

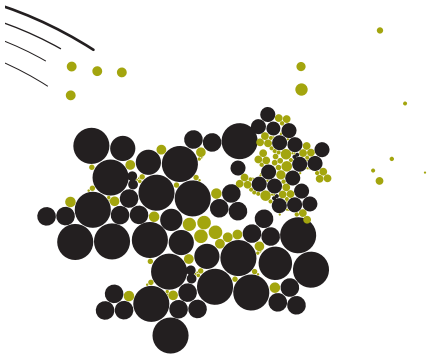
INAUGURAL LECTURE

27 OCTOBER 2011



UNDERSTANDING  
THE LONG-TERM  
IMPACTS OF THE  
EU FRAMEWORK  
PROGRAMME OF  
RESEARCH AND  
TECHNOLOGICAL  
DEVELOPMENT

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# UNDERSTANDING THE LONG-TERM IMPACTS OF THE EU FRAMEWORK PROGRAMME OF RESEARCH AND TECHNOLOGICAL DEVELOPMENT

INAUGURAL LECTURE GIVEN TO MARK THE ASSUMPTION  
OF THE POSITION AS PROFESSOR OF

INTERNATIONAL INNOVATION POLICY

IN THE SCHOOL OF MANAGEMENT AND GOVERNANCE  
OF THE UNIVERSITY OF TWENTE  
ON THURSDAY 27 OCTOBER 2011

BY

PROF. DR. ERIK ARNOLD

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## ABSTRACT

It is a commonplace observation in innovation and research policy that the 'linear model' of innovation is dead; even if it continues to influence policy thinking and practice. A more current perspective is to see innovation and research as parts of a complex 'national innovation system', in which innovation processes can start anywhere (not necessarily with R&D) and where new knowledge production contributes to the 'stock' of knowledge used in innovation. Recognising this and the increasing importance of networks in research and innovation, research and innovation policy interventions have become increasingly complex. The Framework Programme is a leading example. In principle, states play a role in research and innovation policy in order to combat market and systems failures. These interventions should increase the volume and quality of research and the rate of innovation generating knowledge and economic spillovers for the benefit of society. The Framework Programme has been an important instrument of EU policy through which the nascent European state has begun to modify and assume some of the developmental roles formerly tackled at the Member State level, ultimately with the aim of creating an innovation system optimised at the European rather than the national level. This has involved successive extensions to the role of the Framework Programme. While formally a single programme, the Framework is in fact a composite of many sub-programmes addressing different themes and their associated goals. It is nonetheless possible to generate a high-level description of its intervention logic and identify common long-term goals. Existing evaluation evidence tells us that the Framework Programme funds high-quality, pre-competitive R&D, mostly producing 'intermediate knowledge products' that can later be used in R&D and various kinds of networks as well as to increase competitiveness. To a considerable extent, its design reflects the needs and interests of important stakeholders and R&D communities in Europe. Its longer-term effects go beyond these, crucially including

setting agendas, creating road maps and coordinating the efforts of research communities. This can lead to the emergence of new fields and technological trajectories, restructuring of the European research effort, improvements in policymaking and increased competitiveness. This paper details the impact mechanisms through which this is achieved.

Future RTD policy at the European level will become more holistic, combining innovation and research policy to a greater degree, even if we do not see the kind of government-wide integrative governance mechanisms visible at national level. The role of coordination seems likely to become even more important, posing important problems of management and governance. Understanding the continuing and longer term impacts of EU policy at this level will require innovation in governance mechanisms and in newer kinds of evaluation tools that can take better account of governance and other longer-term mechanisms and effects.

## TABLE OF CONTENTS

<b>1. Introduction</b> . . . . .	<b>7</b>
<b>2. Perspectives on Research and Innovation</b> . . . . .	<b>8</b>
2.1 Innovation and the Role of Research . . . . .	8
2.2 From Innovation to 'Innovation System' . . . . .	12
<b>3. The Changing Role of the Emerging European State in R&amp;D</b> . . 14	
3.1 Why the state has a role . . . . .	14
3.2 The changing role of the European state in practice . . . . .	16
3.3 EU Research and Innovation Policy . . . . .	18
3.4 European Added Value (EAV) . . . . .	24
<b>4. Effects of the Framework Programme</b> . . . . .	<b>27</b>
4.1 Expected Effects of the Framework Programme . . . . .	27
4.2 What the existing evaluation record tells us . . . . .	28
4.3 Some lessons from looking at the long term . . . . .	31
<b>5. What Next?</b> . . . . .	<b>48</b>
5.1 Policy. . . . .	48
5.2 Evaluating and understanding the Framework Programme . 49	

## TABLE OF FIGURES

Figure 1 Modern 'Coupling' Model of Innovation . . . . .	10
Figure 2 A National Innovation System Heuristic . . . . .	13
Figure 3 Timing and Budgets of Framework Programmes and their Evaluations . . . . .	20
Figure 4 The Evolving Character of 'European Added Value'. . . . .	26
Figure 5 Expected impacts of the FPs . . . . .	29
Figure 6 Long term impacts of the Framework Programmes . . . . .	42
Figure 7 Impact Mechanisms in the Case Study Areas . . . . .	43

# UNDERSTANDING THE LONG-TERM IMPACTS OF THE EU FRAMEWORK PROGRAMME OF RESEARCH AND TECHNOLOGICAL DEVELOPMENT<sup>1</sup>

## 1. INTRODUCTION

The Framework Programme matters.

- It is the main policy instrument for supporting Research and Technological Development (RTD) at the level of the European Union
- It is probably the largest competitive R&D programme in the world, funding a significant volume of research and innovation and accounting for more than 5% of Europe's state expenditure on R&D
- It is emblematic of the radical changes in the way we perceive and perform R&D over the last three decades
- It plays a pivotal role in coordinating the direction of research and innovation on our continent

To understand the Framework Programme, we need an intellectual framework. In this lecture, therefore, I propose first to discuss the way our understanding of research and innovation has changed since the mid-Twentieth Century from an individualistic, heroic perspective (still highly visible in, for example, the work of the Nobel Foundation) to a more networked, systemic view (of which the Framework Programme is itself an instance). Second, I will relate this change of perspective to the level of overall research and innovation policy and our changing beliefs about the role and potential of the state in the production

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<sup>1</sup> Substantial parts of this lecture are based on Erik Arnold, Malin Carlberg, Flora Giaracca, Andrej Horvath, Zsuzsa Jávorka, Paula Kneev, Bea Mahieu, Ingeborg Meijer, Sabeen Sidiqi and James Stroyan, *Long-term Impacts of the Framework Programme*, Brussels: EC, DG-Research (forthcoming 2011)

of wealth from knowledge. Third, I will explore the history (and a little bit of the pre-history) of the Framework Programme. Fourth, I will illustrate some of the longer-term effects of the Framework Programme – some of which are surprising, given that most of the considerable evaluation literature about the Framework Programme focuses on short-term effects. Finally, I speculate a little about how to make progress in policy, our understanding of the Framework and its evaluation as the nature of the Framework continues to change.

## 2. PERSPECTIVES ON RESEARCH AND INNOVATION

It is a commonplace observation in innovation and research policy that the ‘linear model’ of innovation is dead; even if it continues to influence policy thinking and practice. A more current perspective is to see innovation and research as parts of a complex ‘national innovation system’, in which innovation processes can start anywhere (not necessarily with R&D) and where new knowledge production contributes to the ‘stock’ of knowledge used in innovation. Recognising this and the increasing importance of networks in research and innovation, research and innovation policy interventions have become increasingly complex. The Framework Programme is a leading example.

### 2.1 Innovation and the Role of Research

In relation to innovation, the predominant popular mental model – the so-called ‘linear model’ – suggests that basic science **leads to** applied science, which causes innovation and wealth. Almost all policymakers know that it is wrong – but it nonetheless has a strong influence on policy. Historical examples such as the development of thermodynamics – which was given an impetus by the development of the steam engine to explain why steam engines worked and only later provided a basis for improving their design – give a more useful sense of the interplay between basic research and innovation.

The linear model was more or less invented in response to the startling achievements of physics during the Second World War. The manifesto for the new view of science was Vannevar Bush's 1945 report<sup>2</sup> *Science: The Endless Frontier*, which successfully argued the case for a US National Science Foundation and paved the way for the massive expansion of higher education and research since the war. Bush argued that increasing science funding would automatically increase product and process innovation and therefore national competitiveness as well as military preparedness. With hindsight, we can see how easy it was to take the scientific achievements of the War out of context. They were not 'science push' but responded to clear military requirements and were therefore in a strong sense user-oriented, happening in command economies, where it is possible to force a direct connection between technological advance and economic production

During the 1950s, the science-push model of innovation dominated<sup>3</sup>. But thanks to the empirical work of those such as Carter and Williams<sup>4</sup>, Schmookler<sup>5</sup> and Myers and Marquis<sup>6</sup>, more emphasis came to be placed on the role of the marketplace in innovation. This led to market- or needs-pull models of the innovation process, which were also linear but reversed the direction of causality. During the 1960s and 1970s, a lot of innovation research focused on the importance of links between suppliers and users. By the late 1970s, Mowery and Rosenberg<sup>8</sup> largely settled the argument between push and pull by stressing the importance of coupling between science, technology and

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<sup>2</sup> *Science The Endless Frontier*, A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development, Washington DC: United States Government Printing Office, July 1945

<sup>3</sup> This account of successive generations of innovation model is partly based on Roy Rothwell, 'Successful Industrial Innovation: Critical Factors for the 1990s', *R&D Management*, 3, p 221-239, 1992

<sup>4</sup> Carter, C. and Williams, B., *Industry and Technical Progress*, Oxford University Press, 1957

<sup>5</sup> Schmookler, J., *Invention and economic growth*, Harvard University press, 1966

<sup>6</sup> Myers, S. and Marquis, D.G., *Successful Industrial Innovation*, National Science Foundation, 1969

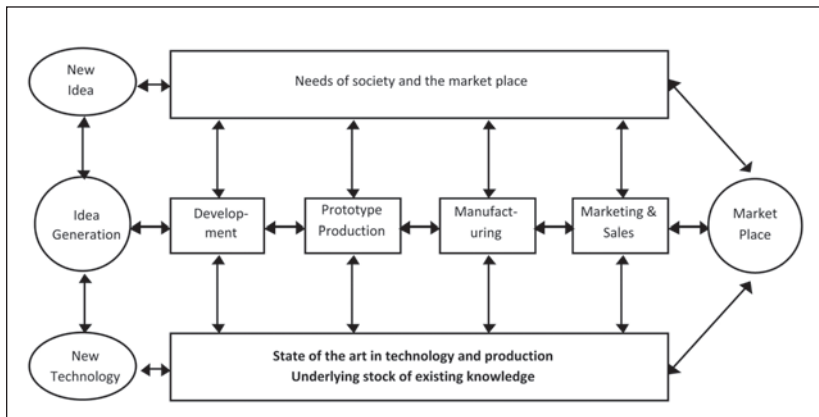
<sup>7</sup> Daniel Shimshoni, *Aspects of Scientific Entrepreneurship*, PhD Thesis, Harvard, 1966; R Rothwell, C Freeman, A Horsley, VTP Jarvis, AB Robertson and J Townsend, 'SAPPHO updated – project SAPPHO phase II', *Research Policy*, 3, 1974, 258-291

<sup>8</sup> Mowery, D.C. and Rosenberg, N., 'The Influence of Market Demand upon Innovation: A Critical Review of Some Recent Empirical Studies', *Research Policy*, April 1978

the marketplace. Since then, models of the links between innovation and research tend to be more complex, as in Figure 1.

The preoccupation of the earlier generations of innovation model is with the link between the **flow** of new knowledge and economic innovation. However, this ignores the huge importance of the **stock** of existing knowledge indicated at the bottom of Figure 1. "Firms very often seek to innovate by exploiting their existing knowledge assets. Unforeseen problems often emerge, however, and these require R&D for their solution. From this perspective R&D should be seen not as a process of discovery that initiates innovation, but as a problem-solving activity within already-existing innovation processes."<sup>9</sup> The vast majority of the knowledge used in any innovation comes out of this stock, and is not created afresh in the project that gives rise to the

Figure 1 Modern 'Coupling' Model of Innovation



Adapted from Roy Rothwell, "Towards the Fifth-generation Innovation Process" *International Marketing Review*, 11 (1), 1994, 7-31

<sup>9</sup> Keith Smith and Jonathan West, *Australia's Innovation Challenges: The Key Policy Issues*, Submission to House of Representatives Standing Committee on Science and Innovation, Inquiry into Pathways to Technological Innovation, April 28, 2005

innovation. Important parts of the knowledge stock can be very old, as was shown in the TRACES and HINDSIGHT<sup>10</sup> projects, which tracked the movement of knowledge elements respectively from mission-orientated and basic research into industrial practice across very long periods of time.

Working with and reworking the **stock** of knowledge is the dominant activity in innovation. Countless surveys of OECD firms show that their main sources of technology are internal knowledge and other firms. Public sector research accounts for a vanishingly small share of their knowledge inputs (though bigger and more successful innovators use more of such knowledge than smaller and less successful ones). In product development, considerable efforts are devoted to monitoring competitors' products and to reverse engineering. A normal pattern is for an industry to experience a continuous sequence of innovations. In so far as every innovation is based on a lot of existing knowledge mixed in with a little new thinking, all innovation is in a sense imitation. The terminology of 'innovation' contra 'imitation' with its connotation of 'superior' contra 'inferior' serves the interests of those who do research to create new knowledge by enabling them to claim high status. But, in terms of economics and development, its connotations are counter-productive. Imitation is perhaps **the** central fact about innovation and economic development under capitalism.

This suggests a 'bucket' theory of knowledge in which innovators use a mixture of old and new knowledge and in which new knowledge enters the stock and is used in research or innovation if and when it becomes useful. This may be immediately, later or never. In this perspective, the Framework Programme produces large numbers of 'intermediate knowledge products' that go into this stock, in addition to

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<sup>10</sup> Illinois Institute of Technology, 1969, *Technology in Retrospect and Critical Events in Science (TRACES: A report to the National Science Foundation)*, NSF Contract C535; Office of the Director of Defense Research and Engineering, *Project Hindsight - Final Report*, National Technical Information Service, 1967

clustering R&D around problems identified or recognised by significant stakeholder groups.

## 2.2 From Innovation to 'Innovation System'

Our increasingly complex view of the innovation process combined with the growing influence of evolutionary economics – which takes explicit account of behaviour, learning, institutions and hence path dependence rather than assuming that economic activity is perfectly rational – underlie the emergence of the 'innovation system' perspective that now dominates thinking about the social and economic role of research and innovation.

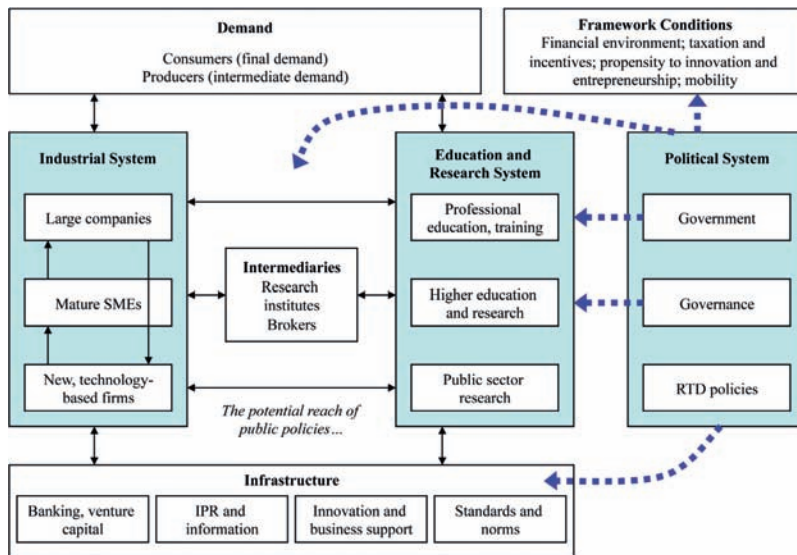
Christopher Freeman introduced the term 'innovation system' into the literature in 1987, in his study<sup>11</sup> that aimed to explain and to learn from the successes of Japanese research and innovation policy. Freeman's definition at that point was rather narrow: he referred to the state institutions involved in defining and performing research and innovation policy. Gradually, it was realised that performance across many interconnected parts of the economy<sup>12</sup>, including what the OECD increasingly referred to as 'framework conditions' (in practice a rag-bag of non-economic contextual factors such as tax regimes, regulations, laws, culture and behaviours), determined success or failure in innovation. Figure 1 summarises this wider scope. Correspondingly, the balance among different system components and the policies that relate to them needs to be appropriate and the policies need to be mutually consistent.

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<sup>11</sup> Christopher Freeman, *Technology Policy and Economic Performance: Lessons from Japan*, London: Frances Pinter, 1987

<sup>12</sup> RR Nelson, *National Innovation Systems*, New York: Oxford University Press, 1993; Bengt-Åke Lundvall, *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Pinter, 1992

Figure 2 A National Innovation System Heuristic



**Source:** Erik Arnold and Stefan Kuhlman, RCN in the Norwegian Research and Innovation System, Background Report No 12 in the Evaluation of the Research Council of Norway, Oslo: Royal Norwegian Ministry for Education, Research and Church Affairs, 2001

There is some evidence in the literature to support our qualitative impression that the importance of systems interrelations is increasing, as Gibbons et al suggested when they argued that the main growth in knowledge production is taking place in 'Mode 2', by which they mean problem-orientated, multi-disciplinary work involving research performers across the economy, in companies as well as research institutes and universities. Econometric estimates of the economic importance of science are tending to rise. Patents are increasingly citing

<sup>13</sup> Henry Chesborough, *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Harvard Business School Press, 2003

scientific literature. Information and Communications Technologies are enabling increasingly networked ways both to do research and to conduct business. Globalisation of industry, (industrial R&D as well as science) changes the context. Industrial R&D behaviour seems to be changing, both fully within the private sector<sup>13</sup> and in the context of state programmes such as the EU Framework Programme towards a much more 'open' model, where firms increasingly rely on the state and each other for key knowledge inputs, especially from more fundamental research.

### 3. THE CHANGING ROLE OF THE EMERGING EUROPEAN STATE IN R&D

In principle, states play a role in research and innovation policy in order to combat market and systems failures. These interventions should increase the volume and quality of research and the rate of innovation generating knowledge and economic spillovers for the benefit of society. The Framework Programme has been an important instrument of EU policy through which the nascent European state has begun to modify and assume some of the developmental roles formerly tackled at the Member State level, ultimately with the aim of creating an innovation system optimised at the European rather than the national level. This has involved successive extensions to the role of the Framework Programme.

#### 3.1 Why the state has a role

The idea that 'market failure' leads to under-investment in research<sup>14</sup> has been the principal rationale for state funding of R&D since the early 1960s.

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<sup>14</sup> Ken Arrow, 'Economic Welfare and the Allocation of Resources for Invention,' in Richard Nelson (Ed.) *The Rate and Direction of Inventive Activity*, Princeton University Press, 1962; see also Richard Nelson, 'The simple economics of basic scientific research,' *Journal of Political Economy*, 1959, vol 67, pp 297-306

Successful innovators (and, since we increasingly conceive science as a collective and not an individual enterprise, also successful researchers) are not successful solely because of their personal qualities and actions but also as a result of their interplay with the research and innovation systems they inhabit, and the quality of those systems.

An important aspect of the innovation systems heuristic (taken over from evolutionary economics) is the idea that firms and other actors have 'bounded rationality' and this – together with the idea of interdependence – makes knowledge, learning and institutions key to overall performance. Learning means there is 'path dependence': what you can do tomorrow depends upon what knowledge and resources you have today and what you can do to adapt these. Interventions to improve knowledge and capabilities, set directions or coordinate activities can change the trajectory of the innovation system and therefore its performance. Correspondingly, innovation and R&D funding is increasingly concerned to improve participants' capabilities, promoting learning or 'behavioural additionality' and not only to 'help firms' or 'fund science.' The Framework Programme demonstrates the importance of a coordinating function for breaking out of such lock-ins.

Cumulated capabilities and experience can 'lock in' parts of the system to configurations that perform badly. Systems that have evolved to perform well at regional or national level will not automatically reconfigure to perform better at higher levels. 'Unlearning' as well as learning may be needed. This may involve the state in playing a role as a change agent (this is in some cases an explicit task of innovation agencies). Systemic failures can arise in capabilities, institutions, networks or framework conditions. Because systems failures and performance are highly dependent upon the interplay of characteristics in individual systems, there can be no simple rule-based policy as is

possible in relation to the static idea of market failure.<sup>15</sup> Rather, a key role for state policy making is ‘bottleneck analysis’ – continuously identifying and rectifying structural imperfections and inadequate behaviours.<sup>16</sup> Such interventions may be increasingly **complex** – rather than ‘treating’ just individual organisations there is a need to bring together multiple interventions to address the capabilities and interactions among networks and their members.

### 3.2 The changing role of the European state in practice

The Framework Programme has developed and grown in parallel with major changes in the ambitions of industry and innovation policy in Europe and in the rules governing competition and the relation between the state and its industrial suppliers. The technological optimism of the 1960s triggered large investments in building national technological champions in areas such as transport, energy and computing. Like defence companies, these tended to function in “development pairs”<sup>17</sup> with national agencies or state-owned companies, such as airlines, railways, telephone companies and power generators. With the national state as a guaranteed launch customer – and in some cases, also, co-developer – many of these companies were able to produce significant innovations and to build strong international as well as national market positions.

Successive liberalisations at national and European levels and changes in WTO rules meant that it became more and more difficult to operate such development pairs. Liberalisation has meant in many fields a reduced role for the state in developing new generations of technology. Breaking the development pairs also meant breaking

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<sup>15</sup> Johan Hauknes and Lennart Norgren, *Economic Rationales of Government Intervention in Innovation and the Supply of Innovation-Related services*, STEP Report 08 1999, Oslo: STEP Group, downloadable from [www.nifu.no](http://www.nifu.no)

<sup>16</sup> Erik Arnold, Stefan Kuhlmann and Barend van der Meulen, *A Singular Council: Evaluation of the Research Council of Norway*, Oslo: Ministry of Education, Research and Church Affairs, 2001

<sup>17</sup> Erik Dahmén, “Entrepreneurial activity and the development of Swedish industry, 1919-1939” American Economic Association Translation Series, New York: RD Irwin, 1970

the link to the national level, reduced opportunities to use national idiosyncrasies to protect national suppliers and a reduced role for national standards. Standardisation power moved up from the national level through the European level and towards the global level.

With globalisation of markets came restructuring of industry. In the case of telecommunications, the Framework Programme was one of the policy ingredients supporting this transition. ESPRIT in FP1 and more especially RACE (later Telematics) in FP2 aimed to set common technology and communications standards and the concentration and development of European telecommunications equipment suppliers in the era of liberalisation. The FP activities were, however, only part of the Commission's policy effort in telecommunications, which also involved setting the liberalisation agenda for Europe and playing one of a number of contributory roles to the definition and implementation of the GSM mobile telecommunications standard at European level<sup>18</sup>. (Contributions to subsequent standards were mostly through pre-normalisation and standards-orientated projects within the Framework itself.) This is an example of connecting research and innovation activities within the Framework Programme to wider set of policies that is too infrequently seen

1960s-style 'technology push' efforts focused on national champions eventually fell into disrepute, in part because they became more or less illegal, in part because their ambitions widened from contexts where the state was the major first customer and had considerable monopsonistic power to situations – most notably in computing – where the state had little influence over demand. A lot of the effort in ESPRIT (especially in FP1) went to prop up 'national champions' like ICL, BULL and Siemens' mainframe computer division at a point

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<sup>18</sup> Herbert Ungerer and Nicholas P Costello, *Télécommunications en Europe*, Luxembourg: Office des Publications Officielles des Communautés Européennes, 1988

where IBM had almost total dominance of the world mainframe markets – and when the new generation of minicomputer technology was already waiting in the wings, eventually to undermine much of the mainframe market. ESPRIT II and especially III marked a move away from “the failure of an industry policy then aiming to sustain IT manufacturing in Europe”<sup>19</sup> and towards a more all-encompassing and more software- and applications-based idea of ‘information society’. ‘Rust belt’ national industry policies to prop up declining industries such as ship building in different ways tried to work against the logic of markets and were equally unsuccessful.

While many academics like to describe the FP as a ‘top down’ instrument, in fact it evolved rapidly away from the ‘national champions’ style into something much more responsive to the needs of stakeholder groups. By accident or design, it learnt the lesson that backing a particular company (or for that matter research group) is an unnecessary act of hubris. Coordinating and promoting competition within areas, which stakeholders identify as having thematic priority, is a more powerful approach because it harnesses rather than resists market forces.

### 3.3 EU Research and Innovation Policy

We can think of three distinct periods in European research and innovation policy: before 2000, when the Commission aimed mainly to network and stimulate activities at the Member State level; 2000-2010, when building the European Research Area (ERA) and enhancing competitiveness via the Lisbon Agenda and the Open Method of Coordination (OMC) came onto the agenda; and the period from the present, when the Commission is moving towards stronger coordination of research and innovation policy across the Member States but increasingly decentralising this coordination.

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<sup>19</sup> Umberto Columbo et al, Esprit Review Board 1996 Report: Making Progress Happen through Development, Application and Diffusion of Information Technologies, Luxembourg: Office for Official Publications of the European Communities, 1994

European science and technology policies in the 1960s and 1970s were heavily influenced by the idea of a 'technology gap' with the USA. Servan-Schreiber's book *The American Challenge*<sup>20</sup> was emblematic of this concern, which – together with a strong spirit of technological optimism in the 1960s – triggered the creation of a range of institutions and grands projets in Europe.<sup>21</sup>

In 1965, the fledgling European Community of six countries set up a sub-committee of its medium-term economic policy committee to deal with science and technology. It took until 1971 to sign a cluster of seven international agreements to cooperate in various technology areas and define the European Cooperation in Science and Technology (COST), which was originally seen as a European-level funder. However, the ineffectiveness of working through treaties led to the Council resolution of 14 January 1974 establishing a Community policy for R&D and internalised the funding function in the Commission. In the following years, the Commission ran a small number of R&D programmes, primarily in energy and data processing.

The FP was launched after a period in which European multilateral R&D cooperation had blossomed, for example through CERN, EMBL and ESF. In the period since FP1 began, in 1984, there have been no significant new European R&D cooperations in which the Commission is not central except Eureka in 1985, which was in effect Paris' reply to what it saw as a shift of power towards Brussels.

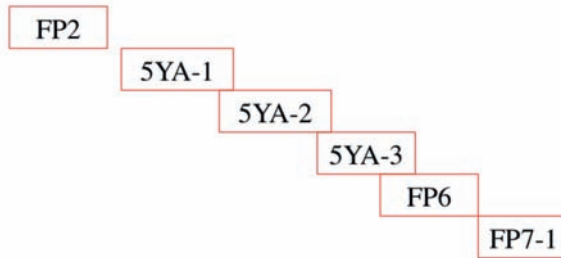
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<sup>20</sup> Jean-Jacques Servan-Schreiber, *Le Défi Américain*, Paris: Denoel, 1967

<sup>21</sup> For example the Ministry of Technology in the UK, the first innovation agency in Sweden (the Swedish National Board for technological Development – STU, the Anglo-French supersonic transport project Concorde as well as new institutions to study science and technology policy such as the Science Policy Research Unit at Sussex University

Figure 3 Timing and Budgets of Framework Programmes and their Evaluations

FP	1	2	3	4	5	6	7
Dates	84-87	87-90	90-94	94-98	98-02	02-06	07-
BC	3.8	5.4	6.3	13.0	15.0	16.3	39.0*



\* 5-year basis; the actual budget for the 7 years of FP7 is €50.5 bn

The first Framework Programmes - industry-oriented and very much 'technology-push' - as well as the Single European Act (ratified in 1987) and the Maastricht Treaty (ratified in 1993) need to be understood in the context of the Commission and European governments' desire to bridge the 'technology gap'. On the one hand, Europe's science and technology capabilities were to be strengthened through the promotion and funding of collaboration; on the other hand, competitiveness was to be enhanced by forcing Europe's 'national champions' to confront more competition in a single European Market.<sup>22</sup> Over time, the Framework Programmes' scope has grown to cover a very wide range of themes and the repertoire of instruments has increased from the early focus on collaborative research to areas like human mobility. Up to and including FP4 (1994-8), European Added Value in the form of networking, cohesion, scale benefits and

<sup>22</sup> John Peterson, Margaret Sharp, *Technology Policy in the European Union*, MacMillan Press Ltd, 1998

so on was largely seen as sufficient justification for the FPs. In FP5 (1998-2002), the focus shifted towards socio-economic benefits.

The Maastricht Treaty (1993) gave the Commission the role of leading the coordination of national RTD policies and extended the scope of the FPs – starting with Fourth Framework Programme (1994- 1998), which now included basic research.

A major change in policy thinking was introduced by the Commission's White Paper "Growth, Competitiveness, Employment. The Challenges and Ways Forward into the 21st Century" (1993)<sup>23</sup> followed up by the "Green Paper on Innovation" (1995)<sup>24</sup>, which identified the so-called "European paradox", i.e. Europe's "comparatively limited capacity to convert scientific breakthroughs and technological achievements into industrial and commercial successes."

The focus of the debate in the 1980s on how Europe could become competitive in new technologies now shifted to debates concerned with **using** new technologies.<sup>25</sup> This shift in thinking was reflected in the more societal orientation of the Fifth Framework Programme (1994 – 1998). Thus, at the end of the 1990s, European R&D policy became part of a more comprehensive innovation policy. From now on, higher-level European policies such as the Lisbon strategy and the European Research Area constituted the overall context for the Framework Programmes.

The 2000 Communication on the ERA<sup>26</sup> argued that Europe lagged the USA and Japan in industrial competitiveness and the ability

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<sup>23</sup> Growth, Competitiveness, Employment: The Challenges and Ways Forward into the 21st Century - White Paper Parts A and B. COM (93) 700 final/A and B, 5 December 1993. Bulletin of the European Communities, Supplement 6/93

<sup>24</sup> "Green paper on Innovation", European Commission, COM (95) 688 final

<sup>25</sup> John Peterson, Margaret Sharp, Technology Policy in the European Union, MacMillan Press Ltd, 1998

<sup>26</sup> COM 2000 (6) Final

to make social and economic use of research. Complaining that there was no European policy on research, it proposed a unified research area, comparable with the idea of the EU as a common market for goods and services. “De-compartmentalisation and better integration of Europe’s scientific and technological area is an indispensable condition for invigorating research in Europe.” Research and innovation actions building on the idea of the ERA were to be pursued but broader policies were also evolved that included improved policies for the Information Society, modernising the ‘European social model’ and macroeconomic policies. Not long afterwards, the Council set the Barcelona target of spending 3% of EU GDP on R&D.

The Sixth Framework Programme (2002-6) aimed to implement aspects of the Lisbon agenda – in particular through the use of larger-scale instruments to ‘structure’ the research communities and to ‘optimise’ their performance at the European rather than the national level.

The idea of ERA has been evolving since it was introduced in 2000. In 2007, the Green Paper that ‘re-launched’ the ERA<sup>27</sup> described its key features as

- An adequate flow of competent researchers with high levels of mobility between institutions, disciplines, sectors and countries
- World-class research infrastructures, integrated, networked and accessible to research teams from across Europe and the world, notably thanks to new generations of electronic communication infrastructures
- Excellent research institutions engaged in effective public-private cooperation and partnerships, forming the core of research and innovation ‘clusters’ including ‘virtual research communities’,

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<sup>27</sup> Commission of the European Communities, Green Paper, European Research Area: New Perspectives, COM(2007) 161 final, Brussels 4.4.2007

mostly specialised in interdisciplinary areas and attracting a critical mass of human and financial resources

- Effective knowledge-sharing notably between public research and industry, as well as with the public at large
- Well-coordinated research programmes and priorities, including a significant volume of jointly-programmed public research investment at European level involving common priorities, coordinated implementation and joint evaluation
- A wide opening of the European Research Area to the world with special emphasis on neighbouring countries and a strong commitment to addressing global challenges with Europe's partners

DG-ENTR brought its innovation programmes together in the Competitiveness and Innovation Framework Programme (CIP), with a budget of just over €3.6bn for 2007-2013 (equivalent to about 7% of the €51bn budget of FP7 for the same period). It continues activities to promote entrepreneurship, adding the ICT-PSP programme (aiming to demonstrate and create market conditions for the take-up of ICT-based innovations) and the Intelligent Energy Programme. It has been supplemented with six Lead Market Initiatives, where demand-side stakeholders as well as various EU R&D groupings (such as the ETPs) have been consulted about how to create demand conditions that will encourage innovation in areas where Europe has the potential to supply the innovations. These conditions include public procurement. Both ICT-PSP and the Lead Markets Initiative aim to provide links to the Framework Programme. The linkage is not strong but these nonetheless do represent some steps towards the kind of 'holistic' research and innovation policy sought at home by increasing numbers of Member State governments. 'Horizon 2020', which is to replace both Framework Programmes' should in principle provide better integration of innovation and RTD policy at European level.

### 3.4 European Added Value (EAV)

From the start, the EU and its predecessor Communities have been expected to justify their actions with reference to the additional value created compared with action at Member State level. This principle of 'subsidiarity' was clarified in the Maastricht Treaty, which also required that EU interventions should be 'proportional': namely, they should not go beyond what is needed to reach the goals of the Treaty. From FP1 onwards, the Commission applied the principles that have since become known as the Reisenhuber criteria in order to justify Community support for R&D. These were to reserve FP money for

- Research activities of such a scale that single Member Countries either could not provide the necessary financial means and personnel, or could do so only with difficulty
- Research that would obviously benefit from being carried out jointly, after taking account of the additional costs inherent in all actions involving international cooperation
- Research that, owing to the complementary nature of work carried out at the national level in a given sector, would achieve significant results in the whole of the Community for problems to which solutions call for research conducted on a vast scale, particularly in a geographic sense
- Research that contributes to the cohesion of the common market and which promotes the unification of European science and technology as well as research that leads where necessary to the establishment of uniform laws and standards<sup>28</sup>

An additional criterion covering the development of scientific and technical potential in Europe via different routes was added for FP4: 1994-1998. This justified research actions which contribute to the

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<sup>28</sup> United Kingdom Parliamentary Office of Science and Technology, Research and the European Union, POST Report Summary, No 83, 1996

mobilisation or improvement of European scientific and technical potential and actions which improve co-ordination between national RTD programmes, and between Community programmes and work in other international fora (S&T potential).<sup>29</sup>

While formally the criteria for EAV used in FP6 were essentially the same as those in FP5<sup>30</sup>, the scope of the activities changed. New instruments were included in FP6 that were intended to influence the structure of the European research community, widely defined to include industry.

A little-noticed novelty of FP5 was the ‘mainstreaming’ of participation in the FP by ‘Third Countries’, ie those that are neither Member nor Associated States. This partly involved bringing in a range of development projects aimed at poor countries and regions outside Europe but – especially in FP6 – it also involved growing participation in mainstream FP projects, not least by Russia and China<sup>31</sup>. FP7 involves a greater degree of what the Commission terms ‘internationalisation’ (as if the EU were a nation – we should more properly speak of ‘globalisation’). As yet, there is little clear strategy for globalisation and the issue appears to receive little priority in EU policymaking.

In parallel with the development of FP6, the Commission expanded the definition of EAV in another new direction, which was incorporated in the Communication “Europe and Basic Research”<sup>32</sup> in 2004 but did not really become operative until the creation of the European Research Council under FP7.

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29 Yellow Window, Technofi, Wiseguys, *Identifying the constituent elements of the European Added Value (EAV) of the EU RTD Programmes: conceptual analysis based on practical experience*, Antwerp, 2000

30 Communication from the Commission, Making a reality of the European Research Area: Guidelines for EU research activities (2002-2006), Brussels 4.10.2000, COM(2000) 612

31 Erik Arnold, Sylvia Schwaag-Serger, Neil Brown and Sophie Bussillet, *Evaluation of Chinese Participation in the EU Framework Programme*, Brighton: Technopolis, 2008

32 COM (2004) 9, final, 14.1.2004

*Until now we have defined European Added Value as the collaboration of teams. Now it is time to bring a new definition to European Added Value, one that incorporates the principle of allowing a researcher in any of our member states to compete with all other researchers to win funding. Competition therefore becomes an essential new, forward-looking definition of European Added Value.<sup>33</sup>*

Figure 4 The Evolving Character of 'European Added Value'

Dimensions of European Added Value	FP1	FP2	FP3	FP4	FP5	FP6	FP7
Scale too big for Member States (MS) to handle alone	X	X	X	X	X	X	X
Financial benefits: a joint approach would be advantageous	X	X	X	X	X	X	X
Combines complementary MS efforts to tackle European problems	X	X	X	X	X	X	X
Cohesion	X	X	X	X	X	X	X
Unification of European S&T across borders	X	X	X	X	X	X	X
Promotes uniform laws and standards	X	X	X	X	X	X	X
Mobilising EU potential at European and global level by coordinating national and EU programmes				X	X	X	X
Contributes to implementing EU policy					X	X	X
Contributes to societal objectives (later 'grand challenges')					X	X	X
Exploits opportunities for the development of European science, technology and industry					X	X	X
Structures the EU R&D community and 'fabric'						X	X
Improves quality through exposure to EU-wide competition							X

33 Achilleos Mitsos, Speech at the ELSF-Euroscience Conference of the European Research Centre, Dublin, 21-22 October 2003; quoted from Daniel Tarschys, The Enigma of European Added Value: Setting Priorities for the European Union, SIEPS 2005:4, Stockholm: Swedish Institute for European Policy Studies, 2005

#### 4. EFFECTS OF THE FRAMEWORK PROGRAMME

While formally a single programme, the Framework is in fact a composite of many sub-programmes addressing different themes and their associated goals. It is nonetheless possible to generate a high-level description of its intervention logic and identify common long-term goals. Existing evaluation evidence tells us that the Framework Programme funds high-quality, pre-competitive R&D, mostly producing 'intermediate knowledge products' that can later be used in R&D and various kinds of networks as well as to increased competitiveness. To a considerable extent, its design reflects the needs and interests of important stakeholders and R&D communities in Europe. Its longer-term effects go beyond these, crucially including setting agendas, creating road maps and coordinating the efforts of research communities. This can lead to the emergence of new fields and technological trajectories, restructuring of the European research effort, improvements in policymaking and increased competitiveness. The paper details the impact mechanisms through which this is achieved.

##### 4.1 Expected Effects of the Framework Programme

As Brian Loasby has rather wryly pointed out, "Nobody knows how a Boeing 737 works."<sup>34</sup> The same can be said for the Framework Programme. Many people are knowledgeable about individual sub-components; some understand the architecture at various points in time; but no one can offer a complete understanding. In fact, the FP may be harder to understand than the aeroplane because while the 737 is designed top-down and optimised towards a particular purpose, the FP is in no small part self organising and its purposes evolve over time.

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34 Brian J Loasby, "Making connections," Symposium on Information and Knowledge in Economic, *Econ Journal Watch*, 2 (1), 2005, 56-65

Figure 5 attempts nonetheless to summarise the overall intervention logic of the Framework Programme – viewed through today’s spectacles. It includes both the impacts that result from or relate to the programmes as a whole and other impacts that are specific to one or other of the themes and instruments. In the next sections, we explore the extent to which these expected impacts are in fact visible over the longer term.

#### 4.2 What the existing evaluation record tells us

In line with the thinking of the New Public Management movement and reforms at the Commission, evaluation of the Framework Programme has increasingly been tied to the programming cycle and regarded as a part of the management process. This means in practice that we have repeatedly been trying to evaluate projects and programmes at mid term and (less often) immediately after completion. We have a series of repeated snapshots of what participants are trying to achieve and what those deeply involved with the projects expect the short-medium term effects will be. This evaluation record tells us a lot of interesting things about the Framework Programme – but not what its longer-term effects are. Since the overall objectives of the Framework have to do with industrial and societal impacts, this is a problem – and it is precisely why we have been trying to study some of these longer term effects.

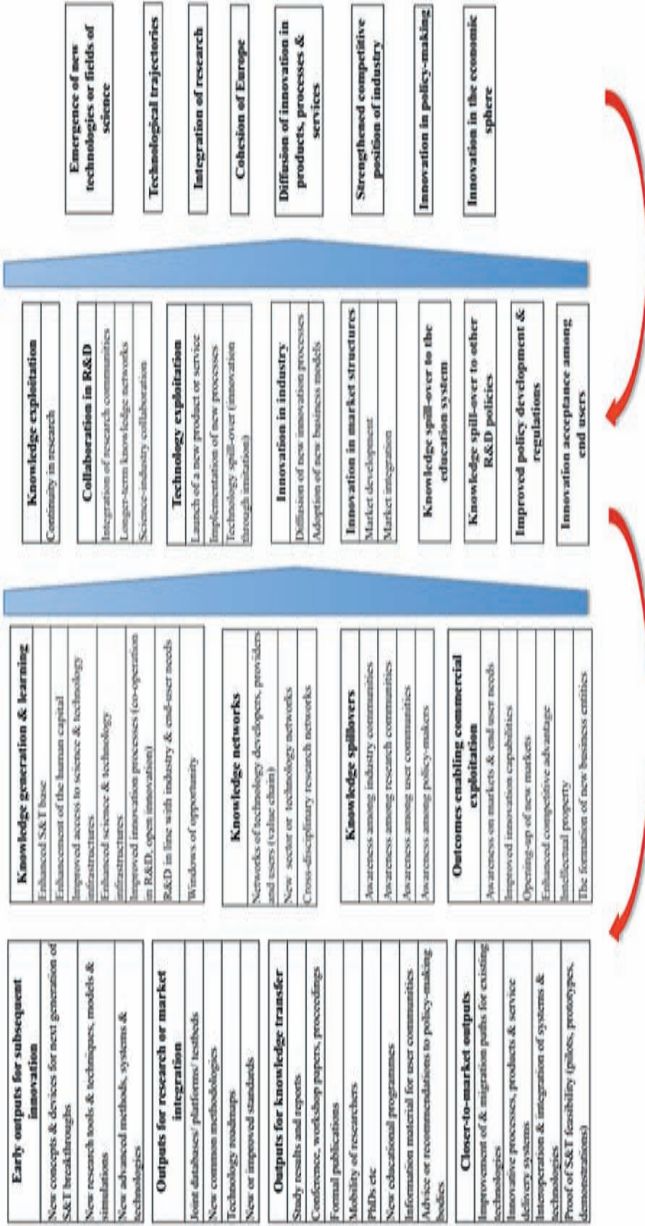
We can nonetheless see a lot from the short-term evaluation evidence<sup>35</sup>.

- The FP funds high-quality R&D: the appraisal processes are tough; the competition is fierce; participating researchers include the scientific elite and their outputs tend to be of higher performance than those of non-participants (measured in bibliometric terms, especially through citations)

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<sup>35</sup> Erik Arnold, John Clark and Alessandro Muscio, ‘What the evaluation record tells us about Framework Programme performance’, *Science and Public Policy*, Vol 32, No 5, 2005, pp385-397; Erik Arnold, *Framework Programme 6: Meta-Evaluation*, Brussels: European Commission, DG Research, 2009

Figure 5 Expected impacts of the FPs



Source: Erik Arnold, Malin Carlberg, Flora Giaracca, Andrej Horvath, Zsuzsa Javorika, Paula Kree, Bea Mahieu, Ingeborg Meijer, Sabeen Siddiqi and James Stroyan, Long-term Impacts of the Framework Programme, Brussels: EC, DG-Research (forthcoming 2011)

- Growth in high-quality international co-publication within Europe has accompanied the growth of the FP
- Just as the FP attracts the more excellent researchers in their fields, so it engages the more research-intensive companies within their respective branches
- It is – by design – a pre-competitive, collaborative programme, so it primarily produces ‘intermediate knowledge outputs’ as well as technical and market network relationships that are re-used in other R&D and business processes. Participants who enter projects with a deliberate product or process innovation objective are more likely to obtain short-term results than others
- With few exceptions, the FP is a place to exploit existing strength. Especially in established areas, it is too competitive to allow capacity building – that has to be done with national resources
- Most participants have only a fleeting relationship with the FP – one or two projects and then they move on. However, new participants appear to learn the value of networked R&D and increasingly to participate in ‘open innovation’ activities, even if they do not stay much involved with the FP
- There is a strong core of established players and networks whose composition slowly shifts over time. Just as with global ‘invisible colleges’, you have to ‘earn your spurs’ in order to join these networks and to carry on delivering value to your partners if you want to survive. However, we know very little of the details of how networks work, how networking relates to strategy or how network shape relates to success<sup>36</sup>
- Despite the trend to larger instruments in recent Framework Programmes, bigger networks do not seem to be more productive than smaller ones – in fact, what evidence there is suggests the opposite

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<sup>36</sup> Except in so far as believing that central positions with connections to many other members are powerful and that positions that make you a ‘bridge’ between two or more networks give superior access to information

- The FP is often associated with pre-normalisation R&D and the development of technical standards
- Most participants believe that FP participation increases their competitiveness. The indirect nature of the FP's effects (through 'intermediate knowledge outputs') makes them very hard to track. Parts of the FP that focus on smaller firms and more direct results have been evaluated using a cash benefit-cost approach, which suggests high benefit-cost ratios. Smaller firms benefit less than larger ones (and are generally less satisfied with FP participation)

### 4.3 Some lessons from looking at the long term

The corollary of the short-term focus of Framework Programme evaluation is that very little research has been done on its longer-term effects. A study in 2008 looked at long-term effects of FP4-6 in

Sweden<sup>37</sup> while a second in 2011 looks at effects at the level of the EU<sup>38</sup>. Both are essentially exploratory and provide sets of case studies.

#### 4.3.1 Evidence from Sweden

Swedish companies spearheaded national participation in the FPs in the 1980s, but the universities entered in strength from FP3 and by FP6 accounted for 60% of the FP funding flowing to Sweden. Volvo; Ericsson; Saab; Vattenfall; and Telia/Teliasonera have dominated the industrial participation. Few other companies have a large or persistent presence. Therefore, vehicles (including aerospace), telecommunications and energy are strongly represented while major Swedish sectors like pulp and paper, pharmaceuticals and chemicals are not conspicuous. Much of the major industrial participation is in areas where there have in the

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37 Erik Arnold, Tomas Åström, Patries Boekholt, Neil Brown, Barbara Good, Rurik Holmberg, Ingeborg Meijer and Geert van der Veen, *Impacts of the Framework Programme in Sweden*, VA 2008:11, Stockholm: VINNOVA, 2008

38 Erik Arnold, Malin Carlberg, Flora Giaracca, Andrej Horvath, Zsuzsa Jávorka, Paula Knee, Bea Mahieu, Ingeborg Meijer, Sabeen Sidiqi and James Stroyan, *Long-term Impacts of the Framework Programme*, Brussels: EC, DG-Research (forthcoming 2011)

past been 'development pairs' between industry and the state. The Swedish industrial research institutes are small and poorly funded by international standards, so their participation has been limited.

In the university context, the FPs have added quite a substantial amount of money to external research income. In so far as research (and education) are good things, then these are good things that should broadly lead to increased social and economic welfare. And Sweden's excellent performance in bringing money home from the FPs means the bargain for Sweden has been a good one: she takes out more than she puts in and most of that additional money goes to the universities.

The additional money complements national resources. It allows more applied and innovation-orientated work to be done by companies as well as academics. It allows some themes that are overlooked or otherwise difficult to fund at the national level nonetheless to be funded. Perhaps the most interesting thing is that by adding **diversity** to a system that some of our interviewees saw as overly focused on basic research the FP funding adds robustness to the Swedish system as a whole.

The FPs have had more influence at the level of individual research groups than they have had on overall university strategies. They clearly added size and scope to researchers' networks, probably increasing quality and including them in more international 'invisible colleges' that make them 'insiders' in groups of researchers working at or near the leading edge in their fields. The practice of staffing FP projects largely with doctorands ensures that they play an important role in doctoral education and also exposes those doctorands to the international partnerships of the FPs, with beneficial effects on their educational, research and career prospects. Swedish universities essentially obtain these benefits because they can apply bottom-up for project funding, largely unconstrained by any strategic considerations

of the FPs, national programmes or their own universities. But the fact that the universities largely lack thematic strategies for their own operations and consistently lack strategies for handling the FPs is an important missed opportunity to use FP resources systematically to promote the development of critical masses.

Our study looked at four industries where we expected to see longer-term impacts of the Framework Programme: pharmaceuticals; ICT; vehicles; and sustainable energy.

Major pharmaceuticals companies tend to do little in the FPs, so the effects of the Framework reach these companies by strengthening their university partners. The FPs have added considerable resources to the Swedish university research effort in life sciences and health. These are areas of pre-existing strength in which Swedish research is highly competitive and Swedish institutions have seized the opportunities provided to widen their thematic research areas in areas prioritised by the FPs. The lack of an explicit Swedish strategy for life sciences and health research means that use of the FPs has to be opportunistic. Sweden has little influence over the FP agenda because it is not clear or agreed how Sweden would like that agenda to change. The limited presence of major Swedish industry in the emerging Innovative Medicines Initiative JTI in the area will ensure that Swedish strategic influence continues to be small.

Swedish ICT participation is dominated by universities and research institutes and has – together with national programmes – supported the need to increase the research and education areas in ICT significantly over the past 20 years or so. FP funding has broadened the research base by supporting some areas of research that were hard to fund from national resources. Numbers of large and small firms have obtained short-term support from the FPs. Ericsson and Teliasonera are the major companies that have worked with the FPs at some scale and

over a long period. Teliasonera's importance as a source of technology and market power has been declining since liberalisation. However, Ericsson's participations in the FP have enabled it to build strong positions in 3G mobile technologies through influencing standards and key choices of technological direction. Innovations derived from participation in FP3 are still being implemented and others from later work are in the pipeline. In this area where Sweden had already established significant industrial strength, the FPs have been a powerful lever on national industrial and technological competitiveness.

In contrast with the other industries studied, vehicles participations are more industry- than university-dominated and the work of the projects is generally more applied. Important aspects of the continuing strength of Swedish positions in the industry build on long-term alliances with Swedish universities in areas like combustion, catalysis and safety. These alliances have been brought into FP participation, extending the scale of national efforts but also building new links to foreign institutions. This industry is very explicit in internally agreeing and then telling the Commission what should be put into the FP strategy via organisations such as EUCAR. As a result, the FPs address longer-term issues of relevance to industry. The complementary combination of national and FP programmes has been instrumental in the survival of the Swedish road vehicles industry in its current form and is – from a Swedish perspective – a major success.

In sustainable energy, the FPs have served to increase the amount of university research in a pattern that reproduces the pattern of national effort. The additional spending is not sufficient to overcome the fragmentation of research within the higher education sector, which essentially uses FP money to do 'more of the same' – although with the added benefits that arise from international networking. The major energy equipment suppliers have tackled the limited modifications to traditional equipment needed for thermal biofuels but are not involved

in the major new potential sustainables. With neither the incumbent companies nor the state stepping up to shoulder the innovation risks, that burden falls to a number of small companies – several of them supported bottom-up through the Framework Programme. However, Swedish policy seems to be unable to move beyond conventional R&D policy to develop the kind of consistent industry, energy and taxation policies, developmental procurement or demonstration measures likely to be needed to accelerate the shift to sustainables – let alone to seize the opportunity to establish industrial advantage in sustainable technologies. In the past, major leaps in energy technology have involved the state as a major customer and risk-taker with new technology and it is not clear that the needed rapid transition to new energy sources can be obtained without a similar type of intervention that goes well beyond the current mandate of the Framework Programmes.

The study suggests that the FPs have had some important impacts in Sweden and that some of the areas of limited impact result from a lack of strategic direction from the Swedish side. Where the FPs have had limited strategic impact, this is because there are not many strategies to impact. This is a vicious circle: in the absence of national strategy, it is difficult to articulate how the FPs' strategies should change in order to serve the national interest. Partly as a result of this, the FPs' ambition to 'structure' research in Sweden has not been realised at all. The FP resources have added a little scale but not changed the structure of the higher education and research sector – and certainly not helped address the long-standing problem of fragmentation in the research community. In principle the FP resources could be used to support restructuring, but only in the presence of national strategies.

Where there are strong industrial lobbies or groupings, the FP has helped generate agreement about technical directions and influenced standards

Perhaps the most striking thing about this analysis is that it points to circularities. Where there is a national strategy or an industry strategy, the FPs can be recruited to this cause. The openness of the FPs to strategic ideas means that where there are powerful lobby groups, their ideas are likely to be adopted. The FP is much less good at dealing with unpredictable or SME-dominated sectors. It cannot tackle areas like sustainable energy very well, where it is not clear who its discussion counterpart is and where it seems necessary to go beyond the existing rules and functions of the FP in order to effect the industrial change that is urgently required.

#### *4.3.2 Evidence from the EU level*

At the EU level, we experimented with co-word analysis of project titles and abstracts as a way to thematically cluster activities and citation analysis to look for the kinds of flurries of citation that tend to happen around breakthrough research. While these techniques have clear promise in analysing science, the different communication style of Framework projects compared with scientific articles and the inadequacy of available databases for identifying all the researcher participants in projects meant that our results were inconclusive. We believe these methods have promise but still need further experimentation. The case study component of the research therefore offers the most interesting account. Our six cases were chosen partly on the basis of the co-word cluster analysis and partly through discussion with officials who had been active in relevant parts of the European Commission during FP3-6. Our aim was not to be representative but to explore a range of impact mechanisms so as to provide a 'map' for future research. We looked at

- Quantum Information processing and Computing (QIPC)
- Brain research
- Stratospheric Ozone (O3) research
- Solar Photovoltaics (PV)

- Automotive industry
- The Manufuture European Technology Platform

The current technology trajectory for ICT, based on semi-conductors, has provided steady performance improvement through increasing miniaturisation during the last 60 years. However, it will reach its limits by around 2020<sup>39</sup>. Already today, quantum effects begin to affect performance. The need for technological alternatives has driven research in a number of fields, including Quantum Information Processing and Communications - QIPC. By harnessing quantum phenomena such as *superposition, entanglement and coherence* to encode, process and transfer information, QIPC will radically increase the speed of calculations and provide communications that are inherently secure. In QIPC, the Framework Programme picked up the emergence of a new field of science and technology more rapidly than the member states, helped it establish scientific and technological agendas, organise and grow in Europe to such an extent that the EU appears fully competitive with the other world R&D leaders. Beginning in the bottom-up part of the Future Emerging Technologies sub-programme, the Commission quickly understood the importance of QIPC. It launched a 'proactive' FET project that reflected the views of over 100 scientists on the way the field should develop. This was followed by greatly increased R&D project funding – but also, crucially, by a series of networking and coordination initiatives that kept the R&D agenda constantly under review by the scientific and industrial communities. The field has not yet reached the stage where products and processes are developed, but Europe has the technological basis and started to develop standards for doing so and therefore for continuing to maintain strong positions in the global computing and communications industries as they go through a paradigm shift in how they process information.

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<sup>39</sup> Source: <http://www.intel.com/technology/mooreslaw/index.htm>

The Framework Programme has been less decisive in Brain Research, which was already well established at the point where FP funding began. Diseases of the brain and central nervous system cause increasing human suffering and economic cost as Europe's population ages. In this area, and in pharmaceuticals more generally, Europe is losing ground to the USA both in terms of public investment in research and in overall share of the drugs market. The Framework Programme has nonetheless made important contributions in imaging and helped support and integrate the European research community in a period when the USA has been investing much more public money in the field than the European Member States have, in sum. Launching the European Brain Council was an important contribution to setting and maintaining a relevant and up to date research agenda in Europe. The FP has been important in keeping Europe 'in the game' in this field. With the launch of the first Joint Programming initiative on Alzheimer's disease, the Framework has decisively increased its agenda-setting role, leveraging large amounts of money and effort at the Member State level.

Damage to the Ozone layer in the atmosphere, which protects us from excessive ultraviolet light and from some of the heating effect of solar radiation on the atmosphere poses a major risk to life. When the Montreal Protocol (the first international treaty aiming to mitigate damage to the Ozone layer) was signed in 1987, European research on stratospheric Ozone lay far behind that in the USA. The Framework Programme has made a major contribution by growing and helping coordinate the European research community, not least through organising multinational research fieldwork campaigns to provide a better evidence base for policy. The European Advisory Science Panel on Stratospheric Ozone advised the Commission of needed research up till the period of FP6 and the coordinating unit that supported the Panel organised repeated reviews of the state of European science that shaped the trajectory of research. The Framework Programme

has helped the European research community move from lagging far behind the USA to working at the global frontier. Research results have shaped the evolving Montreal Protocol requirements and have been so influential at the policy level that Europe has achieved the Protocol's 2020 targets ten years ahead of schedule.

Shifting energy supply towards renewable sources involves not only new knowledge but also making big changes to energy systems and policy. Solar PV makes up a small but rapidly growing part of the energy system. The Framework Programme has supported technological development and demonstration in the area since the 1980s. It has expanded the research community in Europe and enabled it to work at the global research frontier. National demand-side policies have been important in developing solar PV markets but the Commission's role in developing energy policy has also increased since the 1980s. These PV-friendly policies have meant that the industry is now demand-led. With a 15% share of world production, Europe maintains a strategic position in an important and rapidly growing industry that supports a large number of small and large firms and well over 100,000 jobs. By establishing road maps, funding a range of PV technologies at different levels of maturity and linking through demonstration to policy, the Framework Programme has enabled Europe to build a strong position in current and future PV markets. This eases the transition towards renewables and has helped to establish a significant European presence in the supply industry.

The Automotive Industry is one of Europe's most globally competitive sectors, contributing 3% of GDP and accounting for 6% of total manufacturing employment and is a sector where policy-push in the form of regulations and directives is an important driver for innovation. FP-funded research had a very significant effect on the competitive position of the European car manufacturing industry, tackling longer-term high-risk research. Involving the industry in setting the agenda

for parts of the FP has allowed the vehicle manufacturers to define road maps and build capabilities subsequently to be exploited via in-house development. In recent decades, the Framework Programme has contributed to technological breakthroughs strengthening the competitive positioning of the European car manufacturing industry - notably in areas of European technological strengths such as engine technology, combustion, catalysis, safety and Intelligent Transport Systems. FP-funded research has focused on and contributed to technological developments with a direct environmental or social benefit to the citizen, including research for the improvement of fuel consumption, reduction of CO<sub>2</sub>, elimination of exhaust pollutants, and countless improvements of driver safety. A long series of these product innovations can be traced back to individual FP-funded projects. An example is the effective significant reduction of air pollution thanks to the introduction of catalytic converters on passenger cars in Europe at the beginning of the 1990s. In automotive, the Framework Programme's role has been to sustain longer-term research and research in areas such as fuel efficiency, emissions and safety that create not only private advantages for the industry but significant public goods. Exploiting the industry's desire to self-organise to define R&D directions and road maps has been a powerful way to coordinate the longer-term R&D effort and has supported a long series of product and process innovations that help maintain Europe's position among the global leaders in this industry.

The Manufacture Technology Platform is of interest more for its potential than for any socio-economic impacts achieved so far. The Framework programme plays an increasingly catalytic role in integrating and strengthening the European research infrastructure, impacting industry and research communities. Structural effects promoted by the Framework Programme include the creation or strengthening of knowledge networks, often evolving into long-term strategic alliances; the integration of research and industry communities – cross-sectoral, interdisciplinary or transnational; and collaboration networks between

and among European and national R&D policy-makers, in a growing number of cases resulting in joint-programming of research. Manufuture underlines the importance of coordination and self-organisation as mechanisms to integrate research. It has defined a research agenda about which there is broad agreement in manufacturing industry, recruited large numbers of partners and helped define 26 national or regional level platforms and is beginning to influence policymaking (especially in the area of sustainability) and affect industrial processes. At this stage, the longer-term effects of Manufuture are far from clear – and understanding them will pose a significant challenge for evaluators. However, the Platform is an important instance of the shaping and structuring that appears to be one of the Framework Programme's most powerful impact mechanisms. Already at this stage it is clear that its influence is enormously far-reaching.

The most important commonality among these stories is to do with coordination by enabling self-organisation. This is a far cry from the 'technology gap' idea and the associated 'technology push' model that underlay the early FPs. That does not mean that the Framework can evolve into an advisory rather than a funding function. If there are no resources there is nothing to coordinate or organise. The farmer does not listen to the agricultural extension worker because he is wise. The farmer listens to the agricultural extension worker because he is wise and brings the subsidy cheque.

Figure 6 considers the long-term impact categories we defined in the analysis of the Framework Programme's intervention logic (see Figure 5). In generalising, of course, we lose the subtlety of the individual case stories but it is interesting to see that there is a diversity of impact patterns.

Figure 6 Long term impacts of the Framework Programmes

Long-term impacts	QIPC	Brain Research	O3	Solar PV	Auto-motive-	Manu-future
Emergence of new technologies or fields of science	X	X		X		
Technological trajectories	X			X	X	
Integration of research	X	X	X	X	X	X
Cohesion of Europe			X	X		X
Diffusion of innovation in products, processes or services				X		
Strengthened competitive position of industry				X	X	
Innovation in policy-making			X			X
Innovation in the economic sphere				X	X	X

Our earlier analysis on the Framework Programme's intervention logic tries to describe intended causal links: what causes what. Figure 7 (which is undoubtedly not exhaustive) tries to explain how such links are made, based on what is visible in the six case studies. We can see that the scientifically focused cases contain elements of discovery. The Framework is funding serious science and this leads in some cases to progress at a quite fundamental or basic level. Of course, discovery alone is not all that useful. To have societal effects, it must be placed in a wider system that connects it with needs, opportunities, production and eventually markets or other competitive arenas such as policymaking. In four of the cases, the FP made a clear contribution by increasing the volume of knowledge production, especially in relation to applications. This can involve 'translational research' (which 'pushes' fundamental knowledge towards applications) but perhaps more fundamentally makes connections with potential uses and users, often making the mix of work more interdisciplinary, since it is usually the case that the closer research gets to solving real-life problems the more disciplines need to be involved. In one case (QIPC) the Framework Programme appears to have made a decisive contribution to the development of a new discipline.

Figure 7 Impact Mechanisms in the Case Study Areas

Impact mechanisms	QIPC	Brain Research	O3	Solar PV	Auto-motive	Manu-future
Discovery	X	X	X	X		
Creating new knowledge outputs, more generally, especially moving towards applications	X	X	X	X	X	
Discipline development	X					
Focusing device in relation to innovation				X	X	X
Agenda-setting	X	X	X	X	X	X
Promoting self-organisation of stakeholder communities	X	X	X	X	X	X
Influencing regulations or standards	X	X		X	X	
Coordinating or influencing policy		X	X	X	X	X
Strengthening networks, Knowledge Value Collectives; defragmenting the research community	X		X	X	X	X
Changing research network shapes: putting Europe in the centre	X	X	X	X	N.A.	N.A.
Levering funding for R&D	X	X	X			X
Mobility and development of human capital	X	X	X	X	X	
Research infrastructure (Grids, test-beds, etc)			X			
Behavioural additionality: learning a 'new' innovation model		X			X	X
Speeding up industry entry into new technologies	X					
Tackling problems too big for an individual Member State	X	X	X			X
Addressing areas of major socio-economic importance for the EU	X	X	X	X	X	X

Three of the impact mechanisms are examples of 'arenas', with the FP providing the virtual place in which ideas are interchanged: focusing devices; agenda setting; and coordinating or influencing policy.

Nathan Rosenberg coined the term “focusing device”<sup>40</sup> for phenomena in industrial innovation that focus the attention of innovators on problems that they could solve, thereby triggering innovation. We have used the term<sup>41</sup> in a more specialised way to refer to interactions that draw the attention of the research and/or policy communities to innovation opportunities that depend on the conduct of research. In effect, industry signals ‘there is something here that we need to understand better in order to be able to innovate’. We can see examples of this happening in the Framework Programme in the three cases where there are reasonably well-developed markets.

All the cases involve agenda setting, typically by creating scientific research agendas or technological road maps. These focus the effort and increase stakeholders’ willingness to do work and invest by reducing uncertainties. In principle, this activity can be risky. What if we set the wrong agenda? In practice, these things are regularly discussed, revisited and modified. In the case of technology road maps, there are often several adequate potential solutions and a large part of the value of the road map is that it represents an agreement that everyone will work on one of them. Of prime importance is that the coordination is not done by the Commission but by the stakeholder communities themselves. The value added of the FP is to encourage and provide a setting in which that self-organisation can happen.

A similar logic applies to influencing regulation or standards, which is a mechanism also visible among the cases. These help define how markets work, so naturally industry tends to be especially interested in his impact mechanism.

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40 Nathan Rosenberg, *Perspectives on Technology*, Cambridge University Press, 1976

41 Erik Arnold, Barbara Good and Henrik Segerpalm, *Effects of Research on Swedish Mobile Telephone Developments: The GSM Story*, VA 2008:04, Stockholm, VENNOVA, 2008

There is also a strong bidirectional link between the FP and policy. This can involve research results influencing policy, as is especially clear in the Ozone case, or policy influencing research, as with emissions requirements for vehicles. In the detail, even these apparently one-way flows are in fact two-way. Emissions policy is constrained by what is technically possible just as the problems of incrementally improving the Montreal Protocol raises research questions.

Strengthening networks has been recognised as a key function of the Framework Programme since the beginning. The scientific cases show that this is especially important in newer fields and that it is correspondingly harder to make a difference in established ones, even though there may still be good reasons for investing in such established areas. Network relations can be commercial as well as technical. One of the most important aspects is the creation of a large cadre of people in industry and in the knowledge infrastructure who understand and work with digital communications – what Bozeman and Rogers<sup>42</sup> call a Knowledge Value Collective. By this they mean a social configuration able to produce knowledge value. Conventionally, we try to count the benefits of an intervention such as a research programme in the industrial world by looking at its effects on institutions. But to a considerable extent, the community of people who work with a technology persists more strongly than institutions, especially companies.

The scientometric work strongly suggested that the Framework Programme has enabled European actors to become more central and therefore influential and powerful in R&D networks. This can be expected both to create advantage and to move the European research fabric towards the ERA vision.

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42 Barry Bozeman and Juan Rogers, 'A churn model of scientific knowledge value: Internet researchers as a knowledge value collective,' *Research Policy*, (31), 2002, pp 769-794

With most FP projects involving cost sharing, the Framework Programme rests heavily on the idea of using EU money to 'leverage' contributions from project participants. However, well before the attempts to coordinate or leverage national money via the ERA-NETs and more recently the Joint Programming Initiatives, our cases show that the FP was aligning funding and activity at national level.

Mobility and the role of the FP as a 'training school' for the research community are impact mechanisms that for accidental reasons are not much in focus in our case studies but whose importance is well understood, even if their longer-term effects are not well explored.

From time to time, there have been important examples of the Framework Programme organising test beds and other shared facilities that generate European Added Value. There are old examples in ESPRIT and RACE as well as new ones in Grid Computing and ESFRI. In our cases, this dimension did not often appear – the main example being the coordination of infrastructure in the stratospheric Ozone field, especially in connection with the large data collection campaigns. The importance of infrastructure as an impact mechanism should nonetheless not be neglected.

Especially in industry, the Framework Programme appears to have been instrumental in achieving change through the use of a more 'open' model of innovation. Once the tradition of collaboration is established, coordination and self-organisation through activities like road mapping become easier. This openness appears to have been important in introducing QPIC research to industrial partners at a very early stage, both so that they could learn and because this would provide focus to the research, which was ultimately aimed at applications in computing and communications.

In at least four of our cases, the Framework Programme partly achieved its impact because it was uniquely positioned to do the job: the problems at hand were simply too big to be tackled at the national level. In all the cases, a key reason that the Framework Programme was able to be influential was a widespread recognition of the socio-economic importance of the field.

If we relate the Framework Programme back to changes in our perspective on innovation systems, we can see that it is evolving in ways that are consistent with that understanding.

- It does not provide the simple stimuli implied by the linear models but is a complex intervention addressing research and innovation networks and systems
- As a pre-competitive, open innovation initiative, it transfers a lot of knowledge into and out of the stock of knowledge, an activity that inherently has high spillovers
- Its increasing focus on coordination and re-optimising the European innovation system at the European level helps break national lock-ins and provides a way to increase the rate of innovation
- Increasingly, it connects research and innovation to other concerns, moving towards a holistic approach to policy
- While its funding does tackle market failure, the main thrust of the Framework is towards tackling systems failure
- To this extent, it tends inter alia to occupy the policy 'space' formerly inhabited by the development pairs that no longer are viable
- By empowering stakeholder groups to develop and exploit their own strategic intelligence within a wider policy framework, it captures and exploits the power of self-organisation rather than central planning

## 5. WHAT NEXT?

Future RTD policy at the European level will become more holistic, combining innovation and research policy to a greater degree, even if we do not see the kind of government-wide integrative governance mechanisms visible at national level. The role of coordination seems likely to become even more important, posing important problems of management and governance. Understanding the continuing and longer term impacts of EU policy at this level will require innovation in governance mechanisms and in newer kinds of evaluation tools that can take better account of governance and other longer-term mechanisms and effects.

### 5.1 Policy

At the time of writing, the future of the Framework Programme is formally undecided. The design of FP8 has yet to be agreed and the budget has yet to be requested. Informally, much is already clear. The Commission's intention is to merge the RTD Framework Programme with the Competitiveness and Innovation Framework Programme (CIP) in an over-arching programme to be called 'Horizon 2020'. This will include not only the Frameworks but also the wider range of 'ERA Instruments' that sit outside the Framework Programmes and it will be backed up in 2012 by a directive that aims to reduce legal barriers to the ERA and the operation of Europe as a 'common market' for knowledge as well as goods and services. Hopefully, this represents a move towards greater holism in EU-level research and innovation policies.

With growing budgets, DG-Research has experienced major bottlenecks in administration, as it has not been allowed to increase staff in line with the budget rises. This lies behind the creation of an executive agency to handle administration and the growing use of large, decentralised instruments.

A recurring theme is the use by the Commission of new measures that leverage or 'structure' the spending of Member State resources. This not only extends the Commission's sphere of influence but also begins to change the structure of cooperation in the FP, with Member States increasingly participating 'à la carte' in a series of international cooperations.

For both administrative and policy reasons, therefore, Commission research and innovation policy are moving from inclusive measures, where the entire Union can compete in an arena defined top down, to more self-organised measures, into which stakeholders must elect themselves – and in doing so having to pass various informal tests of trust and membership of relevant stakeholder communities.

Since membership of these networks is substantially based on track record, this shift may make it even more difficult for the FP to include capacity building measures. This contrasts with some of the earlier achievements of the FP, for example in establishing and strengthening academic research capacities in IT in Greece and Ireland.

The multiplication of efforts within the Commission leads to the need for multiple responses at national level. Agencies and R&D performers alike will find it increasingly hard to keep up with the proliferation of policies and measures.

## **5.2 Evaluating and understanding the Framework Programme**

Broadly, we can conclude that the evaluation record tells us little about the achievement of high-level (policy) objectives, some things about specific or strategic objectives and quite a lot about operational objectives. Our hypothesis is that, if we can identify and understand more about impact mechanisms, it will be easier to trace not only the longer term but also the higher-level performance of the Framework

Programme. This provides an important research agenda in governance, management and evaluation.

Looking at the past Framework Programme evaluation process and methods, it is clear that these determine many aspects of what we can and cannot see when we try to understand FP impacts..

The growing professionalisation of evaluation has contributed to making it more systematic – but has probably reinforced the tendency of New Public Management-style close-coupling of evaluation to the programming cycle to abstract from the technical content of the FP. As a result, we say a lot about the generalities (“knowledge and networks”) but lose sight of the specific technical achievements and how these relate to movements in the technology frontier and changes in markets.

The low rate of methodological innovation in the evaluation record is striking. On one level, this should not be a surprise. Evaluation is a profession more than a research discipline and professionals win the contest for work by offering tried and tested formulae while evaluation customers have good organisational reasons for being risk-averse. The close link between the timing of evaluation and the programming cycle means that evaluators’ attention is effectively directed towards short-term phenomena – some of which are still in process. This in turn forces the use of participant perception as the ‘lens’ through which to evaluate and excludes the use of many other techniques that would be relevant with a longer-term perspective. Where new approaches have been tried, the returns have not always been very good. Notably, Social Network Analysis is increasingly used to describe the FP but has yet to yield many results that tell us how it works.

Linking FP data to other datasets appears promising because aspects of these external databases tell us about performance. However, such approaches require a radical increase in the ‘cleanliness’ and inclusivity

of FP databases. In some cases they can run into data protection problems because they involve using data for purposes other than those for which they were collected.

Case studies provide a rich way to get a qualitative understanding of FP impacts. They require some understanding of the fields they address and the ability for the researcher to move with the twists and turns of emerging evidence rather than solely relying on standardised techniques. The stories they generate can be confirmed by having participants and observers validate them but they are inevitably stories, lacking the satisfactory solid feel that numbers give.

Mixing scientometric and qualitative techniques turns out to be quite difficult. A key issue is matching the level of granularity. Cluster analysis proved unable to identify a level that made cognitive sense (ie one at which you can understand and tell stories) while the level of historical logic visible in the cases could not accurately be reflected in the scientometric work. Thus the match between the scope of the bibliometrics and the case studies is approximate.

Further progress in understanding longer-term impacts of the Framework Programme including, in particular, its success in reaching higher-level policy objectives can be aided by treating some of the impact mechanisms identified here as hypotheses and exploring them in particular instances. These mechanisms are largely not amenable to an aggregate statistical analysis, so we will need bigger, deeper studies of individual examples. Different parts of the Framework Programme work in different ways – large-scale surveys that ignore this fact will not help us learn much more. Increasing our understanding of the long-term impacts of the Framework Programme – and, by extension, of this style of large-scale intervention – requires some progress in methods.

First, we need more methodological experimentation. Established methods suitable for answering the short-term evaluation questions generated by the programming cycle may be as good as it gets for answering such questions – but are inadequate to the longer term. Getting a better understanding will require taking bigger methodological risks, recognising that not everything will work and therefore that in the short-term evaluation and study results will become more expensive.

Second, we need to maintain the use of multiple methods – none of the tools we can use to understand the Framework is robust in isolation, so we are forced to triangulate.

A key issue in understanding the Framework is linking micro-behaviour and macro-phenomena. For example, the increasing use of Social Network Analysis has led to a growing number of network diagrams appearing in evaluation reports whose operational meaning is essentially unknown. We simply lack a way to link the logic of what people do in networks with the network analyses. Without such an understanding, the network analysis lacks both diagnostic power and policy relevance.

Much of the Framework Programme evaluation tradition treats 'projects' as general and generalisable phenomena. The casework described here underlines the importance of the specificities of individual technologies, markets and scientific communities. It illustrates the need to (re)engage with the Framework Programme on a more technologically and scientifically specific and iterate level in order to understand its operation.

Finally, we have to pay a lot more attention to context. Not least, since the study of long term impacts supports the tendency of the Commission to move towards explicit coordination, we need to connect what happens in the Framework Programme with other policies, market and technological changes.

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