POLICY PAPER 175 ➤ 3 NOVEMBER 2016

JACQUES DELORS INSTITUT
BERLIN

RESKILLING FOR THE FOURTH INDUSTRIAL REVOLUTION. FORMULATING A EUROPEAN STRATEGY

Paul Jasper Dittrich | *Research Fellow at the Jacques Delors Institut – Berlin*

EXECUTIVE SUMMARY

The current wave of digital transformation is rapidly changing industrial production processes. The Internet of Things, cloud computing and other innovations facilitate a more software-driven, individual and efficient way of producing goods and services. And it presents a formidable challenge to EU policymakers, since only a successful transformation of European industry in general and of manufacturing industry in particular can ensure Europe's competitiveness in the future.

If the Fourth Industrial Revolution in the EU is to be a success, an important ingredient is bound to be the mass upgrading of the digital skills of European workers, which will enable them to keep up with the pace of technological progress. This means that in education policy policymakers are primarily concerned with reskilling and upskilling opportunities for companies, employees and skilled craftsmen. Furthermore, reskilling opportunities should be industry-specific and provided at a local level. The main obstacle to a comprehensive provision of reskilling opportunities for European citizens is the multi-faceted digital divide within the European Union. Without outside support, less innovative European regions and SMEs may well miss out on the current wave of digital transformation. In the absence of a regional or internal capacity to develop reskilling programmes or to find out more about the possibilities of new production methods, many European manufacturing companies could easily be outcompeted by their American and Asian rivals.

The need to develop reskilling programmes for connected production and the multi-faceted digital divide within the EU should encourage European policymakers to develop a European reskilling approach. Bearing in mind the institutional constraints within the EU concerning education policy (which to all intents and purposes is in the hands of the Member States), this policy paper makes two recommendations with regard to the development of a European reskilling strategy.

1. Build a "European Coalition for Reskilling and Digitizing Industry" consisting of large European manufacturing companies which can help SMEs throughout the EU to develop their own reskilling programmes. The coalition would be modelled on the Digital Skills and Jobs Coalition.
2. Upgrade the network of Digital Innovation Hubs into a network for innovation and skills development and training. Digital Innovation Hubs can function as regional facilitators that bring together regional SMEs seeking reskilling opportunities and large companies in the European Coalition for Reskilling outlined in 1.

TABLE OF CONTENTS

INTRODUCTION - THE SUCCESSFUL DIGITAL TRANSFORMATION OF INDUSTRY IS VITAL FOR FUTURE EU COMPETITIVENESS

The ongoing digital transformation continues to generate a steady demand for workers with increasingly sophisticated digital skills. This process is multi-dimensional. Thus workers with highly specialized ICT skills[1] are very much sought after. The EU Commission estimates that there could be a shortage of around 800,000 ICT specialists in the EU by 2020.[2] However, digital skills in general are now needed in almost all types of work, including many non-desk jobs.[3] A third dimension is the fact that there is a growing need to reskill the existing workforce, especially in light of the Fourth Industrial Revolution and the incorporation of the Internet of Things (IoT) and cyber-physical systems into the industrial production process. This third aspect of digital skills training is analysed in this paper. It seeks to contribute to the debate on the impact of digital transformation by proposing a Europe-wide strategy designed to reskill workers for the requirements of connected production.

> "THE 2016 MARKET CAPITALIZATION OF THE FOUR LARGEST AMERICAN TECHNOLOGY COMPANIES IS ALMOST AS HIGH AS ITALY'S 2015 GDP"

The terms IoT, Fourth Industrial Revolution, Industry 4.0 and cyber-physical systems are sometimes used synonymously and have recently attracted a lot of attention.[4] What is their transformational significance? The technical innovation behind the mass introduction of Internet of Things applications is to all intents and purposes the combination of platform-based communication with cloud computing, improved sensor technology and the application of sophisticated algorithms to large and unstructured pools of data generated by these sensors. This combination makes it possible to link up an almost infinite number of interconnected physical objects. In point of fact the number of devices connected to the internet is growing at a rapid pace. Juniper Research estimates that the number of connected devices, which stood at approximately 13.4 billion in 2015, will reach about 38.5 billion by 2020.[5] While IoT consumer applications such as fitness tracking bracelets and connected washing machines are already a reality, one of the main economic impacts of IoT is its application within cyber-physical systems[6] in the industrial production process. This facilitates worldwide connected production and the emergence of the "smart factory". "Smart factories" enable companies to manufacture individualized products or adapt more precisely to demand in real time. For example, machines that communicate autonomously with each other can order new parts for the production process automatically or submit a malfunction report to a control centre on another continent. The "smart factory" also opens up new possibilities of individualized and efficient customer care and smoother communication with suppliers in the supply chain logistics. This is based on cloud-based platforms and artificial intelligence.

As far as the EU is concerned, the economic implications of these developments cannot be overstated. The first two waves of digital transformation[7] first of all "disrupted" the media and publishing industries, and subsequently numerous personal services markets such as taxicabs or home cleaning. Both originated in the U.S., where their economic potential has been exploited most successfully. The 2016 market capitalization of

1. Software engineers, app developers, data analysts and other specialists with degrees in information science.
2. Speech by Vice-President Ansip at the European Policy Centre in Brussels, Turning Europe digital, preparing for future growth, 14.04.2015.
3. European Commission, The impact of ICT on job quality: evidence from 12 job profiles. Intermediate Report prepared for the European Commission by Ecorys and the Danish Technological Institute, 15.06.2016.
4. The term "Fourth Industrial Revolution" came into prominence at the 2016 annual business meeting of the WEF in Davos. See also Klaus Schwab, The Fourth Industrial Revolution, World Economic Forum, 11.01.2016.
5. Juniper Research, 'INTERNET OF THINGS' CONNECTED DEVICES TO ALMOST TRIPLE TO OVER 38 BILLION UNITS BY 2020, Juniper Research Press Release, 28.07.2015.
6. A cyber-physical system (CPS) can be described as a system in which software and hardware (for example a machine) are intertwined, and which is steered by an algorithm to perform complex tasks. Autonomous vehicles or an industrial process control system are examples of CPS applications.
7. The Internet of Content in the 1990s (File-sharing, Napster) and the Internet of People in the 2000s (Social media, app-economy, platform-based business models).

the four largest American technology companies (Facebook, Google, Microsoft and Apple) is almost as high as Italy's 2015 GDP, which speaks volumes about the technological supremacy of the US in the ICT sector. However, the current transformation directly affects manufacturing industries, a vital sector for the EU and one where it has a considerable competitive edge. European manufacturing companies, which are often SMEs, manage to survive in a very competitive environment by producing high value-added and specialized goods for the world market.

Can the current digital transformation, the Fourth Industrial Revolution, endanger this competitive edge? The fears of both European managers and politicians are based on the belief that future competitiveness will be determined by algorithms and (American) software applications, for example, as in connected cars, and that profits will be generated mainly by licencing such software, and not by improving the "hardware" ("software is eating the world").[8] Thus the current European attitudes to IoT and robotics/automation have set off alarm bells. Europe may have lost the first round of digital innovation to the U.S., but it should not lose the second. Retaining the competitive edge in industrial production, and retaining jobs and know-how in the EU by getting on the digital transformation train as fast as possible is an existential objective.[9] However, surveys of manufacturing companies and skilled craftsmen show that a majority of SME companies is unaware of the concept and possibilities of IoT and connected production. According to the EU Commission, around 60% of large companies and more than 90% of SMEs feel that they are lagging behind in the field of digital innovation.[10] For this reason the majority of European governments have created public-private platforms to accompany the transformation of their industries and provide information about its technological impact. Plattform Industrie 4.0 in Germany is the most prominent example of such a partnership.[11] In May 2016 the EU unveiled the "Digitising European Industry" initiative, which is part of the Digital Single Market strategy (DSM). It aims, among other things, to promote and interlink these Member State initiatives, and to give SMEs access to technology and information about new production processes.[12]

If all this is managed successfully, the technological advances of IoT, automation and artificial intelligence can yield substantial efficiency gains and greater wealth for the European economies. Manufacturing companies will certainly not be the only beneficiaries. Craftsmen with VR glasses or dentists with 3D printers will be able to improve the quality of their services by using the possibilities of increased connectivity and individualized production.

> "THE CONNECTED PRODUCTION OF THE FUTURE MEANS THAT RESKILLING IS OF CRUCIAL IMPORTANCE"

In any case, one of the main ingredients of success in the digital transformation of industry will be to find the right approach to the acquisition of skills and training. The connected production of the future means that reskilling is of crucial importance. This paper is devoted to analysing the impact of the IoT revolution on digital skills and training, and to suggesting an EU strategy designed to develop and foster reskilling initiatives for connected production throughout Europe. The remainder of the paper is structured as follows. The next section is a brief summary of the impact of IoT on skills and training. The two ensuing sections re-examine the multi-faceted digital divide within the EU and between the Member States, and contain a proposal on how a European Reskilling Coalition for Digitizing Industry could be used to provide reskilling opportunities for SMEs on a regional basis in conjunction with the new European Digital Innovation Hubs.

8. The phrase was originally coined by investor Marc Andreesen in a 2011 Wall Street Journal essay. On software and industry he writes: "Software is also eating much of the value chain of industries that are widely viewed as primarily existing in the physical world", Marc Andreesen, Why Software is eating the World, Wall Street Journal, 20.08.2011.
9. Richard Smirke, "European Commission Unveils Details on Digital Single Market", billboard, 19.04.2016.
10. European Commission, Pan-European Network of Digital Innovation Hubs (DIHs).
11. Plattform Industrie 4.0 Homepage.
12. European Commission, Digitising European Industry. Reaping the full benefits of a Digital Single Market, 19.04.2016.

1. The IoT Revolution and Digital Skills. The Case for Reskilling

The Fourth Industrial Revolution in industrial production will need a new approach to the acquisition of skills and training as tasks become more demanding and complex. Thanks to the ongoing process of automation, the supervision of machines is gradually replacing assembly tasks on the shop floor. Workers with technical skills will also have to operate and supervise connected devices within the production line or solve problems with the help of VR glasses.[13] Thus existing skill sets, such as those in the field of mechatronics, will have to be accompanied by skills that enable employees to supervise the functioning of "smart" interconnected machines. In addition to this, what is the most probable impact of the new software-driven production methods on firms, employee structures, skills and training? Table 1 distinguishes between the impact of the current wave of digital transformation and the impact of the last wave of transformation, the "Internet of data and applications" and the platform economy in order to highlight the specific requirements for training in the age of IoT.

Table 1 ► The Digital Transformation and its Impact on Labour and Skills

IMPACT ON DIFFERENT LEVELS	"PLATFORM ECONOMY / INTERNET OF DATA AND APPLICATIONS"	"INDUSTRY 4.0" / INTERNET OF THINGS
Size and Network	"Small" technology companies, large network effects. Disruption of traditional services	Large/small companies partly become technology companies, network effects after transformation
Workforce	Few employees, highly trained, highly paid	Considerable workforce in production, middle-of-the-road incomes
Nature of Skills	Universal application of skills (tendency to freelancing)	Specialized application of skills (tendency to employment)
Digital Skills Training / Lifelong learning trajectory	University, MOOCs, "street education". Global and intangible assets-based training.	University or vocational training, reskilling, upskilling. Local, tangible and intangible assets-based and industry-specific education.

Source: authors' compilation

> "TWITTER HAS ONLY 4,000 EMPLOYEES. WHATSAPP HAD ABOUT 50 EMPLOYEES WHEN IT WAS ACQUIRED BY FACEBOOK FOR $19 BILLION"

Size and network. The market power of many platform-based technology companies derives from the size of their networks and the sophisticated manner in which their algorithms are able to make sense of the data generated by the networks. The value of a network in a two-sided market grows with the number of users and connections between the two sides within the network. Apple's app store is a good example. Developers produce apps for the app store because they know that many customers visit it. On the other hand, many customers go to the app store on account of the large variety of apps on offer.[14] Furthermore, internet platforms such as social media networks are able to acquire new members for virtually nothing, which means that growth has nothing to do with the size of the workforce.[15] Thus the majority of modern internet companies are small in terms of infrastructure, tangible assets and employees. For example, Twitter has only 4,000 employees. WhatsApp had about 50 employees when it was acquired by Facebook for $19 billion.[16] On the other hand, the Internet of Things will transform "traditional companies" that currently have very large workforces and tangible assets like machines and factories. Similarly, the potential network effects that these companies can harness by becoming more software-driven and introducing platform models are sizeable.[17] At the moment the majority of successful platform

13. Akademie der Technikwissenschaften (acatech), Kompetenzentwicklungsstudie Industrie 4.0. Erste Ergebnisse und Schlussfolgerungen, April 2016.
14. For a comprehensive introduction to the economics of platforms and multi-sided markets see David S. Evans, Platform Economics: Essays on Multi-Sided Businesses, Competition Policy International, 2011.
15. For example, additional costs may be incurred by higher maintenance fees for internet servers.
16. Parmy Olson, "Facebook closes $19 billion WhatsApp deal", Forbes.com, 06.10.2014.
17. Antonio Regalado, The Economics of the Internet of Things, MIT Technology Review, 20.05.2015.

companies continue to be almost exclusively technology companies. Moreover, to a certain extent the Fourth Industrial Revolution will transform many existing industries into technology companies with platform-based business models.

Workforce. Internet companies rely on powerful algorithms and sophisticated code to run their platforms and networks. The employees needed to develop these algorithms are specialists in their field who are highly trained and very well paid. On the other hand, manufacturing companies and other traditional industries have large workforces (for example, Volkswagen has 600,000 employees worldwide) which include numerous technical experts such as welders or mechatronics with middle-of-the-road incomes. Surveys of large manufacturing companies suggest that this may gradually change in the long term, though at the moment the impact of IoT on the size of the workforce is difficult to predict.[18] IoT and the introduction of connected production processes and better automation will make tasks on the shop floor more complicated and intellectually demanding, though technical skills will still be needed. In order to keep up with the pace of innovation, many of these technical experts will have to be reskilled.

Nature of skills. Internet and technology companies tend to employ highly-trained people, many of them on short-term contracts or as freelancers. There are two reasons for this. First, coding, app development and data analytics skills are very much in demand. Thus coders, data analysts and programmers are in a strong position when it comes to choosing employers, workplaces, or countries of residence. Second, their skills are essentially delocalized. The languages and programmes needed to build software applications are universal, and the skills needed to write them can be utilized in a decentralized manner and within individual time schedules. The reality of workers in manufacturing and other industries in the throes of digital transformation is rather different. Their operational skills on certain machines cannot simply be transferred to other companies, and their knowledge of the production process in particular plants makes them much less mobile and more likely to work for the same employer for a longer period of time. Even a fully connected factory will still rely on a core workforce trained for a specific production process with a specific set of applicable skills.

"RESKILLING IS ESSENTIALLY A LOCAL AND INDUSTRY-SPECIFIC CHALLENGE"

Skills training and life-long learning. YouTube tutorials, specialized forums and Massive Open Online Courses (MOOCs) provide ample opportunity to improve one's knowledge of a specific coding language or of an application. That is why for many software applications digital skills training can be organized with a minimum of physical resources and investment. On the other hand, the digital transformation of manufacturing and other industries by IoT-powered cyber-physical systems requires more sector-specific, localized and what continues to be hardware-based training that is best provided either in the region in which a company is located or even in the factory itself, since it possesses the requisite physical tools and machines. Thus reskilling is essentially a local and industry-specific challenge. It should ideally be provided by the companies themselves in close cooperation with local or regional educational partners. The German automation expert Festo is a successful example of such "Industrie 4.0" training provided by a company. It has developed its own training programmes to reskill its worldwide labour force in IoT applications, for example, the use of VR glasses on the shop floor, and is now willing to share its knowledge with other companies and educational institutions.[19] The general aim should be a decentralized distribution of knowledge and education which can provide tailor-made solutions for the specific reskilling needs of a company.

How can policymakers support such reskilling and the distribution of knowledge? Most of the Member States have realized that there is a need for regional and sector-specific IoT knowledge dissemination and have adopted programmes in conjunction with local universities, schools, companies and business associations.[20] However, the multi-faceted digital divide within the EU means that these problem-solving capabilities are spread very unevenly across Europe. There is a risk that entire regions and industries will suffer because

18. There is a widely-held belief with regard to connected production, i.e. that many well-paying middle-of-the-road jobs in manufacturing will be lost as a result of automation. A survey of German companies currently in the throes of digital transformation has revealed that most of them in fact intend to hire more employees, at least in the short term, in the wake of digital transformation, not fewer. See Verband der Bayerischen Metall- und Elektro-Arbeitsgeber, Industrie 4.0 - Auswirkungen auf Aus- und Weiterbildung in der M + E Industrie, Studie erstellt von der Universität Bremen, April 2016.
19. Festo, Industrie 4.0, Qualifizierung für die Fabrik der Zukunft.
20. For a map of existing initiatives see European Commission, Overview of European Initiatives on Digitising Industry.

their local or regional authorities, companies and educational institutions are finding it difficult to deal with the magnitude of the transformation. If the EU wants to make a difference with regard to IoT reskilling, it will have to address the multi-faceted digital divide. Its main features when it comes to digital skills and training are examined in the next section.

2. The Multi-faceted Digital Divide within the EU. Are SMEs and less innovative regions losing out?

The digital divide is a well-known concept that is used to analyze and compare the relative performance of countries, regions and social groups with regard to digital and internet-related indicators. It can be used to describe various aspects of "digital" reality. For example, it has been used in the U.S. to identify gaps in broadband access and their economic consequences,[21] or the differences in internet usage between European citizens.[22] When it comes to IoT, the concept of the digital divide can be applied to several aspects of the phenomenon in the EU. This paper examines the digital divide on three different levels (country, regional, company size) which are of relevance to reskilling and the digital transformation of industry. Table 2 provides an overview of the digital divide in these three categories.[23] The magnitude of the divide should encourage policymakers to close the gap on the European level by cooperating more closely on skills training.

Table 2 ► Three Levels of the Multi-faceted Digital Divide in the EU

LEVEL OF THE DIGITAL DIVIDE?	WHO?	HOW?
Country Level	North-west vs. South-east	Scandinavia, UK, NL and DE are leaders in ICT-related indicators, FR is in the middle group, southern/eastern Europe is at the bottom.
Regional Level	Innovative vs. less innovative regions	Accessibility of skilled labour and use of advanced ICT is higher in innovative regions.
Company Level	Large vs. small companies	Faster adoption of technology and more resources for reskilling efforts in large companies. Many small companies lack knowledge and resources.

Source: authors' compilation

2.1. Country level. A North-west and South-east divide

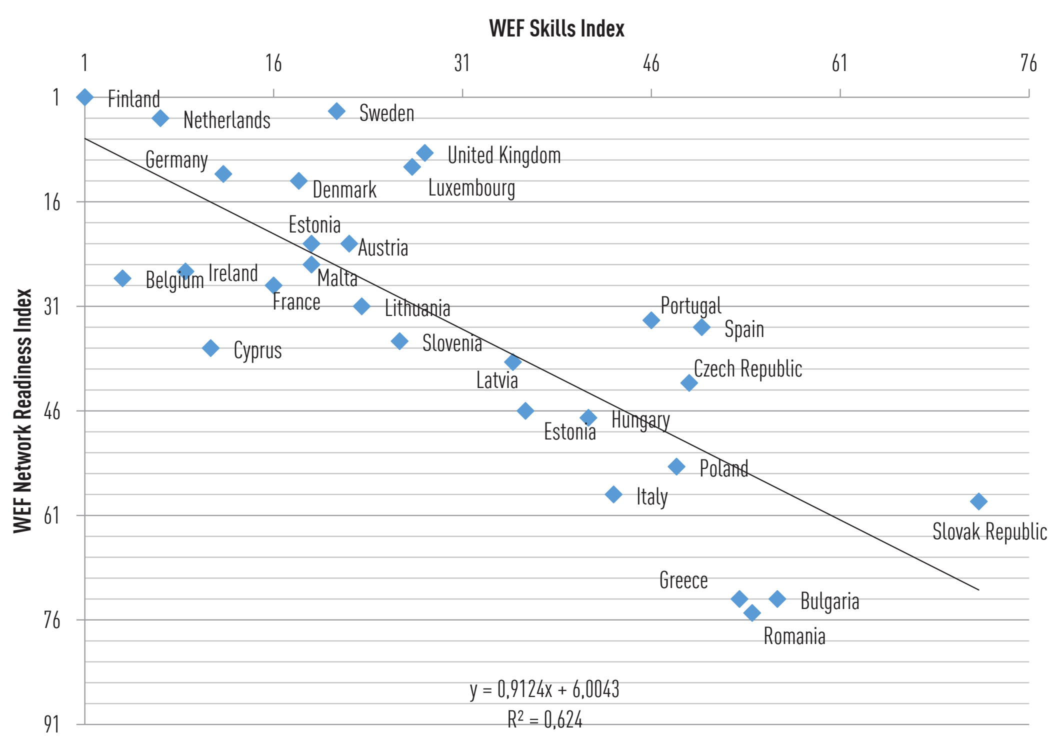
On a country level the digital European landscape is divided roughly between the north and west of the continent and the south and east. The Scandinavian countries, the UK, Ireland, the Netherlands and to a lesser extent France and Germany have managed to reap the opportunities of the digital age more successfully than many eastern and southern countries. This can be measured in terms of the size of the start-up sector, risk capital for new digital enterprises, and the percentage of ICT specialists in the workforce.[24] The overall cor-

21. Council of Economic Advisors to the White House, The Digital Divide and Economic Benefits of Broadband Access, Issue Brief March 2016.
22. European Parliament, Bridging the Digital Divide in the EU, December 2015 Briefing.
23. An interesting aspect of the digital divide that is not covered by this paper relates to the sectoral level and the differences between the ICT adoption rates in the ICT, finance and media sectors and those in the manufacturing, health care, educational and construction sectors. For more information on the sectoral dimension of the digital divide in the EU see: McKinsey Global Institute: Digital Europe: Pushing the frontier, capturing the benefits. June 2016, in collaboration with DigitalMcKinsey.
24. European Digital Score Board: Percentage of ICT specialists in employment. Scandinavian countries top the list with more than six percent of the workforce, while southern and eastern European countries employ fewer ICT specialists.

relation between economic success in the digital economy and general skills training is quite high. This is demonstrated by the WEF Networked Readiness Index of the World Economic Forum (WEF), which compares the performance of 148 countries with regard to their ability to exploit the opportunities of the offered by ICT. Graph 1 plots the overall ranking of the 28 EU-countries in the index against their ranking in the skills sub-index, which in itself is a small set of variables in the overall index computed by the WEF.

It shows that there is a considerable performance gap between EU countries. Within the Networked Readiness Index,[25] the European countries rank from second (Finland) to 75th (Bulgaria). While this is a strong indicator for the digital divide between European countries, there is also an important correlation with the rankings on the skills[26] subset of the index. EU countries on the index range from second (again Finland) to 72nd (Slovak Republic). Closing the gap on the national level calls for robust investment in general and digital skills education and training in particular. These need to be combined with other measures designed to boost the digital economy.

Graph 1 ► Networked Readiness Index vs. Skills Sub-index 2014



Source: WEF -Networked Readiness Index Total, author's visualization

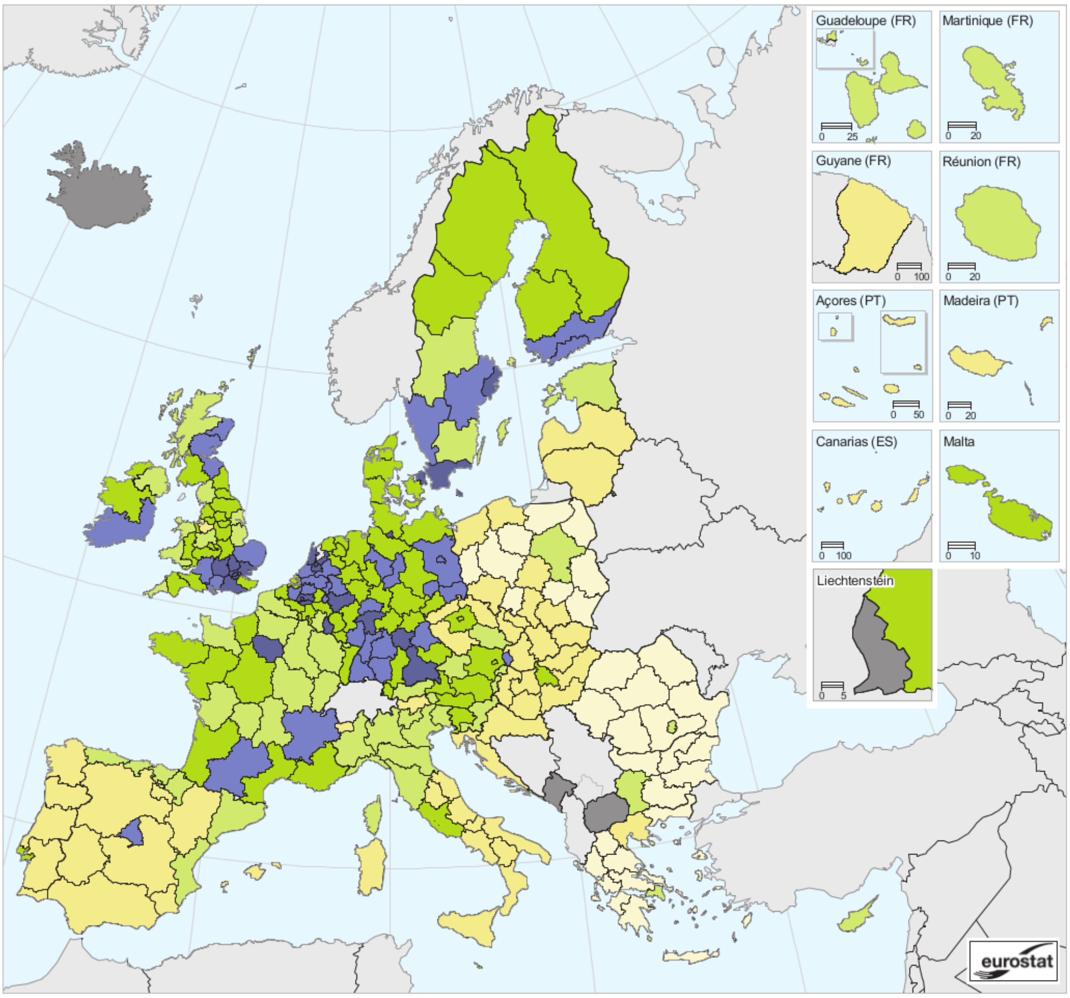
2.2. Regional level. Does a low level of innovation go hand in hand with unreadiness for IoT?

Studies suggest that the significant clustering of advanced services and tech companies in large cities and innovative regions also leads to a clustering of talented and skilled workers in these cities and regions.[27] Once regional clusters have been established, investment in the infrastructure and upmarket educational

25. The World Economic Forum's Networked Readiness Index (NRI), measures the impact of ICT on the competitiveness of nations and is computed on the basis of a large set of indicators. The NRI itself consists of 10 sub-indices (skills is one of them) which in turn build on several sub-categories.
26. The skills sub-index includes four sub-categories: quality of the educational system, quality of maths and science education, secondary education gross enrolment ratio and adult literacy rate.
27. See for example Mark Muro, Bruce Katz, The New "Cluster Moment": How regional Innovation Clusters can foster the next Economy, Metropolitan Program, September 2010.

institutions also tend to be concentrated in these regions. Such clustering dynamics can have unfortunate side effects. Thus some regions do not have access to fast broadband networks, and not enough skilled workers, and this initiates a slow and vicious circle of economic and social decline. More innovative regions in the EU do not find it particularly difficult to attract talent and capital, and to assemble enough knowledge in order to cope with the digital transformation of their industries.[28] How wide are the innovation gaps between European regions? Eurostat data provides an overview of relative regional competitiveness for the innovation sub-index (based on NUTS2) in 2013, which compared the relative potential for innovation in different European regions.

Figure 1 ► Regional competitiveness, innovation sub-index (based on NUTS 2 regions), 2013 (1)



(EU-28 = 0)

EU-28 = 0

- < -1.00
- -1.00 – < -0.50
- -0.50 – < 0.00
- 0.00 – < 0.50
- 0.50 – < 1.00
- >= 1.00
- Data not available

Administrative boundaries: © EuroGeographics © UN-FAO © Turkstat
Cartography: Eurostat — GISCO, 04/2014

0 200 400 600 800 km

(¹) Chemnitz (DED4), Leipzig (DED5), Emilia-Romagna (ITH5), Marche (ITI3), Cheshire (UKD6) and Merseyside (UKD7): estimates based on the NUTS 2006 classification.

Source: European Commission (Joint Research Centre and Directorate-General for Regional and Urban Policy), Eurostat figure accessible here. (EU-28 = 0).

28. In sociology this phenomenon is sometimes described as a variation of the Matthew Effect (advantage begets further advantage). See for example Daniel Rigley, The Matthew Effect. How Advantage begets further Advantage. Columbia University Press, 2010.

While many central and northern regions of the EU display a robust regional competitiveness, southern and eastern European regions do not do as well. It is far more difficult for companies and industry clusters in less innovative regions to acquire the resources that are needed to deal with the digital transformation of industry and to introduce new production techniques and the equipment needed for connected production facilities. Thus they should be the targets for EU reskilling efforts and the dissemination of knowledge and information

The Eurostat data reveals that there are structural weaknesses in many regions. If the EU wishes to help less innovative regions to catch up, it will have to organize a transfer of knowledge on the European level and a crossborder drive to cooperate on digital skills training. This becomes even more apparent when one considers the data on the digital divide at the company level. It shows quite clearly that smaller companies are at a disadvantage in the current digital transformation.

2.3. Company Level. Are smaller companies ready for the digital transformation?

"SMALL COMPANIES OFTEN LACK THE FINANCIAL RESOURCES AND MANPOWER NEEDED FOR FAST TECHNOLOGY ADOPTION"

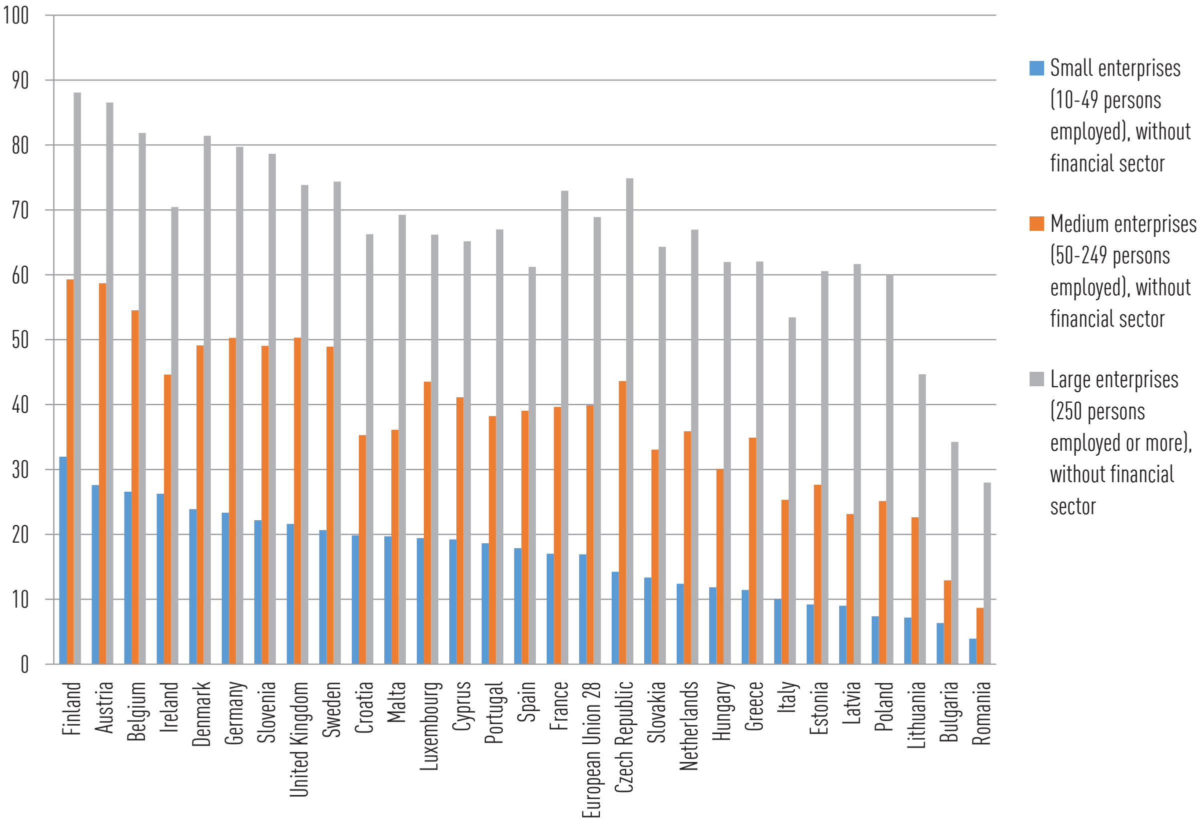
Company size matters to ICT distribution. When it comes to investment in ICT, larger companies tend to adopt and implement new cost-cutting, efficiency-boosting technology much earlier and to reap more substantial benefits.[29] On the other hand, small companies often lack the financial resources and manpower needed for fast technology adoption. Moreover, lower implementation of new technology can lead to a relative decline in productivity growth when compared with larger companies. The failure to adopt more ICT technology as a result of the large number of small companies has been identified as one of the reasons for the slowdown in productivity growth in Italy during the last two decades.[30] Such developments may well become even more noticeable with the advent of IoT and connected production. Even in the case of Germany, which is considered to be a front runner in the Fourth Industrial Revolution, there are wide-spread concerns that SMEs will not be able to cope with the introduction of connected production processes and introduce platform models fast enough.[31] The issue of IoT adoption by SMEs has been taken up by both the German government and the EU, which have set up or supported programmes and regional competence centres in order to introduce SMEs and skilled craftsmen to the new production methods by providing relevant, and specific knowledge on a regional basis.[32]

Although it is of crucial importance with regard to the acquisition of digital skills, smaller companies are also less likely than medium or larger companies (see Table 2 on the next page) to provide ICT training for their workforce. In the EU on average only around 17 percent of the small companies (10-49 employees) provide such training, which is much lower than 68 percent of the large ones (more than 249 employees). These data are not very encouraging when we consider the importance of small companies in the European economies. SMEs account for more than 60 percent of employment in EU 28. Italy, for example, stands out on account of its small manufacturing companies. Almost 70 percent of the workforce is employed by companies with less than 50 employees, one of the highest percentages in the EU.[33] At the same time Italy has one of the lowest scores when it comes to ICT skills training by companies. Only about ten percent of Italian small companies provide such training. As a result of this only a small percentage of Italian workers is currently being trained to acquire digital skills, and are certainly not being prepared for the interconnected workplace of the future. It comes as no surprise that Italy has the highest number of employees (33 percent) who stated in 2011 in the European Commission's Digital Scoreboard that "they do not feel that their digital skills are good enough to change to another job in the course of the next year."[34] Two main conclusions can be drawn from the analysis of

29. S. Fabiani, F. Schivardi, S. Trento (2005) "ICT Adoption in Italian Manufacturing: Firm Level Evidence", Industrial and Corporate Change, 14(2), 225-249. However, company size is only one aspect of ICT adoption. Others aspects that have a bearing on the adoption of new technology are the degree of specialisation, human resources, or the local industrial structure. For an overview see Stefanie Haller and Julia Siedschlag, Determinants of ICT-adoption: Evidence from firm level data, ESRI Working Paper No. 204, July 2007.
30. Fabiano Schivardi, Firm size, technology adoption and aggregate productivity, presentation at the IRIMA workshop in Brussels, 28.06.2016.
31. Christian Schröder, Herausforderungen von Industrie 4.0 für den Mittelstand, Friedrich Ebert Stiftung, 2016.
32. Bundeswirtschaftsministerium, Mittelstand 4.0 – Digitale Produktions- und Arbeitsprozesse.
33. DB Research, Business demographics and dynamics in Europe Trends in the composition of the company landscape, Research Briefing European Integration, April 2014,
34. European Commission, Digital Scoreboard ICT skills perceived as insufficient for the labour market in 2011,

employment structures and skills training on the company level in the EU. 1.) Any EU-wide reskilling strategy will have to take the needs of SMEs into account and to help them proactively in financial and logistical terms as they struggle on their own to train their employees in the skills they need most for digital transformation. 2.) Company size and employment structures are very different in various parts of the EU. Any strategy for the future will have to address these pronounced imbalances by catering as much as possible to local needs of specific companies in a given country when providing access to knowledge and training.

Graph 2 ► Enterprises providing ICT training for their employees (by company size) 2015.



Source: European Commission, Digital Scoreboard.

3. A European Training Strategy. Defining an "EU Mainboard" for Digital Skills

The multi-faceted digital divide within the EU described in the previous section should encourage European policymakers to collaborate and to work towards reducing the gaps between and within EU countries. Furthermore, the nature of the current digital transformation and the introduction of IoT-based production processes need a massive reskilling drive in the case of employees in manufacturing companies. One should not forget skilled craftsmen and workers in service industries. European cooperation would be most effective if it tried to help SMEs and less innovative regions as they struggle to deal with digital transformation. Attempts to reduce the general digital divide in the EU should be based on a policy mix that includes changes in regulation (a Digital Single Market[35]) and investment (for example, better broadband infrastructure via

35. For an overview of the proposals on the planned regulatory overhaul for a Digital Single Market see European Commission Digital Single Market Bringing down barriers to unlock online opportunities.

investments provided by the EFSI[36]). On top of this there is a need for more European solutions with regard to digital skills and reskilling.

3.1. What are the EU's competences?

Can the EU in fact deliver when it comes to digital skills? The growth in demand for such skills has put the issue of training high up on the agenda of European policymakers. In its new "Skills Agenda for Europe" published in June 2016 the EU Commission has emphasized its determination to "tackle the digital skills deficit in Europe".[37] But what can the EU actually do about digital skills? Educational policies, and these include higher education, vocational training and youth education, are in the hands of Member State policymakers. Because of the principle of subsidiarity, the EU is limited to a supportive and coordinating role. Although this principle tends to prevail even today, the Treaty of Lisbon has in fact strengthened the competences of the EU in the area of education policies. Title XII, Art. 9 TFEU states that "the Union shall take into account requirements linked to the promotion of a (…) high level of education (and) training (…)"[38]. Article 165(2) TFEU specifies the objectives of the Union with regard to education and vocational training. A genuinely European dimension in education should be accompanied by the promotion of cooperation and mobility programmes, and the development of ways of exchanging information and experiences between the Member States.[39]

> "THE COALITION FOR DIGITAL JOBS WAS ABLE TO ORGANIZE TRAINING IN DIGITAL SKILLS FOR TWO MILLION EUROPEAN CITIZENS"

How does the EU exercise these competences in the area of digital skills training? A prominent example of a recent training programme coordinated and organized by the EU is the Grand Coalition for Digital Skills. Launched in 2013, the coalition now includes more than 100 stakeholders, leading internet companies, NGOs, social partners and educational institutions which wish to provide decentralized training in digital skills for EU citizens. Each of the partners – and they include Google, Cisco and business associations – has given a pledge to train a certain number of citizens in digital skills, often in conjunction with local universities and other educational institutions. The coalition was able to organize training in digital skills, which included data analytics, modern e-marketing tools, website building and much more, for two million European citizens.[40] In June 2016 the Commission launched its successor, the Digital Skills and Jobs Coalition. Within the framework of the new coalition, the Commission has invited the Member States to build national coalitions based on the European one by mid-2017, and has once again asked for pledges by the various stakeholders to provide digital skills training throughout the EU. Google renewed its pledge to the EU as early as February 2016, after having trained one million European citizens after 2013, and announced that it intended to provide training for another one million citizens by the end of 2017.[41] One feature of the coalition is its ability to organize and support collaboration between companies and governments, and European and regional stakeholders.

3.2. Building a European Reskilling Coalition

Such EU-facilitated coalitions are a step in the right direction. If the development of digital skills programmes is left to the member states, there is a risk that the multi-faceted digital divide between them will be exacerbated. In light of the growing need for reskilling programmes in connected industries, the success of the Grand Coalition for Digital Skills should lead to the organization of another coalition specifically aimed at IoT reskilling. After its inception such a coalition should become a regional or even local facilitator of skills training, especially for SMEs and in less innovative European regions. To achieve this it should be linked to the

36. See Eulalia Rubio, David Rinald and Thomas Pellerin-Carlin, Investment in Europe: Making the best of the Juncker Plan, Notre Europe Jacques Delors Institute, Studies and Reports No. 109, March 2016.
37. European Commission, A new skills agenda for Europe. Working together to strengthen human capital, employability and competitiveness, COM(2016) 381, 10.06.2016.
38. Consolidated version of the Treaty on the Functioning of the European Union, Title XII, Art. 9.
39. European Parliament, Fact Sheets on the European Union, Higher Education.
40. EU-Commission, Digital Skills at the core of the new Skills Agenda for Europe,10.06.2016.
41. European Commission, Grand Coalition, Pledge of Google.

European Network Digital Innovation Hubs which are currently being established. Innovation Hubs provide knowledge and tools for SMEs and entrepreneurs in order to enable them to reap the rewards of connected production methods (for more information see the box on Digital Innovation Hubs on the next page). Digital Innovation Hubs can play a constructive role when it comes to educating entrepreneurs, managers and workers about the possibilities of IoT. They can also facilitate skills training and the use of new tools within the same framework. This would require the help of those who have already developed new learning tools in connected factories, e.g. large European industrial manufacturers such as Bosch, Schneider Electric and the automation expert Festo mentioned above. The Coalition for Digital Skills and Jobs provides a blueprint for another "grand coalition" devoted to reskilling manufacturing workers and skilled craftsmen for the IoT revolution. As in the case of the Digital Skills and Jobs Coalition, large manufacturers would pledge to help a certain number of SMEs throughout Europe to develop reskilling programmes for their connected production systems. Digital Innovation Hubs would function as a link between local companies and the coalition, and could gradually become skills centres.

„DIGITAL INNOVATION HUBS WOULD FUNCTION AS A LINK BETWEEN LOCAL COMPANIES AND THE COALITION, AND COULD GRADUALLY BECOME SKILLS CENTRES"

Box 1 ► Digital innovation hubs

PROVIDING INFORMATION ABOUT IOT TO EUROPEAN REGIONS AND SMES

Digital Innovation Hubs are regional centres of expertise in the areas of robotics, IoT or artificial intelligence which can act as centres of expertise for SMEs and non-tech companies. At a Digital Innovation Hub companies have an opportunity to access and gather information on new internet-enabled production processes, and to experiment with new technology. The EU is supporting and establishing these hubs as a part of the "Digitizing European Industries" initiative, which was launched by the Commission in May 2016. As one pillar of a larger programme designed to accelerate the digital transformation of European industries and the use of IoT, Digital Innovation Hubs should function as regional IoT Competence Centres[1]. These are supposed to be one-stop-shops where SMEs can learn about the technology and the development processes, and use test beds for new production methods such as Fab Labs showcasing applications for 3-D printing. The European Commission wants to have one Digital Innovation Hub in each region by 2020. By creating an EU-wide network of hubs, the EU is trying to strengthen links between the regions and in particular to help less innovative regions to set up their own hubs. €500 million have been earmarked for this purpose. The money for the Digital Innovations Hubs is channelled through the Horizon 2020 programme. In recent years several European regions and cities have set up their own Digital Innovation Hubs in order to provide know-how on the new production methods for regional and local businesses. In many cases local universities, technology centres and businesses have already become involved in the ecosystem of the Hubs.

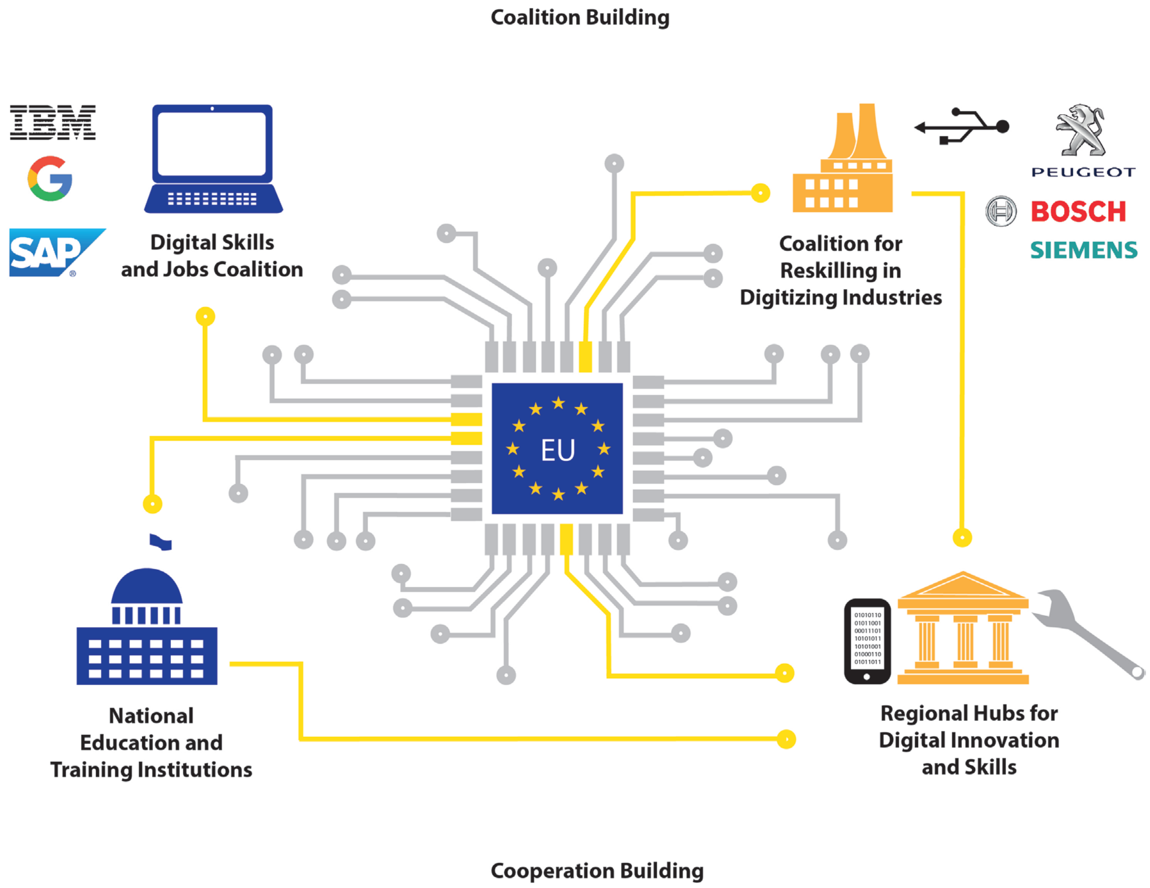
A brief scenario reveals how the coalition would work in practice. A mid-sized manufacturing company in a less innovative region, for example, from southern Italy, would like to introduce a connected production system and a platform-based cloud tool in order to be able to organize its supply chain in the Balkans more dynamically. At the regional Digital Innovation Hub the company's COO is provided with an overview of the existing IoT and cloud solutions which are in a position to re-organize the supply chain. The expertise is provided by a technology centre at the regional university and by partners from other European Innovation Hubs.

After having decided to use a specific IoT system, the COO rolls out the programme. In order to reskill his technical experts so that they can use the new production system, he turns once again to the Digital Innovation Hub, this time asking for help in developing a reskilling programme for his employees. The Digital Innovation Hub uses its European network to acquire a partner from the European Reskilling Coalition. This partner, who, for example, might well be Bosch, has pledged to help 500 SMEs in the EU in a given year to set up reskilling programmes for their connected production. After agreeing to help the Italian manufacturer, reskilling experts from Bosch come to southern Italy and help the local company to set up a reskilling programme for the new system. Documentation of the programme and learning tools are subsequently made available to the regional Digital Innovation Hub in order to build up local reskilling competences gradually in every European region.

CONCLUSIONS. ASPECTS OF A EUROPEAN MAINBOARD FOR DIGITAL SKILLS

A European Coalition for Reskilling of the kind described above could become part of a larger effort by the EU to contribute to digital skills training. By building coalitions and creating opportunities for cooperation between the various stakeholders, the EU has adopted the role of a mainboard with regard to the provision of digital skills training. According to Wikipedia, a typical microcomputer mainboard "holds and allows communication between many of the crucial electronic components of a system, such as the central processing unit (CPU) and memory, and provides connectors for other peripherals". In terms of EU policymaking this analogy aptly describes the function and added value of European policies on digital skills training within the institutional constraints that the EU is up against in the field of education policy.

Figure 2. A European Mainboard for Digital Skill Training



Source: Paul-Jasper Dittrich (2016), Reskilling for the Fourth Industrial Revolution. Formulating a European Strategy. Illustration: Nataly Haas-Arana. Copyright by Jacques Delors Institut - Berlin

A future European mainboard for digital skills and reskilling could have four main components (see graph on next page). The first two parts are already in existence. The other two elements are currently being set up or will be set up in the future. 1.) The Digital Skills and Jobs Coalition, which provides specific digital skills to citizens and companies. 2.) National and regional educational ecosystems which collaborate with local companies to develop curricula and provide training. 3.) Digital Innovation Hubs, which have already been set up in some European regions as one-stop-shop knowledge providers which can help SMEs to understand the new production technology. 4.) As a next step, the EU should bring together large manufacturing companies with experience of IoT applications and reskilling programmes for the connected production process. The manufacturers could then pledge to help a certain number of companies to set up their own reskilling programmes in conjunction with the Digital Innovation Hubs, which would then become Hubs for Digital Innovation and Skills Training.

The added value of this Mainboard for Digital Skills Training would be threefold.

1. The provision of applicable knowledge and training to IoT applications workers.
2. Helping European SMEs in less innovative areas to deal with the challenges of digital transformation of industry by providing free or low-cost training for their employees.
3. Boosting the added value of Digital Innovation Hubs as they progress to become regional centres for skills development.

The Fourth Industrial Revolution constitutes both a risk and an opportunity for the European economies. Reskilling is now a central element in the introduction of connected production. However, not all companies and regions are equally well prepared to deal with the challenges of connected production processes.

By making use of its cooperation-building and coalition-building capacities and by providing reskilling opportunities for companies and regions which are about to lag behind, the EU can make a contribution to digital skills training despite the obvious institutional constraints.

BIBLIOGRAPHY

Akademie der Technikwissenschaften (acatech), Kompetenzentwicklungsstudie Industrie 4.0. Erste Ergebnisse und Schlussfolgerungen, April 2016.

Antonio Regalado, The Economics of the Internet of Things, MIT Technology Review, 20.05.2015.

Bundeswirtschaftsministerium, Mittelstand 4.0 – Digitale Produktions- und Arbeitsprozesse.

Christian Schröder, Herausforderungen von Industrie 4.0 für den Mittelstand, Friedrich Ebert Stiftung, 2016.

Consolidated version of the Treaty on the Functioning of the European Union,

Council of Economic Advisors to the White House, The Digital Divide and Economic Benefits of Broadband Access, Issue Brief March 2016.

Daniel Rigley, The Matthew Effect. How Advantage begets further Advantage. Columbia University Press, 2010.

David S. Evans, Platform Economics: Essays on Multi-Sided Businesses, Competition Policy International, 2011.

DB Research, Business demographics and dynamics in Europe Trends in the composition of the company landscape, Research Briefing European Integration, April 2014.

EU-Commission, Digital Skills at the core of the new Skills Agenda for Europe,10.06.2016.

Eulalia Rubio, David Rinald and Thomas Pellerin-Carlin, Investment in Europe: Making the best of the Juncker Plan, Notre Europe Jacques Delors Institute, Studies and Reports No. 109, March 2016.

European Commission Digital Single Market Bringing down barriers to unlock online opportunities.

European Commission, A new skills agenda for Europe. Working together to strengthen human capital, employability and competitiveness, COM(2016) 381, 10.06.2016.

European Commission, Digital Scoreboard ICT skills perceived as insufficient for the labour market in 2011,

European Commission, Digitising European Industry. Reaping the full benefits of a Digital Single Market, 19.04.2016.

European Commission, Digitising European Industry: A key role for Europe's digital competence centres, presentation at PRACEdays 2016, 11.05.2016.

European Commission, Grand Coalition, Pledge of Google.

European Commission, Overview of European Initiatives on Digitising Industry.

European Commission, Pan-European Network of Digital Innovation Hubs (DIHs).

European Commission, The impact of ICT on job quality: evidence from 12 job profiles. Intermediate Report prepared for the European Commission by Ecorys and the Danish Technological Institute, 15.06.2016.

European Parliament, Bridging the Digital Divide in the EU, December 2015 Briefing.

European Parliament, Fact Sheets on the European Union, Higher Education.

Fabiano Schivardi, Firm size, technology adoption and aggregate productivity, presentation at the IRIMA workshop in Brussels, 28.06.2016.

Festo, Industrie 4.0, Qualifizierung für die Fabrik der Zukunft.

Haller and Julia Siedschlag, Determinants of ICT-adoption: Evidence from firm level data, ESRI Working Paper No. 204, July 2007.

Juniper Research, 'INTERNET OF THINGS' CONNECTED DEVICES TO ALMOST TRIPLE TO OVER 38 BILLION UNITS BY 2020, Juniper Research Press Release, 28.07.2015

Klaus Schwab, The Fourth Industrial Revolution, World Economic Forum, 11.01.2016.

Marc Andreesen, Why Software is eating the World, Wall Street Journal, 20.08.2011.

Mark Muro, Bruce Katz, The New "Cluster Moment": How regional Innovation Clusters can foster the next Economy, Metropolitan Program, September 2010.

McKinsey Global Institute: Digital Europe: Pushing the frontier, capturing the benefits. June 2016, in collaboration with DigitalMcKinsey.

Parmy Olson, "Facebook closes $19 billion WhatsApp deal", Forbes.com, 06.10.2014.

Plattform Industrie 4.0 Homepage.

Richard Smirke, "European Commission Unveils Details on Digital Single Market", billboard, 19.04.2016.

S. Fabiani, F. Schivardi, S. Trento (2005) "ICT Adoption in Italian Manufacturing: Firm Level Evidence", Industrial and Corporate Change, 14(2), 225-249.

Speech by Vice-President Ansip at the European Policy Centre in Brussels, Turning Europe digital, preparing for future growth, 14.04.2015.

Verband der Bayerischen Metall- und Elektro-Arbeitsgeber, Industrie 4.0 - Auswirkungen auf Aus- und Weiterbildung in der M + E Industrie, Studie erstellt von der Universität Bremen, April 2016.

On the same themes...

FROM DISTRACTION TO ACTION - TOWARDS A BOLD ENERGY UNION INNOVATION STRATEGY
Thomas Pellerin-Carlin and Pierre Serkine, Policy Paper No. 167, Jacques Delors Institute, June 2016

A DEEPENED SINGLE MARKET FOR LABOUR AND DIGITAL INNOVATION
Paul-Jasper Dittrich Policy Paper No. 164, Jacques Delors Institute, May 2016.

INVESTING IN EUROPE. MAKING THE BEST OF THE JUNCKER PLAN
Eulalia Rubio, David Rinaldi, Thomas Pellerin-Carlin, Foreword by Enrico Letta, Studies & Reports No. 109, Jacques Delors Institute, March 2016

NOTRE EUROPE
JACQUES DELORS INSTITUTE

Hertie School of Governance

Pariser Platz 6, D – 10117 Berlin
19 rue de Milan, F – 75009 Paris
office@delorsinstitut.de
www.delorsinstitut.de