would be in charge of the management of the Group, but unfortunately, Telecom shares were sold on the Italian stock exchange only to a large number of small investors. Since then, the property of the Group changed hands several times and from 2001, it is being controlled by the financial company Olimpia (conformed by Pirelli, Benetton and other financial investors). Over its short history, Telecom faced serious problems of management stability and of financial nature. The strategic decisions that the Group took with respect to R&D activity affected greatly other companies in the Radio, TV and communication equipment sector. Telecom drastically reduced its interests in the equipment sector and dismissed much of investments in R&D, affecting the whole national value-chain.

At present the highest investor in R&D in the Radio, TV and communication equipment sector is Italtel. The group is participated by the American private equity fund Clayton, Dubilier & Rice (48.77%), Telecom Italia (19.37%) and Cisco (18.40%). Italtel produces telecommunication network equipment and offers a full range of professional services. Its main customers are national and international telecommunication operators, public administration bodies, large enterprises. It serves more than 40 of the world’s top operators, is one of the world leaders in the area of softswitch and is a strategic partner for CISCO for the development and realization of voice/data/video IP solutions. In 2008 the company counted 2300 employees and generated 467.8 M€ of total revenues, investing 104.9 M€ in R&D (22,4% of revenues). 48% of Italtel employees is dedicated to Development & Innovation activities. The company ranks among top-10 Italian enterprises for R&D investments (Italtel, 2006).

\(^6\) [http://www.finmeccanica.com/Holding/EN/Corporate/Profilo/La_storia/index.sdo](http://www.finmeccanica.com/Holding/EN/Corporate/Profilo/La_storia/index.sdo)
\(^7\) Source: InfoCamere, [http://www.infocamere.it/](http://www.infocamere.it/)
3.2 Drivers of BERD intensity in the Aerospace Industry

Role of enterprise-level strategies and structures

R&D efforts in the aerospace industry are hardly driven by firm-level investments decisions. R&D investments costs in this industry are extremely high and are necessarily driven by two factors:

- Government incentives
- Business orders

Italy has provided since 1985 special incentives (in the form of R&D funding) to the aerospace industry. However, what has really driven the increase in R&D efforts in the Italian industry over the last 10 years has been receiving a constant stream of funding from foreign business orders. In fact, interviewees taking part of this study in the business sector stressed that R&D investments in the aerospace industry can be divided in two main typologies:

- Traditional R&D activity, for the development of innovative products or platforms (airplanes, etc.)
- R&D activity necessary to develop products to meet orders

In the first case, R&D investments are linked to the product life-cycle, which in some cases is 30-years. However, in the case of Finmeccanica, the increase in R&D expenditures in the last decade was driven by commercial success, especially in the defence sector:

- Finmeccanica agreed a joint venture between Alenia Aeronautica (Finmeccanica Group) and EADS. In 2005 ATR received orders for 90 new airplanes, plus 26 optional orders form 11 customers around the world. 2005 was the best financial year since 1989 for ATR (+15% turnover, M$ 542).
- In 2003, Alenia Aeronautica won a tender for 12 aircrafts C-27J for the Greek Air Force (to be produced jointly with the US company Lockheed Martin). The Bulgarian government also chose the C-27J to replace its current fleet of planes.
- The UK Defence Ministry ordered a fleet of AgustaWestland helicopters. The British Royal Air Force ordered the AgustaWestland A109 Power, already used by the US Coast Guard Service.

Typically, in the aerospace industry the timeline for the delivery of airplanes and helicopters is very long (i.e. 10 years). Over this period intense R&D activity is carried out to adapt products to specific needs of customers. Over the last ten years, Finmeccanica management team had a clear strategy in focusing the activities of the Group only in the areas where its companies had a real competitive advantage, signing joint ventures with competitors and buying business in order to acquire critical mass and become world leaders. The effects

---

9 Since the beginning of the ATR programme, the company sold 998 airplanes.
10 For example, in the radio-communications sector, SELEX Communications acquired MMA (Marconi Mobile Access), a centre of excellence for radio-mobile technologies and applications. Finmeccanica also signed the definitive contract with GKN to acquire GKN’s 50% share in the joint venture AgustaWestland N.V. helicopters. With this move, Finmeccanica acquired control of the world’s leading helicopter company. Finally, the recent agreements with Alcatel and BAE Systems strengthen the Group’s manufacturing and service activities for space systems and defense electronics. (Source: http://www.finmeccanica.it/EN/Common/files/Holding/Corporate/Sala_stampa/Comunicati_stampa/Anno_2005/ComFin_787_03_08_05_UK_aeronautica.pdf).
of this process of mergers and acquisition on R&D is the division of labour in R&D activity and rationalisation of the use of resources within the Group. Now companies specialise in their areas of competence and can concentrate on what they can do best.

**Role of sectoral determinants**

In the last few years Finmeccanica had to increase R&D investments in order to meet the commercial orders the group was granted. As part of the Group’s expansion strategy Finmeccanica opened new sites around the world and recruited new staff. Staff is primarily recruited locally.

**Business size** is a key factor for platform integrators in the aerospace industry. Finmeccanica signed several joint ventures in order to achieve adequate critical mass in its areas of expertise. Size is a critical factor in the aerospace industry for platform integrators such as producers of airplanes, helicopters, etc. However, it is not important for suppliers and producers of sub-systems, but they depend heavily upon the value chain of the platform integrator. Finmeccanica produces technology platforms, focuses on its areas of expertise and buys subcomponents from other firms. For example, in the case of helicopters, the Group produces around 20% of the necessary components. In many cases, the international organisation of Finmeccanica value chain is influenced by the necessity to make international industry offsets on foreign government orders.

Several **joint ventures** and substantial technological progresses have allowed the national industry to maintain and expand the current position in global markets. For example, Italy and the USA signed a Memorandum of Understanding relating to Italian participation in the industrial program for the new generation Joint Strike Fighter. Finmeccanica took part in designing, developing and manufacturing components for the new plane through its companies Alenia Aeronautica, Galileo Avionica, SELEX Communications and Elsag.

The possibility to carry out **R&D in co-operation** with other firms and sign joint ventures is a key driver to R&D efforts in the aerospace industry. In fact, aircraft companies are among the largest beneficiaries of the European Union Framework Programme. Collaborations with customers and suppliers are found especially in the area of process-innovation (e.g. composite fibers, etc.). When companies are system-integrators (manufacturers of airplanes and helicopters) R&D activity is linked to the development and production of each individual module and is demanded to suppliers. This translates into more R&D activity for suppliers, that aim to develop unique competencies in niche-areas.

Considering the costs of R&D in this industry, alliances allow to concentrate efforts only in the areas of real expertise, leaving to others research activity in areas where the company has no competitive advantage. Therefore, R&D collaborations and partnerships are necessarily driven by both increasing scale and cost of R&D and by the need to access complementary technologies.

**Drivers from the macro level and the role of the framework conditions**

In the area of fixed wing aircraft, the Italian industry has been strongly affected by the evolution of the international scenario that has seen the consolidation of Airbus as a trans-national organisation competing against Boeing. Italy has not subscribed fully to this duopolistic competition, preferring a different strategy. Italian companies are at present suppliers of some components for Airbus aircrafts and important supplier of Boeing aircrafts. After initial concerns about Italy not joining the Airbus consortium, the Italian strategy turned to be
successful because of the significant delays announced in the Airbus’ A380 program.

• In fact, Alenia Aeronautica and The Boeing Company have signed a formal agreement that defines a major role for Finmeccanica in the 7E7 Dreamliner program, the most advanced civil aviation program in the world.

• Finmeccanica has been awarded an initial order of components for 150 aircraft valued at approximately US$1.1 billion.\footnote{This is one of the most significant contracts ever secured by Finmeccanica in the civil aircraft business. Boeing has already received 143 firm orders since launching the program in April 2004. Source: http://www.finmeccanica.it/EN/Common/files/Holding/Corporate/Sala_stampa/Comunicati_stampa/Anno_2005/ComFin_787_03_08_05_UK_aeronautica.pdf}

These new orders, are pushing R&D activity for the development of components and aircrafts.

The role of governments in aerospace and defense is strategic. Thanks to government investments and orders, Finmeccanica was able to develop first-class competencies in niche areas such as radar-systems or helicopters. Government orders provided a stable stream of funding that permitted to invest in R&D and develop competitive technologies.

Companies in the industry are not particularly concerned about intellectual property regimes. Research in this industry is very advanced and there are strong entry barriers to the market. True innovators in the industry are very difficult to imitate. However, the institutional context is very important. The industry would not survive without government programmes and a good education system. Some Italian academic institutions carry out advanced research in the field and provide the industry with very good graduates.

### 3.3 Drivers of BERD intensity in the Radio, TV and communication equipment industry

**Role of enterprise-level strategies and structures**

In the case of Italy, BERD trends in the Radio, TV and communication equipment sector can be attributed to the strategic decisions of Telecom Italia. The change in the ownership structure of the company had dramatic effects on the R&D strategy, on investments and on the organisation of the whole industry. After its privatisation, Telecom specialised in telecommunication services, reducing investments in the production of equipment.

After the privatisation, the main provider of telecommunications in Italy was not as competitive as when the industry was operating under a monopolistic market structure. Telecom dismissed a large part of its R&D activity in the telecommunication equipment sector, starting to focus on R&D in services (software, etc.), pursuing short-term objectives. As a consequence of this, the company lost much of the competencies in key areas such as multimedia.

Telecom’s research and innovation centre “Telecom Italia Lab” was established in 1964 (named Cseit) and employed 1.200 staff (90% researchers) in 2003. By 2001 the Lab generated 169 patents valued M€ 134.\footnote{http://ricerca.repubblica.it/repubblica/archivio/repubblica/2003/01/22/tilab-il-futuro-gia-qui.html} It contributed to the invention of several digital formats such as CD, DVD, mp3 and digital TV. The Mpeg format was born at the Telecom Italia Lab.
During the first few years of life of Telecom Italia, the company had substantial debts. Nevertheless, generous dividends were distributed to shareholders in the attempt to attract investors, but this contributed to undermine Telecom’s competitiveness in an era when competition increased in the telephone services industry, turning them rapidly into a commodity and undermining investments.

The industry saw a global change in the configuration of the value chain, especially in the telephone industry, but Telecom was not as competitive as its foreign competitors in implementing the convergence between landline telephone services, mobile services and the Internet. Confirming this, Telecom reduced R&D efforts much more than its competitors. Those few producers of equipment that survived the privatisation such as Italtel (participated by Telecom) continued investing large amounts of resources in R&D even if their revenues were affected by increased competition. In fact, even if the group invested in 2008 22.4% in R&D, in absolute terms investments diminished.

Even companies’ objectives have changed after the privatisation: in the past, long-term investment in R&D drove business objectives, now all communication equipment manufacturers focus on short-term investments, generating immediate commercial returns.

**Role of sectoral determinants**

The privatisation of Telecom followed a global trend in the industry that saw the separation between telecommunication services and manufacturing of communication equipment. Therefore there was a gradual separation of R&D activities and investments in the two sectors. Research activities in these two areas are quite different: research in services tends to have a problem-solving approach and typically has short-term objectives; research in equipment manufacturing is more “science-based” and has longer-term objectives.

Italy was more exposed to international competition in the area of telecommunication equipment than in the area of telecommunication services. The communication equipment industry underwent a process of consolidation, in the attempt to maintain competitiveness in globalising markets. Manufacturers continued to invest in R&D activities, but in the Italian case, many foreign investors relocated their R&D units to their home countries or cut down research activities in the country (i.e. Ericsson cut R&D employment in its R&D centre in Rome; Motorola closed its facilities in Turin; Siemens closed all the sites in Italy). Even national companies that survived the privatisation such as Italtel outsourced some R&D activities abroad, in India.

The loss of competitiveness that affected Telecom Italia and the whole telecommunication equipment industry, did not affect Finmeccanica’s interests in the telecommunication industry. All of Finmeccanica’s manufacturing activities in the telecommunication industry converge in SELEX Communications. SELEX Communications is a global supplier of advanced communication, navigation and identification solutions. The company specializes in the areas of aerospace and defense, and also develops communication solutions (Broadband Wireless Access based equipment) suitable for civil applications (Telecom Operators, Public Administration, etc.). SELEX was not affected by the effects of market liberalisation because the company does not operate in the value chain of commodity services such as telephone communications but prevalently in niche, high-value added markets such as aerospace and defense.

Unlike in the aerospace industry where there are high barriers to entry, the TV, radio communication equipment sector is very global and much more competitive. Emerging countries are specialising in producing some equipment at

---

more competitive prices with generous support from local governments such as in the case of China. This is setting new challenges for the European industry. At the same time, in the case of Italy the emergence of new telecommunication operators after the market liberalisation resulted in a price-war for fixed-line services that lowered drastically prices, reducing R&D investment. Incumbent players such as Telecom compressed prices, cutting down research activity and reducing market opportunities for the whole national value chain. The liberalisation was disruptive for the whole industry. In fact, the majority of service providers could not sustain competition and disappeared after few years leaving price levels very low.

Drivers from the macro level and the role of the framework conditions

Italy did not have an industrial policy tailored for the Radio, TV and communication equipment industry. Therefore Italian companies found it hard to remain competitive in an era of globalisation. Recent policy initiatives do not seem to change this trend at least for the telecommunication industry. Recent industrial policy initiatives like the long-term development plan “Industria 2015” are gradually shifting from a diffusion-oriented to a mission-oriented approach focusing incentives on few key industries, but telecommunications is not among the industries supported.

At the same time, in Italy, there has never been real competition between mobile phone companies (e.g. the tender in Italy for UMTS licenses generated a small fraction of the income generated in UK and Germany). This kept R&D investment levels low even in the mobile industry.

The Radio, TV and communication equipment sector is extremely dynamic and the Italian industry was already exposed to international competition before it was liberalised. When the telephone industry was protected from a monopolistic market structure, the government financed large investments in communication networks. After the market liberalisation, when the government ceased to place large orders for the development of networks, the telecommunication equipment industry lost competitiveness and its future became uncertain. Industry representatives believe that when the Italian market for telecommunications was opened the whole industry suffered from the total lack of industrial policy. There was no support for high tech industries such as the Radio, TV and communication equipment industry, despite Italy being one of the largest markets in the world and the important contribution that it gave in setting some international standards such as the GSM.

However, industry experts taking part of this study agree on blaming also industry dynamics as one of the causes for the reduction of BERD in the telecommunication industry. When technologies (in this case telecommunication services) turn into commodities, R&D efforts are minimised, and the whole value chain (in this case telecommunication equipment) is affected.
4 The role of public policies in determining BERD performance and BERD intensities

The governance of the Italian national innovation system is assigned to several different public bodies. Policy initiatives in support of research, innovation and technology transfer are developed by the central government as well as by regional administrations. The three main central actors in charge of developing policies for innovation and research are: the Ministry of University and Research (MIUR), The Ministry for Economic Development (MSE) and the Inter-ministerial Committee for Economic Planning (CIPE). Following the reform of the Italian Constitution in 2001, regions have acquired more autonomy in developing own economic policies, in several areas including innovation policy. The decentralisation process, together with the increasing relevance of regional policies for research and innovation has contributed to the creation of several regional policy initiatives. In most cases, the regional strategies for R&D and innovation are presented and discussed with the regional stakeholders. Regarding the financial resources involved in financing such programmes, these tend to be shared between regional governments, the national government and the EU Structural Funds.

The Inno-Policy Trendchart report identified as one of the key objectives for Italy the promotion of research and innovation with targeted incentives to strengthen public-private partnerships and increase BERD. Inno-Policy Trendchart concludes that the Italian government still devotes an insufficient amount of public funds to R&D. However, over the last few years the government increased the relevance of R&D as a policy objective, introducing new R&D incentives and increasing funding. Over the period 2003-08 the central government and regional administrations promoted 251 different incentives in support of business R&D and innovation (19 national and 232 regional).\textsuperscript{14}

R&D and innovation is the second policy objective in terms of number of initiatives promoted (19.2%), after the “consolidation and development of the productive system” (36.6%). Over the period considered the government

\textsuperscript{14} R&D and innovation incentives:
- 46/82 (artt. 14, 19) – Fondo innovazione tecnologica (FIT)
- 808/85 – Sviluppo tecnologico imprese aeronautiche
- 488/92 – Ricerca
- D. lgs. 297/99 (artt. 12, 13) - Fondo agevolazione alla ricerca (FAR) Procedura negoziale
- D. lgs. 297/99 (artt. 14, 16) - Fondo agevolazione alla ricerca (FAR) Procedura automatica
- D. lgs. 297/99 (artt. 5, 6, 9, 10, 11) - Fondo agevolazione alla ricerca (FAR) Procedura valutativa
- D. lgs. 164/2000 – Ricerca petrolifera
- 388/2000 (art. 103) – Credito d’imposta per commercio elettronico
- 388/2000 (art. 103) – Collegamento telematico nei settori tessile, abbigliamento e calzaturiero (quick response)
- 448/2001 (art. 59) – Formazione e valorizzazione stiliisti
- 166/2002 (art. 35) – Programma di ricerca industria navale meccanica
- 13/2006 (art. 5, c. 3) – Promozione ricerca industria navale meccanica
- 296/2006 (art. 1, c. 1040 ) – Innovazione tecnologica industria cantieristica
- 296/2006 (art. 1, c. 280 - 283) – Credito d’imposta per ricerca e sviluppo
- 296/2006 (art. 1, c. 842) - PII - Efficienza energetica
- 296/2006 (art. 1, c. 842) - PII - Mobilità sostenibile
- 296/2006 (art. 1, c. 842) - PII - Nuove tecnologie per il made in Italy
- PIA Innovazione (Misura 2.1.a PON SIL 2000-2006)
- PIA Networking (Misura 2.1.c PON SIL 2000-2006)
distributed incentives for R&D and innovation to businesses worth BN€ 14. Incentives in the area of R&D and innovation accounted for 23.4% of total incentives. R&D and innovation incentives were prevalently promoted from the central government (83.2%). Since 2003, funding to R&D and Innovation increased by 32%,\(^\text{15}\) against an average increase for all objectives of just 5.5%.

### Table 3. Business incentives granted over the period 2003-08

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>M€</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D and innovation</td>
<td>14034.9</td>
<td>23.4</td>
</tr>
<tr>
<td>Internationalization</td>
<td>2647.7</td>
<td>4.4</td>
</tr>
<tr>
<td>New entrepreneurship</td>
<td>4365.7</td>
<td>7.3</td>
</tr>
<tr>
<td>Consolidation and development of the productive system</td>
<td>10118.1</td>
<td>16.9</td>
</tr>
<tr>
<td>Reduction of regional disparities</td>
<td>18845</td>
<td>31.4</td>
</tr>
<tr>
<td>Credit access and financial consolidation</td>
<td>7550.8</td>
<td>12.6</td>
</tr>
<tr>
<td>Environment/Energy</td>
<td>730.9</td>
<td>1.2</td>
</tr>
<tr>
<td>Services/Infrastructures for enterprises</td>
<td>742.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Rationalization and conversion of economic sectors</td>
<td>434.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Other</td>
<td>544.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Total</td>
<td>60014.3</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: DSE, 2009

Historically government has undertaken few initiatives in support of specific industries with the exception of the automotive sector. The Italian aeronautics sector is one of the largest in Europe, however it has not been a focus for national industrial policy or financial support (as compared with the automotive sector). The Italian government has done little to support exports, but has sought to exploit offset policies, maintaining good relations both with the US and with European partners.\(^\text{16}\)

The ministry of defence is an important customer for the national aeronautical industry, and a sponsor of R&D performed in both private and public sectors, however its role is nothing like so significant as is the case in France, the UK and the US. Indeed, defence is a very small component of GDP in Italy, with defence-related R&D amounting to around 3% of total government expenditure on R&D (OECD, 2008).

The main policy initiative for the Radio, TV and communication equipment sector was the market liberalisation for telecommunications, which followed a European directive and indirectly affected the whole value chain of suppliers.

\(^\text{15}\) R&D and innovation funding increased especially after 2007.
\(^\text{16}\) The MSE also activated a small general framework programme to support the modernisation of the aeronautics sector in Italy (Piano Aeronautico). This programme aims at assisting national businesses in establishing medium- to long-term strategic objectives, which reflect better the realities of international competition. However, the programme seems to have been of very limited strategic value.
**Law n. 808/1985**

Italy has special incentives for companies operating in few sectors: the fashion industry, the naval industry, oil exploration, e-commerce, aerospace and defense. No special incentives are granted to the telecommunication industry. In 1985 a law was promoted to regulate policy initiatives in support of the aircraft industry in Italy (Law n. 808, 24 December 1985). The law provides direct funding for R&D, production and commercialisation of aircraft products. After the first few years, the law has been fundamentally targeted at the promotion of R&D activities, whilst support to production activities has been abandoned. Over the period 2004-07 aircraft companies claimed the reimbursement for BNC 1,333. The law granted funding for 75% of total costs (minimum reimbursement K€ 244, maximum reimbursement M€ 59). In the last decades Italian companies participated in very few research programmes of exclusive national interest. They aimed at developing competencies in specific systems. It is believed that the Law 808/85 provided a key contribution to the acquisition of technological capabilities in several aerospace research areas. In fact, according to the MSE (Corte dei Conti, 2009), R&D policy support played a key role in sustaining competitiveness and R&D investments in a period of intensive competition. The Law n.808/1985 was very effective in reducing direct R&D costs for aircraft businesses, whilst in other countries the industry underwent a process of rationalisation of production activities and cost reduction to respond to international competition.

**Law n. 296/2006**

Industry and policy experts agree on the fact that R&D performing companies in every industry benefited greatly from the tax credit for R&D costs introduced in 2006. The initiative grants a tax credit of 10% of industrial research costs or 40% of costs for research contracts signed with universities or research centres. This initiative was so successful that the entire budget allocated for tax credits was allocated within days and not all applications were accepted. Industry experts agree on the idea that tax credits should cover the full R&D costs.

According to ISTAT (2008), the analysis of the regional distribution of R&D expenditure confirms that the tax credit had some effects on the distribution of R&D expenditure. The expenditure is concentrated in just 3 out of 20 Italian regions (Piemonte, Lombardia and Lazio), which together account for 50.5% of total R&D expenditure. These three regions account for 59.1% of BERD, 54.1% in public institutions and 31.7% in universities.

Furthermore, despite high presence of Small and Medium-Sized Enterprises (SMEs), BERD is largely concentrated in large enterprises. In 2005, 73.8% of investments in R&D was done in enterprises with more than 500 employees, whilst, SMEs accounted for only 18.6% of total investments (COTEC, 2008).

The tax credit greatly influenced the distribution of BERD in 2006. This indirect incentive to R&D mitigated the reduction in R&D expenditure in some relevant manufacturing sectors such as automobiles, fostering investments in “marginal” enterprises. According to ISTAT (2008), the tax credit had a greater impact in those businesses that were not determined in investing in R&D than in innovative businesses that systematically invest resources in R&D. In fact, R&D expenditure grew more in those sectors with a higher share of SMEs and therefore in those regions where the presence of those businesses is more widespread. Therefore, expenditure grew more in regions such as Veneto, Emilia-Romagna and Marche.

---

17 In July 2009 MSE allocated M€ 500 to research projects in aeronautics in the area of homeland security to be assigned over a period of 15 years. (Source: http://www.sviluppoeconomico.gov.it/primopiano/dettaglio_primopiano.php?sezione=primopiano&tema_dir=tema2&id_primopiano=364)
where there are more SMEs, whilst it decreased in those regions where BERD was higher.

**Table 4.** Regional distribution of BERD

![Bar chart showing regional distribution of BERD]

Source: ISTAT, 2008

**Technology districts**

Interviewees taking part of this study agree on considering positively the recent creation of technological districts in Italy. The technology districts initiative was launched by MIUR in 2002-03 with the initial objective of creating territorial poles of excellence for research and innovation. Over the following years the initial mission of research valorisation changed into the support to industrial innovation (EC, 2007). Out of the 25 technology districts promoted by MIUR, only 7 have already been activated: Wireless applications (Piedmont), Nanotechnologies (Veneto), Mechatronics (Emilia Romagna), Aerospace technologies (Lazio), Molecular biomedicine (Friuli Venezia Giulia), Polymeric materials and compounds (Campania), and Integrated smart systems (Liguria), whereas the remaining ones are in different phases of development. Especially relevant for the Aircraft industry is the Aerospace technologies district located around Rome. For the TV, Radio and communication equipment, the relevant district is Torino wireless. Both districts are catalysing R&D investments from national and foreign companies. However, it is too early to evaluate the effectiveness of the technology districts initiative in fostering industry competitiveness.
5 Conclusions, lessons learned and policy options

The comparison of R&D investment in aerospace and Radio, TV and communication equipment leads to the conclusion that in both industries the role of the government has been very important in driving R&D. R&D efforts in both industries are only partially driven by firm-level investments decisions: Framework conditions have deeply affected companies behaviour and competitiveness.

Industry experts participating to this study agree that in the case of Italy excessive privatisation of state companies and market liberalisations killed technological excellence in too many cases. In the last few years the government dismissed its stakes in several industries such as the chemical industry (Montedison, etc.) or in the telecommunication industry (Telecom Italia). When the government sector stopped financing business research activity in high tech industries they rapidly lost competitiveness, competencies and innovation capabilities. The aerospace industry was an exception to the rule because it was less exposed to international competition and because its customers are very often governments. The industry was more protected from international competition and had more time to adjust to globalising markets.

Industry experts participating to this study agree that in high-tech industries “The real invisible hand is the state, not the market”. In many cases successful European and world industries receive directly or indirectly strong support from governments and thanks to this they have been able to become very competitive.

Market liberalisations in fragile industries such as those requiring very high levels of R&D investments need being implemented very carefully or they may have disruptive effects on incumbent companies. The radio, TV and communication Italian industry provides a clear case for this. Telecommunication operators in the service sector lowered tariffs to unsustainable levels, reducing margins and investments in the equipment industry. Fierce competition in the service sector affected manufacturing activity wiping away much research capabilities that in the past contributed to the development of the whole world industry (e.g. GSM and MPEG standards).

A tight relationship between government, industry and the education sector is needed to make high-tech industries prosper. High tech industries need support from governments with the creation of innovation systems, provision of skilled human capital and financial support.

More consolidation processes in high tech industries are needed at the European level. The efforts that Finmeccanica put into consolidating competencies are proving to be a winning strategy. The Group focused on few key areas and with the help of acquisitions and joint ventures gained rapidly critical mass and world-class expertise in several strategic sectors. This would have not been possible if the company were operating in industries with low entry barriers.
CONTACT DETAILS

Case study author
Alessandro Muscio
GRIF – Università Luiss Guido Carli
Viale Romania, 32 - 00197 Roma
T: +39 06 85225983
F: +39 06 85225949
amuscio@luiss.it
www.luiss.it

Experts taking part of the study group as interviewees
Andrea Aparo
V.P. Technology Intelligence
Finmeccanica S.p.A.
Piazza Monte Grappa 4 – 00195 Roma
T: +39 06 32473492
andrea.aparo@finmeccanica.it
www.finmeccanica.it

Andrea Bonaccorsi
Full Professor
Università di Pisa
Via Diotisalvi, 2 - 56126 Pisa
T: +39 050 2217378
a.bonaccorsi@gmail.com
www.unipi.it

Mauro Mallone
Dirigente Unità Innovazione
Istituto per la Promozione Industriale (IPI)
Viale M. Pilsudski, 124 - 00197 Roma
T: +39 06 80972234
mallone@ipi.it
www.ipl.it

Andrea Prencipe
Full Professor
Università G. D’Annunzio
Viale Pindaro, 42 - 65100 Pescara
T: +39 08545083224
a.prencipe@unich.it
www.unich.it

Maurizio Pignolo
Head of Collaborative R&D initiatives
ITALTEL S.p.A.
Via Reiss Romoli, località Castelletto
20019 Settimo Milanese
T: +39 02 43882617
Maurizio.Pignolo@italtel.it
www.italtel.it

Stefano Pezzella
ITALTEL S.p.A.
Administration and Finance Grants and Soft Loans Manager
Via Reiss Romoli, località Castelletto
20019 Settimo Milanese
T: +39 02 43887975
Pezzella@italtel.it
www.italtel.it
Bibliography


Corte dei Conti (2009), Sezione Centrale di controllo successivo sulla gestione delle Amministrazioni dello Stato, INTERVENTI AGEVOLATIVI PER IL SETTORE AERONAUTICO, Magistrati istruttori: Cons. Ennio Fazio, Cons. Stefano Siragusa.


EC (2009), European innovation scoreboard 2008 Comparative analysis of innovation performance, PRO INNO Europe paper N°10.


ISTAT (2008), La Ricerca e Sviluppo in Italia nel 2006, Statistiche in Breve, Roma.


MSE - Ministero dello Sviluppo Economico (2009), Relazione sugli interventi di sostegno alle attività economiche e produttive, Giugno, Roma.

Muscio A., L. Orsenigo (2009), Politiche Nazionali e Regionali di Diffusione della Conoscenza, in Bianchi P. e C. Pozzi (eds), Le Politiche Industriali alla Prova del Futuro – Analisi per una Strategia Nazionale, Il Mulino.

OECD (2008), Main Science and Technology Indicators, Paris.
“Sectorial analysis of the long-term dynamics of business R&D intensity”

In relation to (DG-RTD-2005-M-02-01):

“Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators”

Case study
Business Expenditures in R&D: the case of the Chemical sector

Tomasz Jerzyniak
Technopolis Group

Coordinated by

Brussels, 05 October 2009
1 Synthesis 447

2 BERD performance in Poland and its Chemical Sector 448
   2.1 The Chemical sector in Poland 451

3 Drivers of BERD intensity 454

4 The role of public policies in determining BERD performance and BERD intensities 459

5 Conclusions, lessons learned and policy options 463

Bibliography 465
Business Expenditures in R&D in Poland: the case of the Chemical sector

1 Synthesis

The share of the Polish chemical sector in total BERD has declined from slightly more than 8% to 5% between 1995 and 2006; while BERD intensity in chemicals has declined from 2.01 to 1.08; and value added of chemical production from 1.19 to 0.89 in the same period (Rindicate, 2009).

Although the sector has not been hit strongly by the 2008-2009 economic downturn and according to the annual report of main companies the investments are growing, the sector continues to under-spend on R&D activities, which account for a mere 10% of all investments. The main share of investment is still spent on machinery, infrastructure, new installations, training etc. in order to meet western European standards. At the same time, there is evidence that the chemical sector is increasingly aware of the role R&D activities play in securing long-term growth and competitiveness of the companies.

The study identified several BERD drivers at the level of the company and industry, at the macro (policy) level as well as drivers coming from the market (consumer preferences).

Since 2004, Polish chemical companies have been intensifying their efforts to coordinate and manage more effectively their R&D efforts by establishing specialised R&D offices (organisational innovation); and the size of the company in this context is seen as a strength to undertake innovative actions, which means that larger companies are better able to undertake R&D efforts. The observations of the competitors as well as incentives from the consumers turn out to be important factors for the chemical companies when deciding to introduce new or improved technologies. Cooperation with public research institutes, although still not well developed, is a strategic and indispensable element of the long-term growth of the chemical sector as the companies are reliant on the R&D infrastructure and R&D results of public research institutes.

Public sector investment in support of BERD, notably due to the inflow of EU Structural Funds, is perceived as a decisive element to enhance the innovative potential of Polish chemical firms. The public research institutes as well as the companies consider that the financial support measures of the 2007-2013 programming period offer unprecedented financial resources. The Operational Programme “Innovative Economy” is the most important intervention. The sectoral technology platform “Polish Technology Platform for Sustainable Chemistry”, although it does not contribute directly to R&D activities, helps to shape framework conditions for the sector. The chemical firms argue that there is an urgent need for more institutional policy measures, most notably tax incentives for technology implementation, which is a bigger financial burden for chemical companies than R&D activity itself. Furthermore, more financial inputs are necessary for applied research instead of fundamental research, which rarely leads to commercial applications. Measures oriented at developing practical applications of chemical knowledge for students and young researches need to be supported as well.

Policy options to improve support for BERD in the Polish chemical sector include reviewing the selection criteria for public grants, most notably the industrial applicability potential as well as public-private partnership, fiscal incentives for implementation of R&D results and stability with respect to pursuing long-term R&D strategies.
2 BERD performance in Poland and its Chemical Sector

To analyse the development and situation of the chemical industry and its research and development activity, it is crucial to have an overall look at the situation of Polish industry.

The total gross domestic expenditure on research and development (GERD) has remained rather constant since a 10% drop in 2002, and amounted to around 0.57% of GDP in 2007; this is one of the lowest values when compared to EU average of 1.8%. Although, the relative value remains unchanged, the real expenditure on R&D increased by more than three times between 1995 and 2007 (Table 1). Moreover, the structure of Polish GERD represented by the ratio of GOVERD plus HERD to BERD, shows exactly an inverse proportion from the one sought by the objective set in 2002 by the European Council. With 2/3 of funds coming from the State budget and only 1/3 from private sector, the Polish R&D landscape is shaped mainly by governmental expenditures.

Table 1: GERD in national currency and as ratio to GDP (in million)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>GERD</td>
<td>2132.8</td>
<td>4796.1</td>
<td>4858.1</td>
<td>4522.1</td>
<td>4558.3</td>
<td>5155.4</td>
<td>5574.6</td>
<td>5892.8</td>
<td>6673.0</td>
</tr>
<tr>
<td>GERD ratio</td>
<td>0.63</td>
<td>0.64</td>
<td>0.64</td>
<td>0.58</td>
<td>0.56</td>
<td>0.56</td>
<td>0.57</td>
<td>0.56</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Source: Central Statistical Office (2009)

Polish manufacturing value added made up 19.0% of total value added on average during the entire period from 1995-2006, with 19.4% and 18.0% in the first and second half of the period respectively. The contribution of the chemical sector to the overall national value added was on average 1.2% in 1995-2000 and 0.9% in 2001-2006, which makes up around 5% of manufacturing sector value added.

On average, total value added generated by services increased from 61% from 1995 to 2000 to 65% from 2001 to 2006. The share of BERD in services also increased from 16% to 22% over the two periods, while the share of BERD in manufacturing declined from 73% to 66% over the two periods. Average BERD intensity, measured as BERD over value added, was more than 10 times higher in manufacturing than in services, and it decreased in both industries. In manufacturing it decreased from 1.12% to 0.69% from one period to the next and in services it decreased from 0.08% to 0.06% from one period to the next.

The overall total BERD as a percentage of total value added, or BERD intensity, has remained at a consistently low level in the last two decades (Table 2); taking the longer period 1995-2006 into account, the BERD amounted to around 0.24% on average. In the first part of the period, between 1995 and 2000, it accounted for 0.29% on average, with its peak of 0.32% in 1999. In the second part, 2001-2006, the private expenditures on R&D as a share of GDP decreased significantly to an average of merely 0.19%. The lowest BERD/GDP ratio was observed in 2002, with only 0.13% and the highest in 2005 and 2006 with 0.2%. According to the most recently available data, BERD shrank again to 0.17% of GDP in 2007.
**Table 2: BERD development 1995-2007**

<table>
<thead>
<tr>
<th></th>
<th>BERD/GDP</th>
<th>Periodical average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>0.31</td>
<td>0.24</td>
</tr>
<tr>
<td>1999</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>0.17</td>
<td>0.19</td>
</tr>
<tr>
<td>2004</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>0.17</td>
<td></td>
</tr>
</tbody>
</table>

Source: Rindicite (2009)

The top ten industries, performing R&D in Poland in the period 2001-2006, accounted for only 65% of total BERD. The highest share in total private R&D expenditures had Machinery and equipment (29), Pharmaceuticals (2324), and motor vehicles (34), which altogether explain only 28% of it (Figure 1). Chemicals accounted for around 5% of Polish BERD; this is considerably lower than the 8.1% share of the 1995-2000 period. When comparing the periods 1995-2000 and 2001-2006, significant changes occurred in BERD distribution (Figure 2). The clear ‘winners’ are Pharmaceuticals with a share of more than 10% and Software with 3.75%; the latter sector increased its share by more than 20 times, from 0.15% of BERD in the first period. Other sectors with improved shares include the R&D sector (73), wholesale and retail trade (50...52), and instruments and clocks (33). The biggest loss was recorded by machinery and equipment (29) from 14.33% to 10.38% and chemicals (24-2324) from 8.07% to 5.07%, followed by a decrease in the BERD share of rubber and plastics (25), other transport equipment (35-353) as well as communication equipment (32).

---

1 The classification is based on the ISIC Rev.3.1, International Standard Industrial Classification of United Nations. When talking about chemical sector, it refers to Chemicals excluding Pharmaceuticals, i.e. 23-2324.
Figure 1: Structure of BERD 2001-2006

![Structure of BERD 2001-2006](image)

Source: Rindicate, 2009

Figure 2: Trends in the shares for BERD 1995-2006 with winners and losers

![Trends in the shares for BERD 1995-2006 with winners and losers](image)

Source: Rindicate, 2009

There were significant changes with respect to the BERD intensity in individual sectors. During 1995-2000 the overall BERD intensity amounted to 0.29% as indicated previously. The highest sectoral BERD intensity in 1995-2000 (Figure 3), measured as BERD of a sector over its value added, was achieved by aerospace (353) with 12.11%, followed by pharmaceuticals (24-2423) with 4.19%, motor vehicles (34) with 3.32% as well as electrical machinery (31) and machinery and equipment (29) with 3.10% and 2.68% respectively. During 2001-2006, aerospace was ranked again as the most R&D intensive sector with 9.95%, however it recorded the largest decrease of BERD intensity. Pharmaceuticals and software are the most pronounced winners, as they increased their BERD intensity from 4.19% to 5.41%, and from 0.05% to 0.73%.
respectively. Less significant gains were made by the R&D sector with a change from 1.93% to 2.19%, as well as instruments and clocks and office and computing equipment with improvements from 0.99% to 1.14% and 0.70% to 0.83% respectively. Important reductions in BERD intensity were recorded by electrical machinery, other transport equipment, communication equipment, motor vehicles and aerospace. The chemical sector’s BERD intensity dropped as well: from 2.01% in 1995-2000 to 1.08% in 2001-2006 on average.

**Figure 3: Trends in R&D Intensity with winners and losers**

![Graph showing trends in R&D intensity with winners and losers](image)

Source: Rindicate, 2009

In 2007, the chemical sector spent on R&D less than €20m, split between €13m on current expenditure and €5.1m on capital expenditure. In addition, chemical firms managed to attract around €0.11m funds from abroad, of which slightly more than a half from EU regional policy and research funds. The R&D expenditure, although at a relatively very low level, is not the only way to increase companies’ innovativeness in order to strengthen their long-term competitiveness. Indeed, formal R&D activity accounts for only 10% of all innovation expenditures in the Polish chemical sector. The rest is spent on acquisition of disembodied technology and know-how, new software, buildings, instruments and equipment, staff training connected with innovation activity as well as marketing for new and significantly improved products. Notwithstanding, if R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, then Poland has still a big gap to close.

### 2.1 The Chemical sector in Poland

There are around 20,000 companies operating in the Polish chemical sector; however, about 16,000 are very small enterprises (less than nine employees).

---

2 The amount earmarked for R&D activities financed by EU structural funds were modest during the 2004-2006 programming period. A significant increase took place for the current period 2007-2013. However, first payments started in late 2007.
The sales volume of the chemical industry amounted to almost €22b in 2008, which is 4.7% more than a year before.

The main actors in the sector is a group of large companies (Table 3) labelled as a “Great Synthesis”: Grupa CIECH S.A., Zaklady Azotowe Kedzierzyn S.A., Zaklady Azotowe "Pulawy", Zaklady Azotowe Tarnow-Moscice, and Zaklady Chemiczne “Police”, which are mainly in state control. The remaining small and medium sized enterprises (SMEs) play a supportive role as subcontractors, suppliers and distributors. They rarely possess the necessary financial means or infrastructure to carry out any important R&D activities. The branch of consumer chemicals was privatised in the 1990s and currently consists of international firms concentrating on distribution and production with their R&D centres located abroad. In addition, several large applied research institutes are active (Table 4).

**Table 3:** The top 10 players in the Polish chemical sectors, who are members of the Polish Chamber of Chemical Industry (in terms of revenue in 2008).

<table>
<thead>
<tr>
<th>Company</th>
<th>Total revenues in million EUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grupa CIECH S.A.</td>
<td>948.00</td>
</tr>
<tr>
<td>Zaklady Azotowe &quot;Pulawy&quot; S.A.</td>
<td>650.00</td>
</tr>
<tr>
<td>Zaklady Chemiczne &quot;Police&quot; S.A.</td>
<td>600.50</td>
</tr>
<tr>
<td>ANWIL S.A.</td>
<td>503.45</td>
</tr>
<tr>
<td>Zaklady Azotowe &quot;Kedzierzyn&quot; S.A.</td>
<td>412.80</td>
</tr>
<tr>
<td>Zaklady Azotowe “Tarnow-Moscice” S.A.</td>
<td>319.20</td>
</tr>
<tr>
<td>PCC Rokita S.A.</td>
<td>176.50</td>
</tr>
<tr>
<td>PROCHEM S.A.</td>
<td>91.25</td>
</tr>
<tr>
<td>YARA Poland Ltd.</td>
<td>66.75</td>
</tr>
<tr>
<td>Zaklady Chemiczne “SIARKOPOL” Tarnobrzeg Ltd.</td>
<td>65.35</td>
</tr>
</tbody>
</table>

Source: Polish Chamber of Chemical Industry (2009)

**Table 4:** Main public applied research institutes in the chemical sector (JBRs)

<table>
<thead>
<tr>
<th>JBR (Research and Development Unit)</th>
<th>Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instytut Chemii Przemyslowej im. Prof. I. Moscickego (Industrial Chemistry Research Institute)</td>
<td>285</td>
</tr>
<tr>
<td>Instytut Przemyslu Organicznego (Institute of Industrial Organic Chemistry)</td>
<td>-</td>
</tr>
<tr>
<td>Instytut Ciekiej Syntezy Organicznej &quot;BLACHOWNIA&quot; (Institute of Heavy Organic Synthesis)</td>
<td>163</td>
</tr>
</tbody>
</table>
The largest chemical group in Poland\(^3\), Grupa CIECH S.A., had total revenue in 2008 amounting to €0.9bn, which ranked the company outside the European top 30. For example, the largest EU (and global) chemical company, BASF, made revenues of €39bn in 2006 (Eurostat, 2007). The share of Polish chemicals in the EU27 chemical industry is around 1.92%, which makes it the biggest chemical sector in EU12\(^4\), with the overall share of newer Member States standing at 6%.

The main concerns of the chemical sector is a low share in the European chemicals (less than 2%), high dynamic of import and growing negative trade balance, and low chemical consumption per capita (less than half of the Western EU consumption), which indicates, however a growth potential. Some studies (PAIiIZ, 2006) reveal that among the most important challenges facing the chemical sector in Poland are the lack of investment in technological processes, the lack of cooperation and linkages with R&D centres, and the privatisation of the biggest chemical enterprises and the lack of favourable economic conditions for SMEs operation in the sector.

---

\(^3\) The largest company active in the chemical sector is Plocki Koncern Naftowy ORLEN S.A., with almost EUR 15b. However, the company is the largest Polish company in the petrol and fuel sector, so that only a part of its activity can be accounted for chemical output.

\(^4\) EU12 are countries, which joined the EU in 2004 and 2007.
3. Drivers of BERD intensity

This section considers the main drivers of R&D activity in the Polish chemical sector. The emphasis is placed on drivers within the company (micro level), drivers from industry (meso-level), drivers from the market as well as drivers from the macro level concerning the framework conditions.

**Micro-level**

Usually, companies in the sector develop their own strategy documents, where the main economic goals and development options are identified; it also includes the expenditures on research and development activities. However, it is only in the last 2-3 years that Polish chemical companies have begun creating **specialised R&D departments and offices** in order to enhance the effectiveness and coordination of all innovative and research actions. This **organisational innovation** demonstrates the increasing awareness of the need of R&D activities as an indispensable prerequisite to grow and remain competitive. For example, the CIECH Group (Grupa CIECH, 2009) founded in 2007 a specialised R&D office, which coordinates R&D and innovative activities in the whole group. It creates an institutional framework in the company and is responsible not only for coordination of internal R&D activities but to develop cooperation with research institutes. Moreover, the CIECH created a high level council of experts to advise the President of the management board. The main role of the new **advisory body** is to give opinions on strategic questions regarding R&D and innovative activities as defined in the strategy. The members of the council are highly renowned Polish scientists in chemical sciences. In addition, in the second half of 2008, the post of **EU management representative** was established within the company to coordinate and support work connected with analysis of projects and other activities that could be subject to co-financing from EU and national funds as well as with the preparation and the processes of applying for public co-financing. Previous to the introduction of such ‘institutional innovations’, there was no such systematic management process for R&D; rather there were only ad hoc advisory initiatives in order to get an opinion on a single project or a specific R&D activity. The corporate strategy and organisational structure are expected to become important drivers of BERD intensity inside the company.

Beyond doubt, the **size of the company** in the chemical sector is a crucial factor determining BERD intensity. The chemical sector is very capital-intensive and entry barriers are very high, which makes entrepreneurial start-ups intricate. The larger companies have an advantage when performing R&D activities due to the fact that they are much better equipped with material and financial resources as well as the awareness of the need to invest in R&D is stronger. The importance of the size factor has been confirmed by a recent study prepared by the Central Statistical Office (2008). Among the factors hampering innovation activities in Polish industrial enterprises, the cost factors (lack of funds within the enterprises or from sources outside the company) play the most decisive role; the gravity of this factor was inversely proportional to the size of a company. The vulnerability of small firms to market, demand and knowledge factors turned out to be higher than in large companies, so that they sometimes rely on an old technology, which allows them to remain operational at least for a certain period of time. Medium sized companies seem to be more promising due to their better endowment with financial resources, however the number of such companies in the Polish chemical sector is still low. In this context, the access to new EU financial emerges as an important factor strengthening the position of medium-sized enterprises.
Ownership structure is a specific factor with a potential impact on BERD trends in the Polish context, as the most important players in the chemical sector are still state-owned. It is obvious that the long-lasting problems with privatisation and continuously projects regarding its implementation keep the sector in strategic suspense and uncertainty. The role of this factor is not unambiguous. On the one hand, the fact that the CEOs and managers are appointed not only to their merits but also by their political affiliation causes a fundamental problem based on the principle that whenever the political constellation in the country changes, it affects respectively the composition of the company’s authorities. As the changes of government occurred in Poland relatively often\(^5\), so did also management of the state-owned companies as well as their priorities and strategies. This variability results in the lack of strategic and long-term planning, which is crucial for R&D investments, and since the management is often transitory, it makes it reluctant to take decisions, which are risky and with long pay-offs. The problem was brought up in the context of cooperation with public research institutes. Firstly, it is difficult to cooperate, as it needs “to make friendships”. However, the conditions for fruitful business friendships are time and continuity, which in this case are difficult to come about. Secondly, as the managers know that they might not stay long with the company, they seek to evidence their successful activity and proliferation of the company in the short-term. This is only possible if they acquire fully applicable technology, instead of spending money on long lasting cooperation and risky developments of new technologies. On the other hand, it is claimed that a good level of continuity and strategic planning can be maintained, although the management is subject to frequent changes. This is the human factor, which is decisive in taking decisions, and in the chemical sector its quality is perceived as very high. Indeed, a good R&D strategy can be designed, developed and, most importantly, pursued, even if the owner is public. This seem to be plausible to a fair extent as the educational and professional competences of senior managers in the largest chemical companies are in most cases in line with the requirements needed to meet the challenges of the sector\(^6\).

With reference to the quality of the human resources as an R&D driver, it should be noted that there are no major problems in the supply of high skilled specialists (mostly chemists). Despite a decreasing number of young people interested in pursuing chemistry studies, the ones who are keen on working in the chemical sector (research or industry) are well prepared. However, an important problem is the quality of the training, as it tends to be very theoretical at the universities. In chemistry, the contact with practical application of knowledge is crucial. The problem is more complex, due to a general propensity in the Polish research community to give a priority to fundamental research rather than to invest more funds in applied solutions.

**Meso-level (Industry)**

The specificity of the chemical industry in Poland lies in the structure of the sector. It consists mainly of large and capital intensive companies with high entry barriers and scale/scope economies, defined in the literature as Schumpeter Mark II\(^7\). As mentioned before while discussing the importance of the company

---

\(^5\) In 2001-2005, 2 social-democratic governments, 5 different ministers of treasury (responsible for state-owned companies and privatisation); in 2005-2007, 2 right-conservative-populist governments, 4 ministers of treasure (including prime ministers as acting ministers of treasury); and finally since 2007, 1 government with persistent minister of treasury.

\(^6\) The large companies show on their homepages detailed curricula of the management board members.

\(^7\) In the 1940s Schumpeter argued that big companies are the main drivers of innovation as they have the financial and human resources to invest in R&D activities. This is the opposite to the view that Schumpeter expressed in his early research on innovation (called as Schumpeter Mark I), in which
size, only large organisations are able to act in such industry, due to infrastructural and financial critical mass; therefore, start-ups and spin-offs usually do not come about.

In the chemical sector R&D expenditure is not the heaviest investment burden for a firm; decisive are the costs related to the implementation of new technology (implementation costs), most notably construction of new installations and other infrastructure. The R&D activity followed by documentation, technical writing and project design account on average for a modest share of implementation costs, which in turn often exceed the R&D costs many times over.

Another intrinsic aspect of the sector is a low level of R&D outlays as a percentage of all investment expenditures. In Poland, less than 10% of all innovation investments of industrial enterprises are dedicated to R&D activities, compared with around 60% in Western European countries (Central Statistical Office, 2009). This is attributable to the fact that the Polish chemical sector has still a lot of catching-up to do and the main investments stream is directed towards development of basic infrastructure and technologies as well as to meet common standards, which have already been achieved in other European developed economies. The companies see the main source of inputs to increase their innovativeness level in capital expenditure on buildings, machinery, and equipment as well as enhancing of marketing activities and design and trademarks.

Drivers from the market

The drivers from the market are largely those in case of the Polish chemical industry. On the one hand observation of the competitors is definitely a driving R&D force, however more in the long-term context. Due to the fact, that some products are offered only by a single company (quasi-monopoly in a sub-market), the area of competition and its monitoring extends to the European and sometimes global level. If there are signals that other players in the market are working on a specific problem, it is a potential sign that the company should commence own R&D efforts. In the short-term context, on the other hand, incentives to conduct R&D are more often due to meeting needs of consumers, in particular in regard to development and improvement of product features and quality. As an example, a company developed a new technology upon request coming from customers to change the characteristic of soda to avoid excessive dusting during transportation.

The firms that engage in co-operation tend to invest more in R&D than non-cooperating ones. However, regarding co-operation, the Polish chemical companies tend not to collaborate with competitors in the field of R&D activities; neither vertical nor horizontal cooperation comes about; except some initiatives when formulating general strategies or framework conditions for the entire industry (strategic networking). Notwithstanding, the companies seek to share the risk and costs through cooperation with public research institutes and universities.

Firstly, the Polish chemical companies are reliant on cooperation with public R&D organisations as they lack highly specialised human resources and above all advanced research infrastructure. All relevant companies have framework cooperation agreements with certain technical universities and most notably with Research and Development Units (in Polish: Jednostki Badawczo-Rozwojowe, or JBRs)\(^8\), which are specialised public institutes in the field of applied research. The companies tend not to employ researchers per se but rather experts (production

---

\(^8\) JBR – Jednostka Badawczo-Rozwojowa, Research and Development Unit.
engineers) responsible for the implementation of new technologies. Hence, the laboratories they operate have as their main goal to monitor technological developments and assure quality; they are not equipped to perform large-scale research. It is simply easier and cheaper to outsource most of the research. However, this is not the case when the companies have very specialised needs: Zakłady Azotowe Kedzierzyn has recently decided to set up its own R&D laboratory to handle research specific to its product lines. The motivation is that public research units do not possess such specific infrastructure for a particular, company-related problem.

Secondly, the companies do cooperate when they seek to minimise the risk associated to the R&D process and its outcomes. Unfortunately, the collaboration is often limited to the acquisition of commercially ready-to-use solutions, without participation in the R&D process, and accordingly without sharing the risk with public institute. This means that all the costs and risks are initially born by the public R&D unit. For the public R&D institutes this causes significant problems, as their budget is very limited. Although JBRs are very active and they contribute to 70-80% of new solutions in the Polish chemical sector, the share of private financing of JBRs is only about 30%.

Summarising the cooperation aspect, positive trends can be observed, as several companies included in 2007 and 2008 cooperation with public research institutes as one of the central objectives in their strategies. The experts interviewed for this study also underlined the intention to use public research infrastructure more intensively and to increase the participation in R&D activities carried out at the public research institutes. Some new policy measures (see next section) are expected to enhance this trend to a greater extent.

**Macro level**

The regulatory requirements play a role when deciding to invest in R&D, however are not a crucial factor. Not surprisingly, the EU Regulation REACH\(^9\), which entered into force on 1 June 2007 with the aim to improve the protection and regulate safe use of chemicals, has had the most impact on R&D activity to meet new safety requirements. Other legal requirements to modernise and upgrade existing technologies are taken into account by companies as pertaining to the chemical industry, so that they are not perceived as an explicit driver. The same applies to patent procedures and costs. They are neither perceived as an obstacle nor as an incentive. The regulatory framework for cooperation as well as other institutional arrangements does not seem to cause any major impediments.

**Public policy** is playing an increasingly important role, most notably thanks to the contribution from the EU Structural Funds. The Operational Programme “Innovative Economy” for 2007-2013 is a main source of funding and offers around €9.71b (ERDF contribution €8.25b) for implementation of different kinds of projects aiming at the improvement of innovativeness of the Polish economy, supporting entrepreneurs, business support institutions, research and scientific entities and institutions of public administration.

**Tax incentives** for corporate R&D are available in Poland since few years. However, they have turned out to be an ineffective measure to enhance R&D activity. This is due to the fact that large companies can claim only 30% of R&D

---

\(^9\) REACH is a new European Community Regulation on chemicals and their safe use (EC 1907/2006). It deals with the Registration, Evaluation, Authorisation and Restriction of Chemical substances. The new law entered into force on 1 June 2007. The aim of REACH is to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances. At the same time, innovative capability and competitiveness of the EU chemicals industry should be enhanced. The benefits of the REACH system will come gradually, as more and more substances are phased into REACH. More: [http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm](http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm).
expenses (e.g. acquisition of a new technology) but no expenses for implementation of the technology can be deducted from the tax base\textsuperscript{10}. The main reason for failure of this instrument is the fact that acquisition of new technology accounts for a small share of the expenditures needed for the implementation of technological investment. The companies deducted in 2007 a mere €0.2m.

\textsuperscript{10} Act of 29 July 2005 on some forms of supporting innovation activities.
http://www.google.com/url?sa=t&source=web&ct=res&cd=4&url=http%3A%2F%2Fisip.sejm.gov.pl%2Fservlet%2FSearch%3Ftodo%3Dfile%26id%3DDDU20051791484%26type%3D1%26name%3DDDU20051484L.pdf&ei=vw7LSpqfHNL44AbAxAz3HAQ&usg=AFQjCNF8u-Lu_R49e8XKxXjdZba9PLw_q&sig2=10l9dmQ0uJvHx5q2d6mIgg
4. The role of public policies in determining BERD performance and BERD intensities

Public policies are playing an increasingly important role in enhancing innovative R&D activities, foremost thanks to the contribution from the EU Structural Funds; the main assistance is in the form of direct financial support to both private and public organisations. The Polish Chamber of Chemical Industry (2009) confirms in its annual report 2009 that the most important way to increase domestic level of innovation of the chemical sector in Poland is to enhance the involvement of firms in the programmes financed from the Structural Funds. Polish chemical companies are still too poorly interested in their use what delays the process of improving the competitiveness of the industry, therefore it is of urgent importance to have this situation changed.

In Poland, several R&D and innovation measures are being developed and implemented at the national level. However, they rarely have sectoral character. The policies can be organised according to a framework of policy mix, which means that the combination and interaction of individual policy instruments from various domains influence the quality and quantity of R&D investments (Policy Mix R&D, 2008). The most common are public financial support (R&D Domain) provided by the governmental authorities to the companies, innovation organisations and R&D institutions (in addition to statutory funding and regular financing of Science); support of technology centres (Innovation Domain, e.g. technology parks, knowledge transfer etc.), legal and institutional instruments (Finance Domain, e.g. legal acts, tax policy etc.) and support to strengthen human resources in the economy (Human capital Domain).

Public financial R&D support (R&D Domain)

In principle, the R&D and innovation support in Poland is mainly based on the priorities and actions within the EU Structural Funds; the domestic funds are spent to complement them. The most important Operational Programme is “Innovation Economy” (OP IE)\(^\text{11}\) with a budget of €9.71b (ERDF contribution €8.25b) for 2007-2013, which is a significant amount of money dedicated to boost R&D and innovation in Poland; for the purpose of comparison the total annual government allocation to R&D activities (GOVERD and HERD) amounts to approximately €1b.

The most important measures for chemical companies as well as industrial and chemical R&D institutes are the measures 1.4 (Support for goal-oriented projects)\(^\text{12}\), 4.1 (Support for implementation of R&D solution)\(^\text{13}\), 4.4 (New investments with high innovation potential)\(^\text{14}\), and measures 1.3.2\(^\text{15}\) and 5.4\(^\text{16}\) (Financial support for the protection of industrial property generated in scientific entities as a result of R&D work). Some of these measures require a joint application from a consortium consisting of a public research organisation and a company, generating a side-effect enhancing cooperation and transfer of

---

\(^{11}\) Detailed presentation of the OP IE with its priorities, measures and actions, the management and implementation authorities as well as the budget allocation can be found under: [http://www.poig.gov.pl/english/Stroje/Introduction.aspx](http://www.poig.gov.pl/english/Stroje/Introduction.aspx).


459
knowledge between the public and private sectors. Due to additional funding opportunities, a popular government instrument is also IniTech\(^{17}\) (Technology Initiative II).

Another relevant programme providing financial resources to the chemical sector is funded by Structural Funds “OP Infrastructure and Environment”\(^{18}\). It does not support R&D activities directly, but provides financial support to the implementation of new (notably required by regulations), environmentally friendly solutions.

**Technology centres, clusters etc. (Innovation Domain)**

The OP IE also finances innovation policy measures; the main emphasis of the measures is placed on cooperation between entities, (e.g. development of regional systems), diffusion of innovation as well as support to institutions and organisations creating and enhancing innovative environments. Relevant measures provide support to innovation cooperation linkages at national level: 5.1\(^{19}\), support to innovation centres 5.3\(^{20}\), support to networks of intermediary organisations providing innovation services at national level 5.2\(^{21}\). There are several other innovation measures like Innovation Voucher, Innovation credits, Knowledge transfer centres, academic incubators etc., however they are targeted mainly at small (or even micro) and medium sized enterprises.

In 2003 started the creation of the European Technology Platforms, supported by the European Commission. The 2008 evaluation report (European Commission, 2008) confirmed the benefits and the need of continuation of this Europe-wide initiative. One year later the first Polish technology platforms started their activity. The Polish Technological Platform for Sustainable Chemistry (PPTZCh)\(^{22}\) was created at the beginning of 2005 on the initiative of the PCChI. Its primary objectives are the development of strategic initiatives for the chemical sector, concentration of all the key business and R&D partners around joint strategies, and optimal use of Structural Funds from the point of view of the competitiveness of the chemical industry in 2007-2013 as well as promotion and advocacy of any research and development activities in favour of the chemical industry. The platform is supported by the Ministry of Economy and Ministry of Science and Higher Education as well; and operates as a forum for discussions and exchange of opinions.

---


\(^{19}\) http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=detail&id=9225&CO=27


\(^{21}\) http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=detail&id=9223&CO=27

Legal and institutional measures (Finance Domain)

The R&D relevant legal measure is a possibility to deduct 30% of R&D expenditures (50% for SMEs) from the tax base; however, the impact of this measure is very limited. According to the OECD (2007) the tax deduction represents rather a weak form of support for R&D since it merely recognises R&D spending as a cost eligible for deduction from revenues before pre-tax profits. There are no tax deductions from the costs spent on the implementation of a research result.

Human resources (Human Capital Domain)

The SF Operational Programme “Human Capital” supports the development of human resources. The measures concentrate notably on support of various training activities developing personnel of modern economy, e.g. measure 2.1.1 (PL52). An important measure to provide highly skilled human capital for industry, including chemicals, is a new initiative of the Ministry of Science and Higher Education that started in 2009. The idea is to provide monthly grants to students, who decide to study so called “ordered courses”, which have a strategic importance for the Polish economy: engineering, physics, chemistry, etc. The monthly grant amounts around EUR 250, which is a relatively large amount of money. Some public research institutes offer valuable options for prospective chemists; for example the “Blachownia” Institute of Heavy Organic Chemistry offers each year a number of traineeships for students, and the best of them are given the opportunity to write their master thesis under the supervision of the institute. The companies offer limited opportunities for traineeships and do not engage actively in sponsoring of professorships and chairs. However, the observed increase in a number of concluded agreements between chemical firms and public research institutes gives hope to reverse this trend.

Assessment of policy measures

The public financial R&D measures (SF) are turning out to be very successful and desirable according to the representatives from the chemical sector taking part in this study. They provide a substantial support, most notably to the public research institutes (JBRs), which was confirmed by the interviews. The OP IE is also very attractive for the chemical companies, as there is an opportunity for modernisation and development through the new funding schemes. With respect to domestic funds, too large a share is spent on basic research, which does not provide any meaningful impact on industrial applications, and hence stimulate more BERD. The National Centre for Research and Development, a government body responsible for applied research, has recently launched a programme with a budget of €75m dedicated to energy and chemical research, which is seen by the sector as a big step forward to boost R&D activities and foster cooperation between public and private organisations. Notwithstanding, the desire of the chemical sector and research institutes (JBRs) is to change the general approach of R&D policy, so that essentially more resources are dedicated to proof of

---


25 Chemik 10/2008; Interview with Mr Marian Gryta, Director of “Blachownia” Institute of Heavy Organic Synthesis.
concept type solutions, which have a direct chance to be applied in industry\textsuperscript{26}. This is still not the case and ongoing reform of the research system in Poland does not address all the needs; for example reduction in funding for goal-oriented projects, which are a great opportunity for joint collaboration between chemical companies and public R&D units and universities.

Innovation measures play an important role and chemical companies are interested to locate in technology parks or join industrial clusters, which receive significant funding from national and EU funds. For example, Zaklady Chemiczne “Police” S.A. has intensified its cooperation within the West Pomeranian Chemical Cluster “Green Chemistry”, which gives an opportunity to work together with the Szczecin University of Technology; Zaklady Chemiczne “Zachem” (Part of CIECH Group) is active in the Bydgoszcz Industrial Cluster, etc. Although small companies are not able to compete with large chemical players, they should also have a chance to develop at least small innovative initiatives in specific projects.

The potential of legislative and fiscal measures to support BERD in the chemical sector in Poland is unfortunately not fully exploited by current government policy. As already mentioned, the existing tax allowances do not respond to actual needs of the chemical industry. The Main Council of JBRs as well as the recent VI Congress of Chemical Technology\textsuperscript{27} discussed a draft bill regarding the tax changes in the field of R&D activities, which extends the applicability of the tax deduction to the implementation of new technology. As the financial resources of the companies are still limited, the tax deductions encompassing acquisition and also pilot installations as well as launch of large-scaled production, are likely to be a more effective tool to increase considerably the level of Polish BERD.

Another urgent need is to complete the long-lasting process of privatisation\textsuperscript{28} of the chemical sector in Poland and to bring to an end the instability. The companies and research community jointly advocate a consolidation of the chemical sector with a dominance of public ownership due to the strategic role this sector plays in the Polish economy. For that reason, interviewees stressed that it is important to avoid privatisation through acquisition by foreign investors, who most likely will not be interested to maintain the R&D activities in Poland, but merely use the production infrastructure (as already happened in the case of household chemicals).

Human resource policy should aim at provision of practical experience to the potential employees of the chemical sector. The measures like grants for those studying chemistry are very good but not the sufficient measure as long as the study programme will be not more practical oriented. This problem is again linked to the insufficient financing of applied research and poor research infrastructure at the universities. An integral part of chemical education should be training in laboratories and companies, not only to foster applied knowledge but also to enhance the awareness of the need to invest more in R&D. Financial and legal incentives should be directed to close that gap.

\textsuperscript{26} For example: the opinion of the Main Council of the R&D Units on the suggested reform of the financing of science and the National R&D Centre; Polish version: http://148.81.190.219/e107/330.pdf


\textsuperscript{28} Several articles in specialised newspapers and magazines.
5. Conclusions, lessons learned and policy options

The study identified, described and analysed drivers of private R&D expenditure in the Polish chemical sector, barriers that negatively influence the level of BERD as well as described and analysed existing policy framework and its role in determining BERD intensity. The key messages of the case study can be summarised as follows:

1. BERD in the chemical sector is low and its intensity decreasing. The chemical firms are still largely in a phase of catching up, through investment in plant and equipment, with European and global standards; although the first signs of a strategic structuring of R&D activities in the largest chemical firms can be noted in the period since 2007.

2. Cooperation between public and private organisations needs to be intensified. The private sector is not able to remain competitive without knowledge and R&D infrastructure of public R&D entities, which in turn need to obtain more funds from companies to deploy their whole R&D potential;

3. The cost of implementation of R&D results is the main financial burden in the chemical sector, not the R&D activity itself. The legal framework (tax regulations) does not help to overcome the difficulties associated to implementation of new technologies;

4. Privatisation is an urgent need to stabilise the sector. Many decisions, also regarding long-term R&D strategies, are suspended, due to insecure ownership situation;

5. Policy measures are likely to improve the situation mainly due to the unprecedented funding through Structural Funds. The level of public investment is likely to leverage private expenditure as well as encourage public R&D institutes to carry out more R&D projects;

Despite the current economic crisis and a drop in demand, the chemical companies do not plan to cut radically the investment and R&D expenditure. They seem to become more aware of the role the R&D activities play to secure a long-term competitiveness and sustainable growth. Based on the analysis of the problems and challenges related to the R&D intensity in Polish chemical sector, following lessons (policy options) can be learned:

- Public funds need to be directed more towards applied research, which provide solutions for industry. The industrial applicability potential of R&D results and private-public partnerships benefiting from R&D synergy effects need to be the key evaluation criteria when deciding of funds distribution.

- Favourable conditions for R&D performance must be created, most notably introducing tax incentives for implementation of a technology, and not only for R&D activity. Companies must be fiscally disburdened in order to release financial resources for BERD.

- Temporariness of the current ownership structure must be brought to an end. Growth, development and successful R&D cooperation need stability and consequent follow-up of strategies. Public policy must ensure that favourable conditions will be created in order to pursue long-term R&D strategies (stability of high-level management).
CONTACT DETAILS

Case study author:
Tomasz Jerzyniak
Technopolis Group Belgium
Avenue de Tervuren, 12
B-1040 Brussels
Belgium
T: +32 2 734 7440
tomasz.jerzyniak@technopolis-group.com
www.technopolis-group.com

Experts taking part of the study group as interviewees:

Prof. Dr hab Jacek Cybulski, Deputy Director
Industrial Chemistry Research Institute
Ul. Rydygiera 8, 01-793 Warsaw
Tel.: +48 22 5682172
jacek.cybulski@ichp.pl
www.ichp.pl

Mr Eugeniusz Sutor, R&D Expert
ZAK Spolka Akcyjna
Ul. Mostowa 30A, 47-220 Kedzierzyn-Kozle
Tel.: 48 77 4812101
eugeniusz.sutor@zak.com.pl
www.zak.com.pl

Doc. Dr Marian Gryta, Director
"Blachownia" Institute of Heavy Organic Synthesis
Ul. Energetykow 9, 47-225 Kedzierzyn-Kozle
Tel.: +48 77 4873570
gryta.m@icso.com.pl
www.icso.pl

Mrs Wieslawa Niegodzisz, R&D Expert
CIECH Spolka Akcyjna
Ul.Pulawska 182, 02-670 Warsaw
Tel.: +48 22 6391485
wieslawa.niegodzisz@ciech.com
www.ciech.com

Mr Jerzy Majchrzak, Director
Polish Chamber of Chemical Industry
Ul. Sniadeckich 17, 00-654 Warsaw
Tel.: 48 22 8261665
jerzy.majchrzak@pipc.org.pl
www.pipc.org.pl
Bibliography

VI Congress of Chemical Technology: Resolution Nr 5 and 6 from 25 July 2009 including annexes.


Chemik 10/2008 Interview with Mr Marian Gryta, Director of “Blachownia” Institute of Heavy Organic Synthesis

Chemik 01/2009 Interview with Mr Jerzy Majchrzak, Director of the polish Chamber of Chemical Industry

Chemik 03/2008 Interview with then CEO of CIECH Mr Miroslaw Kochalski


Nowy Przemysl 30.07.2009 “PARP: 5 firm z GPW otrzyma dofinansowanie w ramach PO IG” (PARP: 5 companies present at the Polish Stock Exchange granted funding within the OP IE)

Nowy Przemysl 16.07.2009 "Pomimo kryzysu Pulawy inwestuje (Despite crisis Pulawy keep on investing)

Nowy Przemysl 16.07.2009 “Jak CIECH inwestuje w kryzysie” (How Is CIECH investing during the crisis)

Nowy Przemysl 27.07.2009 “Program prywatyzacji ponownie do Komitetu rady Ministrow (The privatisation programme back again to the Council of Ministers)

OECD (2007) “Policy mix for innovation in Poland: Key issues and policy recommendations”


Policy Mix R&D (2008) “Monitoring and analysis of policies and public financing instruments conducive to higher levels of R&D instruments: The Policy Mix project”; Case study Poland


Rindicata (2009), Interim Progress Report no. 2: results of Phase 1 activities, Sectorial analysis of the long-term dynamics of business R&D intensity, Directorate General Research European Commission, Brussels
Other sources used in the study

Database EraWatch and Trendchart

Polish Legal Acts concerning R&D, Science and Innovation

Annual reports of main chemical companies
“Sectorial analysis of the long-term dynamics of business R&D intensity”

In relation to (DG-RTD-2005-M-02-01):

“Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators”

Case study
Business Expenditures in R&D in the telecommunications services sector in Spain

Lorena Rivera León
Technopolis Group

Coordinated by

Brussels, 12 October 2009
# Table of contents

1 Synthesis

2 BERD performance in Spain: the case of the telecommunication services sector

3 Drivers of BERD intensity

4 The role of public policies in determining BERD performance and BERD intensities

5 Conclusion, lessons learned, and policy options

List of annexes

A.1 Bibliography

A.2 Figures on BERD performance in Spain
Business Expenditures in R&D in Telecommunications Services Sector in Spain

1 Synthesis

Business R&D in Spain is concentrated, with seven sectors accounting for over 52% of the total in the period 1995 to 2006. The clearest trend in the country has been an increase in the relative importance of three service sectors in terms of the volume of R&D: Telecommunications services, Computer services and Other Business services. These three sectors have also increased their R&D intensities. Internal business R&D constituted around 40% of total expenditures on innovation among Spanish enterprises in 2007, whereas R&D acquisitions (or external R&D) constituted 15% of total.

The telecommunications services sector is global and its R&D trends and strategies respond to the global strategies of a small group of world leaders. Since 2001, the sector in Spain has moderately lost its dynamism after a strong expansion due to a boom of mobile services and broadband access. New technologies have been developed in order to increase the quality, the traffic and the speed of data of various Internet access services that has overall resulted in the major increase of revenues in 2008 in the sector. Nevertheless, in the EU27, the sector is characterised by low R&D intensities. Almost 30% of firms in the communications services sector were innovative in the period 2005-2008.

The telecommunication services sector in Spain is characterised by having most of their investments in fixed assets and equipment, whereas internal and external business R&D represent each 12% of the total. The Spanish market is highly concentrated in terms of players, and also geographically, following the corporate strategies of the main players. There is no real critical mass for R&D outside the main focal centres (large cities) that account for 76% of total R&D in the country. Market competition has increased due to the emergence of mobile virtual operators creating pressure for cost reductions by all market players. Most public incentives for R&D expenditures are allocated to innovations that solve the problem of lack of accessibility and the introduction of infrastructures to rural areas. Business R&D centres are also centralised and concentrated geographically in specific regions and localities, notably the large cities. Global competitive pressures had forced operators to internationalise, delocalise, externalise and/or cut some of their operations. Competitive advantages in terms of accessibility to highly qualified personnel remains an important determinant of BERD. One of the biggest challenges of Spain is moving the production activities towards more technology intensive sectors, and/or towards those creating greatest value added to the economy. The general focus should be in increasing the capacity of the sector in producing new and innovative demanded services. Two main challenges related to R&D investment and innovation have been identified in this case study: the increase in the number of medium high and high technology industries; and the increase in the availability of human capital and skills. These challenges call for specific policy responses presented in this study.
2 BERD performance in Spain: the case of the telecommunication services sector

In terms of broad aggregates, around 69% of Spanish Business R&D (BERD) is accounted for by manufacturing industries (NACE 15-37) and 25% by services (NACE 50-99). The main trend over the period 1995 to 2006 has been a decrease of the relative importance of the former, with its share of the total decreasing from 78% in 1995-2000 to 65% in 2001-2006, and an increase in that of the latter, with the share going from 17% to 29%. R&D intensity in manufacturing industries combined is 2.3% and in services is 0.2%.

Business R&D in Spain is concentrated, with seven sectors accounting for over 52% of the total in the period 1995 to 2006: Pharmaceuticals (12%); Motor Vehicles (9%); Telecommunications services (7%); Computer services (6%); Machinery and equipment (6%); Aircraft (6%); and Other Business services (6%).

The clearest trend in the country has been an increase in the relative importance of three service sectors in terms of the volume of R&D: Telecommunications services, Computer services and Other Business services. In fact, Spain had one of the highest average annual growth rates of BERD in the services industries in the period 1995-2004 if compared with the rest of the OECD countries (just behind Ireland) (OECD, 2008). The biggest change in terms of shares has been in the Computer services sector, which has increased its share from 4.1% of the total in 1995-2000 to 6.7% in 2001-2006. At the same time there has been a steep decline in the shares of Radio, TV and Communications equipment (from 10.3% of the total to 3.3%). A decrease in the share of BERD can be seen for Aircraft, Other Transport and Pharmaceuticals.

For the country as a whole, 15 out of the 16 sectors that account for more than 80% of BERD have increased their R&D intensity (see Figure A.2.2). The biggest increase has been in Pharmaceuticals. The telecommunication services sector increased its intensity from 1.2 to 2. The only sector to show a decline has been Radio, TV and Communications equipment. Contrasting with the 80% share of total R&D, the same 16 sectors account only for 23% of total value-added in the country. There have only been minor changes in the relative importance of these sectors between 1995 and 2006 (see Figure A.2.3).

Spanish performance in the global telecommunication services sector: main BERD trends

The telecommunications services sector (class 6420 ISIC rev 3) includes the transmission of sound, images, data or other information via cables, broadcasting, relay or satellite (including telephone, telegraph and telex communications; and the maintenance of the network). The sector is mostly divided in the provision of four services: landline communications, mobile communications, Internet access and audiovisual services (radio and television).

The telecommunications services sector is global and its R&D trends and strategies respond to the global strategies of a small group of world leaders, which account for most of the revenues, clients and innovations in the sector. The sector has

---

1 The 16 sectors listed in Figure A.2.1 in annexes account for more than 80% of all industrial R&D.
2 In 2006, the ten world leading operators generated 53% of world total revenues in the sector (CEPAL, 2008). These are: Verizon Communications (USA), NTT (JP), Deutsche Telekom (DE), Telefonica (ES),
experienced substantial transformations in the last decade, mainly regarding regulatory changes and by intense processes of mergers and acquisitions. In the last years, the sector has moderately lost its dynamism after a strong expansion due to boom of mobile services and broadband access. Mobile communications, including mobile Internet access (3G access increased 82% from 2007 to 2008), has gained importance over fix/landline communications. Favourable market perspectives in Spain include mobile and wireless communications; broadband connections; Voice over IP (VOIP); multimedia UMTS terminals; and all contents and services to be offered through these channels (television, video, music, photo, etc.). The decrease in the number of lines, traffic and prices has impacted the revenues of all telecom operators. Technological changes and the development of new services affect the nature of the operators and force them to focus on emergent services of high value added (CEPAL, 2008). New technologies have been developed in order to increase the quality, the traffic and the speed of data of various internet access services that has overall resulted in the major increase of revenues in 2008 in the sector (equal to 41.6%). Nevertheless, in Europe, the sector is characterised for having low R&D intensities if compared with other sectors (i.e. pharmaceuticals, biotechnology and other IT sectors) (EC JRC, 2008).

The tendency in the Spanish telecommunication services sector is the rapidly increasing importance of Internet services, the moderate growth of mobile communications and the decrease of importance in landline communications and audiovisual services (CMT, 2009). This tendency is mainly due to mobility and the increase in the speed of broadband connections (Lorenzo Matensanz, 2007). Total investment in the sector decreased by almost 11% from 2007 and 2008 (CMT, 2009). Total BERD in the sector increased its share between the periods 1995-2000 and 2001-2006 from 6.2% to 7.3%. If referring to individual firms, only one Spanish company made it to the top 100 in the 2008 EU industrial R&D investment Scoreboard: Telefónica, the largest telecommunications company of the country (EC JRC, 2008). The company is ranked 41st in the scoreboard with a total R&D investment of €594m in 2007.

According to the Spanish Survey on Technological Innovation in Business 2007 (INE, 2008), internal business R&D constituted around 40% of total expenditures on innovation among Spanish enterprises in 2007; whereas R&D acquisitions (or external R&D) constituted 15% of total. When looking at sectoral patterns, enterprises in telecommunications and post services accounted for the highest share of total Spanish enterprises undertaking innovation expenditures, representing France Telecom (FR), AT&T Inc (USA), Vodafone (UK), Sprint Nextel (USA), Telecom Italia (IT), and BP (UK).

The decrease in the number of landlines was also due to the diffusion of ADSL technologies and the appearance of VoIP services (voice over Internet), which pushed down drastically the prices of services. The increasing importance is based in the growth rate of revenue for final services in the period 2007-2008.

Other important players in the national market are: Vodafone, Movistar, Orange, Ono, Telecinco, Grupo Abertis, Televisió de Catalunya, Yoigo, R Cable, Sogecable, RTVE, Euskaltel, Jazztel, Hispasat, Telecable de Asturias, and Colt.

No other Spanish telecommunications firm is present in the top 1000 of the 2008 EU industrial R&D investment Scoreboard.

In Spanish: Encuesta sobre Innovación Tecnológica en las Empresas 2007

When analysed by firm size, this corresponds to 46% for enterprises between 10 and 249 employees, and 34% for enterprises with 250 and more employees in terms of internal business R&D; and 13% and 17% respectively in terms of external R&D.

In the Survey (INE, 2008), innovation activities and expenditures are the group of activities that lead to the development and introduction of innovation, including seven activities: scientific research and
10.5% of the total (INE, 2008). 27% of firms in the post and telecommunications sector found it important to innovate on products because of the impact this has in terms of sales. Almost 30% of total firms in the communications services sector were innovative in the period 2005-2008. Additionally, Spain has shown the second highest average annual growth rate in the communication services sector among the OECD countries (just behind Finland and close to Belgium) of around 20% between 1995-2004 (OECD, 2008).
3 Drivers of BERD intensity

At the beginning of the decade, in 2000, there was a belief that the economic downturn would re-organise the global telecommunications sector. In Spain, it had a strong impact that resulted in a reduction of total investment since 2001, which impact was bigger given the relatively low R&D intensities of the sector if compared with others in the country. Investment decreased in order to reduce debt\textsuperscript{10}, together with the emergence of operational improvements (CEPAL, 2008). The sector is in fact characterised by having most of investment in fixed assets and equipment (52\% of total investments), whereas internal and external business R&D represent 12\% of total each.

Market concentration and barriers to entry are main characteristics of most of knowledge-intensive sectors and the Spanish telecommunication services sector is not an exception. The Spanish market is highly concentrated in terms of players, and also geographically, following the corporate strategies of the main players. In terms of geographic concentration, 45\% of total R&D in the sector is concentrated in Madrid, the capital of the country. In 2007, total business R&D was concentrated in mainly five regions (Madrid, Cataluña, Andalucía, País Vasco and Valencia) that account for 76\% of the national total (Cotec, 2009). This suggests that there is no real critical mass for R&D outside the main focal centres. In terms of market concentration, Telefonica is the main player of the country in terms of R&D expenditures. Nevertheless, the operator invests considerably less in R&D in Spain, relatively to its global competitors in other countries. For example, BT (United Kingdom) invested 2.9 times more (1705 million euros in 2007) than Telefonica, and France Telecom (France) 1.5 times more (894 million euros). Academic experts signalled that acquiring critical mass of users is indeed one of the main drivers of the industry. Even underperforming in the global telecommunication services market, the Spanish sector does not have a critical mass of players whose R&D expenditures are able to have a relevant impact in the market. Government experts expressed that concentration of BERD performance in the telecommunication services sector is relative because it is linked to the capacity of enterprises to innovate. Despite having similar patterns of expenditures in percentage, BERD in big players is considerably higher than those of small players because of their levels of revenue and sales.

Academic experts underlined that because the telecommunications services sector is global, its R&D trends and strategies respond to the global strategies of the main world players, regardless of their location. In fact, geography does not seem to be relevant in this global sector because of its intensity in knowledge and the facility to transfer it through ICTs. This is also the case of Spain. Telefonica, the main operator, has followed different strategies in order to respond to increasing competition in the internal market. The degree of internationalisation of Telefonica is high and operations in foreign markets represented more than one third of Telefonica’s total revenue in 2006 (CEPAL, 2008) having presence in all segments of the sector in Latin America\textsuperscript{11}, and concretising

\textsuperscript{10} Debt increased among the main Spanish operators (and also among many of the European competitors) due to the cost of licenses of third generation mobile communications (3G) in Europe.

\textsuperscript{11} In 2007, Telefonica acquired Colombia Telecomunicaciones (Colombia) in a transaction worth €1.9 billion. In November 2008, it acquired the Chilean ‘Compania de Telecomunicaciones’, worth €635 million, and representing the largest Latin American deal of the world sector in 2008 (PWC, 2009).
acquisitions in the Czech Republic (Czech Telecom), the United Kingdom and Italy (Olimpia SpA).\footnote{The acquisition of Olimpia SpA was the fifth largest telecoms deal in 2007, for a total value of €4.4 billion (PWC, 2008).}

Market competition has pushed the main Spanish operators to reduce costs and offer new convergent services, resulting in Multi-Pack alternatives. The development of Multi-Pack puts the telecommunication operators in competition with audiovisual services providers; and Internet services providers that lead to even stronger competition. For example, Auna, an alternative cable-television operator that launched Multi-Pack alternatives in the market of landline communications, became progressively a serious competitor of Telefonica (CEPAL, 2008). Nevertheless, traditional operators continue to act as ‘articulators’ of Multi-Pack offers and packages in the market. Market competition has increased more fiercely due to the emergence of mobile virtual operators (MVOs) that distinguish themselves from traditional operators by offering lower prices and/or differentiated and ‘personalised’ services to market niches.\footnote{MVOs are not owners of infrastructures. They are major ‘customers’ of traditional operators, but also their major competitors, due to their ‘aggressive’ commercial strategies and low rates offered to final consumers.} This has resulted in fierce price competition setting pressures over cost reductions of all market players. Nevertheless, Carrasco Amador believes that cost reductions would not affect the propensity to spend in R&D of market players, particularly of the large and traditional operators whose competitors and strategies are global.\footnote{In order to overcome pressures over cost reductions telecoms operators are using strategies related to delocalisation, externalisations of some of their operations and reduction of personnel.} Spending in R&D and being innovative creates competitive advantages and sets barriers to entry to non-Spanish global operators aiming to enter the Spanish market. Investment by MVOs normally results on fixed assets and infrastructures rather than in R&D and has been historically more volatile relative to external pressures.\footnote{For example, MVOs have invested considerably in the deployment of 3G technology networks since 2007 (CMT, 2009). UMTS active stations increased 35% in 2007, but only 9% in 2008, mainly due to the global financial crisis and the decrease of revenues.}

Mergers and cooperation among traditional operators have resulted in large associations such as Redtel -that groups Ono, Orange, Telefonica and Vodafone- whose main objective is private investment in networks and infrastructures. Investment culture among these operators remains traditional. One of the association’s recent publications (Redtel, 2008) sets as their main role to become the providers of the infrastructures that could boost productivity pushed by public policies and partnerships for the Information Society. The R&D component of the investment effort of these operators remains somewhat secondary. Nevertheless, Carrasco Amador believes that this tendency will change once the entire country has access to digital communications, particularly in rural areas. For now, most of public incentives for R&D expenditures are allocated to innovations that solve the problem of lack of accessibility and the introduction of broadband network infrastructures to rural areas.

Business R&D centres in the telecommunications sector are also centralised and concentrated geographically in specific regions and localities, notably the capitals and following normally corporate decisions. The main R&D investor in the sector, Telefonica, has five R&D centres in Spain (in Barcelona, Granada, Huesca, Madrid and Valladolid) and two centres in Latin America (Brazil and Mexico, opened in 2002 and 2004 respectively). Since 1988 the centres have developed global innovations.\footnote{These are related to public landline communications, large network management systems, Internet access services, platforms for the development of intelligent network services, IP Networks for}
highly involved in public funded projects, sometimes linked to national strategic plans\footnote{For example, in 1993, results related to network and services from the RECIBA project (Experimental Network of Integrated Broadband Communications), were integrated as fundamental cores of the National Broadband Plan.}. According to the latest available Annual Report (TelefónicaI+D, 2007) the company took part in more than 190 projects financed by public administrations\footnote{From the 190 projects, 5 of them were CENIT (Specific line of the Programme Ingenio 2010), the Spanish Ministry of Industry promoted 57, 41 by the Autonomous Communities, and 87 by the European Union (Telefonica I+D, 2007).}, making the firm an important recipient of public funding. For Carrasco Amador, the fact that large companies such as Telefonica hold large shares of public financed BERD and participate in large R&D projects is natural and somehow positive because of their capacity to invest in technology peaks. SMEs firstly rely on regional and local policies and initiatives to then rise to the national and EU levels, hence the importance of efficient and inclusive local and regional policies to boost R&D among small market players. Global competitive pressures had forced operators to internationalise, delocalise, externalise and/or cut some of their operations. In 2008, the R&D branch of Telefonica announced a desired cut on personnel costs of around 8\% of total (around 94 employees) in order to comply with new corporate strategies related to the increase of investment on risk capital, and increase the purchases of innovations conceived by external firms. The positive effects of these external acquisitions of R&D in the Spanish market are still to be observed. Despite the fact that small business units find it difficult to invest in R&D, and normally appropriate third-party solutions to their operations, Spanish SMEs participating in value chains of traditional operators are usually in the non-value added activities of the chain. International cooperation seems to be the tendency that allows more efficient appropriation of R&D effects related to externalisation and outsourcing strategies by large firms.

Competitive advantages in terms of accessibility to highly qualified personnel remains important. When asked if accessibility was essential in determining where operators locate their R&D centres inside Spain, the interviewees suggested this factor was irrelevant. Direct public incentives seem to be the major determinant. Nevertheless, given the global nature of the sector, accessibility to highly qualified workers in the country as a whole remains crucial, especially since there seem to be a disparity between supply and demand of qualified workers in the labour market. Although the interviewed experts say there are as important as fiscal and direct incentives to firms, they consider that access to top-class human resources is more relevant in the long term. SMEs, the majority of enterprises by size, have usually difficulties to benefit from fiscal incentives, partly because of lack of knowledge, and partly because of lack of trust in the instruments. Brain drains remain high. Interviewed experts call for reforms to the education system to link better industry and academia in order to promote entrepreneurship, and attract highly qualified workers instead of exporting them. This argument is valid for all the sectors in the economy.

The Spanish Survey on Technological Innovation in Business (INE, 2008) analyses the factors that drive the decision of firms on \textit{not} to innovate\footnote{These figures do not distinguish between the size of enterprises and sectors.}. In 2007, the 'cost' was the

multimedia services, services for the digital home and the connected car, interactive voice services, solutions for IP television, and mobile services. Examples of innovations developed within Telefonica include \textit{Modular Public Telephone Booths} that provided public telephone services in 40 countries on five continents; management systems such as Operating and Switching Structure (EOC), Traffic Management Systems (SGT), GEISER management system for the transportation network, SIGRES management system for Latin America etc.; internet access services such as ‘Infovia’; platforms for intelligent network services such as White Pages Directory Spain Direct and Remote Voting services.
main factor hindering innovation in firms (34%), followed by 'lack of interest' (33%), 'lack of knowledge' (24%) and the 'market' (22%). In fact, for most of the experts interviewed for this case study, the main reason hindering innovation in firms is 'mentality' and related cultural factors. Firms in Spain remain traditional and conservative in their investments. Inclusive organisational structures of firms, that promote collaboration among workers and managers seem favourable for guaranteeing productivity and boosting R&D. The European Innovation Scoreboard 2008 (European Commission, 2009) classified Spain as a 'Moderate innovator' and identified as relative weaknesses in relation to the country's average performance, the investments of firms, and the creation of linkages and entrepreneurship. The report also highlights the significantly low growth in performance in human resources relative to the EU average. These results explain the importance of promoting the benefits of investing in R&D at all levels. The global financial crisis will set big challenges for the country. The projections are negative and there is the belief among interviewed experts that due to economic adjustments and reduced government income from tax receipts, public investment in 'non-primary' budget lines, such as support to innovation, will be either terminated or will not grow at the desired rates.

Regarding drivers from the industry and country-specific factors, the Cotec Report highlighted that since 2006 there are structural differences regarding business expenditures on R&D. These relate to the national production system and the weight traditional sectors have on the Spanish economy (Cotec, 2006), notably in manufacturing and non knowledge-intensive services sectors. The OECD Science, Technology and Industry Outlook 2008 signalled as a major challenge for the country to boost R&D in the business sector, mainly because most industries in Spain are low technology and firms are small and medium-sized (OECD, 2008).

The deregulation of the telecommunications sector has been without doubt beneficial for the EU's internal market, notably in terms of access to better rates and services to final consumers due to increasing competition among operators and the appearance of VMOs. The expectations on the process were high. Nevertheless, because competition in the sector is global, competitiveness achievement at the global level seems to take precedence over the internal market needs and requirements. Additionally, according to experts in terms of BERD, the deregulation efforts have almost no impact on the propensity to invest on R&D by firms. Traditional operators and large players are likely to remain ahead in terms of investment efforts. As the emergence of new players in the market increases, mergers, acquisitions and strategic alliances will most probably increase. Although the consumer had a central role in making the sector more dynamic, this does not seem to be the case in terms of demanding better high-quality services, probably because of cultural factors and/or because of a vicious circle related to prices and critical mass of users: new services would not be developed requiring investment in R&D, without a critical mass of users, and this would most likely not increase, if the prices are not accessible to final consumers. The general focus should be in increasing the capacity of the sector in producing new and innovative demanded services.
4 The role of public policies in determining BERD performance and BERD intensities

Since 2000 there have been increasing efforts from the public sector to increase R&D expenditures in enterprises. This section describes the existing R&D policies in the country, using the "Policy Mix" methodological framework developed by the European Commission\(^{20}\), with a focus on the policy instruments that influence the quantity and quality of R&D investments in the private sector generally to the country, and particularly to the telecommunications services sector when possible.

Two main challenges related to R&D investment and innovation have been identified in this case study: the increase in the number of medium high and high technology industries; and the increase in the availability of human capital and skills. These challenges call for specific policy responses that are briefly presented below.

Most of the policies related to R&D in the private sector are included in the National Plan for Scientific Excellence, Development and Technology Innovation, updated every three years. The VI National Plan (2008-2011) was approved in 2007 and it encompasses measures included in the National Reform Programme (NRP)\(^{21}\), and sets out the policy instruments for reaching the objectives of the National Strategy on Science and Technology (2008-15), approved by both national and regional governments. The main R&D financing body for private firms is the Centre for the Development of Industrial Technology (CDTI). The Centre gives financial support to R&D projects performed by enterprises\(^{22}\), and is the main articulator of generic innovation policies of the Innovation domain of the Spanish policy mix. The response of the Spanish government to the Lisbon Strategy is the Ingenio 2010 Programme, one of the main pillars of the NRP ("The Research and Development and Innovation Strategy")\(^{23}\). Ingenio 2010 sets as objective to raise the private sector's contribution to R&D investment from 48% in 2003 to 55% in 2010. Although there are not yet assessments on the effectiveness of the programme, policymakers interviewed for this case study have mentioned its relevance particularly in terms of boosting cooperation among participants in the innovation system (e.g. technological centres, universities, etc.); but most particularly they see this programme as a good initiative for extending the scope of technological applications to more traditional sectors in the Spanish economy. The nature of the initiative is focussed on horizontal support thus promoting R&D more strongly at all levels.

In the context of Ingenio 2010, the experts interviewed recurrently mentioned the CENIT Programme (National Strategic Consortiums of Technical Research, launched in 2005) as an efficient instrument in promoting R&D collaboration amongst companies, universities, public research bodies and centres, and technological parks and centres.

---


\(^{21}\) The NRP was set to reach convergence in terms of reaching convergence in per capita income and reach the EU employment rate by 2010. It identifies seven priorities as necessary to achieve productivity growth and job creation.

\(^{22}\) The CDTI finances three categories of technological projects: projects for technology development (creation and improvement of production processes, projects or services); technology innovation projects (introduction of emerging technologies in enterprises); and arranged industrial research projects (for precompetitive research projects).

\(^{23}\) The main objectives of the Ingenio 2010 Programme are: to promote the investment of more financial resources in R&D and innovation; create new strategic programmes and regulatory measures; and establish a new Integrated System of the Monitoring and Assessment of R&D and innovation policies.
This project reveals to be important particularly with the identification of worsening linkages and entrepreneurship in Spain mentioned in the European Innovation Scoreboard 2008 as a factor hindering innovation. Thanks to the CENIT Programme an increasing amount of linkages between the public and private sectors have been created. This is positive for boosting BERD as it offers opportunities for knowledge sharing, knowledge exchange, technology transfers and entrepreneurship enhancement. This is particularly relevant for the telecommunication services sector because of the recent trends in outsourcing R&D by big players. This, in support of the Fund of Funds initiative, also part of CENIT, that seeks to strengthen private venture capital investment in technology companies in the infant and start-up phases, is likely to help integrating enterprises in the telecommunication services sector into value-added activities of the sectoral value chain. CENIT has been particularly successful in integrating SMEs into strategic international projects, mainly because they reduce the financial insecurity that is usually associated to R&D investments. A specific measure of the CENIT Programme, the Torres Quevedo programme, is signalled as a good instrument for integrating highly qualified technology management experts in private firms. Although, there are no evaluations on the success of this measure, more than 1000 researchers have already joined private enterprises, technology centres, universities and public research centres (EC, 2008). The CENIT Programme is subscribed as an R&D/Innovation policy-Linkage in the R&D domain of the Policy mix for R&D in Spain, Route 1 “Promote the establishment of new indigenous R&D performing firms”.

A position paper by industry, through the Redtel network that groups the traditional telecoms operators (Redtel, 2008b) calls for public private partnerships (PPPs) for boosting productivity and innovation in the sector, particularly in remote areas with no or below-average infrastructures. Most importantly, the network asks for demand-side policies such as transfer schemes to support access to services to excluded niches. These policies would be effective for reaching a critical mass of users and would serve as an incentive for R&D investments. According to experts, policies directed to increase R&D in the public sector, for example through public procurement, have also been effective in boosting R&D. The Redtel network calls for collaboration from the public sector in order to develop a good and extended offer of e-government, e-health, e-learning (e.g. through the FORINTEL Programme, and the AVANZ@ Programme of Ingenio 2010) and e-business services; and generally promote better and more use of telecoms services in public administrations. PPPs seem to be a way forward in view of the potential limited public resources due to the global financial crisis, in order to make efficient use of public and private funds.

Other policy instrument directed to the R&D domain of the policy mix is the PETRI Programme that promotes the transfer of research outcomes from universities or technology centres to the private sector. Regarding R&D specific financial and fiscal policies such as fiscal incentives for R&D, they remain relevant but not determinant for boosting R&D in businesses. The Spanish Fiscal Incentive System for R&D is considered one of the most generous among the OECD countries. Nevertheless, as it was mentioned previously, enterprises make very little use of them because of excessive bureaucracy, legal insecurity and lack of information and technical knowledge in the companies (Uyarra, 2006).

Regarding policy measures outside the R&D domain, education policy plays a central role. Spain remains characterised by having a bipolar educational structure. An important proportion of students do not complete the secondary level, although almost 30% of those who complete it continue at a tertiary level (EC, 2008).
University Law was recently modified with the objective of improving the quality of the education system and provides more and better skills to graduates. The reform of the University Teachers’ Statute gives the opportunity to university teachers to participate in business projects without comprising their positions at university. The CENIT Programme, as described above, includes measures to motivate students to continue their education to the PhD level. Nevertheless, experts called for more specific measures in order to reduce the brain drain in the country and attract foreign highly qualified technical workers to the country. Other sub-theme policy focus should be the inclusion of policies that support creativity and entrepreneurship; as cultural factors have been mentioned by all experts as important for hindering innovation and R&D in businesses.

Regarding the policies and Programmes at the European level, experts mentioned the Seventh R&D Framework Programme (FP) of the European Commission as having several restrictions related to the treatment of fixed assets. Contrary to the previous FP, the FP7 does not provide direct incentives for the investment of fixed assets dedicated to R&D, and only does in terms of the value of the amortisation of these assets. Experts identified this to be a disincentive to innovation and R&D, making the management role of projects by regional administrations more complex.
5 Conclusion, lessons learned, and policy options

To summarise key points in this case study report:

• The telecommunications services sector is global and Spanish BERD trends respond to the global strategies of the main world players, regardless of their location. Geography does not seem to be relevant in this global sector because of its intensity in knowledge and the facility to transfer it through ICTs.

• One of the biggest challenges in Spain is moving the production activities towards more technology intensive sectors, and/or towards those creating greatest value added to the economy.

• Initiatives such as the Programme Ingenio 2010 are of particular relevance and effectiveness because it helps in boosting cooperation among participants in the innovation system. It also extends the scope of technological applications to more traditional sectors in the Spanish economy because of its horizontal nature of application.

• Demand-side policies such as transfer schemes to support access to telecommunication services to excluded niches would be of effectiveness for reaching critical mass of users and would serve as incentive for R&D investments. This requires the increase of Public Private Partnerships. Better use of public procurement for boosting BERD should be enhanced.

• There is a need for specific measures in order to reduce the brain drain in the country and attract foreign highly qualified technical workers. There should be a focus for the inclusion of policies that support creativity and entrepreneurship as cultural factors are perceived as important factors hindering innovation and R&D in businesses.

• The Seventh R&D Framework Programme of the European Commission is perceived as having several restrictions related to the treatment of fixed assets and thus being a disincentive to innovation and R&D in businesses and thus, making the management role of projects by regional administrations more complex.
CONTACT DETAILS

Case study author:

Lorena Rivera León
Technopolis Group Belgium
Avenue de Tervuren, 12
B-1040 Brussels
Belgium
T: +32 2 734 7440
lorena.rivera.leon@technopolis-group.com
www.technopolis-group.com

Experts taking part of the study group as interviewees:

Juan Vicente García Manjón
Vice rector of the European Space of Higher Education and Employment at the
European University Miguel de Cervantes
C/Padre Julio Chevalier, No. 2
47012 Valladolid
Spain
T: +34 983 228508  ext. 236
jvgarciam@uemc.es
www.uemc.es

Juan Pablo Carrasco Amador
Director of the Area Research, Development and Innovation
Foundation for the Development of Science and Technology in Extremadura
C/Montesinos, no. 28. Edificio Almuzaffar
E-06002 – Badajoz
Spain
T: +34 924 014 600
juanpablo@fundecyt.es
www.fundecyt.es

Rafael Muguerza Eraso
Director of the Service on Innovation and the Information Society, Department of
innovation, Enterprises and Employment
Government of Navarra
Parque Tomás Caballero, 1-4 pl
31005, Pamplona
Spain
T: +34 848 427 663
rafael.muguerza.eraso@cfnavarra.es
http://www.navarra.es/home_es/Gobierno+de+Navarra/Organigrama/Los+departamentos/Innovacion+Empresa+y+Empleo/

José Jiménez Delgado
Telefónica I+D
Emilio Vargas 6
28043, Madrid
Spain
T: +34 913 374 215
jimenez@tid.es
www.tid.es

Rafael Mompó
Director Electronic and Communications Department
European University of Madrid (Laureate International Universities)
C/ Tajo, s/n. Urb. El Bosque
28670 Villavciosa de Odón (Madrid)
Spain
T: +34 912 115 677
rafa@rafaelmompo.com
www.uem.es
List of annexes

A.1 Bibliography


CEPAL – Comisión Económica para América Latina y el Caribe (2008), *La sociedad de la información en América Latina y el Caribe: Desarrollo de las tecnologías y tecnologías para el desarrollo*, Wilson Peres and Martín Hilbert (Eds.), Santiago de Chile.


Gual, Jordi (2001), *La desregulación de las Telecomunicaciones en España*, Documento de Investigación No. 431, División de Investigación IESE, Universidad de Navarra.


Redtel – Asociación Española de Operadores de Telecomunicaciones (2008), Contribución de las Operadoras de Telecomunicaciones al Desarrollo Económico y Social de España, www.redtel.es

Redtel – Asociación Española de Operadores de Telecomunicaciones (2008b), La Iniciativa Privada en el Desarrollo de las Infraestructuras de Comunicaciones Electrónicas y la Sociedad de la Información, Spain.


A.2 Figures on BERD performance in Spain

Figure A.2.1. Trends in the shares for BERD in Spain: 1995-2006

![Bar chart showing trends in the shares for BERD in Spain: 1995-2006.]
Figure A.2.2. Trends in Sectoral R&D intensity in Spain: 1995-2006
Figure A.2.3. Trends in the shares of Value-added in Spain: 1995-2006
Figure A.2.4. Changes in the shares of BERD, Value-added and R&D intensity in Spain: 1995-2006

Table A.2.1. Typology of sectors in term of their contribution to the 3% target

<table>
<thead>
<tr>
<th>Sectors making good progress towards the 3% target</th>
<th>Sectors retarding progress towards the 3% target</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pharmaceuticals</td>
<td>• Radio, TV and Communications Equipment</td>
</tr>
<tr>
<td>• Motor Vehicles</td>
<td></td>
</tr>
<tr>
<td>• Telecommunications services</td>
<td></td>
</tr>
<tr>
<td>• Machinery and equipment</td>
<td></td>
</tr>
<tr>
<td>• Aircraft</td>
<td></td>
</tr>
<tr>
<td>• Computer services</td>
<td></td>
</tr>
<tr>
<td>• Other Business services</td>
<td></td>
</tr>
<tr>
<td>• Instruments</td>
<td></td>
</tr>
<tr>
<td>• Electrical equipment</td>
<td></td>
</tr>
<tr>
<td>• Other Transport</td>
<td></td>
</tr>
<tr>
<td>• Machinery &amp; Equipment</td>
<td></td>
</tr>
<tr>
<td>• Food, Drink, &amp; Tob.</td>
<td></td>
</tr>
<tr>
<td>• Fabricated Metals</td>
<td></td>
</tr>
<tr>
<td>• Other Business Services</td>
<td></td>
</tr>
<tr>
<td>• Financial Services</td>
<td></td>
</tr>
</tbody>
</table>
“Sectorial analysis of the long-term dynamics of business R&D intensity”

In relation to (DG-RTD-2005-M-02-01):

“Multiple Framework Service Contract for Expert Support with the Production and Analysis of R&D Policy Indicators”

The ICT industry in Estonia
Case study

Katrin Männik
Ruta Rannala
Alasdair Reid
Technopolis Group

Coordinated by

Tallinn/Brussels, 13 November 2009
## Table of contents

1 Synthesis .......................................................................................................................... 491
2 BERD performance in Estonia ......................................................................................... 493
3 Drivers of BERD intensity ............................................................................................... 498
4 The role of public policies in determining BERD performance and BERD intensities in the ICT sector ............................................................................................................. 505
5 Lessons learned, case uniqueness and success factors ..................................................... 508
1 Synthesis

The ICT sector in Estonia contributes significantly to the total BERD in Estonia; while, the sector’s contribution to value added is less than might be expected. Observing the contents of innovation activities of ICT businesses in general, the R&D activity consists of a minimum share of research. Hence, the situation reflects the ICT businesses' performance more towards operational and shorter-term innovative activities instead of more strategic research projects. However, the situation is likely to improve, for instance, through public-private funding for technology competence centres (two in the ICT sector).

One of main drivers of the Estonian ICT sector lies in the leading role of public sector. The public sector has acted to create a market through large-scale infrastructure investments as well as public procurement in the ICT field. From a negative point of view this is said to reduce willingness of local companies to invest abroad. However, presently the ICT sector has reached the limits of domestic market. Though, not exploited fully in other sectors of economy (in education, health care, industry, energy, finance services, ICT security). Moreover, the need to increase the export share of ICT businesses is a priority of the sector. Due to the smallness of the market and resources of businesses joint actions between themselves and in co-operation with research institutions are necessary to sustain competitive positions internationally.

Estonian firms in the ICT sector can be characterised by advanced level of information technology solutions, especially in Internet banking and mobile solutions. ICT companies in Estonia have also initiated actions by themselves without any significant public support in certain fields (m-parking, e-school, etc.).

The performance of major players like Skype but also Playtech in Estonia has stimulated developments in and improved the image of the sector as a whole. Estonia has gained from the experience of developing large peer-to-peer networks. However, the absence of major player(s) in other industry or service sectors in Estonia impedes the potential spillover effects from firms like Skype. The need to create and develop several additional major players in the ICT field is considered to be a critical success factor for future economic competitiveness.

Specific knowledge and know-how in the ICT field in Estonia can be found in hardware development, embedded systems, signal processing and bio-informatics, but also classical computer sciences, computer and integrated electronic systems, user interfaces and security systems (e.g. the NATO Cyber Security Centre established in Estonia). The most efficient sub-sectors in turning R&D investments into the IT-related innovations are considered to be telecom and media, financial services, private healthcare as well as the public sector in Estonia, which continues to be the major customer e.g. in healthcare, legal services, state register development.

So far, information policy related activities in Estonia have mainly been focused on the development of ICT infrastructure and the creation of systems necessary to implementing sectoral policies. However, in future, more emphasis needs to be put on the development of citizen-centres and inclusive society and a knowledge-based as well as transparent public administration. Cross-border initiatives in ICT were emphasised by the Ministry of Economic Affairs and Communications to be opportunities for Estonia’s public sector as well as for businesses.

In terms of future developments, the process and results of information technology foresight EST_IT@2018 (initiated by the Estonian Development Fund) has received a positive feedback from diverse stakeholders. The results are used
by the Estonian Association of Information Technology and Telecommunications as well as assessed highly by the Ministry of Economic Affairs and Communications, in particular, through a follow-up of the foresight, in the form of working groups developing six field-specific roadmaps (financial services, health and well-being, education, logistics, energy, ICT security systems) or the IT-Academy established by major higher-education and related institutions in Estonia. Indeed, future growth of R&D intensive ICT in Estonia will be highly dependent on continuing to train and attract skilled ICT professionals, and human resources is a major potential bottleneck in the system.
2 BERD performance in Estonia

**Trends in R&D Intensity**

Between 2000 and 2006, gross expenditure on R&D (GERD) in Estonia has risen markedly by 211\%\(^1\) albeit from very low levels. Despite a rapid increase in GERD intensity (GERD as a percentage of GDP grew at an annual average rate of 11.1\%\(^2\) during the same period), Estonia’s R&D intensity had reached only 1.14\%\(^2\) in 2006\(^2\) compared to the EU27 average of 1.84\%. Prior to the economic crisis in mid-2008, the rate of growth of GERD was tending to increase and to outstrip the rate of growth of GDP. The average annual growth rate of GDP was 11.9\% during the period 2000-2004 and 17.5\% during 2004-2006, while GERD grew by 22.2\% and 35.1\% in the respective periods.

The top 10 industries performing R&D from 2001 to 2005 in Estonia accounted for 82\% of total BERD, of which Computer and related activities (72), Pharmaceuticals (2423), Financial intermediation (65 to 67), and Petroleum (23) explain only 39\% of it. Figure 1 shows the structure of BERD for Estonia as an average between 2001-2005. More recently, in 2007 the picture has slightly changed, *Computer and related activities composing 28\% of total BERD, Pharmaceuticals 11\%, Storage and Communication 10\% and Electrical and Optical Instruments 8\% as four main stakeholders in business R&D in Estonia (57\% in total)*\(^3\).

Figure 1. Structure of BERD 2001-2005

Source: SPRU, NIFU STEP

---

1 DG RTD 2009  
2 Ibid.  
Figure 2 shows the evolution of BERD for the top 10 industries in Estonia from the three year prior to 2001 and four years from 2001. Figure 3 shows the top 5 winners and top 5 losers in the share for BERD between the two time periods. The three top winners are financial intermediation (65 to 67), Radio, TV and communication equipment (32), and Computer and related activities (72); and the top three losers are other business services (74), motor vehicles (34), and Transport, storage and communications (60 to 64).

**Figure 2. Trends in the shares for BERD in Estonia, 1998-2005**

**Figure 3. Winners and losers in the shares for BERD in Estonia, 1998-2005**

Source: SPRU, NIFU STEP
Annex 1 gives the sectoral R&D intensity for the top 10 industries as well as showing the top 5 industries and bottom five industries in terms of their dynamics, irrespective of there sectoral contribution to total BERD, over the two periods. Coke, and refined petrol production (23) made the greatest gains to become the industry with the highest R&D intensity. Instruments, watches and clocks (33), and computer and related activities (74) were the other big winners.

Not surprisingly given the relative scale of the economy, no Estonian based companies made it into the 2008 EU Industrial R&D Investment Scoreboard. The Estonian-based ICT companies gave only 0.04% of total BERD of the EU ICT sector in 2004. However, it is common knowledge that, as in most Member States, a few companies are responsible for a significant share of Estonian BERD. In particular, Skype which according to a 2009 statement by the President of the Republic of Estonia “accounts for around half of the private sector research and development money spent in the country”.

Considering the specific pattern of BERD in Estonia in more depth, 50% of total BERD is accounted for by 10 companies (and some 80% by 45 companies). If computer and related activities are looked at separately, a single company contributes 50% and four companies account for 80% of BERD. Regarding the electrical and optical equipment sector, two companies generate 50% of total R&D expenditures (and eight companies account for 80%). In general, the Estonian ICT market is dominated by 100 main business players (compare with around 3000 active businesses in the ICT sector in Estonia).

Trends in Value-added by Sector

On average, total value added generated by services increased slightly from 66.9% total value added from 1998 to 2000 to 67.8% from 2001 to 2005. The

___

4 There are no obvious losers in Estonia, but it should be kept in mind, that R&D statistics were not collected from firms in industries (source: SPRU, NIFU STEP).
7 Skype is an internet telephony service (Voice over Internet Protocol, or VoIP) that has more than 30 million daily users worldwide. Skype was created by the Swede Niklas Zennstrom and Dane Janus Friis, backed by a team of four Estonian software engineers. In 2009, more than half of Skype’s global workforce is located in the Estonian capital. Skype Technologies S.A. (Luxembourg registered) was bought by Ebay (NASDAQ quoted) in 2005 for $2.6 billion. According to the Ebay Annual Report 2008: “Skype had a terrific 2008. Revenue of $551 million was up 44 percent, and registered users reached 405 million, up 47 percent from the prior year”. In September 2009, Ebay divested in Skype, despite this strong performance, to an investor group led by private equity firm Silver Lake Partners. Other investors include VC firms Andreessen Horowitz and Index Ventures (a previous investor in Skype), as well as the Canada Pension Plan (CPP) Investment Board. The new investors bought approximately 65% of Skype, with eBay continuing to own 35%, in a deal valuing Skype at $2.75 billion US.
8 Compared to 2007, it is clear that the role of Skype has increased in the last two years.
10 Interview with the Statistical Office of Estonia, 16 September 2009.
The share of BERD in services is high in Estonia, but it decreased from 56.6% to 50.5% over the two periods, while the share of BERD in manufacturing increased from 41.6% to 44.1% over the two periods. Average BERD intensity, measured as BERD over value added, increased from 0.15% in the first period to 0.34% in the second period. BERD intensity was about 3 times higher in manufacturing than in services\textsuperscript{12}. Figure 4 shows the evolution of value-added for the top 10 industries. While these industries make up 82% of total BERD from 2001 to 2005, on average, they made somewhat more than 26% of value added.

Figure 4. Trends in the shares of Value-added in Estonia: 1995-2005

Annex 2 shows total BERD as a percentage of total value added, or BERD intensity. If R&D intensity is a reasonable measure of the progress toward the 2% target for BERD envisaged by the Barcelona objectives, Estonia has shown considerable progress in moving toward the target, but it still has a long way to go. Annex 2 also illustrates the relationship between the change in BERD intensity (X axis) and the change in the share of BERD (Y axis). The figure contains four quadrants: (1) the upper right hand indicates increasing BERD intensity and share of BERD; (2) the lower right hand quadrant indicates increasing BERD intensity and decreasing share of BERD; (3) the upper left hand quadrant indicates decreasing BERD intensity and increasing share of BERD; and (4) the lower left indicates decreasing BERD intensity and decreasing share of BERD. The least dynamic industries will appear within the large cluster in the centre of the

\textsuperscript{12} It should be noted that BERD was obtained from the Eurostat industrial database, and therefore based on the main activity of the firm, and value added was obtained from the EU KLEMS database. The R&D statistics have some problems. Data were not collected for all industries during the first period and the industrial disaggregate added up to just over 100% in the second period.
scatter diagram. The upper right-hand quadrant contains clear winners and the lower left-hand quadrant contains clear losers. There are many winners in the Estonian economy and very few losers. The three most notable winners are Radio, TV and communication equipment (32), Instruments, watches and clocks (33), and computer and related activities (72). Other business services (74) is a notable loser from the point of view of a declining share in BERD.
3 Drivers of BERD intensity

The present performance of the sector

The ICT sector in Estonia has developed significantly during last decade. In terms of the relative importance of specific sub-sectors in the ICT market in Estonia: telecommunications accounted for 50%, computer services 17% and hardware 33% in 2006\textsuperscript{13}. The ICT sector sales, net profit and a number of employees accounted for 4-5% of Estonia’s economy\textsuperscript{14}.

Within the sector itself, the highest share of value added (58% of total) originates from telecommunications, after which computer services and manufacture of electronic and communication equipment followed by 17% and 15%. The productivity per employee in telecommunication services (€90,499) exceeds the Estonian average level four fold\textsuperscript{15}. Telecommunication services has undergone a rapid and vigorous development. However, the potential for increasing the number of users in Estonia is now exhausted and the prevailing trend is that the profit margins for telecommunications are falling. This in turn forces the sector to look for extra services (M-parking etc.) and move to other markets (cable TV etc.).

In terms of innovativeness, according to Community Innovation Survey (CISIV, 2004–2006), the Estonian ICT sector outperforms other sectors. The share of innovative enterprises in the ICT sector is 74%\textsuperscript{16} compared to an average for the business sector of 48% (2006 data). Computer service companies have shown some decline in innovativeness compared to the period of 2002-2004 but remain ranked amongst the most innovative sectors (innovative enterprises 66.3%). Innovation dynamics among the telecommunication sphere showed some decline between 2002-2004 but increased to 78% in 2006. Generally, the sector exhibits relatively intense innovative activities.

As for the ratio of innovation expenditures to net sales turnover by innovative enterprises, expenses both in case of industry and services amount to 2%, including 1.3% spent on R&D activities and the remainder on the purchase of equipment. According to interviewees, the R&D activities of most Estonian ICT firms largely consist of development work with a minimum share of research\textsuperscript{17}. Hence, the structure of innovative activities reflects the performance of ICT businesses towards more operational and short-term innovative actions than running longer-term research projects.

The main obstacles to undertaking innovative activities for the Estonian ICT sector is the shortage of qualified staff (especially acute in the ICT industry), for around 10 years and, considering the population statistics and market development, it as well as the limited cooperation of firms with research institutions will become the primary limiting factors of development in the nearing years\textsuperscript{18}. The same problem will also increasingly haunt the sectors of economy using IT solutions. In the case of telecom firms, the domination of a few large

\textsuperscript{13} Association of Information Technology and Telecommunications, 2006.
\textsuperscript{14} EST_IT@2018. Eestit infotehnoloogia tulevikuvaated. Estonian Development Fund. – Eesti fookuses, No 2/2009.
\textsuperscript{15} EST_IT@2018. Eestit infotehnoloogia tulevikuvaated. Estonian Development Fund. – Eesti fookuses, No 2/2009.
\textsuperscript{17} Innovation in Estonian Enterprises. – Innovation Studies, No. 7/2007.
\textsuperscript{18} Innovation in Estonian Enterprises. – Innovation Studies, No. 7/2007.
enterprises, which have established themselves in the market, can be considered as a barrier to entry of smaller more innovative firms.

At present the ICT sector is faced by a situation, where the domestic market limits further developments. The majority of the Estonian ICT sector activities are directed to the domestic market (particularly in telecommunications). From another perspective the domestic market may have not be using all opportunities accompanying ICT business in Estonia. The ICT market is fragmented (in terms of non-concurrency of demand and supply side of business) and diversified (from the large SMEs like Webmedia, Skype Technologies Ltd, Regio to micro- and one-person companies). Representatives of the sector points to its low profitability, the shortage of qualified employees and relatively modest export share.

The average share of high-tech products in total Estonians export was 9.6% in the period 2000-2005 (14.8% in 2005, Eurostat). In absolute numbers, the export volume reached €638m in high-tech sector (incl. IT, telecom, electronics, research equipment, pharmaceuticals, military, etc) in 2005. Of this total, 80% originated from electronics, IT and telecom products19.

Out of the IT sector turnover the share of export is approximately 10%20, with a large share being software developers’ subcontracts to neighbouring countries. At the same time the influence of Estonian IT firms on foreign markets is significantly higher than revealed by the turnover figures, Skype and Playtech are the best-known examples, but not the only ones21. The Ministry of Economic Affairs and Communications foresees the situation improving, in general, as even smaller companies have more seriously started to look abroad.

**The main forces determining the sector development**

*National level*

At national level the macroeconomic stability of Estonia has been until recently one of the main drivers of economy. Although, due to its smallness it may not be always sufficient to sustain growth and the relative openness of the economy makes it susceptible to the influence of global shocks. From another point of view the size of country may be considered an advantage, particularly in high-tech fields as well as enabling the public sector to react more rapidly to new technological challenges. Indeed, interviewees, such as the Ministry of Economic Affairs and Communications22, underlined that the smallness of Estonia creates favourable conditions for rolling out large-scale public projects, for instance in e-health23.

The location of Estonia close to world technology leaders (Finland, Sweden) is an additional advantage for future technology development and offers additional opportunities for Estonian companies, and vice versa facilitates the establishment of subsidiaries of Nordic companies in Estonia. However, geographical closeness to countries close to the technology frontier alone cannot be a basis for a national strategy. Attracting more strategic business activities (besides sub-contracting of production) is only made possible by the existence of specialist knowledge and skills in Estonia (both in the business sector and academia). Hence, the Nordic aspect was not overestimated by ICT sector representatives, since it is the wider

---

22 Interview with Ministry of Economic Affairs and Communications, Department of State Information Systems, 29 September 2009.
23 See more at http://www.e-tervis.ee/
global demand and opportunities of the ICT sector which remain the main influence.

Estonia needs to pay much more attention to developing knowledge-intensive and high-productivity services oriented towards external markets. Estonia’s industrial structure has clearly a significant influence on the potential for further ICT development, since currently it by no means resembles a contemporary knowledge-based economy. Rather, it is composed of activities based on availability of cheap labour and services (for instance, programming service provided by computer service companies). It is imperative to change the structure of industry towards an increasing relative importance of sub-branches with higher productivity (for example, production of precision instruments, medical equipment, sophisticated electronics components and equipment). The importance of knowledge-intensive services in the economy needs to increase as well.

The shortage of qualified labour was mentioned to be and will become even more the major obstructing factor of ICT development in Estonia. The existence and availability of human resources, i.e. high-skilled and educated people, is a key input for innovation. In overall terms, Estonia is characterised by high educational attainment. The rate of Estonia’s tertiary graduates (in science, engineering, social sciences and humanities) equals the EU mean but it falls behind in the rate of doctoral graduates. The graduates are in demand and relevant for service activities and in developing non-technological innovations. Estonia’s higher educational potential contrasts however with a lag in lifelong learning rates.

The public sector in Estonia has played a strong leadership role in the development of the ICT field since the re-establishment of independence in 1991. Since 2000, ICT expenditures (for operating systems, investments in software and infrastructure) on average has accounted for 1% of annual state budget. An innovative mindset in the public sector and the choice of high-quality IT solutions (service-oriented approach to the development of state information systems and a secure data exchange layer called X-Road; citizen portal at www.eesti.ee, where authorised users can log-in as citizens, entrepreneurs or civil servants) as well as ID-card infrastructure and solutions (digital signature, public transportation functions, e-ticket, e-elections) are explanatory factors for positive trends in Estonia’s ICT sector. Wide use of ICT in education (dissemination of the Internet in secondary-schools, increasing ICT skills among teachers), advanced communications network and good Internet availability add extra value to the public role in ICT developments. Also, high willingness of Estonians to use innovative solutions (e-Tax Office, Internet banking, M-parking) has influenced the diffusion of ICT. From a negative point of view, as the state has also been a significant purchaser of ICT services in Estonia, companies with certain narrow specialisation in the sector may have become too dependent on public procurement, which has limited their willingness to find clients from abroad (although this is not the case for companies like Skype, Regio, Webmedia or Cybernetica).

The E-Health project can be presented as a good practice of public intervention.

28 Rannala, R. An Electronic Health Record for every citizen: a global first. Estonia. By Technopolis Group for the study for DG REGIO of the European
linked to the ICT sector level and which has significantly gained from the well-developed IT infrastructure and improved the sector collaboration in Estonia. Below critical success factors of the project are illustrated.

**AN ELECTRONIC HEALTH RECORD (EHR) FOR EVERY CITIZEN: A GLOBAL FIRST**

1. The effective application of the e-health service has been achieved by using the highest possible security level for storing the health records in the nationwide IT system, and enabling access at any time from any location in the country. To achieve that, the importance of close cooperation and mutual trust between the counterparts should be stressed, and wide discussion in society encouraged.

2. It is of great importance that Estonia has developed and maintains a public e-services infrastructure (X-road, ID-Card, digital signing certification system)

3. The active political leadership of the Ministry of Social Affairs gives ongoing political support for elaboration of the sufficient legislative framework; the Ministry also actively interacts with the partners, as well as establishing consultation groups or bodies (e.g. the Council for Electronic Health Record project).

4. The visibility of the E-Health progress creates a positive impact on the partnership and policy-making institutions: open discussions and pro-active public relations policy led by the Ministry and the E-Health Foundation have created trust as we as attracting new partners from health care sector service providers, educational institutions (e.g. Tartu University), and public authorities (e.g. Estonian register of Causes of death).

**Sector level**

Looking at the pattern of sectoral specialisation, the specific knowledge in hardware development, embedded systems, signal processing and bioinformatics, but also classical computer sciences, computer and integrated electronic systems, user interfaces and security systems29 (for example, the NATO Cyber Security Centre established in Estonia) are considered as advantages of the Estonian ICT sector in international comparison. This in turn reflects Estonia’s educational advantages in certain fields.

In the private sector, an advanced level of application of information technology, especially in Internet banking and mobile applications, can be considered as drivers in the ICT field. The role of Skype but also Playtech (and others) in Estonia should not be under-estimated as they have encouraged the development of the sector as a whole, particularly in terms of attracting and training people in their technology field and the competition. The Estonian ICT community has gained from the experience of developing large peer-to-peer networks30.

According to interviewees, Skype in turn has attracted extra investments into Estonia in the ICT and related fields. However, the absence of major players in other related industrial or service sectors may impede the potential influence of Skype to a significant extent. Also, in terms of perspective, the need should be emphasised for several major players in the ICT and related sectors. Based on interviews, for instance, the recent decision of Google not to invest in a server centre in Estonia but in Finland instead is considered as a missed opportunity to boost the IT cluster in Estonia.


Considering firm-specific factors representatives of the sector do not consider that changes in the scale of companies in the sector have significantly influenced R&D investment trends in Estonia since 2000. Even in Estonia (where most companies are small by EU standards), the size of a company does influence decisions to invest in R&D (larger companies or subsidiaries of multinationals have advantages in recruiting people or securing finance R&D or to collaborate with other partners). However, the capacity to investment into R&D or other fields is more dependent on the growth of market share and the possibility to enter new markets than other factors (e.g. WebMedia, Regio). Growth of leading Estonian ICT companies has been essentially determined by new market opportunities. For instance, Regio exports its products and services not only to the EU but also to Saudi Arabia, United Arab Emirates or India while Skype is now part of a worldwide group, operating in eight countries; Webmedia has expanded development centres into several European countries.

According to the opinion of the Association of Information Technology and Telecommunications in Estonia, the most efficient sub-sectors in turning R&D investments into the IT-related innovations are considered to be telecom and media, financial services, private healthcare as well as the public sector in Estonia, which continues to be the major customer e.g. in healthcare, legal services, state register development.

There is a positive trend amongst Estonian companies (even among small and micro firms) towards a “global approach” to access foreign markets and not to limit themselves to satisfying domestic demand. The experience abroad, in turn, adds value to the companies' knowledge management practices. Increasing global competition as well as 'visionary' view of companies in the field are considered to be drivers in the sector. Estonian companies have shown relatively good capacity to develop completely new services and products in short time (e.g. e-public services, e-sales and gambling, e-social network platforms).

The need for cooperation, between businesses or businesses and research partners has extensively risen during last five years. Although there is no visible consolidation between companies in ‘normal’ business terms in Estonia, technology competence centres\(^{31}\) have proved to be suitable vehicles to carry out joint R&D. The centres help companies to access complementary technologies, equipment and human resources, but also to better understand customer demand. There are eight competence centres established via the Competence Centre Programme in Estonia (the first five from 2004-2005, the rest from 2009), out of which two operate in the ICT field. The profile of each individual competence centre differs but in principle they support joint R&D between business and academia on the basis of multi-annual strategic plans with an emphasis on applied research\(^ {32}\). In response to the second call in 2009, Skype Technologies, WebMedia, Cybernetica, Delfi, Regio and Swedbank created the Software Technology and Applications Competence Centre (STACC). Around 25-30 ICT companies are associated with the programme and most of them have a leading role in the sector. Hence, the IT-oriented centres are expected to influence the sector performance in general. According to the interviewees from Skype and Webmedia, and supported by the general opinion of the association, the main driver to consolidate business and public efforts in the form of competence centres is a joint operational structure for the commercialisation of research.

*Company level*

\(^{31}\) See http://www.eas.ee

\(^{32}\) See also mid-term evaluation of the Competence Centre Programme at http://www.mkm.ee/index.php?id=345246
As has been already mentioned, there are a number of major players (best-known internationally is Skype\footnote{See ch.2, reference 6.}) in the sector. Another example, studied in this case, is WebMedia\footnote{See http://www.webmedia.ee}, founded in 2000, and which has been the fastest growing software development company in the Baltic States ever since. Today, Webmedia is one of the largest software development companies in the Baltics, currently employing close to 300 people in software development with front offices and development in Estonia, Lithuania and Denmark, and additional development centres in Romania and Serbia. The international activities were started in 2004.

It specialises in high-end software development, employing hand-picked specialists and training them on a constant basis to sustain the quality and competence levels. The company is focusing on four vertical areas in terms of customers: telecom, finance, health-care and public administration and government.

The company strategy is to build up a network of companies in Europe that support the near-shoring development process and utilise the flexibility in resource usage and the ability to adjust quickly to market movements. It is utilising different business models for different countries including subsidiaries, joint ventures and strategic partnerships with leading local companies.

The CEO of Webmedia Estonia considers that certain foreign investments, like Skype, increased government funding on R&D, public procurements and global competition have been the important drivers of the ICT field during last decade. Moreover, European funding of certain programmes, like establishing competence centres, has had a useful influence in developing business-research partnerships. The CEO of Skype also outlined some long-term drivers like the impact of energy-consumption to the ICT infrastructure and costs of services, and development of the global value chain.

Although the general effects of the Competence Centre programme on the business sector may remain modest due to limited participation of companies, a number of major players (at least in ICT field) are involved, which allows higher expectations for the programme than a single company could foresee. Webmedia and Skype are both partner companies in the STACC and have joined the centre to obtain and share access to complementary technologies, equipment and human resource. A very important factor is the opportunity to create closer customer relations and involve customers in product development. In general, the centre is expected to facilitate a more rapid commercialisation of R&D.

Aside from the competence centre collaborations, both interviewed companies outsource R&D to other organisations. For WebMedia, these services currently account for ca 2% of total R&D expenditures of the company, while for Skype about 50%. Such a significant difference is explained by the different products and services, degree of specialisation, and the individual business strategies on IP, product development, marketing, etc. in the two companies. Additionally, the R&D contractors are also different. In the case of Webmedia, the services are mostly provided by the University of Tartu or other domestic or foreign universities, and in case of Skype, by other R&D-oriented ICT companies. Skype finds other R&D firms as service providers to be more flexible compared to universities, and IP agreements are easier to manage at business-to-business level.

WebMedia explained further that the external R&D decisions are usually made for certain specific or one-time services, for which the company does not have a
permanent need. The reason for certain outsourcing is often related to limited access to specific human resource or certain equipment. The CEO of WebMedia was of the opinion that limited availability of human resource and access to specific and expensive research infrastructure drives outsourcing in many other companies (particularly for micro companies or highly specialised companies).

Considering the role of framework conditions, the companies found the existing technical infrastructure, legal frameworks on IP and standardisation and regulative role of the authorities sufficient. The educational infrastructure and curricula of ICT and science specialities in the University of Tartu and Tallinn Technical University in general are considered to be at least of a satisfactory level, providing universal academic knowledge ground with good potential for further specialisation in master programmes and in professional life.

A more urgent issue, concerning human resource development, mentioned by the companies is related to shortage and specialisation of available specialists. As the local human resources are limited, WebMedia has a continuous need to undertake specialist search externally. Even if a right person is identified, the relatively high social and unemployment taxes (near to 40% of the net salary) and strict immigration rules for certain foreigners restrain hiring specialists from abroad. Skype added, that in some cases, due to the size limits of the Estonian labour market, they also need to hire people from abroad because of rotation, people just need some changes and new challenges, etc. Skype is using extensively different work organisation, including distance work, web-meetings etc, but it depends more on in-house development teams, i.e. physical presence of people. The direct collaboration creates the necessary “spirit” for an effective knowledge exchange and creative ideas. So, even traditional work organisation is far more expensive than the distance work, it is necessary expenditure for a technology leader.

Skype did not place the same emphasis on social taxes as a specific single constraint for hiring people, but focused more on a general framework for creation of so-called “smart” jobs. Obviously, liberal taxation system is a part of that.

Business representatives consider that promoting the establishment of new indigenous R&D-performing firms as well as stimulating existing ones in the ICT sector is crucial due to the need for structural changes in the economy. However, the CEO of Skype was sceptical about too great an intervention of the state in business processes, i.e. not counting too much on various measures. For instance, the policy support measures should be as feasible and minimal as possible, and only to boost certain activities, collaborations, etc, not to “subsidise” companies on a regular basis.

The CEO of WebMedia considered in respect of the support instruments, that the public programmes are necessary not only to raise R&D capacities but also to improve marketing, sales, export, international collaboration of Estonian companies. At the same time, attracting R&D performing firms from abroad should be given greater attention by the Government. Webmedia would encourage the EU and the Member States to remove the barriers to free movement of personnel and services across the EU states, still observed by the company. For instance, public procurement conditions in Sweden and Finland are considered by WebMedia as discriminatory against the participation of foreign companies.
4 The role of public policies in determining BERD performance and BERD intensities in the ICT sector

The Estonian Government’s commitment to increasing the innovation intensity of the economy has been constant since 2002 and the adoption of the first Knowledge Based Estonia Strategy. Public funds for R&D have been rising although in relative terms they remain below the EU27 average. The public investment in R&D in the ICT field is relatively minor.

The main emphasis of Estonian policies has been to raise the R&D intensity of existing national R&D performing firms. Although there is some emphasis on high tech start-ups (via the Estonian Development Fund, Enterprise Estonia and KredEx), the scale of operations of most of the more recent ‘research-intensive’ start-ups (bio-medical, software, etc.) remains small implying a relatively limited impact on both BERD and value added (and other macro-economic indicators).

Estonia has made considerable progress towards the information society (see section 3). Estonia’s achievements in developing the information society have been recognised in various EU and international surveys, such as the European Commission’s Information Society Benchmarking Report 2005, Global Information Technology Reports (published by the World Economic Forum), Top 10 Who are Changing the World of Internet and Politics (compiled by the global eDemocracy Forum). This success has been based on the implementation of priorities set out in the Principles of Estonian Information Policy, adopted by the Estonian Parliament in 1998 (and an update of the document in 2004).

The Estonian Information Society Strategy 2013 (entered into force in January 2004 and updated in 2009) is a sectoral development plan, setting out the general framework, objectives and respective action fields for the broad employment of ICT in the development of knowledge-based economy and society. So far, information policy related activities in Estonia have mainly been focused on the development of ICT infrastructure and the creation of systems necessary for implementing sectoral policies. However, in order to increase the competitiveness of the society, more emphasis needs to be placed on the development of citizen-centred and inclusive society, knowledge based economy as well as transparent and efficiently functioning public administration. According to interviewees, the state should continue implementing large-scale investments to opening additional opportunities for private sector entities, elaborating new

---

36 Eurostat.
37 In 2005-2006 the ICT sector business investments to R&D were accordingly 15 and 20 million euro. The Ministry of Education and Research and Enterprise Estonia as largest public supporting institutions invested into ICT R&D €1.6m in 2005 and €2.2m in 2006. Needless to say, the Estonian ICT BERD, while important nationally, forms a minor part of the total EU ICT R&D investments (in 2003-2006 approx. €25b annually by member states and business sector together).
38 See http://www.arengufond.ee
39 See http://www.kredex.ee
dimensions for e-service as well as developing ICT market through public procurement.

At programme level, information and communication technologies is presented as a priority policy area for Estonia in the Knowledge Based Estonia Strategy. The R&D programme specifically for the ICT sector has not yet been developed by the Ministry of Education and Research but it is expected to be implemented during current programming period of the strategy (until 2013). The launch of such a programme is considered to be useful (by the Ministry of Economic Affairs and Communications) particularly for integrating individual public actions (including state information systems) in the ICT field and dissemination and implementing ICT in other sectors of economy (e.g. in traditional industry, energy sector, transport, etc.) as well as socio-economic fields (health care, life environment, etc.). Some important steps towards the ICT R&D programme have been taken, for instance, the launching of an ICT foresight by the Estonian Development Fund or the elaboration of a development plan for the ICT sector by the Estonian Association of Information Technology and Telecommunications.

Since 2008 the Estonian Development Fund has undertaken the information technology foresight EST_IT@2018\(^{42}\), the aim of which is to clarify in which areas can ICT contribute the most to economic growth and social development over the next 10 years. The experts that participated in the EST_IT@2018 consider that emphasis in the future should be more on an increase in the capability to apply new technologies, and to a lesser extent to modify and develop them further. The future comparative advantage of Estonia in ICT will depend on the capability to combine foreign technology areas with own business processes and to increase export share significantly.

The service sector has an important untapped growth potential, in particular, the successful implementation of ICT in the knowledge capacity in service areas, such as financial services, health and well-being, education, logistics, energy, ICT security systems (e.g. ID card) etc.

Critical success factors of the ICT sector identified through a web-based questionnaire are as follows\(^{43}\):
- to increase R&D quality of ICT in universities
- to increase technology interest of pupils and attract them to ICT field
- to improve the quality of ICT education incl. part-time study abroad
- to strengthen ICT technology and product development in businesses
- more extensive application of ICT solutions in Estonia to overcome the digital divide
- better coordination of state ICT governance incl. better management of investments by different public services
- to improve access to venture capital for new technology based firms (NTBFs);
- to support export performance of ICT businesses;

The recommendations presented as a result of the foresight include:
1. To increase the quality of higher education in ICT to international level (e.g. IT-Academy).
2. To strengthen international business management of ICT businesses.
3. To develop roadmaps for ICT systematic application in focus areas (education, health care, industry, energy, finance services, ICT security).

\(^{42}\) [http://www.arengufond.ee/foresight/estit2018/]
The objective of the development plan for the ICT sector (compiled in 2009) is to give directions (primarily) to the sector itself and to its support structures for the next five years. The development defines focus areas for investment and competences to be developed. The conclusions of the ICT foresight report carried contributed considerably to the elaboration of the development plan. In addition, outputs of the strategy will be used as an input for new projects in the framework of a recently launched cluster development programme by Enterprise Estonia.

A good practice in Estonia has been the establishment of competence centres (as mentioned previously one being in the ICT sector) in 2004-2005 which has fostered longer term programme-based R&D and innovation planning jointly by business and academia (please see also section 3). The centres were created as private entities on a basis of a three-year research programme. The programme tackle low research and innovation capabilities and encourages Estonian industry to become technologically more competitive.

The financing of the competence centres by Enterprise Estonia was not as stable as expected by during the first years of programme. However, in June 2009, €83m in additional funds were made available by Enterprise Estonia to invest in eight competence centres (the five original and three new centres) until 2013. From this, €57m is EU Structural Fund support while the rest will come from participating enterprises (totalling some 100) and universities. Two of the centres are active in foodstuffs, two in medicine, two in ICT and electronics and one in nanotechnology.

The findings of the mid-term evaluation confirm that competence centres focus on pre-defined research problems in specific fields of technology. The centres have extended the quantity, quality and time horizon of the innovative activities of nationally important consortia, while focusing research and education activity on areas of national need (thereby also increasing the number of PhD students). The main area of weakness is internationalisation and integration with the international community. Learning about the difficulties in launching these sophisticated types of entities may be useful for policy makers in other transition countries.

Finally, the Ministry of Economic Affairs and Communications finds the participation rate of Estonian public sector institutions and businesses in ICT projects funded under the EU’s Competitiveness and Innovation Programme (CIP) too modest so far. Out of 400 successful partner organisations of the first call eight of them were of Estonian origin taking part altogether in nine proposals, though not as a co-ordinator in any of them.

For comparison, in the Sixth Framework Programme (FP6) 54 partners (incl. both companies, R&D and high education institutions, others) from the ICT field were involved during the whole programming period from Estonia. Mostly, larger SMEs or large companies from Estonia are capable to participate in such-type of projects, for instance, Regio, which is presently involved as one partner company in the FP7 project “Integrated mobile security kit” with total project funding €14.86m.

44 See more at http://www.itl.ee
45 Mid-Term Evaluation of the Competence Centre Programme (2008), Erik Arnold, Berghold Bayer, Sten Ljungström, Katrin Männik, Ruta Rannala, Alasdair Reid. See: http://www.mkm.ee/index.php?id=322932#analysis
47 Archimedes Foundation
48 http://cordis.europa.eu
Lessons learned, case uniqueness and success factors

The uniqueness of the Estonian ICT sector lies on a combination of several success factors played a role since the beginning of 1990s. The leadership role of public sector in the ICT field has to be mentioned first, as encouraging the sector development and BERD, more specifically. An innovative mindset in the public sector and the choice of high-quality IT solutions as well as ID-card infrastructure and solutions are explanatory factors for positive trends in Estonia’s ICT sector. Wide use of ICT in education, advanced communications network and good Internet availability add extra value to the public role in ICT developments. In the future, from the government view, more emphasis needs to be put on the development of citizen-centres and inclusive society and a knowledge-based as well as transparent public administration.

In the private sector, an advanced level of application of information technology, especially in Internet banking and mobile applications, can be considered as another dominant driver in the ICT field in Estonia. The ICT sector has also gained significantly from the experience of developing large peer-to-peer networks. The performance of internationally well-known players like Skype or Playtech in Estonia is found to attract extra investments into the field and related ones. Considering the expected future trends, the absence of major player(s) in other related industrial or service sectors may limit the potential influence of Skype-type companies to a significant extent.

There is a positive trend amongst Estonian companies towards a “global approach” to access foreign markets and not to limit themselves to satisfying domestic demand. Increasing global competition as well as ‘visionary” view of companies in the field is considered to be drivers in the sector. The capacity to invest into R&D or other fields is mostly dependent on the growth of market share and the possibility to enter new markets than other factors. The availability of specialists is becoming a determining factor in scale and scope of expanding activities to abroad.

Attracting new major players to Estonia as well as creating opportunities to grow for present ones, Estonia needs to pay much more attention to developing knowledge-intensive and high-productivity services oriented towards external markets. Estonia’s industrial structure has clearly a significant influence on the potential further ICT development. The service sector has an important untapped growth potential, in particular, the successful implementation of ICT in the knowledge capacity in service areas, such as financial services, health and well-being, education, logistics, energy, ICT security systems as figured out through the information technology foresight EST_IT@2018.

Business representatives find that promoting the establishment of new indigenous R&D-performing firms as well as stimulating existing ones in the ICT sector is crucial due to the need for structural changes in the economy. The policy activities in stimulating cooperation between businesses or businesses and the academia (such as competence centres) are most expected public initiatives by business stakeholders involved in the study. Through competence centres they appreciate the opportunity to get and share access to complementary technologies, equipment and human resource as well as to create closer customer relations. From the government side, the internationalisation aspect of existing centres has to be focused on more systematically than experienced so far.
CONTACT DETAILS

Interviewees:
Marek Tiits
Estonian Development Fund
http://www.arengufond.ee
Tornimäe 5, Tallinn 10145
Phone: +372 616 1100
E-mail: info@arengufond.ee

Aavo Heinlo
Statistics Estonia
http://www.stat.ee
Endla 15, Tallinn 15174
Phone: +372 625 9217
E-mail: aavo.heinlo@stat.ee

Margus Püüa
Ministry of Economic Affairs and Communications
http://www.mkm.ee
Harju11, Tallinn 15072
Phone: +372 6397640
E-mail: margus.puua@mkm.ee

Taavi Kotka
The Estonian Association of Information Technology and Telecommunications/Webmedia
http://www.webmedia.ee
Raatuse 20, Tartu 51009
Phone: +372 7 309 399
E-mail: taavi.kotka@webmedia.ee

Sten Tamkivi
Skype Technologies OÜ
http://www.skype.ee
Akadeemia tee 15b, Tallinn 12618
E-mail: sten.tamkivi@skype.net
References
Arengufond (2009) EST_IT@2018 Eesti Infotehnoloogia tulevikuvaated.


European Commission (2009), Key Figures of the European Research Area 2008-9


ANNEX 1

Sectoral R&D intensity in Estonia by industry, 1995-2006

Top 5 winners and losers in R&D intensity by industry, 1995-2006
ANNEX 2

Evolution of BERD intensity over time, 1998 to 2005

Correlation between the change in BERD intensity and the change in the share of BERD