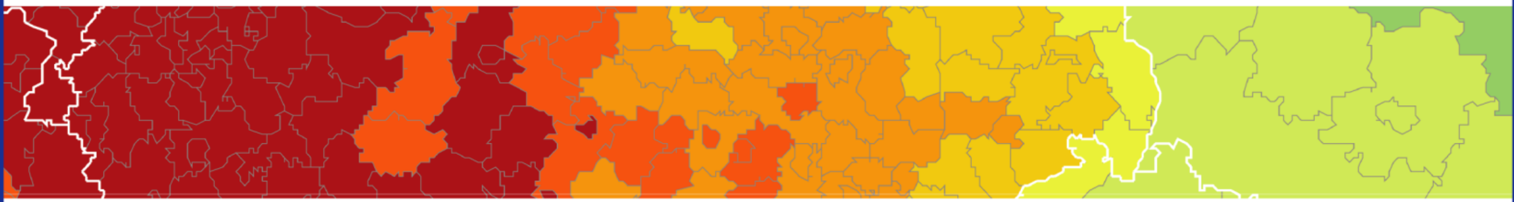
Co-financed by the European Regional Development Fund

Inspire Policy Making with Territorial Evidence



T^4 – Territorial Trends in Technological Transformations

Applied Research

Synthesis Report

Draft Synthesis Report

This applied research activity is conducted within the framework of the ESPON 2020 Cooperation Programme.

The ESPON EGTC is the Single Beneficiary of the ESPON 2020 Cooperation Programme. The Single Operation within the programme is implemented by the ESPON EGTC and co-financed by the European Regional Development Fund, the EU Member States and the Partner States, Iceland, Liechtenstein, Norway and Switzerland.

This delivery does not necessarily reflect the opinion of the members of the ESPON 2020 Monitoring Committee.

Authors	**Reposnsible for**
Politecnico di Milano (POLIMI) – Roberta Capello and Camilla Lenzi	Sections 1, 2, 3, 4, 5, 7
Technopolis Group (TG) – Reda Nausedaite	Section 6

Advisory Group
Project Support Team: Marinko Ajduk, Wolfgang Pichler, Christine Wallez Cuevas
ESPON EGTC: Martin Gauk, György Alfoldy

Information on ESPON and its projects can be found on www.espon.eu.

The web site provides the possibility to download and examine the most recent documents produced by finalised and ongoing ESPON projects.

Contact: info@espon.eu

ISBN : 978-2-919795-59-8

Synthesis Report

T^4 – Territorial Trends in Technological Transformations

Version 06/07/2020

Disclaimer:
This document is a Synthesis report.

The information contained herein is subject to change and does not commit the ESPON EGTC and the countries participating in the ESPON 2020 Cooperation Programme.

The final version of the report will be published as soon as approved.

Table of contents

1 Aim of the project

The current technological revolution is a cumulative outcome of the interaction between specific fields of technologies. Automation, digitalisation and artificial intelligence technologies, in fact, are at the core of the technological revolution, which opens the way to a socio-economic transformation. A comprehensive and systematic picture of the technological transformation and of its intertwined regional/sectoral/technological effects is still missing and **the main aim of the present project is to cover such gap**. **The project therefore delves into the understanding of the technological transformation and of its socio-economic impacts**.

2 Definition of technological transformation

The project defines the 4.0 technological transformation as technology-driven structural socio-economic changes. In particular, it distinguishes the following types of technological transformations:

- **the restructuring of the technology invention's market**. By this transformation in the technology invention domain, market opportunities can open to newcomers and to user innovators, generating new growth opportunitites to weaker regions;
- **Industry 4.0**. This is a label for the transformation in the adoption of 4.0 tecnologies in industries characterised by batch production. This transformation leads to the smart factory which is based on cyber-physical systems (CPS), comprising smart machines, storage systems, and production facilities, able to exchange information, initiate actions, and mutually control each other. Their interconnection via Internet, also termed as the Industrial Internet of Things (IIoT), generates technological leaps in engineering, manufacturing, material flow, and supply chain management.
- **Servitisation**. This transformation deals with the phenomena that are related to the creation of virtual markets thanks to digital intermediaries like Amazon, Uber, Ebay, Booking etc., leading to Internet of Things (IoT). Digital markets allow an important shift from purchasing goods to using goods and paying for the utilization, for the function or the utility they extract from the product. Moreover, digital markets enable companies to operate without owing the resources; in fact, Uber operates without owing a fleet of cars, Foodora or Justeat operate without having restaurant facilities. Consumers-to-consumer transactions are also part of Servitisation, made possible by intermediation services that organize a virtual market, on which people share their goods once they do not use them. Home sharing, car sharing, car-pooling all belong to what has been called a sharing economy.
- **Robotisation of traditional manufacturing activities**, in the case of manufacturing sectors. By this process, a manufacturing firm introduces robots replacing blue collar workers, with heavy effects on the labour market; the difference with the smart factory (i.e. with Industry 4.0 transformation) is that the last one calls for drastic reorganization of the production system, while robotisation is a labour-saving technological progress, with limited economic gains..
- **Digitalisation of traditional services**. This represents a process of digitalisation of the delivery of the service, and the product is bought thanks to the existence of the company website. The product sold is not new, the market is not new, but the delivery of the product at home is something new.

3 Where does technological transformation take place?

3.1 Spatial trends in technology markets

The changes in the technology market are deep and disruptive, provoking also **a new spatial distribution of technology's inventions**, and the consequent growth opportunities for some areas. Results show that:

- **the degree of knowledge cumulativeness is pretty high** as most of high performing regions in 4.0 technologies exploit an existing edge in 3.0 technologies (i.e. ICTs), accumulated in previous times, or an existing attitude and openness towards new technological developments in 3.0 fields. These regions are mostly located in leading countries (e.g. Germany, Scandinavian countries, France, the UK, Switzerland, Netherlands) and in advanced areas of follower countries (e.g. Italy and Spain);
- more interestingly, **regions exist able to leapfrog on the 4.0 technological frontier even in absence of a strong knowledge base in 3.0 technologies**. These regions are the **new islands of creative destruction and innovation***.* Interestingly, these areas are located both in relatively less innovative areas of leading countries (e.g. in France, UK, Sweden, the Netherlands and also one in Germany) but also in follower countries (e.g. the area traditionally known as Third Italy, Norte in Portugal, Pays Basquos, Aragona and Asturias in Spain) and, even more importantly, in Eastern countries and not only in capital regions (e.g. Poland, Czech Republic, Slovenia, Romenia). This confirms the possible rise of new islands of innovation and creative destruction in 'technologically virgin' areas;
- importantly, there a few **regions that potentially can become new islands of creative innovation** in the future if the existing 4.0 technological opportunities are valorised at most. They are all located in weak or intermediate areas of follower countries (e.g. in Central Spain and Southern Italy) but also in laggard regions in Eastern Europe (e.g. Czech Republic, Romania, Hungary);
- finally, **more than 40% of regions are excluded from substantial inventing efforts in the development of 4.0 technologies**, highlighting both the difficulties in unlocking a pre-existing technological gap (80 cases) but also of missing the opportunities of 4.0 technologies and losing the edge achieved in 3.0 technologies (i.e. 26 regions lost their niche or leader status in 3.0 and that, at present, are no 4.0 regions). Whereas the former phenomenon mainly applies to regions that traditionally have shown little knowledge intensity (mostly Eastern European regions), the latter predominantly apply to weak regions in technologically more advanced countries.

3.2 Spatial trends in servitisation, Industry 4.0 and digitalization of industry and service activities

The **transformations are sector-specific, since they differ according to the role sectors play in the production and adoption of such technologies.** In this respect, three types of sectors can be identified:

- **the 'technology' sectors can be defined as that group of sectors that produce 4.0 technologies.** The 'technology' sector includes computer and electronic product manufacturing, telecommunications, data processing, hosting, and related services, other information services, and computer systems design and associated services;
- **the 'carrier' sectors include those sectors that are the most visible and active users of digital solutions and automation.** The high adoption rate driven by the great advantages foreseen leads firms belonging to the 'carrier' sector to be creative and

become innovators themselves, frequently by applying open innovation business models based on co-design and co-creation of new technologies[1] For example, around 80 per cent of the installed robots in the world are in the automotive, computers and electronic equipment, and electrical appliances sectors. At the same time, the automotive sector is a major producer of robots, for both its own and for commercial purposes. Alternatively, high-tech sectors such as aeronautics and vehicles are among the primary users of artificial intelligence patents. On-line digital platforms are new business models which start to dominate digital services sectors and drive 4.0 technology production / adoption;

- **the 'induced' sectors represent sectors which take limited advantages from the technological revolution because of their specific production structure**. Because of their structural characteristics, in fact, these sectors are likely to enjoy lower advantages from the technological revolution. In these sectors, a total information-intensive system based on remote production machine interconnection through digital platforms does not fit the continuous production processes of such sectors. At the same time, reorganisation costs of production and management within firms to achieve efficiency gains are not contained. These sectors go through a process of robotisation and automation of some phases of the production. The efficiency advantages exist, but to a more limited extent.

Based on the industrial specialisation in the different types of sectors and on the intensity of adoption of 4.0 technologies, regions have been grouped so to identify specific technological transformation patterns, namely:

- **Servitisation**. This transformation takes place in a few number of regions, especially large city regions, characterised by a high penetration of digitalisation in service and a high entrepreneurial capacity. This last feature highlights the creative ability in exploiting such new technologies for new business models;
- **Industry 4.0**. This is present in a few number, located mainly in Southern Germany and Northern Italy;
- **digitalisation of traditional service**. This transformation is identified mainly in Southern Italy regions, some regions in Spain, parts of the UK (with the exception of London and its surroundings), Baltic regions, regions in Norway, Northern Germany, part of the Netherlands;
- **robotisation of traditional manufacturing**. This transformation is identified especially in France, Poland, Central Italy, Hungary register the adoption of robots in induced sectors;
- **niches of robotisation.** This transformation is located mainly in Eastern countries, Greece, part of Spain and a few regions in France. These regions show a very low adoption, and a specialisation in manufacturing sectors which are however very small sectors. These areas are characterised by a very high risk of job automation.

4 Which is the economic impact and where does it take place the most?

4.1 Impact of 4.0 technology adoption on GDP growth

The impact is a rather complex element to measure, since it depends on the type of sectors involved (and therefore on the type of transformation), on the type of technology adopted, on

[1]https://www.espon.eu/sites/default/files/attachments/Policy%20Brief%20-%20Digital%20Innovation%20in%20Urban%20Environments.pdf, last visited 15/06/2020.

the capacity of the regions to exploit the technology, and on the period of time. Last but not least, the impact can be on different aspects of the economy, namely GDP or productivity growth. The project takes all these elements explicitly into account, since **only by analysing all of them one can be sure to be able to interpret the complex transformation process**. The analysis is carried out for two different periods of time, the crisis period (2007-2012) and the recovery one (2013-2017). After controlling for many other explanatory factors, **the highest GDP per capita growth is registered in the most complex and articulated technological transformations**, namely the Servitisation and the Industry 4.0 ones. Regions where the adoption is limited to niche of excellence (niches of robotisation) are characterised by the lowest rates of GDP per capita growth.

The interesting following step is therefore to directly link the GDP performance to the adoption of 4.0 technologies. **To which extent does GDP growth depend on the adoption of 4.0 technologies**? **The adoption impact is definitely positive**. **A higher increase in robots' (both in induced and technology manufacturing sectors) and in online sales' adoption in induced services generates an increase in GDP growth rate**. Over time, the impact of adoption slightly changes, decreasing for technologies that require a more complex adoption, namely robots in the technology sectors, and increasing for technologies that need a simpler adoption. This result suggests that simpler technologies require a learning process on how to be exploited in a strategic way.

The positive impact is however differentiated across technological transformations. T**he impact of the adoption of robots in technology manufacturing sectors over GDP growth is the highest in Industry 4.0 regions** followed, in terms of intensity, **by regions characterised by robotisation of traditional manufacturing**, by digitalisation of traditional service and by those that go through a servitisation. **Regions with niches of robotisation do not register any impact**. Over time, **the impact of robots in technology manufacturing sectors on GDP per capita growth increases only in Industry 4.0 regions**, while it remains constant in the other patterns of transformation regions. **A cumulative positive impact takes place over time when the adoption regards the specific technology on which the regional technological transformation is based**.

The results differ when looking at the **impact of robots in induced manufacturing sectors on GDP per capita growth** in the period 2013-2017. In this case, **the highest impacts on GDP per capita growth are registered in regions with niches of robotisation and in regions with robotisation of traditional manufacturing**, while both the 4.0 Industry regions and the Servitisation regions obtain from the adoption of such technology the lowest impact on GDP per capita growth.

Compared to what obtained in the case of robots for technology manufacturing sectors, the main message is that **regions are able to obtain the highest advantage from the specific technology that characterises their transformation**. This message is reinforced when the impact of online sales in induced services on GDP per capita growth is analysed. **Online sales' adoption in induced services, in fact, generates its highest positive impacts in terms of**

GDP per capita growth in regions characterised by digitalisation of traditional services and, to a lesser extent, in regions where Servitisation takes place.

4.2 Where do best practice cases of 4.0 technology adoption occur?

Within each transformation pattern, the degree of adoption efficiency is certainly not evenly distributed. The adoption efficiency is identified by looking at the degree of adoption and the adoption impact at the same time. **Best practices -** when a high adoption is accompanied by a high positive impact - **tend to be located in Scandinavian countries, down to Northern France and Germany, till Northern Italy**, while they are totally absent in Eastern countries. **The low adoption potential case** - when both the adoption and the impact are low - **is merely present in Eastern countries, in Greece, and some spots around Europe**. **The other two cases are in a limited number**, witnessing that the adoption of the specific transformation's technology in most cases leads to advantages. However, some exceptions exist, and are extremely interesting from a normative point of view, since they call for different kinds of policy interventions. **The high adoption efficiency case**, where there is a high impact but a low adoption, requires policy interventions on stimulating adoption, and concerns mainly France, Italy and Germany, while **the low adoption efficiency,** where adoption is high but the impact is low, calls for normative actions to increase technology exploitation. This situation characterises countries like UK, Spain and Ireland.

4.3 Impact of 4.0 technology adoption on productivity growth

Robot adoption, both in induced and technology manufacturing sectors, increases productivity growth, while online sales do not impact on such performance. In the case of robots in technology manufacturing sectors, the impact on productivity growth is constant over time, while in the case of robot in induced sectors the impact increases over time, showing, as in the case of GDP growth, a necessary period for adopters to learn how to use new technologies in traditional sectors in a strategic way.

Impact on productivity growth differ across technology. **Only robot adoption increases productivity growth, while online sales do not impact on such performance. Instead, the impact of robots in technology manufacturing sectors is concentrated in manufacturing transformation regions. The Industry 4.0 pattern registers the highest impact**. Also regions with a robotisation of their traditional manufacturing activities are able to grasp productivity gains.

Interestingly enough, the achievements of productivity growth advantages are more difficult to be grasped with respect to GDP growth advantages, as they take place mostly in the sectors strongly related to the use of the technology, and with limited spillovers to other sectors.

5 Where does the social impact take place the most?

The impact of technology adoption on the labour market has provided interesting results. Starting with the impact of technology adoption on the employment level, it seems that only **the**

adoption of robots in technology manufacturing sectors generates a negative impact on employment level in both periods and regardless the transformation pattern taken into consideration, suggesting that **robots replace jobs when adopted in technology manufacturing sectors**. **The adoption of robots and online sales in all other sectors does not seem to have a direct effect on employment levels**, in general.

An important concern is **what categories of jobs are more likely to be replaced and/or created by the introduction of robots and the servitisation and/or digitalisation of traditional services**. In fact, 4.0 technologies differ from 3.0 ones in their capacity to substitute not simply routine manual and cognitive jobs but also non-routine ones. This important issue has been analysed by examining the impact of technology adoption on the share of employment in low-skill and high-skill occupations.

Starting with **low-skilled employment**, opposite effects are at place when considering the adoption of robots and the implementation of online sales, regardless the period of time examined. **The introduction of robots in induced manufacturing sectors does replace low-skill jobs**. This effect is especially strong in manufacturing-related transformations, i.e. in Industry 4.0 and robotisation patterns. **The adoption of online sales in induced services, instead, generates an expansion of the share of low-skill jobs, a phenomenon commonly known as the rapid expansion of gig-jobs**. This effect is pervasive across all regions, regardless their transformation pattern, highlighting complex intra-regional sectoral interdependencies.

In the case of **high-skilled employment** as well, opposite effects are at place when considering the adoption of robots and the implementation of online sales, regardless the period of time examined. **The introduction of robots in both technology and induced manufacturing sectors replaces also high-skill jobs**, **with an especially strong effect in manufacturing-related transformations**, i.e. in Industry 4.0 and robotisation patterns. The adoption of online sales in induced services, instead, generates an expansion also of the share of high-skilled employment, **leading to the creation of élite jobs**. The concomitant enlargement of the low-skill and the high-skill segments (i.e. gig jobs and élite jobs), with a nil effect on total impact, erodes middle-skill jobs, **a phenomenon commonly known as polarisation**.

6 Case study analysis: common results

The development of 4.0 technologies is highly differentiated among regions within the same country. This holds for both advanced and less advanced countries, and highlights the fact that **the process is not only due to national and institutional elements**.

Two main drivers emerge for the adoption of 4.0 technologies in the regions. The first is the r**egional sectoral specialisation backed up by regional suppliers for 4.0 technologies**. This facilitates regional/national Industry 4.0 value chains. The second main driver is **internationalisation**, which emerges as either international companies operating in the region (4.0 technology adoption is driven by decisions from the parent company) or regional companies entering international markets (4.0 technology adoption is driven by market demand, pressure to adopt latest solutions in order to maintain competitiveness). This facilitates international Industry 4.0 value chains. However, specific regional aspects affect the adoption rate with Industry 4.0 presenting new challenges. In particular, common to all regions is the **lack of specialised workforce**, especially in the industrial sector. At the same time, **in less developed regions, 4.0 technologies are commonly viewed as solutions to already on-going labour shortages**. While i**n more developed regions 4.0 technologies are more commonly associated with increased efficiency, quality and revenues**.

However, adoption of 4.0 technologies is generally in its **very initial stage**. **Large potentialities for their exploitation still exist**.

7 Tailored-made policy recommendations

Policies, at both regional and urban level, have to support the technological transformation underway. Some lessons have been learnt from the results of the research, that can be helpful to suggest some policy recommendations.

1) **Policy measures should concentrate on supporting especially laggard regions the possibility to become islands of innovation, creating and supporting the necessary creativity to occur**. In this sense, the launch of training programmes for professionals and entrepreneurs with relevant background is important, so to avoid outdated skills and competences in new 4.0 technologies.

2) Much of the 4.0 technological transformation and penetration depends on the sectoral specialisation of the region. Each sector is in fact influenced by a particular technological transformation, by making use of and get advantages from specific 4.0 technologies. **Policies necessarily have to be tailored to the technological transformation present in the region**.

3) Complex technology transformations call for a blending between technological scaling up, experiment and utilisation of cutting-edge technologies, and business ideas in order to be exploited to achieve efficiency gains. **Policies have to be balanced among technological knowledge, new business opportunities and stimuli of new opportunities**.

4) **A large potential exists for such technologies to display their effects in some areas, either because of unexploited technology adoption, or because of unexploited technology adoption efficiency**. **The first case requires soft policies (through best practice examples), able to support a better use of the existing technologies, the second case incentives for further adoption**.

5) As in the previous technological revolution, capital or large cities are the drivers of the technological transformation. Instead, differently from the past, the traditional dichotomy rich and technologically leading countries vs. poor and technologically lagging behind countries is no longer true. Countries like Italy is a major driver of technology adoption in the industry sector, together with Germany, while France is a leading country in the 4.0 technological transformation in the service sector. The impression is that national digital infrastructural and regulatory conditions have strongly influenced the national trend of adoption: **the degree of technological transformation, therefore, shapes, and is shaped by, institutional and policy contexts**.

6) The impact in a region is higher when the adoption relates to the technology typical of the transformation that characterises that region. This result is in line with all previous innovation processes, and with the recent Smart Specialisation Strategy adopted by the European Commission for the present programming period, which claims that a **"one size fits all" policy is impossible to be designed for regions.** This is also valid for the 4.0 technological transformation. **Policies are called to have a nation- and region-specific nature, according to the 4.0 technological transformation profile of the region**.

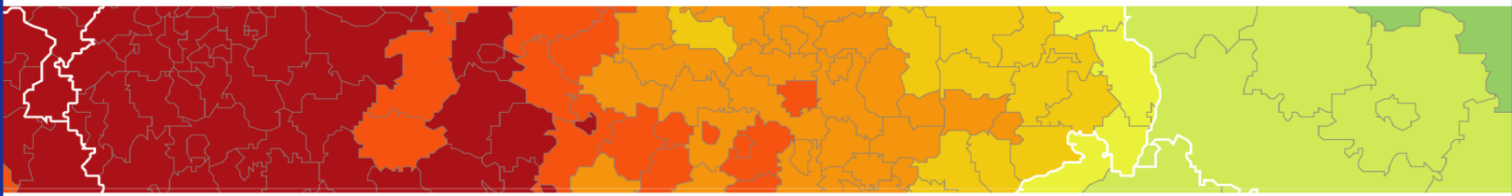
7) Best practices exist for each transformation. **Policies have to make the best use of such situations, and exploit them as pilot cases**. An efficient way to transfer the know-how from best practices, especially in the public sphere, is through cooperation agreements among local institutions. The "Oulu declaration cooperation on Digital Transformation and Smart Growth" is a good example in such respect.

8) **Policies should guarantee that Eastern countries are not be left behind in this process**. This would be a mistake that all Europe would in the long run pay in terms of integration and cohesion. However, as the policy review has shown, the aims of the existing policy measures are rarely those of overcoming adoption barriers in lagging regions**. 4.0 technologies should instead be interpreted as an effective way to solve underperformance of regions, and policy measures should be developed in such direction**.

9) **Policies to support simple technology transformations (e.g. digitalisation of traditional services) should not only concentrate their attention to hard and soft infrastructure**. They should intervene so to develop a strategic adoption of new services to achieve new efficiency levels. This is especially true for the public sector, where **the support to adoption of 4.0 technologies should be oriented not to the pure digitalisation of traditional services, but should solve needs of citizens, with a human (rather than technological) perspective**.

10) **Education and training policies – in the form of increase intake in HEI to ensure future supply of Industry 4.0 professionals, of cooperation between universities and industries in the design of curricula, of attraction of professionals from best practice regions and countries – are necessary actions to be undertaken**. The priority should be to speed on digital skills for both young people and adults by updating the Digital Education Action Plan, as suggested by the political guidelines for the European Commission 2019-2024 (van der Leyen, 2019).

11) The **substitution of jobs with technology calls for legislation for a coordinated European approach on the human and ethical implications of Artificial Intelligence**. In this respect, the proposal of the new President of the European Commissioner, Ursula von der Leyen, to develop a **new Digital Services Act** to upgrade liability and safety rules for digital platforms, services and products, **and achieve a Digital Single Market,** is well taken.



ESPON 2020 – More information

ESPON EGTC
4 rue Erasme, L-1468 Luxembourg - Grand Duchy of Luxembourg
Phone: +352 20 600 280
Email: **info@espon.eu**
www.espon.eu, **Twitter**, **LinkedIn**, **YouTube**

The ESPON EGTC is the Single Beneficiary of the ESPON 2020 Cooperation Programme. The Single Operation within the programme is implemented by the ESPON EGTC and co-financed by the European Regional Development Fund, the EU Member States and the Partner States, Iceland, Liechtenstein, Norway and Switzerland.