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Intelligent tools driving the next great transformation:

How the European Union and the EU Member States are addressing digital transformation

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1. Executive Summary

This study has three main objectives. First, it describes what the on-going great digital transformation means to Europe, its regional and national economies, to European manufacturing sectors, what kind of future skills (human capital) are required to master it and to benefit from it; and what are the key (digital) intelligent tools/trends driving and influencing the great transformation.

Second, it explores why digital transformation matters to policy makers in the European Union and among its Member States. This study provides examples of chosen regional and national strategies to address digital transformation from various aspects.

Third, this study provides selected insights how the European policymakers and businesses should design and implement policies and strategies to meet the challenges of digital transformation.

Brazil faces digital transformation similar to the EU Member States. This study is highly relevant to Brazilian policy makers looking for ways to best adapt to and steer the digital transformation of their society based on the local conditions and characteristics.

The authors presented the key findings of this study in Brasilia, Brazil on 30 October 2018 at the Seminar in Advanced Industry, organized by the Secretariat of Technological Development and Innovation (SETEC) of the Ministry of Science, Technology, Innovation and Communications (MCTIC).

The insights and views presented in this study derive from work conducted in 2018 by the authors.

Primary sources used are EU and national expert workshops and seminars on key subjects such as artificial intelligence (AI), blockchain (DLTs), platform economy, future work skills and on regional/national/local innovation ecosystems during March-October 2018.

Discussions with individual industry and research experts have been conducted for further details and opinions on selected topics.

Secondary sources used include analysis of official and public documents on EU and national digital strategies by the European Commission, national governments, industry associations, research organizations/universities and multinational organizations.

The above sources and their analysis suggest that there is a growing European consensus why and how to prepare for digital transformation and how to develop advanced manufacturing strategies, however the levels of investments, chosen priorities and the depth of encouraging public-private partnerships/networks vary within European countries.

There also exists a momentum to advance cross-EU Member State co-operation for joint activities to share the burden for industrial innovation. This is evidenced in both the private and the public sector.

Two key observations from the analysis of the primary and secondary sources are:

- throwing money at supporting digital transformation initiatives does not produce sustainable results, if specific measures are not made to address the internal culture changes among the participating organizations

- conventional industry networks are, usually, not able to master digital transformation, where interdependencies transcend traditional boundaries and require new demand-driven business modelling and the formation of new kind of ecosystems

Many European digital policy and industry sector actions still primarily focus on accelerating technology changes, often leaving the vital, transformative human capital aspects (i.e. developing new business leadership and workforce skills) into a secondary position.

Getting the most benefits out of the current and future digital transformation requires addressing both technology developments and the human-centric aspects around it.

2. Introduction

The Great Transformation

The seminal work by Karl Polanyi (1944) on "*the great transformation*" of the European civilization from a pre-industrial to an industrial economy has been used by many economists and policymakers to examine the specific role for governmental intervention in the forming markets.

It is noteworthy to mention that Polanyi wrote his book before mainstream economics stated that self-regulation in the markets does not necessarily produce the best efficiencies when information is imperfect or the markets are incomplete (Stiglitz 2001).

Fast forward to the present day and the on-going digital transformation in the European countries. We understand that digital technologies are impacting the European societies in multiple ways, but the extent and scope remains yet undefined, we do not have all the information nor are the markets anywhere near complete. This is especially true in the digitizing industrial markets.

In a basic scenario, the best we can do in Europe is to educate our decision-makers, raise awareness among the general population and prepare our national structures to adapt to the digital transformation. In this basic scenario, the role for the European governments remains a reactive one; fostering innovation and experimentation in conventional ways that have produced series of successes and failures.

In a more advanced (activist) scenario, the role for public policy becomes a more participatory one, not merely adapting to the change, but driving and shaping the change trajectories of the digital economy – "*digital technology does not, in and of itself, dictate a single answer*" (Zysman and Kenney 2018).

This means that social and political choices are and will play central roles in determining how digital technologies will impact our societies – e.g. for the Future of Work-domain, there are policy priorities between augmenting

the workforce and/or replacing workers, chosen policies set the rules for digital platforms and acknowledging that digital technologies simultaneously replace, transform and create work.

The first chapter will first examine the European digital policy choices with selected examples: objectives of the Digital Single Market (DSM), an idea on "*softer*" digital promise stemming from past successes, an overview on research and development innovation approach in the making (Horizon Europe - FP9) and listing strategic European digital policy issues for the future.

The second chapter will highlight how five key **Intelligent Tools** are driving, enabling and influencing European digital transformation.

These tools or drivers include reflections on:

1) *the effects of automation and robotics*
2) *understanding the impact of artificial intelligence (AI)*
3) *spurring the free flow of data for wider economic benefits*
4) *the use case of 5G in smart manufacturing*
5) *bringing trust creation and cybersecurity to the forefront in European policymaking*

The third chapter will introduce three key European Commission (EC) initiatives supporting regional approach to digital transformation:

1) Digitizing European Industries (DEI)
2) EU Digital Hubs Initiative (DIH)
3) EU 2030 Skills Vision

These three EC initiatives aim at accelerating digital transformation among European companies, raising the level of awareness for action and creating the required new skills and competences for future European competitiveness.

The fourth chapter briefly presents five EU Member States fostering national growth and innovation amidst global digital transformation:

- Finland
- Germany
- Italy
- Portugal
- Sweden

The last chapter examines an active role for the policy makers to meet the challenges brought forward by digital transformation; what measures can be taken and what are the key recommendations to address the contemporary and future socio-economic changes.

3. European Digital Policies

The European Union (EU) and its Member States all acknowledge that digital transformation is changing their social and economic landscape in profound ways. Responses to this vary.

This study concludes that the EU, namely the European Commission and the selected EU Member States (Finland, Germany, Italy, Portugal and Sweden), have adopted a partially shared, activist digital policy approach.

Such a proactive European Digital Policy Approach allows the above EU Member States to prepare for addressing the wider socio-economic ramifications of digital transformation via a regional and national visions and initiatives.

In the following chapters, this study highlights how these key regional and national efforts are entwined, increasingly interdependent, thus reflecting the global nature of their target: digital transformation.

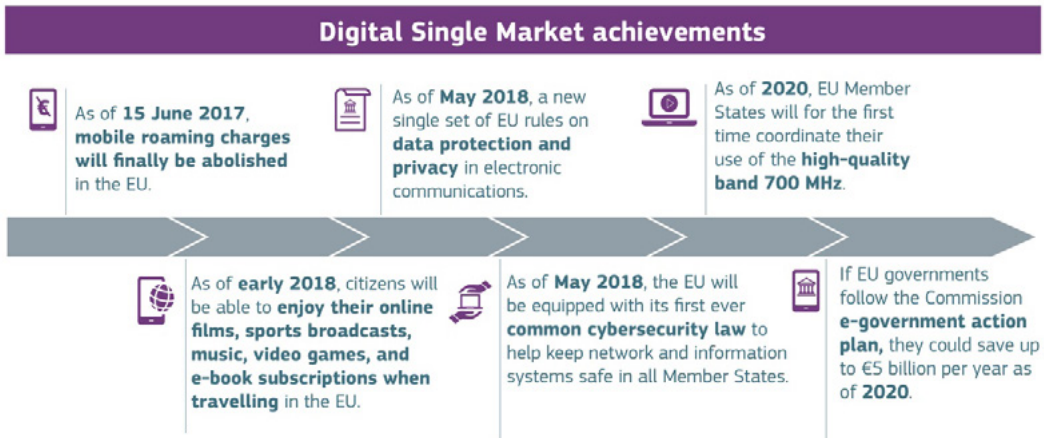
Hence, the below described policies aim at shaping the markets and addressing digital transformation with wider economic and social implications at the centre of their activities, not just focusing on technological progress.

EU Digital Single Market (DSM)

During the past 15 years or so, a common tool to analyse and picture the common European digital policy has been the progress on the EU Digital Single Market (DSM) with its envisioned goals for spurring regional and national economic growth, creating new jobs and opening new business opportunities.

The current European consensus on DSM envisions that a fully functional digital single market of a 500 million people could contribute a EUR 415 billion per annum to Europe's economy (EC, 2018).

Since 2015, advancing the DSM strategy has formed a key political priority for the EC approach. The below graph summarizes its key developments or "achievements" by 2018.



Source: European Commission, 2018

Among the DSM strategy objectives, **digital skills** and **digitizing industry and services** policy areas are of specific interest for this study. These are elaborated in the third chapter of this study.

It is also important to note, that all of the specific EC digital policy areas presented in this study are seeking co-operation between the regional and the national EU Member State strategies/activities. This has been evidenced in multiple forums and events aiming to identify synergies and joint action lines for shared goals.

In terms of generating greater efficiencies in resource allocation and shared objectives, advancing both horizontal and vertical co-operation between the EC and the EU Member States, as well as between the EU Member States themselves, is a rational approach amidst the global competition over skills, talent and ideas.

Thus, in the two DSM policy areas of digital skills and digitizing industries, views on human capital development should be a primary focus area to build for, what some researchers and thinkers call, a "*digital promise*" for all European countries.

Digital Europe Initiative

> "Having the first pan-European digital program is a major step for strengthening Europe's world leadership in the digital transformation. We will invest in key strategic digital capacities, such as artificial intelligence, high performance computing and cybersecurity, and, as is the case with all our digital initiatives, European citizens will stay at the heart of this program. One of the main pillars of the program is investment in our citizens to acquire the advanced digital skills they need for accessing and using the latest digital technologies."
>
> **Mariya Gabriel, Commissioner for the Digital Economy and Society**

The EC launched Digital Europe in summer 2018 with the intention to complement the DSM strategy. It envisions Digital Europe adding an investment arm to the DSM regulatory framework. Thus, Digital Europe is a new program and part of the "*Single Market, Innovation and Digital*" chapter of the EU's long-term budget proposal.

The Digital Europe initiative will bring forward EU investments of EUR 9.2 billion to align the next long-term EU budget 2021-2027 with increasing digital challenges.(EC 2018)

The EC proposal builds on five areas:

- **Supercomputers**: A €2.7 billion fund will be allocated to projects to build-up and strengthen supercomputing and data processing in Europe, which is crucial for the development of many areas – from health care and renewable energy to car safety and cybersecurity. The funding will ensure a more effective and wider use of supercomputing in both the public and private sectors, including small and medium-sized enterprises. The planned initiatives will build on the EU strategy on supercomputers "that will help the EU advance in many areas from health care and renewable energy to car safety and cybersecurity".

- **Artificial intelligence (AI)**: €2.5 billion is planned to help spread AI across the European economy and society. This budget builds on the EU approach on AI: the aim is to boost investments to make the most out AI, while considering the socio-economic changes brought about by AI and to ensure an appropriate ethical and legal framework. The Digital Europe program will give better access for public authorities and businesses, especially smallest ones, to AI testing and experimentation facilities in Member States, while increased investments in research and innovation under Horizon Europe will ensure that the EU stays at the forefront of scientific and technological developments in AI. The EC proposes to develop common *'European libraries'* of algorithms accessible to all, to help the public and private sectors to identify and acquire whichever solution would work best for their needs. Open platforms and access to industrial data spaces for artificial intelligence will be made available across via the EU Digital Innovation Hubs, providing testing facilities and knowledge to SMEs and local innovators.

- **Cybersecurity and trust:** €2 billion will be invested into safeguarding the EU's digital economy, society and democracies through boosting

cyberdefence and the EU's cybersecurity industry, financing state-of-the-art cybersecurity equipment and infrastructure as well as supporting the development of the necessary skills and knowledge.

- **Digital skills:** €700 million will ensure that the current and future workforce will have the opportunity to easily acquire advanced digital skills through long-and short-term training courses and on-the-job traineeships, regardless of their EU Member State of residence. In the Digital Europe program, the Digital Innovation Hubs will carry out targeted programs to help small and medium-sized enterprises and public administrations to equip their personnel with the needed advanced skills to be able access the new opportunities offered by supercomputing, artificial intelligence and cybersecurity.

- **Ensuring a wide use of digital technologies across the economy and society:** €1.3 billion will ensure the digital transformation of public administration and public services and their EU-wide interoperability and facilitate access to technology and knowhow for all businesses, notably SMEs. Digital Innovation Hubs will be 'one-stop shops' for small and medium-sized enterprises and public administrations, providing access to technological expertise and experimentation facilities, as well as advice to better assess the business case of digital transformation projects. A network of Digital Innovation Hubs will be supported, ensuring the widest geographical coverage across Europe. Digital Innovation Hubs are today one of *the key elements of the Digitising European Industry strategy*. (EC 2018).

The Digital Europe initiative links to the existing activities in EU Digital Innovation Hubs (EU DIHs) discussed later in this study and the Connecting Europe Facility (CEF), which focuses on projects of highest European added value and particularly on cross-border connections.

CEF will contribute in ensuring that all main socio-economic drivers such as schools, hospitals, and transport hubs, main providers of public services and digitally-intensive enterprises will have access to future-oriented broadband connections by 2025.

EU Future of Work-debate

> "The rise of intelligent computers can and should be good news for the economy. It will bring great material prosperity, better health, and other benefits that can't be foreseen. But a broadly shared prosperity is not automatic or inevitable. In the new age of machines, it will take humans to achieve that."
>
> **Brynjolfsson and McAfee, 2016**

The Future of Work-debate in Europe often revolves around getting smartly prepared to meet the challenges to the changing the existing labour market norms and the contemporary industrial landscapes.

EU re-industrialization or maintaining manufacturing production and skills within Europe is an important aspect in the EU Future of Work-debate. It remains a concrete challenge, but policymakers should realize that Internet usage and Internet-enabled B2B-services are strongly culture-dependent.

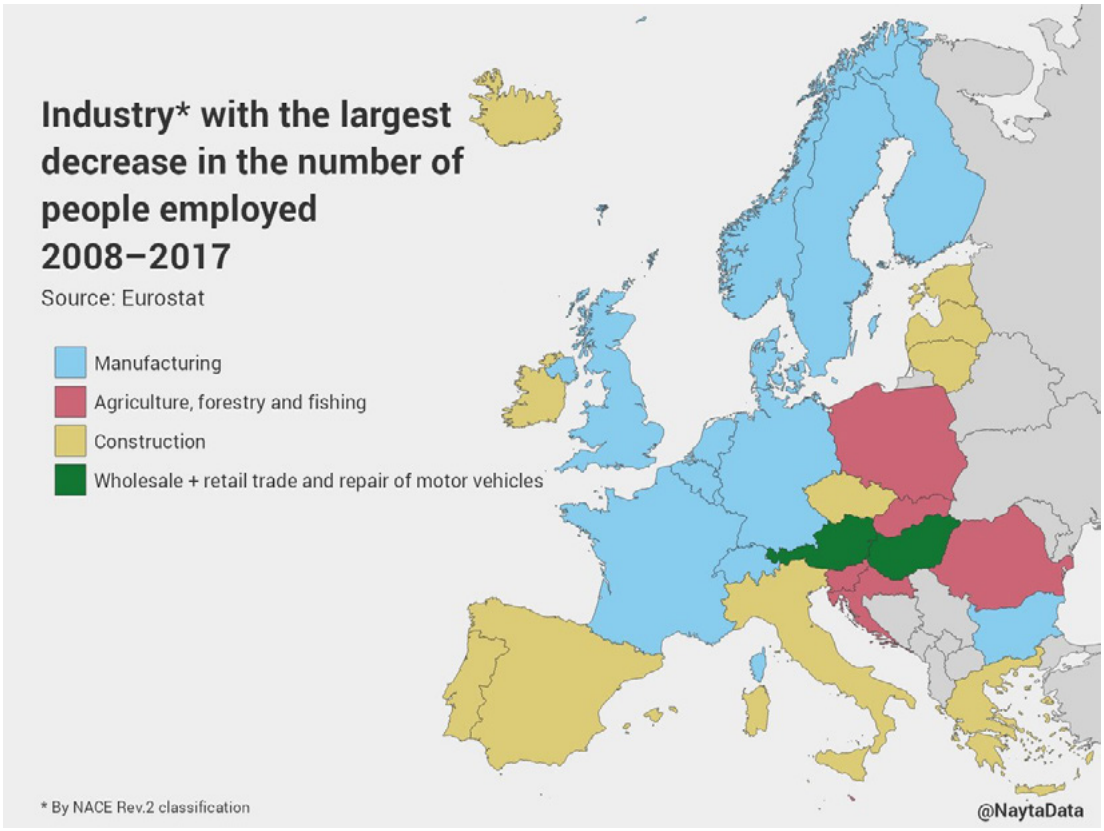
Thus, EU manufacturing policies should focus on the immobile and hard to replicate areas in production and build new innovation ecosystems around these interdependencies (ETLA, 2017).

Many of the chosen public policy approaches within the EU aim to advance national, industrial and individual-level innovation, while keeping the European assets and values for future manufacturing competitiveness and workforce skills development at the centre.

For access and availability of work is a crucial building block for economic and social stability in nations, workforce input is a key to productivity in firms and working not only provides economic means and security for individuals, but is central to their sense of identity.

Furthermore, the profound impact of digital technologies on work also transcends national boundaries influencing international relationships in multiple ways. This has resulted in hard discussions on the paths of globalization, the importance of manufacturing for nations and how to arrange work.

The below picture highlights the current challenges in the European manufacturing landscape.



Source: DEMOS, 2018

Following the above pictured labor market changes, there is an increasing debate on the positives and negatives of the digital technology-enabled transformation and how policymakers should best prepare and plan at times of *"technology and innovation surge"* (Brynjolfsson and McAfee, 2016).

The changing manufacturing landscape has resulted in the following key focus areas in the European labor market:

- Acquisition of new skills
- Adjustment to new business models or shifts in consumer preference

- Diversity and irregularity in working patterns and conditions
- Flexibility in work contracts
- Increase of part-time working
- Mobility of work and its location
- Changes in the lifetime of jobs
- Balance between periods of employment and non-employment

A digital promise and human capital development

The concept of a *digital promise* is based on the Nordic model for economic development and has been considered a model for digital transformation adaptable to all EU Member States (DEMOS, 2018).

It calls for the public and private sector activities to focus on:

- Developing digital technology solutions to fundamental problems of human well-being (e.g. poverty, illness)
- Investing resources to things that people value (e.g. health, education, free time and goods that serve identity purposes)
- Creating new digital skills and capabilities for people to transcend their previous limits

The above conceptual areas may seem a bit "soft" for some experts, but there is a concrete historical case behind them.

Without specific national strategies (around the above principles), sometimes intentionally and sometimes unintentionally, adhering to raising the educational level of Nordic populations and transcending their previous limits in skills, the Nordic countries (from the mid-1860s to the 1960s) would not have been able to transform their economies and their technology-base to become leading global manufacturing and technology nations.

The Nordic model was constructed around close co-operation between the public and private sectors on shared goals for educational priority areas.

An updated "*digital promise-story*" with specific policy recommendations has been given to policymakers working on the Finnish EU presidency in 2019. Its messages for European policy-makers aim to identify new sources for European economic competitiveness, and plan a move from a technology-driven development to more human capital-driven development.

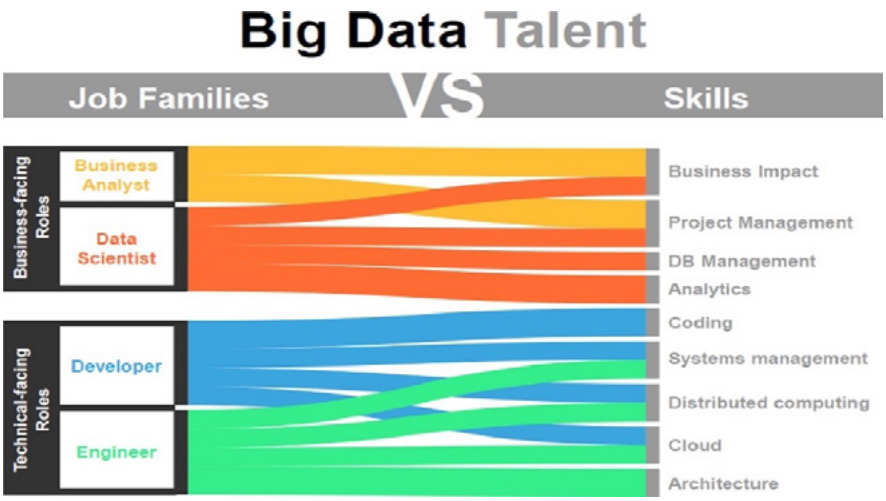
Furthermore, in October 2018, the World Bank released its "*Human Capital Index*" (HCI), with individual country briefs on the status of investments in education and basic skills development.

One of the most important findings of the HCI is that spending more on education does not equal better outcomes – the quality of education matters more than quantity in raising the skills levels of the population (World Bank, 2018).

The HCI-approach applies well to the human capital development in digital skills, we cannot all become coders, even if coders are in great demand in Europe.

The right skills are highly-dependent on wider demand and priorities – for example greater adoption of the data and platform economy clearly requires broad systems thinkers, not just data-analysts.

The below picture highlights the need from the industry for Big Data-skills by a 2017 analysis (Aalto University, 2017).



Source: Digital Disruption in Industry (DDI), Aalto University 2017

From research to markets: Horizon Europe (FP9)

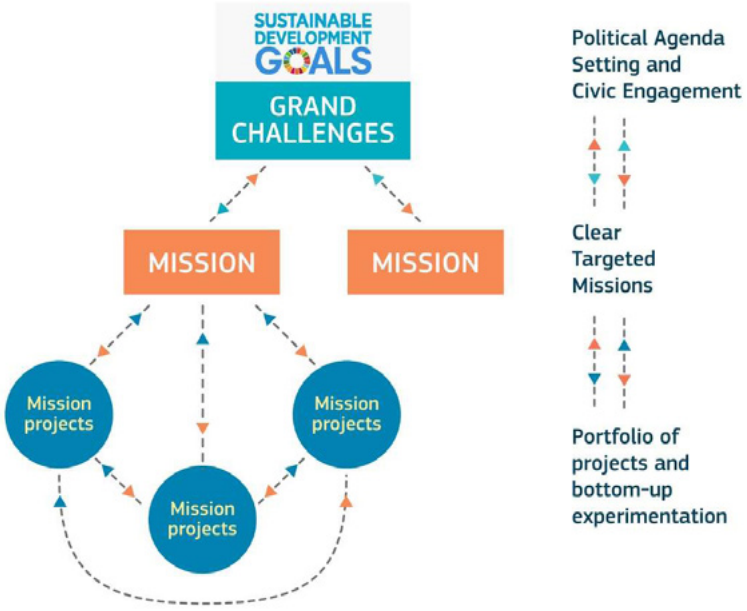
Besides the DSM strategy, the EU has fundamental instruments at its disposal outlining the framework for identifying future digital growth opportunities and skills development.

From the EU industry perspective (large companies and SMEs alike), a key one is the planned EU research and development Framework Program 9 (FP9) or "*Horizon Europe*".

Horizon Europe/FP9 officially calls for a "*mission-oriented policy approach*" for regional EU actions. The perceived missions range from "*plastics-free oceans*" to "*decreasing the burden of dementia*".

What is a common theme is the integration of several different R&D areas under a single goal to avoid siloed-projects.

The below picture describes his approach as a movement from broad societal challenges to a portfolio of more focused missions (EC 2018).



Source: European Commission 2018

The envisioned "mission-oriented" and "no-siloes approach" documented in the FP9 plans is a crucial element for creating lasting enablers for future economic growth and new business opportunities in the intelligent tools' development.

According to the industry specialists and researchers advising the EC on FP9, this will be a way to achieve less technology-driven, but a systems-driven roadmap for EU-funded R&D activities.

Furthermore, the FP9 is also seen as an important EU tool in keeping up with the US, Japan and China in developing software-oriented and demand-driven industry solutions for various sectors ranging from automotive and healthcare to energy.

Without it a there is a danger that the European R&D projects fail to have the perceived comprehensive impact.

4. Strategic issues for future EU digital policy

As the European Commission and EU Member States will address digital transformation in 2019-20, there are key future strategic issues under careful consideration (Based on an ITIF study, 2018):

1) **Creating a vision for Digital Europe.** Europe should focus on the existing core competencies and build on their supporting industries and future technologies. In the past, new emerging ICT markets have led to different firms and regions/nations gaining competitive advantage. Thus, the winners in the next digital technology development phase (e.g. robotics, autonomous systems, blockchain, quantum computing, artificial intelligence, 5G, Internet of Things...) are not yet clearly defined. European businesses should focus on winning global market share in these technology areas. European policymakers are in good position to support this goal by providing the best enabling business environment.

2) **Putting competitive advantage in the centre.** Competitive advantage needs to be the cornerstone for selected strategies and policies. The next phase in digital technologies combines them with physical things and activities (e.g. smart sectorial developments in agriculture, urban development, smart energy, smart manufacturing, autonomous and connected vehicles). Considerable strengths in engineering, with improved software capabilities, are the key. Also, defining EU developments around *Industry 4.0* in broad terms. All physical systems, including transportation, agriculture, transportation, and logistics are being digitized and these are all areas where Europe has real strengths.

3) **Seeking cross-industry and cross-border benefits.** Digitally-enabled business services present good opportunities for growth (e.g. accounting and finance, engineering services, supply chain and logistics, environmental compliance and others). Europe has real strengths in these areas and their development is supported by the EU and national government policy innovation initiatives.

4) **Reduce the digital divide within the EU.** There is a considerable gap in Europe between the frontrunners and the "laggards" — the latter being companies that have low productivity growth and limited ICT adoption. In Europe, there also is less evenly distributed adoption of ICT between industries than in the United States. A US National Bureau of Economic Research (NBER, 2017) working paper shows that the regional dispersion of productivity across firms in the European Union is about twice as large as that in the United States. This means that the digital divide between the most-productive and least-productive firms in any particular industry was higher in Europe than in the United States.

5) **Focus on proactive digital policies.** European policymakers should also consider an active policy framework which supports digital innovation and increases the attractiveness of the EU as a destination for foreign ICT investment. The EC has taken some actions, including efforts to ban data localization and harmonize spectrum policies and allocation across nations. Creating a truly European market for digital services and ensuring that emerging digital business models face the right regulatory regime is required.

In addition, to the above listed strategic issues, EU and US economists interviewed for this study have stressed that Europe should build on its relatively unique advantages such as the Public-Private Partnerships (PPPs).

In comparison to the United States, the EU is more open to PPPs as evidenced in key technology development areas. Such openness and experience should be extended to PPPs in a wide range of areas (incl. smart grid, smart cities, health IT) which can help the EU to advance in *discrete ICT areas requiring mutual trust.*

5. Intelligent tools driving digital transformation

This chapter describes the *intelligent tools* or key technology trends increasingly shaping the global digital transformation.

The intelligent tools described have become universal and accessible to all players, in fact there is a growing abundance of them, making it necessary to focus on development areas where new advantages and key differences can be created and developed.

The European Commission and the highlighted EU Member States in this study are all focusing resources on the below listed tools to advance their global position. The below selection of the intelligent tools' stems from the chosen priority areas within the EU as described in expert workshops, official publications and discussions with key policymakers

Defining the Intelligent Tools

The digital transformation of national economies, industry sectors and individual companies is dependent on digital technologies, their deployment and the socio-political context around them.

The below sections describe a set of key technology areas or *intelligent tools*, which can be considered essential for driving digital transformation in Europe.

The term intelligent tools are based on the lead author's co-operation with the University of California's project *"Work and intelligent tools and systems – WITS"* with the Berkeley Roundtable on the International Economy and the Research Institute for the Finnish Economy (ETLA).

The selected key intelligent tools are listed below. In all of these drivers, Europe maintains key advantages varying from key technology assets to skills and to a common policy approach, not necessarily leadership in specific technology development:

- Automation and robotics
- Augmented workforce
- Artificial Intelligence (AI)
- Cybersecurity
- Data flows
- Mobility – 5G

It is important to note, that the above listed global technology drivers derive from major technological innovations or disruptions, but technology alone does not explain their significance and their current pace of change, which according to many observers seems to be getting faster by the year.

First, the falling prices in computing technologies and the abundant availability of affordable services such as cloud services are moving industry investments towards technology areas deemed important for the **new data economy** such as artificial intelligence (AI) and data-driven business solutions.

This is changing the industry needs and demands for workforce skills leading to industry calls for faster government responses in the fields of education for systemic flexibility and modernization.

Second, the growing adaptation of digital technologies in communication and information networks and services has led to **new usage patterns transforming communications culture.**

This transformation in communications patterns and networking has not stopped in consumer services (B2C), but is increasingly influencing and shaping the ways of working in business interactions (B2B).

Third, the rise of digital technology-enabled **platform economy business models** in consumer services is being applied to industries with new versions of horizontal, vertical, closed and/or open platform ecosystems.

The platform approach calls for increasing information technology (IT)

investments beyond mere automatization of current industrial processes and identifying new ways how to run business and how to establish new cross-industry/cross-sectoral business models, where the smart use and sharing of data play crucial roles.

European policy responses to the above described technology drivers in the abundance of computing power, changing communication/interaction patterns and enabling platform economy business models vary in different nations – the answer depends on the specific characteristics of the country in focus.

Automation and robotics

At a recent gathering of European and US economists, professor Hal Varian of the Chief Economist of Google gave a keynote on the estimated impacts of automation at workplaces; variances between countries, industries and people depending e.g. on demographics, industry sectors and educational backgrounds were examined (ETLA, 2018).

Professor Varian stated that *"automation commonly replaces tasks, rarely replaces jobs…as most jobs are more complex than intellectuals recognize"*.

It can be said that some recent estimates on jobs being replaced by automation and robotics fail to recognize the actual complexity of tasks to be automated and how robots armed with contemporary technology cannot yet perform e.g. the job of a hotel maid.

Furthermore, professor Varian dispelled common myths and fears by using historical and modern examples to highlight how humans will continue to do non-routine manual and cognitive tasks at workplaces despite advancements in technology.

This means that out of the existing jobs, currently the routine manual and cognitive jobs are in real decline. One concrete example, is the TESLA car factory, where automated assembly line comes to a halt as robots could not fit auto parts without human intervention.

Professor Varian called this the return of the "*fitters*", an industrial term from the Henry Ford-era, when standardized auto parts required a worker called the fitter to work on them prior to putting various parts together. In April 2018, Elon Musk admitted that "*humans are sometimes superior to robots*".

Dispelling myths and fears about automation and robotics remains a crucial task in Europe. Besides professor Varian, several other Future of Work-thinkers have aimed to highlight the positives of automation, AI and robotics.

In the "digital promise"-discussion automation and robotics is often integrated to the values of smarter jobs and increased free time. Obviously, a key challenge for businesses remains to retrain the workers e.g. according to the augmented workforce-ideas.

Augmented workforce

An augmented workforce can be described as a "blend of human employees and technology on tasks together" (Accenture 2018). The utilization of digital technologies such as AI is seen essential to develop efficiency in workforces.

From the technology-driven approach this sounds an ideal way to join intelligent tools with humans. However, the challenge is the readiness for change.

Large management consultancies such as PwC, KPMG and Accenture have laboured multinational surveys of business leaders, workers and policymakers to develop indexes and scenarios to assess the current state and to plot paths for future development.

Common to most of them is identifying the challenge to transform the workforce to match the opportunities or "employers underestimate the willingness of employees to acquire the relevant skills".

In fact, one the global surveys indicated that only 3 per cent of the employers interviewed intend to significantly increase investments in trainings and reskilling programs in the near future (Accenture 2018).

The above described paradox between employer expectations and workforce concerns has been identified in many of the European regional and national initiatives as a clear call for a strong governmental role to ensure the reskilling of their working populations.

Furthermore, a 2017 Eurobarometer general survey (Special Eurobarometer 460) found out that 74 per cent of the EU respondents expected that due to the use of robots and AI, more jobs will disappear than new jobs will be created. Also 72 per cent of the EU respondents believed that robots will steal people's jobs.

However, the above survey results only deliver a partial perspective. For example, in Germany strong fears or concerns over the effect of automation are not found in national studies. The German debate calls for an active government role to mitigate the risks by new educational models, strong co-determination models between the employers and the workforce (e.g. work councils).

Similarly, in Finland a recent study found that a national strategy on the impact of automation and robotics would avoid pitfalls in social discussion and provide consensus-based responses to challenges (Finnish Ministry for Economic Affairs and Employment, 2018).

EU push for difference in Artificial Intelligence (AI)

At recent EU computer scientists' meetings, the current debate around AI in Europe takes them back in time to discussions on the promise of neural networks some 20 years ago.

However, what makes the contemporary situation different is the broad socio-economic consensus or agreement that advancements and availability in computing power, private sector's readiness to invest in the development of AI solutions and the constructive policy initiatives around AI, which are driving European AI development.

Europe is seeking an active role in AI development and deployment with strong linkages to its competitive advantages, thus focusing in areas that differ from the US and Chinese policy strategies.

EC on the principles and objectives for developing European AI

The EC has published the objectives of for its AI strategy (Communication on AI, April 2018) with the following two main principles.

First, the EU should have a coordinated approach to make the most of the opportunities offered by AI and to address the new challenges that it brings forward.

Second, the EU can lead the way in developing and using AI for good and for all, building on its values and its strengths. These have been identified by the EC as follows:

- **EU world-class research and startups**. The EU is also strong in robotics and has world-leading industry, notably in the transport, healthcare and manufacturing sectors that should be at the forefront of AI adoption.
- **Digital Single Market**. Common rules, for example on data protection and the free flow of data in the EU, cybersecurity and connectivity help companies to do business, scale up across borders and encourage investments.
- **Access and availability of data.** A wealth of industrial, research and public sector data can be unlocked to feed AI systems. The EC is promoting to make data sharing easier and to open up more data – the raw material for AI – for re-use. This includes data from the public sector in particular, such as on public utilities and the environment, as well as research and health data.

According to the EC, Europe is competitive in the global AI landscape, with bold investments that match its economic weight.

Furthermore, European stakeholders in research and innovation should develop the next generation of AI technologies, and their deployment by ensuring that companies – in particular small and medium-sized enterprises (SMEs) which make up 99% of business in the EU – are able to adopt AI. The EC states that *"no-one is left behind in the digital transformation".* (EC, 2018)

Thus, the EC calls for actions in the following areas for the EU Member States policymakers:

- AI is changing the nature of work: jobs will be created, others will disappear, most will be transformed.
- Modernization of education, at all levels, should be a priority for governments. All Europeans should have every opportunity to acquire the skills they need.
- Talent should be nurtured, gender balance and diversity encouraged.

EU industry activities around EU AI strategy

Wider adoption and innovation around AI are strongly supported by the EU industries. Industry associations, individual companies and industry ecosystems are all actively contributing to the EU-level vision, initiatives and investment roadmaps to guide the regional, national and local efforts.

It can be said that AI has galvanized European industry activities in ways which are having profound effects in EU Member States innovation policy agendas.

Many EU Member States have already published their national AI strategies or are fastly integrating AI as a key integral element in their existing national policies for growth and innovation.

A high-level expert group chaired by Pekka Ala-Pietilä, a former President of Nokia Corporation and a supervisory board member of SAP is advising the EC on the AI development and deployment topics (EC, 2018):

- **How to address AI-related mid to long-term challenges and opportunities** through recommendations which will feed into the policy development process, the legislative evaluation process and the development of a next-generation digital strategy.
- **Propose a draft on AI ethics guidelines**, covering issues such as fairness, safety, transparency, the future of work, democracy and more broadly the impact on the application of the Charter of Fundamental Rights,

including privacy and personal data protection, dignity, consumer protection and non-discrimination.

- Support further engagement and outreach mechanisms to interact with a broader set of stakeholders in the context of the **AI Alliance**, share information and gather their input on the group's and the Commission's work.

The above-mentioned focus on the **ethics of AI** is gaining further European momentum as a source for new European competitive advantage in the field. This has been supported by leading EU Member States and European industry associations/consortiums.

According to the current thinking, European AI developments should be able to gain from the specific European values and unique market conditions when facing global competition.

EU Ministerial conference in AI (AI Forum 2018)

In October 2018, Finland hosted a Ministerial conference on AI Helsinki. The conference had an objective to bring EU AI activities together, seek priorities for the coming Finnish EU Presidency in 2019 and start the work for a shared EU vision on AI with the leading question: *How do we ensure that Europe remains competitive in the age of artificial intelligence?*

Prior to the conference, several international expert workshops were arranged where the socio-economic impact of AI and digitalization were discussed. Greatest social policy challenges were identified as impacts to European employment, education and income-distribution. (Finnish Ministry for Economic Affairs, 2018).

Thus, the European social policy recommendations were identified as follows:

- National action plans on artificial intelligence should focus on innovations that complement human work, a significant share of which are social and socio-technical. Productivity will only grow extensively once artificial

intelligence technology is complemented by changes in the modes and organization of work that support the take-up of AI.

- In education contents, the need for combining technological and interaction skills should be addressed, as artificial intelligence will shape the task contents of most occupations. While the proportion of employment that can be automated in full is relatively small, a considerable share of jobs contains tasks that will be automated. This means workers will face changing skill requirements.
- Technological development is associated with a so-called skills mismatch, also in the context of artificial intelligence: there is a shortage of experts, while those with a lower education level cannot find jobs. To ensure a sufficiently high level of employment and reduce the risk of exclusion, ensuring that everyone has adequate learning skills and that the number of those with no education after comprehensive school is as small as possible is crucial.
- The scaling of AI technology makes the creation of monopolies possible. Any abuses of dominant market power should be intervened through smart regulation and competition oversight.
- Labor mobility should be supported to move workers on to tasks that are a better match with their skills, for example by improving employment services.

Cybersecurity and the creation of trust

For multiple reasons, European cybersecurity efforts are at the center of digital transformation. The below chapter will focus on trust creation as an essential element of for digitally-enabled growth and business opportunities.

To address cybersecurity issues, the EC and the EU Member States have implemented strategies at regional, national and local levels.

A good example driving the need for joint European cybersecurity developments and practices, is the increased use of cloud computing among

European industries. In 2014, the EC already laid out principles for a *safe and fair cloud computing*.

Thus, on 13 September 2017 the Commission adopted a cybersecurity package. The package presents new initiatives to further enhance EU cyber resilience and response.

For the manufacturing sector, the below key areas of the cybersecurity package are important (EC, 2017):

- **Establishing a single cybersecurity market**: The growth of the cybersecurity market in the EU – in terms of products, services and processes – is held back in a number of ways, also due to lack of a cybersecurity certification scheme recognized across the EU.
- **A joint EC-industry initiative** is working to define a *"duty of care"* principle to reduce product and software vulnerabilities and promote a *"security by design"* approach for all connected devices.
- **Implementing the Directive on security of network and information systems (NIS Directive**): It is necessary to swiftly implement NIS directive adopted in July 2016. The NIS directive focuses on required cybersecurity preparedness by Member States and promotes cooperation and common European culture of security across sectors, vital for our economy and society and moreover rely heavily on ICTs, such as energy, transport, water, banking, financial market infrastructures, healthcare and digital infrastructure. The NIS directive states that businesses in these sectors will have to take appropriate security measures and to notify serious incidents to the relevant national authority. Also, key digital service providers (search engines, cloud computing services and online marketplaces) will have to comply with the security and notification requirements under the new Directive.

Defining trust for digital transformation

Trust is a key factor in digital transformation. Without mutual levels of trust between the stakeholders, there is no real space for increased data-sharing and identifying real opportunities in the envisioned data-driven business models.

To mitigate the current lack of trust challenge, leading European businesses (in various individual sectors and cross-sector networks) have sought to establish private sector-led innovation ecosystems to learn, experiment and share best business practices.

In most cases, these innovation and/or business ecosystems aim to create secure environments for experimentation and knowledge sharing, where potential problems on security, trust and on Intellectual Property Rights (IPR) are pre-agreed with collaboration agreements.

For EU policymakers, the above kind of European industry ecosystems are dialogue forums, where private and public sector can more openly share ideas and opinions how to best address cybersecurity and digital transformation in the private sector.

Policymakers should also understand what are the regional and local driving forces for these voluntarily industry networks to tackle digital transformation as they are not miscellaneous gatherings of private sector actors nor conventional industry networks.

A common driving force for the industry-led ecosystems to address digital transformation is that they largely represent industry movements from traditional industry value-chains towards networks of intentions and interdependencies between industry actors. (ETLA, 2017).

Free flow of data

How to use, share and who owns industrial data is a currently hot topic among EU industries and policymakers. This is highlighted by the above described EC objectives on AI as well.

The issue of data management is being advanced by technology trends such as artificial intelligence, from the industry side data-driven solutions and business models and also the public discourse on data privacy, ethics and trust partly stemming from global and EU personal data management experiences.

It has also led the EU private sector to lead standard initiatives for the ethical use of data and to sponsor new industry ecosystems to create mutually agreed best practice-frameworks for data management. A key EU industry-led initiative is described below.

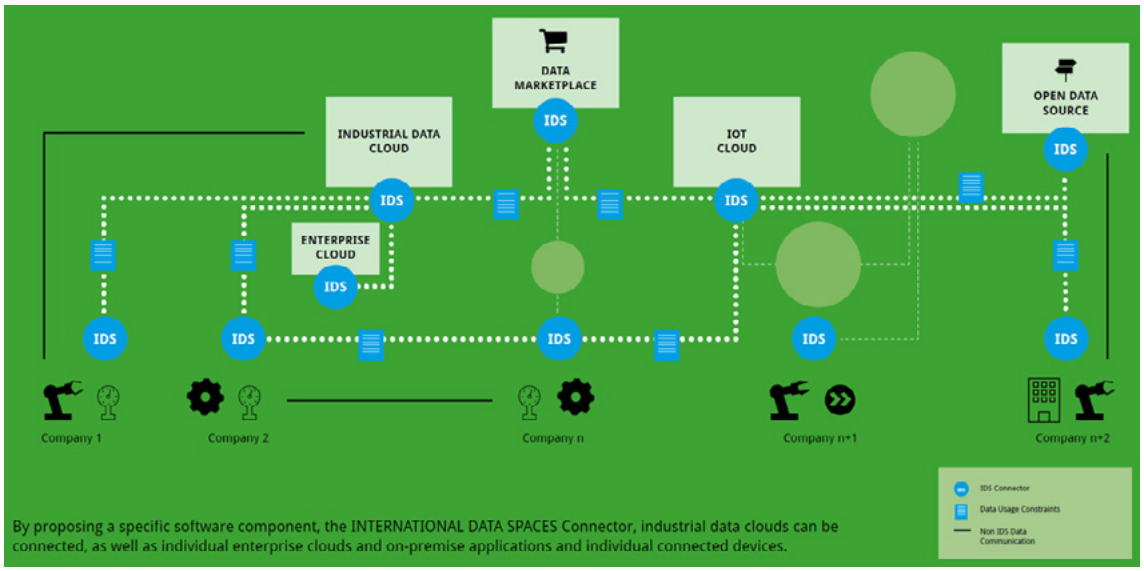
International Data Spaces Association (IDSA)

The International Data Spaces Association (IDSA, formerly *Industrial Data Spaces*) represents a growing consortium of companies, associations and research organizations. It aims to create trusted models for companies to exchange data in ways that the control remains with them.

The IDSA has strong links to German Industrie 4.0-thinking and its networks and it operates a networking model for its stakeholders. This IDSA network's key objectives are:

- to build use cases for secure data exchange
- to participate in the international standards creation over data management
- to demonstrate data-driven business models and the value of data for the companies

The below figure presents the IDSA approach for architecture and how the connectors and constraints for smart data exchange are identified. During 2017 and 2018, the promise and influence of IDSA has increased among the EU stakeholders as companies are looking for ways to meet the demand for increased data utilization and problems related to trust between companies.



Source: IDSA, 2018

EU and the free flow of non-personal data

The European Commission has introduced a plan to advance the *"free flow for non-personal data in Europe"* (most recently in August 2018). The overall objective is to enable and promote data-sharing between EU companies and greater utilization of the data in seeking new growth opportunities.

This will also highlight the need for skilled workforce in data-analytics, which according to many EU companies are already a scarce resource. Thus, the EU private sector is initiating national drives for educational reforms to create more data-analytics competences.

The EC plan states as the main barriers for increased free flow of non-personal data in the EU Digital Single Market as follows:

- unjustified data localization restrictions by Member States' public authorities
- legal uncertainty about legislation applicable to cross-border data storage and processing

- a lack of trust in cross-border data storage and processing linked to concerns amongst Member States about the availability of data for regulatory scrutiny purposes
- difficulties in switching service providers (such as cloud) due to vendor lock-in practices
- To overcome the above listed barriers, the EC is recommending new data legislation to ensure:
- free movement of non-personal data across borders. This means that every organization should be able to store and process data anywhere within the EU
- data should be made available for regulatory control. Thus, public authorities will continue to have access to data, also when it is located in another EU Member States or when it is stored or processed in the cloud
- easier switching of cloud service for professional users. Self-regulation is being endorsed and service providers are encouraged to "develop codes of conduct" to support porting data between cloud providers and downloading it back to their own IT systems
- A comprehensive cybersecurity package to apply to any security requirements in storing and processing data across borders in the EU or in the cloud

Mobility - 5G

EU 5G Infrastructure PPP

If the European policies on AI and data have galvanized the EU policymakers and industries on future opportunities and prospects, the European 5G developments builds strongly on the existing cornerstones of European technology leadership in telecom equipment and services.

This is further evidenced in the structure and objectives of the EU 5G Infrastructure PPP-program, where private sector participation and investments have surpassed planned expectations.

The 5G Infrastructure PPP is also active in creating a wide international network for joint activities, including with Brazil 5G stakeholders. Earlier in this study, the PPPs have been identified as one of the unique sources for new competitive advantage for the European industries.

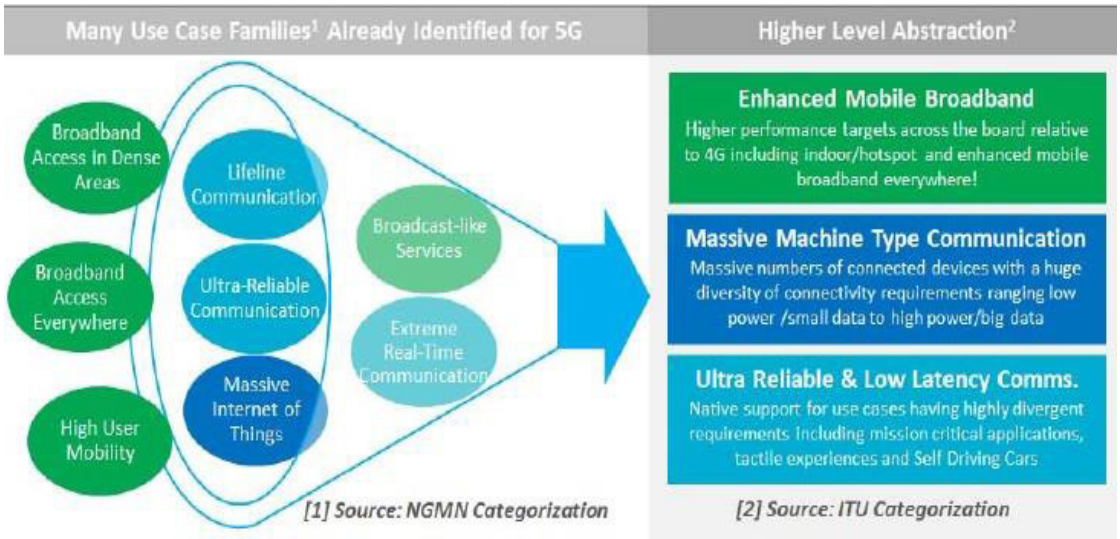
Currently, the 5G Infrastructure PPP is EUR 1.4 Billion joint initiative between the European ICT industry and the EC to rethink the infrastructure and to create the next generation of communication networks and services that will provide ubiquitous super-fast connectivity and seamless service delivery (5G Infrastructure PPP 2018).

The next chapter describes a 5G use case for the European manufacturing sector.

5G use cases for smart manufacturing

The EC and European telecom equipment providers and service providers are increasingly working on business and technology solutions which combine two EU technology strength areas: smart manufacturing and 5G.

To generate the right smart manufacturing messages on 5G opportunities, the following pictured industry benefits have been highlighted.



Source: 5G Use Case Families ITU, 2015

Manufacturer's benefits are identified as reduction of secondary tasks, which allows smart factories to focus on their main activity and adopt new processes quickly and efficiently.

Benefits for the workforce are identified e.g. through the monitoring and management of alerts. These alert management processes are usually managed and controlled by specific resources supported by dedicated systems of varying degrees of complexity.

With the deployment of new and smarter technologies within a smart factory environment, such centers can be replaced by automated and tailor-made systems. In very dangerous working environments, the health and safety of human workers could be better protected.

6. Europe: key regional activities

Europe is not alone in its quest to utilize the above described intelligent tools/ technologies to improve or maintain its global competitive position.

All global economic actors are assessing their own competences - competitive advantage in advanced-technology industries - according to the below guidelines (Moschella, 2017):

- Which nations have the most skilled programmers, engineers, and workers?
- Who has the most advanced networks and related infrastructure?
- Which countries generate global technology companies, and which do not?
- How important and effective are various industrial policies and strategies?
- Where is the national technology ecosystem doing world-class work?
- Are government ICT policies mostly effective, or counter-productive?

To answer the above considerations, the EU has initiated specific actions to emphasize the European competitiveness in manufacturing. The following chapters will describe them.

Digitizing European Industries (DEI)

Rationale for DEI

The EU manufacturing sector currently represents 16% of Europe's GDP and remains a key driver for innovation, productivity, growth and job creation within the EU Member States.

The EU manufacturing also employs around 30 million persons and twice as many in support activities such as logistics.

In such socio-economic context, the European manufacturing industry sector is the second most important sector in Europe, with a total of 23.8% of GDP (including support activities), behind only the services sector. (IDC, 2018)

The European manufacturing sector has gone through various evolution cycles over the past centuries, and the Factory of the Future is the next development of the industrial sector.

At the end of the 18th century, the arrival of electric power allowed for mass production and finally, in the middle of the 20th century, machine control and robots allowed the automated production. **Factory of the Future** (started as an EU PPP in 2012) represents the next phase of the European manufacturing industry.

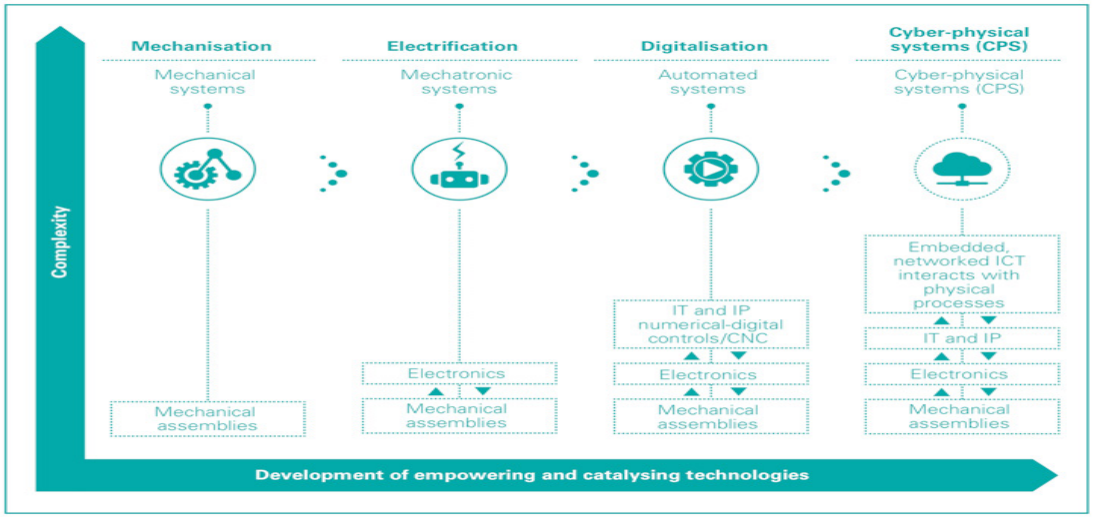
Basically, Factory of the Future merges two distinct areas: factories and the Internet.

Factories have automated production mechanisms to operate equipment without human interventions. However, factory staff are required to monitor, maintain, repair robots and tools.

On the other hand, a new area has emerged on top of the *Internet of Things* (IoT) paradigm: the CPS, Cyber Physical Systems, also called IIoT (Industrial Internet of Things) which provides factories with IoT solutions.

Here emerges the Factory of the Future-concept, *a connected factory*, representing the upcoming transformation of the manufacturing industry: **processes based on new and Internet-related technologies and innovative concepts**.

In this domain, the production and supply chains, tools and workstations communicate constantly. Machines, systems, and products exchange information both among themselves and with the external environment.



Source: Industry Lifecycle, KPMG 2017

Compared with the previous industrial technology evolutions, it is important to note that all the key technology components already exist for the Factory of the Future:

- The Internet of Things
- Big Data solutions
- Cloud applications with paradigms such as Software as a Service (SaaS), Platform as a Service (PaaS) and the next models could be Machines as a Service or Equipment as a service.

Thus, the Factory of the Future evolution is more about the integration of new IT technologies in the modes of production, relying strongly on the network infrastructure being wired or wireless.

DEI and Smart Specialisation

Besides the EU DEI, the European Commission addresses geographical and sectoral differences to adapt to digital transformation with an active cohesion policy. The Smart Specialisation Platform (S3) guides EU Member States to direct structural funds for growth-oriented policies.

Driven by the Joint Research Centre (JRC) of the EC, the S3 Platform provides advice to EU countries and regions for the design and implementation of their *Smart Specialisation Strategy* by:

- Providing guidance material and good practice examples
- Informing on strategy formation and policy-making
- Facilitating peer-reviews and mutual learning
- Supporting access to relevant data
- Training policy makers

This local conditions-based approach together with the Union-wide DEI activities works under the below principles (EC/JRC, 2018):

Smart specialisation is a place-based approach, building on the assets and resources available to regions and Member States and on their specific socio-economic challenges in order to identify unique opportunities for development and growth.

To have a strategy means to make choices for investment. Member States and regions should support only a limited number of well-identified priorities for knowledge-based investments and/or clusters. Specialization means focusing on the competitive strengths and realistic growth potentials supported by a critical mass of activity and entrepreneurial resources

Setting priorities should not be a top-down, picking-the-winner process. It should be an **inclusive process of stakeholders' involvement centred on "entrepreneurial discovery".** This is an interactive process in which market forces and the private sector are discovering and producing information about new activities, and the government assesses the outcomes and empowers those actors most capable of realizing this potential.

The strategies-chosen should embrace **a broad view of innovation**, supporting technological as well as practice-based and social innovation. This would allow each region and Member State to shape policy choices according to their unique socio-economic conditions.

A good Smart Specialisation strategy must include **a sound monitoring and evaluation system** as well as a revision mechanism for updating the strategic choices.

Structure and objectives of EU DEI

The Digitizing European Industry-policy (DEI) within the Digital Single Market (DSM) strategy aims to assist European companies of all sizes to better adopt and utilize new digital technologies. It builds strategic networks between existing national and regional initiatives to create information and best practice exchange.

Source: European Commission, 2017

A recent DEI-report (2017) presented the following list as key findings on how DEI can best network with, provide support to and endorse existing EU Member State national initiatives in the field of digitizing industry.

It was based on the analysis of 15 Member State national digitizing strategies:

• **Digitization or digitalization is a key element of national industrial policies.** Some EU Member States are among the 'trend-setters' and many are 'fast-followers' in absorbing the emerging trends.

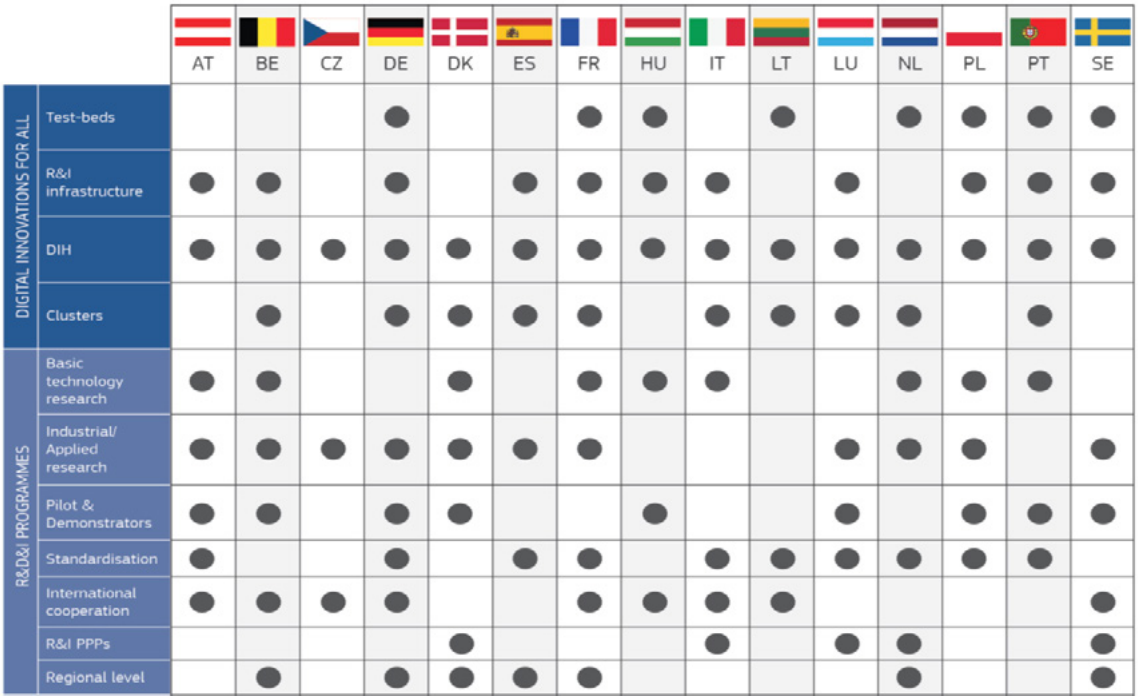
• **EU-collaboration brings added value**, prepares for legal certainties and encourages essential co-investments to successfully reach leadership positions in critical business areas.

• **Investments**: Specific measures employed by EU Member States to encourage investments in research, development and innovation (R&D&I) related to digitization include incentives and access to finance. The EU DEI strategy makes significant progress towards the mobilization of close to €50 billions of public and private investment until 2020.

• **Digital skills:** EU Member States recognize the need for digital skills and have set up actions related to education and training.

• **Synergies**: Addressing the needs of national industrial fabrics has led to a variety of measures which are anchored to the EU Member States' priorities and are often in line with European goals as well.

The below table highlights the current activities adopted by the EC DEI-unit selected EU Member States supporting digital transformation in the manufacturing sector. The EU Member States reviewed in this study are all present, except Finland, in the below table. The reason Finland is not included was related to the launch of its strategy after the DEI-study was started in 2017.



Source: European Commission, 2017

EU Network of Digital Innovation Hubs

"We need to work for SME's on the ground to master their digital transformation. This is the primary objective of the European Network of Digital Innovation Hubs." Dr. Max Lemke, DG Connect, European Commission, 2018

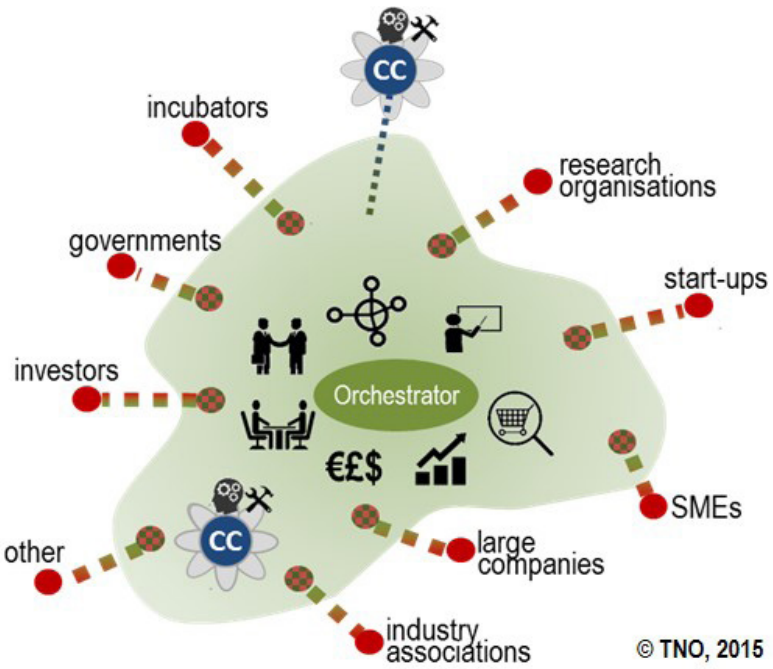
In the new Digital Europe initiative (program) Digital Innovation Hubs (DIH) have been highlighted as a cornerstone of activity to improve digital skills among EU firms and workforce.

Most EU Member States have set up national and local digital transformation networks. These national and local knowledge and competence transfer centres aim to support the digital transformation progress within their industries.

The national networks are active on a broad spectrum on their activities, but a common objective to all is to advance digital transformation among the Small and Medium-sized Enterprises (SMEs) of their respective regions.

European SMEs are considered to lack behind the large enterprises in their digitalization efforts in the EU Member States. Obviously, the situation is not as black and white, some EU SMEs actually represent the vanguard in their digitalization efforts.

The common objective for spurring digital transformation among the SMEs brings together the public and private sector stakeholders to seek and create new networks to share ideas, experiments and finding the right business rationale why and how to implement digitalization. The below picture describes the idea – cc marks the competence centre.



Source: TNO, the Netherlands, 2015

Structure and objectives of EU DIH

The EU DIH-initiative is structured along three main objectives to bring the existing national digital innovation hubs closer together.

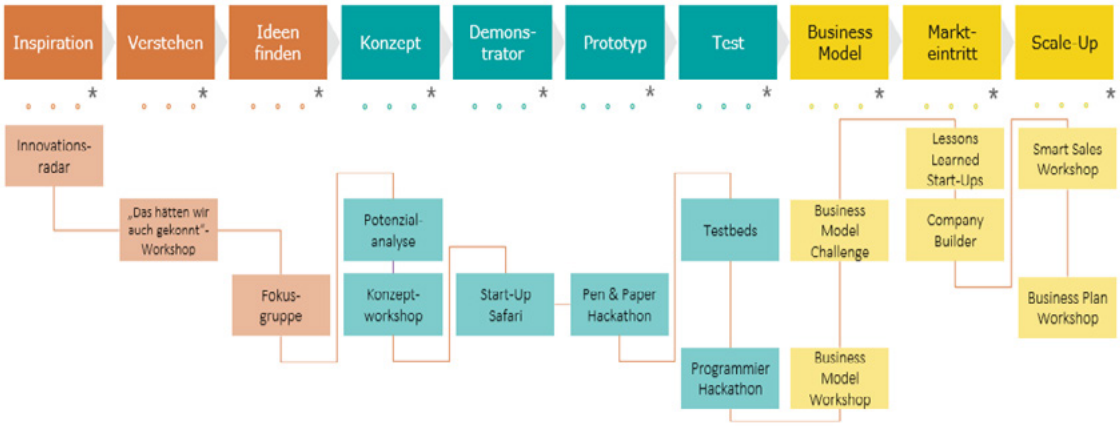
These three main objectives for the EU DIH initiative are:

1. *Upgrading EU digital innovation capacity in all sectors of the economy.* Boosting digital innovations in all sectors and building partnerships for European leadership in digital technologies in value chains and platforms

2. Adapting the regulatory framework notably on data, liability and security in line with the Digital Single Market (DSM) objectives

3. *Re-skilling and preparing the workforce* to benefit from the digital transformation of industry.

The below graph presents a German DIH (competence centre) and its operations model.



Source: Digital.Hub Logistics Dortmund – step wise support model, EC, 2018

For the EU DIH initiative, four main topics relevant to digital ecosystems and partnering have emerged:

- DIHs having focus in different dimensions, but this is a rationale for collaboration
- different approaches on how to connect competences locally and strengthening the regional innovation eco system
- how to connect to external competences
- the DIHs should connect to the before-mentioned regional EU Smart Specialisation strategy (S3)

EU 2030 Skills Vision

"The key is a future workforce that is capable and motivated to intensively work with them; thus, corporates, governments and territories need to implement skills strategies according to their contextual needs and circumstances, which will empower and ensure the skills development for excellence, prosperity and personal development by pursuing the following objectives"

EU 2030 Skills Vision preparatory document 2018

The EC has started process for an EU 2030 Vision for Smart Specialisation and Digital Transformation. This on-going vision work on future skills outlines the core objectives and plans for a common European vision in three steps:

1. Defining the objectives on the horizon of 2030
2. Formulating a comprehensive strategy with five pillars for all involved stakeholder groups
3. constructing a toolbox to provide hands-on modules to harness the full potential of the skills challenges under the rising technologies of the *"Fourth Industrial Revolution"*.

The EU 2030 Vision on Skills is intended to showcase European best practices (private, public, PPP), anticipate arising industrial change, as well as providing guidance to strategic challenges such as timing and financing. This overall goal is also strongly supported by the 2018 Digital Europe initiative.

The key aspects of the EU Vision on Future Skills strategy are as follows (PwC, 2018):

- **Identify competencies for 2030**: The high-tech skills of the future must speak to the three dimensions of sectorial skills, technology skills and transverse skills. Since they cover high-tech skills equally as human skills, they may be defined as "H-Shaped Skills".
- **Re-think personal learning**: Individuals will benefit from life-long learning, facilitated by trainings of collaborative initiatives from

different stakeholders (public, private, PPP) and benefit from an agile education system which is enhanced by state-of-the-art technological advancements.

- **Re-think education systems**: The educational system will be well supported by the industry to shape and align curricula to the jobs and skills of the future.
- **Be economically responsible**: The skills challenge will have strong economic impacts on companies, states and individuals, which the vision will reflect to raise awareness and a proactive approach to face it and leverage on its opportunities.
- **Stabilize the *skills-job-nexus***: For ensuring excellence, prosperity and individual development, the bond of skills and jobs will be strengthened and frequently reassessed.
- **Anticipate**: Forward looking based on foresights on emerging technologies and corresponding skill needs.
- **Be agile**: The vision will be agile for new technological advancements and adjust according to frequent evaluations.
- **Build on world class excellence**: Provision of specific support measures to already well-performing cities and regions to make them to EU & Global Champions.
- **Be inclusive**: Provision of basic and advanced digital skills for the majority of EU citizens.
- **Be a realist**: Leveraging on already tested solutions and success stories.
- **Stress feasibility**: In terms of funding, timing (i.e. short, medium and long-term actions), incentives.
- **Encourage participation**: Consensus driven between all players of public, private and collective actions across all stages including design, implementation and monitoring.
- **Inspire**: Encourage and motivate citizens, industry, education and training providers to reach world-class excellence and championship.

- **Be socially and culturally responsive**: Tackle social challenges along with training the workforce to the state of play of rising technologies. (PwC 2018)

The Objectives for EU 2030 Skills Vision

The core objectives for the EU 2030 High-Tech Skills Vision is strongly tied to the future competitiveness of the EU industry and preparing EU to retain and enhance its global position.

The EU 2030 Vision supports the European industry activities to embrace new technological breakthroughs and to leverage on the opportunities the digital technologies present along the following guidelines:

- **Create collaborative training programs**: Creating and supporting joint training programs of universities and corporates.
- **Build world class curriculums**: Ensuring world class curricula, which are hands-on to required skills for operating rising technological advancements.
- **Construct a high quality single market**: Creating a high quality, demand-driven single market for training in the EU and for specific adjustments of the university system according to industrial developments.
- **Develop interactive curriculars**: Supporting the creation of new curricula in consequence of new professions in accordance with an EU qualification framework.
- **Utilize smart education methodologies**: Increasing effectiveness and efficiency of conventional training programs with rising smart education methodologies.
- **Foster *dual track system:*** Fostering a dual track training system in most industries, inspired by the German education system.
- **Promote skills over qualifications**: Instead of more qualifications, it is the clear objective to improve required skills.

7. EU Member States Cases

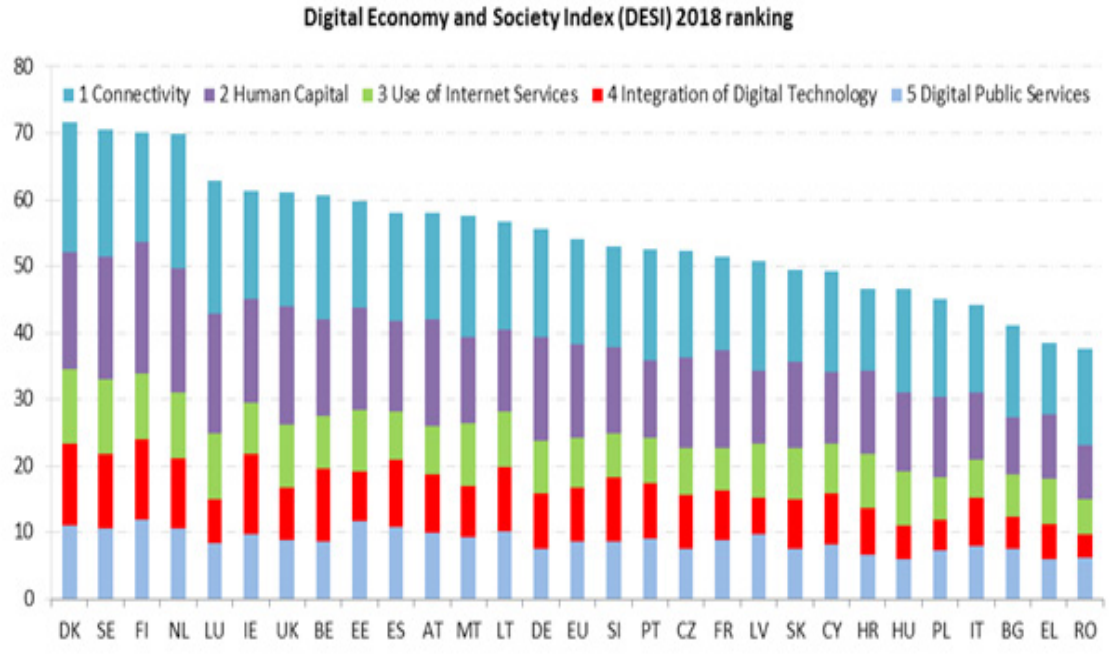
The above described Intelligent Tools and EU-level developments are familiar to national policymakers and their chosen strategies and initiatives. As mentioned, there is a growing consensus among European policymakers how to address digital transformation's key challenges and opportunities.

The following chapters describe advanced manufacturing and reskilling the workforce activities in a group of five (5) selected EU Member States. The selected EU Member States are Germany, Finland, Italy, Portugal and Sweden.

The selected countries, except one, represent the top and mid-tier ranking countries in the European Commission's *Digital Economy and Society Index* (DESI). (see below 2018 table).

For future study purposes, the addition of Slovenia and Slovakia could add further insights to the Brazilian advanced manufacturing strategy.

The EU DESI-tool is a useful composite index summarizing selected key indicators on country's performance and presenting a historical series to monitor the evolution of Member States in "digital competitiveness" (DESI 2018). It provides policymakers a useful guide to measure their nation's performance and ranking among the EU Member States.



Source: EC, 2018

Finland

"Finland's national AI strategy was published 11 months ago. Free flow, fast access and operability of data are central topics of our national AI policy. Health data is one important example in our context, as we have collected systematically health records of each citizen for decades. When making decision on data policy, we need to consider privacy,"

Mr Mika Lintilä, Minister for Economic Affairs, October 2018

Digital Finland Framework

The Finnish government launched in October 2017 two key national digital strategies: on Platform Economy and on Artificial Intelligence.

During the past months, most of the Finnish activities have been discussed under the overall AI-strategy, where all other digital economy areas are seen to integrate.

The two national strategies comprise the Finnish "*Digital Finland Framework*" which was launched in 2018 to coordinate efforts for sustainable digital transformation in the country. This also includes specific instruments to address smart manufacturing and automated transport and logistics.

The Digital Finland Framework focuses on three key areas of development:

1. Digital innovations exploiting the benefits of platform economy and the transformation of the spearhead industry sectors
2. Seamless support for sustainable digital transformation
3. Responses to global megatrends and sustainable development goals

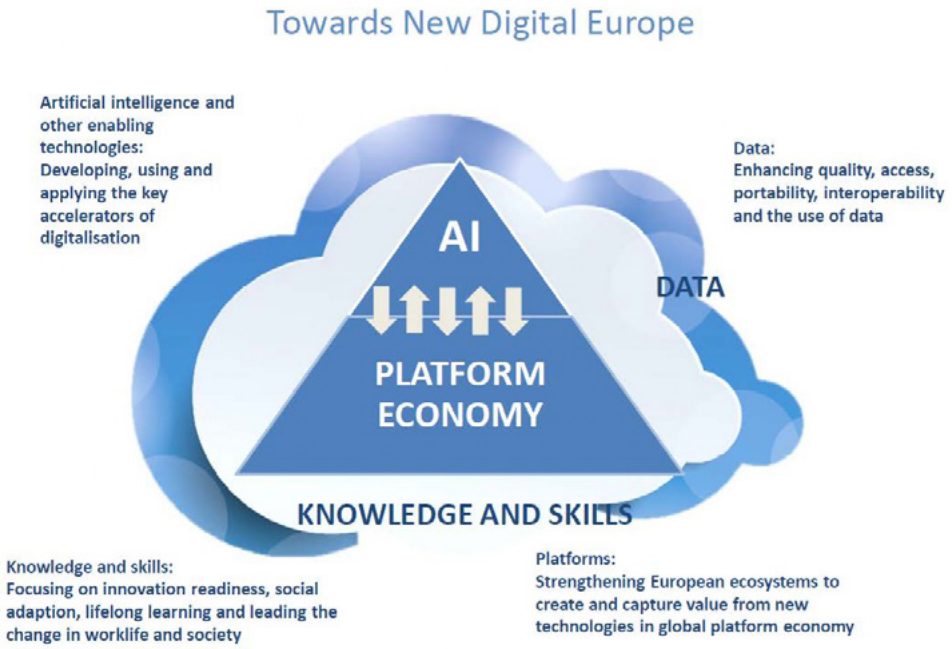
These domain-specific development areas complement earlier Finnish governmental activities around modifying the national regulatory framework to allow for greater flexibility and experimentation in sectors such as transport and healthcare.

In smart manufacturing, the Digital Finland framework emphasizes industrial renewal and skills development for future-oriented digital skills, thus reflecting the European Future of Work-debate.

To prepare for the Finnish EU Presidency in 2019, Finland has adopted the below plan to communicate what it considers to be the key European priorities to address digital transformation.

The Finnish plan is called *"Towards a New Digital Europe"*. The below picture presents its key focal areas: AI, data, platforms and; knowledge and skills.

The EC initiatives presented earlier in this study have been closely analysed by the Finnish government to build bridges between the regional and national activities. A twist comes from the Finnish (Nordic) model for social development and technology evolution.



Source: Finnish Ministry for Economic Affairs and Employment, 2018

Also, a recent report on "*Finland's Age of Artificial Intelligence*" lists eight (8) key actions for taking Finland towards the age of AI.

1. ***Enhancement of business competitiveness through the use of AI***. Similar to the EU initiatives to endorse digitalization among SMEs, also in Finland SMEs (with some notable exceptions) are considered to lack in progress in comparison to the front-running large enterprises.

2. ***Effective utilization of data in all sectors***. Access to and availability of good data is a clear limiting factor for many EU experiments and solutions ranging from healthcare to smart urban services. Finland has largely opened its data resources for trials.

3. ***Ensure AI can be adopted more quickly and easily***. Understanding what AI and is not is crucial to address this issue. The current AI-debate is sometimes inaccurate and overpromising in regards to the current

technological capabilities. Furthermore, the role and limits of humans versus machines needs to be understood in a *human-adaptive* or *human-centric* AI context.

4. ***Ensure top-level expertise and attract top experts***. A good example is, the founding of the Finnish Centre for AI (FCAI) combining national AI research efforts and networking with international counterparts.

5. ***Make bold decisions and investments***. This objective aims to combine private and public sector resources with joint goal-setting.

6. ***Build the world's best public services***. Finland envisions to upgrade its public services with the ethical use of AI.

7. ***Establish new models for collaboration***. Former innovation clusters 'thinking has been replaced by innovation ecosystem-oriented approaches.

8. ***Make Finland a frontrunner in the age of AI.*** In Europe, Finland has already built AI-partnerships with key EU Member States and aims to take a leading role in creating the strategic agenda in the EU discourse. This is also a key objective of the Finnish EU Presidency in 2019.

Developing digital competence and skills in Finland

In the Finnish national thinking states that " with digitalization, companies gain access to new technologies, big data, and new business models based on these assets. For consumers and corporate customers, this means that new products and services blend the physical with the virtual." This thinking is common to all EU Member States national strategies.

Furthermore, software products and data sets are seen to form an increasingly essential business resource, particularly in the *platform economy,* in which companies can generate new revenue with quite modest physical resources. There is a popular saying that "*a digital enterprise can be founded with a single credit card*".

For the Finnish industry, digitalization underlines *the significance of services and networked business practices*, both in commercial and industrial

operations. Thus, the national emphasis on new kind of ecosystems over traditional or conventional industrial networks.

"Also, apart from developing and implementing new technologies, companies must utilize their immaterial capital, ensure the global scalability of their products and services, design new business models, and establish connections with innovation and business ecosystems and digital platforms." (Business Finland, 2018).

Finland sees that the efficient utilization of digitalization requires change readiness from companies and new competencies from employees. Continuous learning on the job and changing careers will play an increasing role in the world of work for everyone.

The above national activities are fostered through various programs funded by Business Finland (a new organization founded from the 2017 merger of TEKES, the Finnish Innovation agency and Finpro, the national agency for export promotion. VTT, the Technical Research Centre of Finland supports these activities with research operations. All the Finnish activities are closely connected to EU- and international-level activities.

Currently the relevant digital technologies, where new competencies and skills are deemed imperative, are as follows:

- work phase automation
- robotization
- machine learning
- artificial intelligence
- big data analysis
- virtual and enhanced reality
- blockchain technologies

Digital transformation of the Finnish industry

There is a private-sector led national program to advance digital transformation among the Finnish manufacturing sector. It is called DIMECC (Digital, Internet, Materials and Engineering co-creation). It's network or an ecosystem currently consists of 2000 R&D&I professionals, over 400 national organizations.

DIMECC is funded by 69 shareholders and employs a network of competence development facilities with co-creation facilitators. These co-creation activities are developed with open innovation models between companies, universities and research institutions.

DIMECC also manages and facilitates national networks such as the Finnish Industrial Internet Forum (FIIF) to complement public sector-led initiatives.

Besides the national initiatives run by the Finnish government entities and DIMECC, individual companies have launched their own competence and skills development centers around the country for specific skills in close co-operation with local universities, industry partners and polytechnics.

A more recent phenomena, is company shareholder-launched joint initiatives to spur digital transformation within a selected and closed group of companies. A good example is Combient, *by industry for industry*, a Nordic industry network, which brings together Finnish and Swedish companies to tackle digital technologies and services, experiment, share best practices and knowledge and ultimately scale the best opportunities among the participant companies.

Combient is rapidly expanding its operations in both Finland and Sweden; and is driven by long-term Nordic shareholder interest represented by the Wallenberg family.

Germany

Germany continues to play a major role in driving and setting the *Industrial Internet*-dialogue in Europe. The German title for digital transformation

in industries (Industrie 4.0) has also become a global term to describe the change since 2011.

Germany's national activities to drive digital transformation in manufacturing are coupled with growing regional co-operation activities with other EU Member States. A good example is, the German-French-Italian co-operation agreement on Industrie 4.0-related developments.

Due to the size of the German economy, making it the largest European economy and being the third largest exporter in the world (1.2 trillion euros in goods and services, 2017), Industrie 4.0 sets the model for digital technology-enabled export-oriented growth strategy.

Industrie 4.0 defined

The concept of Industrie 4.0 has been developed by a research union, an advisory board to the Federal Ministry of Education and Research (BMBF), and subsequently brought into practice by the three German industry associations BITKOM (digital industry), VDMA (manufacturing industry) and ZVEI (electrics and electrotechnology industry) together with scientists from the German Academy of Science and Engineering (acatech).

The basis Industrie 4.0-concept addresses embedded intelligent and digitally networked systems along with the vision that through these *cyberphysical system,* a largely self-organized production system will be possible.

In 2015, the Ministry for Economic Affairs and Energy (BMWi) announced together with the Ministry of Education and Research (BMBF) to enforce the Industrie 4.0-platform as a national instrument for the development of the German economy.

Since this move, Industrie 4.0 has evolved from a lighthouse counseling project to a national platform initiative working on solutions to maintain Germany's position as a central economic and production location.

Currently, there is a broad German consensus that Industrie 4.0 can increase the profitability of production, enhance the future competitiveness of German

industry and that the flexibility of German production can be increased with the converging information technology (IT) and operational technology (OT) environments for business operations.

The below picture shows the envisioned and planned Industrie 4.0-evolution path. A crucial step is the increase of software skills within the German industry to reach the planned stages.

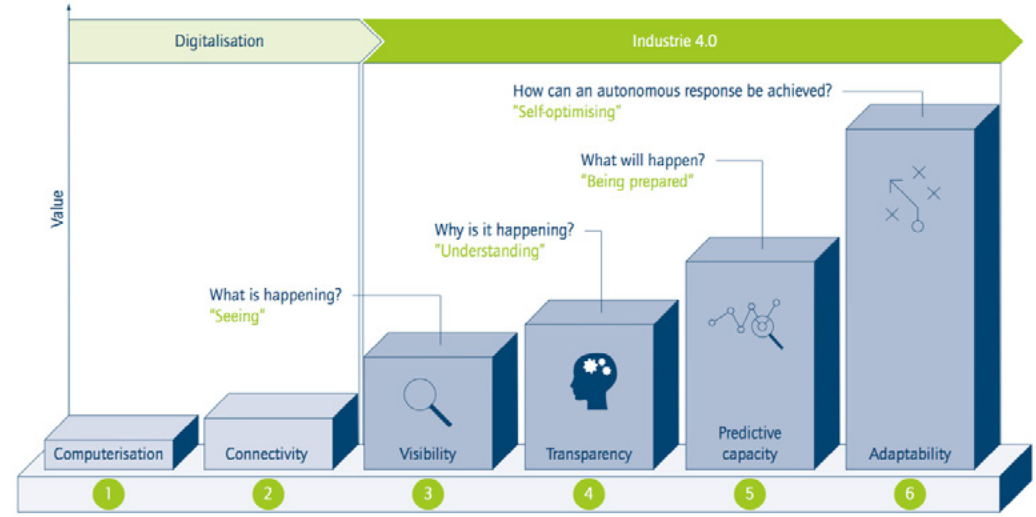


Figure 5: Stages in the Industrie 4.0 development path (source: FIR e. V. at RWTH Aachen University)

Source: European Commission, 2018

Next to the national platform Industrie 4.0 initiative, digital transformation of the German industry has been promoted through a varied of other measures and initiatives by the German government. These include e.g.:

- the technology transfer and uptake of *Industry 4.0 to SME* through a network of SME 4.0 Competence centers
- a national lighthouse project *"IUNO"* for developing IT Security for Industrie 4.0.
- broad national discussions on the societal, legal and ethical aspects of the digital transformation of German industry.

- significant local initiatives in the area of Industrie 4.0 have been initiated by the German Lander (States). These are largely driven by industry corporations or by research organizations.
- lighthouse projects are managed to apply digital technologies in business use cases funded by the BMWi.

Germany and EU strategies

The German government has stated and described its digitization policies in a number of strategy documents (to name a few key documents):

- the *"Digital Strategy 2025"* (2016, Federal Ministry for Economic Affairs and Energy; BMWi)
- the *"Digital Agenda 2014-2017"* (BMWi, Ministry of the Interior and Ministry of Traffic and Infrastructure)
- the *"New High-tech Strategy"* (2016, the Federal Ministry of Education and Research; BMBF).

These governmental documents have been closely examined by other EU Member States and the EC to align their strategies to match priorities.

For Germany, the modernization of the German economy with Industrie 4.0 technologies is one of the major foci of the above strategies.

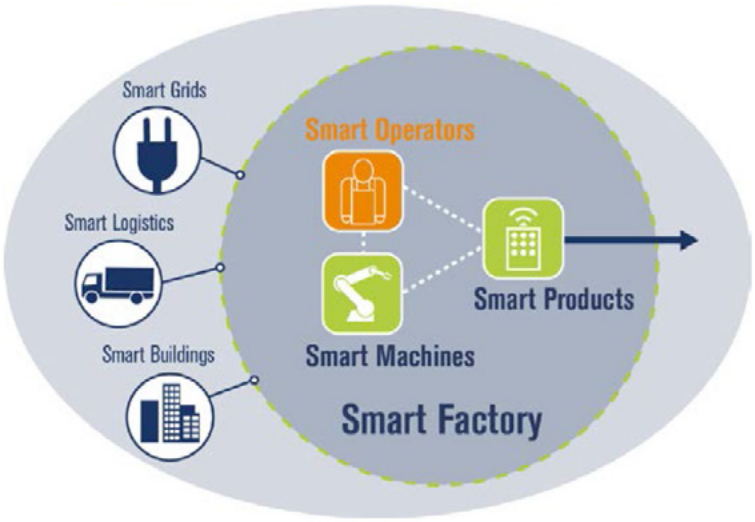
Based on the national visions and plans, Germany aims to develop autonomy and technology leadership in various high technology fields including:

- IT security
- big data
- cloud computing
- service platforms

The key German ministries are actively supporting this overall technology autonomy and leadership goal.

BMWi has announced plans to implement the recommendations developed by the five working groups of the Platform Industrie 4.0, particularly in the areas of standardization, legal framework, IT security and future of work.

Furthermore, BMWi has announced to a EUR 1 bn funding program in microelectronics as part of a European IPSEI-program. Other national innovations are especially intended in the area of data economy and in the SME-based research via the BMWi Central Innovation Program Mittelstand "ZIM".



Source: BMWi, 2018

Concerning infrastructure development, the German government has initiated the "*Network Alliance for a Digital Germany*" that will invest EUR 8 bn in broadband network deployment ("Gigabit society").

Further activities are set on digital skills development, and for public services "eGovernment ("*Digital Administration 2020*", "Open Government Partnership Action Plan 2017-2019"). All of these are identifying and spurring the right elements for digital transformation with all the stakeholders, with the German government in a facilitating role.

Based on the above set of objectives, the German Research, Development and Innovation Actions have been specified in the following priority areas:

- **Production Research** – ("Human and work in an intelligent and networked plant"),
- **ICT Research in Industry 4.0** (Embedded 'cyberphysical' Systems, Virtualization technologies for the plant of the future),
- **the excellence Cluster Its OWL** ("intelligent technical systems"), and
- **trans-national production research** (ERAnet Manunet; Smart Maintenance).

In its current strategy, BMBF focuses on four key areas that will be funded during the next years:

- Industrie 4.0 application in SME,
- Standards and IT architectures (research on the RAMI model),
- IT security (national lighthouse center IUNO)
- Qualification (work design, competence development).

BMBF is also funding parts of the EU ECSEL program "*Productive 4.0*" as well as cooperative research projects in smart manufacturing with the Czech Republic and with China (02/2017). BMBF is funding research and development into Industrie 4.0 technology and applications with almost EUR 500 million.

BMWi is funding applied research programs in the area of autonomous systems with a close relation to Industry 4.0 ("Autonomik for Industrie 4.0", "PAiCE"). As part of the BMWi program "PAiCE", the lighthouse project "Industrial Communication for Factories" (IC4F) aims at the development of secure, robust and real-time communication solutions for the processing industry. This is also linked with EU 5G developments.

Driving digital transformation in businesses: Platform Industrie 4.0

The German *Platform Industrie 4.0* aims at developing joint recommendations for all stakeholders that serve as the basis for a consistent and reliable framework.

The platform is led by the federal ministers of BMWi and BMBF together with representatives from industry, associations, science and the trade unions.

The platform's technical work is carried out in five (5) thematic Working Groups;

- reference architectures
- research & innovation
- security
- legal framework
- education and training

The platform initiates alliances and networks at the pre-competitive stage and proactively supports activities in the market, such as founding demonstration centers, funding research projects, overseeing standardization actions and general support to the overall understanding of Industrie 4.0.

The recent developments of the Platform Industrie 4.0 include the following:

- **Public and industry involvement as a governance instrument**: communication and discussion of strategies and results with a public audience (e.g. Hannover fair, National Digital summit)

- **Strategic expansion of the Industrie 4.0 platform**: Next to an agreement on a "Trilateral European Cooperation" (Germany, France, Italy), a number of bilateral alliances (Industrial Internet Consortium; France; Japan; Czech Republic; China, Australia) have been set up.

- **Setup of a "Standardization council Industrie 4.0"** that aims to initiate standards for digital production and to coordinate these nationally and internationally.

- **Support of complementary regional Smart Manufacturing Platforms and test centers**: The association "LNI4.0" has been founded with the mission to support German SME through associated demonstration

and test centers. BMBF complements this with the "*test bed*" funding measure addressing SME that need to test Industrie 4.0 technology in complex test environments.

The platform Industrie 4.0 hosts an interactive map which at the moment lists a total of 55 test bed centers all over Germany. Prominent examples are the SmartFactoryOWL (Lemgo), the demonstration plant (WZL) Aachen or the SmartFactory Kaiserslautern as well as the Robotics and Mechatronics Center (Oberpfaffenhofen).

Current initiatives are the "Track and Trace" testbed (Industrial Internet Consortium; SAP) or the Learning factory (University of Braunschweig). BMBF has initiated a program for Industry 4.0 test environments for SMEs.

Developing standards is at the center of German strategy

A central activity of Industrie 4.0 is the German standardization roadmap. This Industrie 4.0 roadmap not only describes the current technical status of Industrie 4.0 and gives an overview on all relevant standards and specifications (including the RAMI architectural model), but also gives concrete recommendations for action and outlines standardization needs in the various areas.

Following the roadmap work for standardization, a regulatory framework work (2016), has been initiated by the Ministry for Economic Affairs to design and plan for digital platforms, a growing engine for digitalization. The Ministry has observed that platform markets are currently dominated by American and to a certain extent by Asian internet services and they are currently conquering one analogue industry after another or inventing completely new ones and growing into new giants.

BMWi also intends to use field test labs as regulatory experimentation spaces. These "laboratories" allow the testing of innovations under real conditions, by adapting the existing requirements in time and space.

BMWi announced to anchor an innovation and investment friendly regulation within the national implementation of the new telecommunications' regulatory framework.

The Federal Ministry of Labor and Social Affairs has presented a "White Paper Work 4.0". There have been intensive discussions on regulation necessities relating to a digitized work environment and the effects of digital platforms on the working conditions in Germany.

Furthermore, the parliament adopted the Federal Open Data Act in May 2017. The new Act initiates cultural change in the administrations and obliges federal authorities to publish unprocessed data in the future.

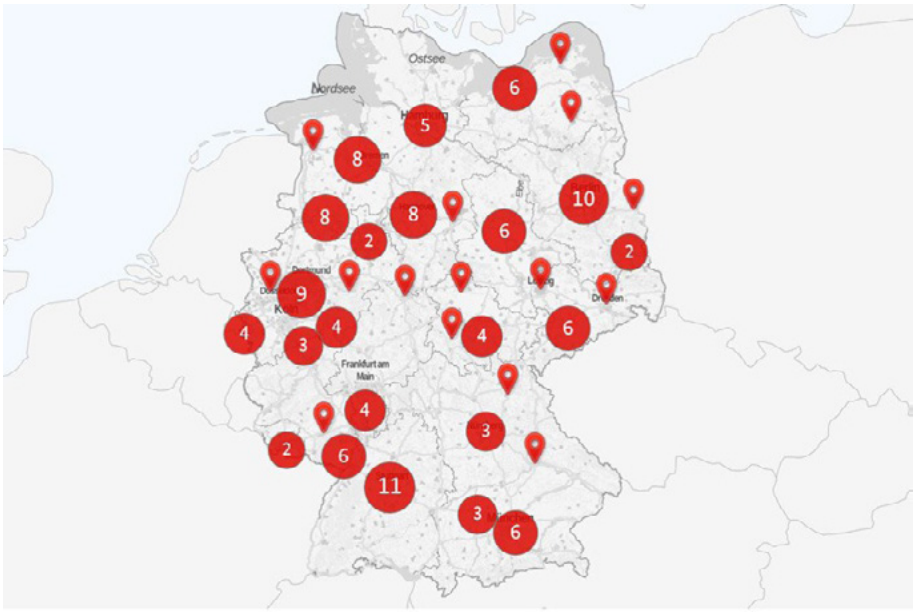
Competence transfer in Germany

The national digital hub initiative developed by BMWi seeks to support the establishment of digital hubs in Germany to foster cooperation between companies and business start-ups within a confined area.

At the German Digital innovation hubs, start-ups, scientific institutions, SMEs, industry and government shall evolve to centres of the digital transformation.

BMWi is working on establishing a common label and a hub agency for the large German hubs that act as flagships (networking of hubs throughout Germany, *knowhow transfer*).

BMWi also will strategically promote these digital hubs abroad with the help of Germany Trade and Invest. Since the launch of the Digital Hub Initiative at the IT Summit 2016, selected hubs in major locations with different focus areas have started their work.



Source: German competence centre network, BMWi, 2018

SME 4.0 competence centres: The Federal Ministry for Economic Affairs and Energy (BMWi) has launched the funding initiative *"SME 4.0 – Digital production and work processes"* ("**Mittelstand digital**").

One element of this initiative are so-called SME 4.0-Competence Centres (Mittelstand 4.0-Kompetenzzentren). Their goal is to pool the relevant knowledge on the digitization and networking of business processes in their demonstration and learning factories and to pass them on to companies SMEs in their regions *("speaking the language of SMEs").*

Furthermore, the *Go Digital*-program by HHI, a Fraunhofer research centre in Berlin is advancing digital transformation among the German SMEs.

For decades German innovation processes have been product-centric excelling in practice and technology, adding digital elements to them is going to be a long cultural and transformative process.

Developing future work skills in Germany

BMWi is also funding a number of Future of Work-measures according to its program *"Future of the German Mittelstand"* that predominantly target SMEs.

An alliance has been built to strengthen vocational training, an activity for SME consultation; continuous work with the social partners on regulations for modernizing vocational training and an activity on social skills for workers.

BMBF is reorganizing vocational training in the "Berufsbildung 4.0" (vocational training 4.0) to better reflect the future working skills needs.

Promoting German innovation

Tax incentives for R&D are not implemented in Germany. However, at Hannover fair 2017, BMBF announced that Germany wants to raise the gross domestic expenditures on R&D (GERD) from 3,0% to 3,5%.

Therefore, after the election, the government has planned to invent tax research funding for businesses up to 1000 employees. BMWi funds activities with **innovation vouchers** for SME ("*go digital*") in addition to traditional programs *(go innovative, KMU innovative)* of BMBF and BMWi.

The BMWi program *"InnoKom"* aims at compensating the lack of industrial research in structurally weak regions in Germany. Within the program "WE!" ("WIR!"), BMWi engages in regions with particular challenges in structural change.

BMBF has presented an agenda for innovation with the following key pillars or *"Innovation policy cornerstones - Bringing more ideas into the market":*

- first, a technology-driven subsidy, which supports entrepreneurs in making decisions on technologies to invest in
- Second, the promotion of specific, particularly worthwhile future technologies

The BMWi program WIPANO supports SME in securing and using intellectual property for economic exploitation.

Already since 2007 BMBF has launched leading-edge cluster competitions as part of their *"High-Tech Strategy"* to pool regional potential along value chains. These selected clusters are sponsored for a maximum of five years with up to EUR 40 million per cluster. Examples are the Software Cluster (Karlsruhe), "Silicon Saxony" (Dresden) or the Logistics Cluster (Dortmund

Currently, BMBF promotes the internationalization of leading-edge clusters and future projects. Germany is making use of EU ESIF funds with a total budget of EUR 595 million. This is the case especially in two of the east German Lander: Saxony (EUR 157 million) and Sachsen-Anhalt (EUR 152 million).

Italy

Defining a national plan for digital manufacturing

The PNI 4.0 was launched in late September 2016 and was largely received by the 2017 Budget Law. The Plan puts in place horizontal measures, i.e. adopting a technology neutrality approach, addressed to all types of enterprises, regardless of their size or sector, with the purpose to boost the investment in new technologies, research and development, and revamp the competitiveness of Italian companies.

This is complemented by: An Ultra Broadband Plan, to improve connectivity; international cooperation for the definition of IoT standard platforms; measures to trigger private investment to support I4.0, especially venture capital and private equity.

In addition, the PNI 4.0 seeks to contribute to the empowerment of skills by promoting I4.0 education programs, strengthening vocational training, skills development, Competence Centres, Digital Innovation Hubs and the financing of I4.0 Technology Clusters and Industrial PhDs.

The PNI 4.0 governance involves several Ministries – with the Italian Ministry

of Economic Development playing a pivotal role – and embraces a multi-layer – with Regions involved – and multi-stakeholder approach, encompassing a plurality of players ranging from academia and research centres to industrial associations and trade unions.

PNI 4.0 platform actions

The PNI 4.0 considers the implementation of complementary guidelines with the objective of leveraging enabling infrastructures boosting the competitiveness of the Italian industry and encouraging private investment in new technologies and innovative processes through fiscal

Beyond the national funds made available as part of research programs and smart specialization strategies, one of the main incentives consists in 50% tax credit on incremental R&D expenditure, up to an annual ceiling of €20 million a year per beneficiary. By doing so, the tax credit aims to boost R&D by more than 11€ billion within the 2017-2020 timeframe.

The combination of super- and hyper-depreciation aims to increase private investment in capital goods by 10€ billion just in 2017. These two measures, jointly with the tax credit on R&D, costs about 13B€.

Standardization activities in Italy

The Piano Industria 4.0 promotes open standards and interoperability criteria that should ensure that Industrial IoT does not result in disconnected islands of equipment and data that would hamper data-driven industry 4.0 services and applications.

As a part of the international cooperation effort to promote standardization, in June 2017, at the Digitizing Manufacturing in the G20, it has been announced that the key digitizing manufacturing initiatives of France, Germany and Italy have agreed on a trilateral cooperation to support and strengthen the digitalization processes of their manufacturing sectors as well as to promote according European efforts.

Spurring digital innovation hubs in Italy

The initiative Piano Industry 4.0 has defined in May 2017 the national network for Industry 4.0 and provides for different types of organizations aimed at supporting technology transfer and a broader cooperation between the academia and businesses.

- **newly-introduced network comprises *Digital Enterprise Points* (PID**). Local Dissemination of basic knowledge in the field of technologies for Industry 4.0. EUR 45 million are budgeted as part of the support to the national network of chambers of commerce to deploy this digital one-stop- shop.

- **Innovation Hubs (DIH**). Advanced training on technologies and development of industrial solutions for specific areas of competence. Consolidation and coordination of structures for digital transformation and technology transfer centres.

- **National Competence Centers**. Higher education and research and experimental development of projects. The national initiative has already budgeted EUR 200 million for the establishment of selected I4.0 competence centres and EUR 240 million for the Strengthening of technological clusters "Fabbrica Intelligente" and "Agri-food".

The Italian network for Industry 4.0 brings together the capabilities from chambers of commerce, national industrial associations and sectorial associations to leverage a harmonized and coordinated network for provision of high-quality services for the digital transformation of Italian industry.

Developing Italian skills

The Piano Industria 4.0 consists of separate actions for digital skills development:

- addressing the implementation of the "*Scuola Digitale*" (with budget of EUR 355 million)

- selected learning initiatives on “Industria 4.0”, specialization of academic courses, masters and executive masters on “Industria 4.0” topics in partnership with industrial and technological players (100 M€)

- increase the number of students attending professional institutes focused on “Industria 4.0” topics

- development of working class skills through dedicated funds and programs.

These specific actions complement the Italian actions for the development of a national support network of Industry 4.0.

Promoting Italian innovation

The Italian national plan for industry 4.0 provides and allows a combined application of such fiscal incentives, already approved by the 2017 budget law, which are intended to increase the investment, retrofitting and development of productive competitive advantages through industry 4.0 technologies and products.

A favourable tax scheme for digital businesses is also intended for the attraction of international investments in the country economy. To stimulate private investments in Industry 4.0 technologies, the national initiative considers the *“Nuova Sabatini”* to leverage more credit (up to EUR 2 million per project) for innovation supporting businesses requesting bank loans to invest in new capital goods, machinery, plant, factory equipment for use in production and digital technologies.

These actions will be complemented by a new framework to bolster the finance in support of I4.0, VC and Start-ups (EUR 2,6 bn activated in the Italian economy).

In particular the initiative considers a tax deduction for investments in start-ups and innovative SMEs, that allows a 30% break on personal income tax

for investments up to 1 million euros, or a 30% deduction from corporate income tax basis, up to 1,8 million euros and a "sponsor" company program that in case of failure/bankruptcy the schemes exempts from regular bankruptcy regulations.

To ensure the Italian industry competitiveness, the national plan is making available a Guarantee Fund (EUR 22,9 bn), covering up to maximum of 80% of the loan with a maximum contribution of EUR 2,5 million per business. Finally, the national initiative considers the implementation of a Productivity – salary taxation exchange (EUR 1,3bn), which allows a rate of 10% on bonuses that are awarded for productivity increases; up to EUR 4,000 € per employee.

Portugal

Background for a national initiative

The national initiative Portugal i4.0 presented in 2017, is part of the National Strategy for the Digitalization of the Economy.

The overall objective of the National Strategy for the Digitization of the Economy includes an initial set of measures of valorisation, promotion and investment in the digitization of the Portuguese economy.

The Ministry of the Economy, intending to generate the conditions for the development of the national industry and services in the new paradigm of Digital Economy, decided to launch an initiative to identify the needs of the Portuguese industrial fabric in the scope of its digital transformation and guide measures (public and private) of awareness, adoption and massification of new technologies in the business models of Portuguese companies.

According to EC DESI study, Portugal should focus on improving the digital skills of the population (half of the population does not have basic digital skills and 28% have never used the internet). Measures to be developed under the Industry 4.0 initiative should be in line with these conclusions, with the preponderance of measures at the human resources level.

In Portugal, the so- called traditional sectors (e.g., textiles and footwear) are of great importance in the economy, and these are sectors where great penetration of robotics is unlikely and undesirable (because several manual operations are necessary for the production of luxury products).

Creating the national plan

According to the EC analysis (2017), the Industry 4.0 strategy in Portugal was built by using "a bottom-up strategy, expert interviews, workshops and auditions, participated by 88 companies – coming from 4 fields of business relevant to the Portuguese economy for their number and importance and their level of preparation for the technological adoption – as well as 25 other entities – of various kinds such as academic institutions', institutes or associations." (EC, 2017)

The Industry 4.0 Program was presented 2017, when the Portuguese Ministry of Economy launched a national Portugal i4.0 Program, dealing with the National Strategy for the Digitization of the Portuguese Economy, which is composed by 64 initial measures (public and private) identified from April 2016 at the bottom-up strategic dialogue.

The selected set of national measures was further validated by a Strategic Committee, made up of several multinationals with Industry 4.0 experience in their countries of origin, as well as other national entities and companies.

Core objectives for Portugal

The Strategy for Industry 4.0 is a set of 64 public and private initiative measures that are expected to impact more than 50,000 companies operating in Portugal and, at an early stage, will enable the retraining and training of more than 20,000 workers in digital skills.

The core objectives for Portugal are:

1. Accelerate Industry 4.0 concepts and technology adoption by Portuguese businesses

2. Provide the business community with knowledge and information
3. Promote a set of tools for business transformation
4. Empower and readjust the national workforce
5. Promote Portuguese companies as international Industry 4.0 players to Capitalize the scientific and technological ecosystem
6. Create a favourable context for the development of i4.0 startups
7. Promote national technological solutions abroad
8. Make Portugal an attractive location to invest in Industry 4.0
9. Communicate the country as a HUB of experiences and know-how sharing in order to attract resources
10. Create favourable conditions (legal and fiscal) for investment related to i4.0

Measures to advance digital transformation

The consultation and cooperation process in the field of industry 4.0, identified key challenges and potential policy and digital enablers in the following areas. (Furthermore, it has calculated the number of measures for each area):

- **Human capital qualification (22 measures).** The main aim is to adapt the formative contents of the national education system to new technologies and promote retraining and training of professionals.
- **Technological cooperation ecosystems (24 measures**). To promote cooperation for the development and subsequent implementation of innovative solutions and technologies in the framework of the 4th industrial revolution.
- **Startup i4.0 (4 measures).** Recognize the role of startups in technological innovation and develop a set of measures aimed at Industry 4.0 in line with the National Strategy for Entrepreneurship of Startup Portugal.

- **Financing and investment incentive (4 measures).** Develop a set of financing mechanisms for projects with Industry scope 4.0 in order to accelerate investments and encourage the adoption by the Portuguese business community.
- **Internationalization (7 measures).** Promote Portuguese technology for the foreign market, thus encouraging the internationalization of companies and attracting investment in the country.
- **Standards and Regulation (3 measures**). Ensure legal adaptation and technical standardization in the face of the challenges of the new industrial revolution, creating an environment conducive to technological development and investment.

Sweden

Swedish Digital Strategy

Sweden's economy has the highest share of value added coming from information and communication (ICT) technologies of OECD countries and is among the top ten exporters of ICT services.

Use of digital technologies has helped Swedish firms to integrate into global value chains in manufacturing and move up the value chain to focus on high value-added services like product design and marketing. Sweden is also a leader in the Internet of things (IoT).

While Sweden is also on a solid path to reach its goal of having 98% of households and firms connected to 1 gigabit per second Internet by 2025, it should now focus on enhancing co-ordination among national, regional and local broadband deployment strategies and expanding networks in sparsely populated areas.

The use of digital technologies by people with lower levels of income or education could be further increased. Sweden also lags other countries in opening up government data to citizens. (OECD 2018).

Similar to Finland and Germany, Sweden has a strong export-oriented manufacturing sector. The Swedish government has identified that following attributes are key to maintain its global and European competitiveness amidst digital transformation (based on Swedish Ministry for Economy priority lists, 2018):

- **Digital skills** – Everyone in Sweden will be able to develop and use their digital skills.
- **Digital security** – Sweden will provide the best conditions for securely taking part in, taking responsibility for and building trust in the digital society.
- **Digital innovation** – Sweden will provide the best conditions to ensure that digitally driven innovations are developed, disseminated and used.
- **Digital leadership** – In Sweden, the digital transformation will promote relevant, targeted and legally sound efficiency improvements.
- **Digital infrastructure** – All of Sweden should have access to infrastructure that provides high-speed broadband and reliable mobile services, and that supports the digital transformation.
- **Future work**– This will enable us to influence how technology changes our society.

On the business side, while digital tools are widely used in Swedish firms, most are slow to seize opportunities to analyse big data. There is also a limited supply of advanced ICT skills in the Swedish workforce.

As an international hub of scientific and technological leadership, Sweden should strengthen its policy priorities and publicly funded programs for digital innovation.

Concerns about digital security are higher among Swedish people than in many other OECD countries. The government should promote a clear vision of digital security risk management as an economic and social responsibility of all and provide stronger policy leadership.(OECD 2018)

Sweden Smart Industry

According to the Swedish government and industry analysis, the Swedish industrial sector is faced with crucial challenges.

Digitalization is pushing the industrial sector's already high rate of transformation even further, paving the way for new business models and making others redundant. For SMEs in particular, it is an enormous challenge to keep up with the pace of technological development.

Furthermore, digitalization is central to many other countries' industrial strategies, not least Germany's Industrie 4.0. The digitalization of the industrial sector's production, products and capacity to transform enormous quantities of data into new businesses is completely vital to the Swedish industrial sector's future competitiveness. (Swedish Ministry for Economy 2018)

However, the perspective of the Industrial Internet activities needs to be wider than this. This is because ever greater demands are simultaneously being placed on the long-term sustainability of production and the utilization of resources.

That is why Sweden's strategy for new industrialization aims beyond connected industry and also encompasses the ambition to cope with the *demand for renewal* that growing sustainability requirements are placing on the industrial sector and its products. For this purpose, Sweden is also employing the experiences of its successful digital services sector to facilitate digital transformation of the production sector.

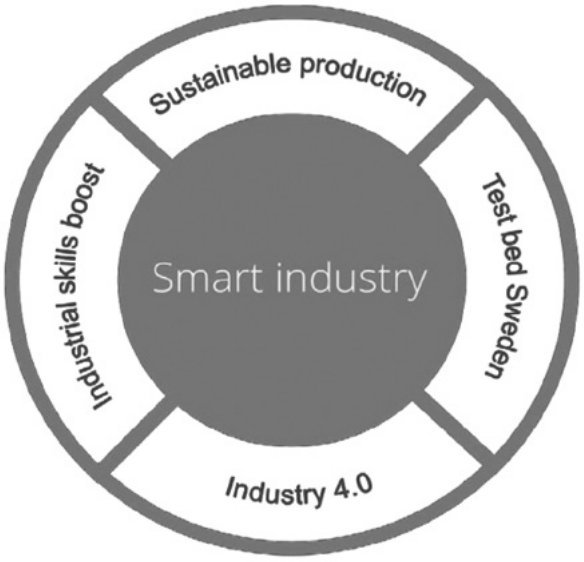
The Swedish government's strategy for new the industrialization is to strengthen companies' capacity for change and competitiveness on chosen four focus areas of particular importance to this:

- **Industry 4.0** – Companies in the Swedish industrial sector is to be leaders of the digital transformation and in exploiting the potential of digitalization.
- **Sustainable production** – Increased resource efficiency, environmental

considerations and a more sustainable production are to contribute to the industrial sector's value creation, job creation and competitiveness.

- **Industrial skills boost** – The system for supplying skills is to meet the industrial sector's needs and promote its long-term development.
- **Test bed Sweden** – Sweden is to lead research in areas that contribute to strengthening the industrial production of goods and services in Sweden.

The chosen focus areas are pictured below in the "Smart Industry" circle. An unique Swedish perspective is focus on *sustainable production*, (related also to the EC circular economy activities).



Source: Swedish Ministry for Economic Affairs, 2018

Swedish digital industrial platforms

The Swedish Government has traditionally worked via its innovation agency Vinnova (also the Swedish Energy Agency and Formas) to carry out funding initiatives for strategic innovation areas.

Vinnova currently runs 16 strategic innovation areas of which two are specifically relevant for European digital transformation of manufacturing:

- **Produktion 2030** aims at translating industry challenges to relevant and innovative solutions for the industry; it also aims at building and strengthening cooperation networks, both in Sweden and internationally. The manufacturing industry and research organizations can apply for funding for short-term high-risk projects that will test whether ideas can contribute significantly to increased sustainability in the Swedish manufacturing industry. Funding is not more than SEK 500,000. The manufacturing industry must account for at least 30 percent of the project budget.

- **Processing IT and Automation (P!IA)** – aims at strengthening the process industry as well as industry suppliers to develop their innovation abilities. PiiA holds 2 calls for proposals each year.

Along with the Swedish governmental focus area "Sustainable production", the government charts mining waste for new green technologies. Two assignments were made to map the need for metals necessary for the development of new technologies in the solar cells of the future.

The Swedish Standards Institute has a close cooperation with Vinnova which has been assigned SEK 35 million (2017-2020) for standardization activities concerning smart industry.

Smart Industry is a national strategy for the new industrialization for Sweden, aimed at strengthening capacities for digital transformation and competitiveness, boost leadership, foster sustainable development (production, resource efficiency etc.), value creation, jobs and skills development. Test Bed Sweden in the Swedish Smart Industry strategy is underpinning research and innovation.

Linking to EU Digitizing European Industries, the Swedish "Smart Industry Action Plan" is outlining measures to implement the new "Smart Industry" strategy.

The Swedish national plan presents actions in several policy areas that support the work of "Smart industry" in the form of ongoing efforts. The measures have been prepared after a dialogue process with the social partners, companies and academia.

The "smart industry" strategy as well as the action plan will be continuously updated. The strategy will be monitored with the help of a number of key indicators, which together give an indication of the industrial sectors' ability to adapt and capacity for renewal in relation to the strategy's aims and objectives.

Furthermore, the Swedish government has defined so called "innovation partnership programs" in five areas:

1. Next Generation Travel and Transport;
2. Smart cities;
3. Circular bio-based economy;
4. Life science;
5. Connected industry and new materials.

The above areas differ from the other EU Member States with the strong combination between targeted service-areas outside of the manufacturing sectors. However, according to the Swedish experts the above innovation partnerships closely reflect EU PPP programs. They expect that Sweden and Swedish companies are directly able to tap into the larger EU markets with national experiments.

Swedish Digital Innovation Hubs

Sweden has installed a specific instrument ("*Vinnvaxt*") to support the regional level activities. Examples for the Swedish competence centers are "CENIIT" (Linkoping) or "FindIT" (Gavleborg). "ProcessIT Innovations" (Lulea, Umea). "Automation Region" is an innovation platform where SME, large corporations, academia and public sector collaborate in interdisciplinary projects.

In 2016, the Swedish government assigned the Swedish Agency for Growth with the task of stimulating and strengthening the supply with skills for industrial SMEs. A pilot project encompasses information campaigns, searchable support and follow-up.

8. What can governments do?

According to major studies from multinational organizations such as the OECD and from regional research organizations such as the EU Joint Research Centre (JRC), governments and policy makers should develop an **innovation policy mix** to address the various aspects of digital transformation.

The below chapters highlight the key areas for innovation policy actions, where the government can have a dynamic, legitimate role along the principles of "great transformation" to steer and intervene the markets; thus, preparing the country for the future.

Such a role has also been highlighted in the above described EU digital policy actions and EU Member State cases.

Such a role for the government is necessary to provide an enabling business environment i.e. regulatory framework for businesses for experimentation and other measures to spur their digital transformation.

Furthermore, government and its policymakers can act as a catalyst for industry collaboration, especially where the digital innovations require new kind of ecosystems, instead of conventional industry networks to spur lasting changes in the existing structures and cultures.

Moreover, as evidenced in all the cases presented in this study European governments are increasingly mandated to maintain their countries competitiveness by providing their populations with the required skills for future work and modernizing their education systems accordingly.

However, this does not happen in isolation – transforming the national skills base requires active public-private sector co-operation. In the German-case vocational training is even controlled by the private sector. The German model is also being exported to other EU Member States.

In general, all of the examined European governments in this study are hard at work aiming to cover the above areas.

While keeping the above considerations in mind, national governments can also act in the below listed specific areas to support overall digital transformation. The below listed actions are primarily based on OECD *Going Digital*-project (2017-) and other key sources, including expert opinions on how policymakers can best advance digital transformation.

Creating a National Vision

There are three key reasons, why the public sector has an important role in driving and ideating the vision-driven national development plan.

1. **Social context is an integral part of technology evolution**. Political decisions and social investment guide the direction of national digital transformation process. This means that social and political choices influence the outcome. In the industrial era, the development and usage of technologies reflected the availability of affordable energy, standardization in consumption patterns and the creation of social security systems (Mazzucato and Perez 2014).
2. **Economic history tells us that governmental innovation and R&D funding have had a crucial role in breakthrough innovations**. A good example is the birth of the Internet and how publicly-funded inventions have set the stage for commercial innovations. Similar developments are now taking place in all of the Intelligent Tools-fields described in this study.
3. **Technology development often produces nice-to-have solutions, instead of providing tools for solving societal challenges and problems**. The current abundance in computing power should be directed to solve problems and create trust, instead of creating more problems and sowing distrust. This is a crucial task, where government leadership is required.

Tools to foster new industrial ecosystems

Government should not select the winners, but to set clear objectives for the funded innovation projects. In order to do this, the government should adhere to the following key principles:

1. Developing both vertical and horizontal networks to allow for innovations in the same chain and among competing companies. To create sustainable impact a right balance between them is needed.
2. A vision-driven approach should focus on generating networks and ecosystems. Individually-funded projects seldom produce lasting changes and create new business ecosystems.
3. Recognizing all the key players for network creation. This includes investors, companies, public authorities and universities in addition to entrepreneurs.

Preparing for the Future of Work

National governments can also aim to set a *"human-centric agenda to prepare their populations for high-tech skills"*. Such an agenda needs to be a highly collaborative one at its core.

It can build on all relevant stakeholders and their activities – cross-sectoral, cross-border – envisioning specific roles for each key stakeholder. These roles are described below.

Ecosystem role

Active Interface of the Skills Strategy: Ecosystems play a key role in defining and executing the skills strategy as active interface between the industry, academia and governments

International Partnership Building: Facilitate the definition and execution of the skills agenda through international partnerships with different ecosystems

Enhance Skills Provision Responsiveness: Collect and define requirements and skills gaps of companies to actively enhance the skills provision from private and public stakeholders

New Skills Provision: Actively engage in the provision of new skills for the key technology advancements

Communication Module: Support stakeholders in communicating and advertising training initiatives for meeting future skills demand

Policymaker role

Providing leadership and governance: Providing an overarching vision with clear responsibility allocation for various Ministries (Ministry of Economy, Ministry of Labor, Ministry of Education), including measurable objectives.

Drafting a skills Strategy: Develop detailed a skills strategy in line with country, industrial and technology priorities to orientate the sourcing and production of relevant skills in a sustainable manner. With focus around the following: Local / international Sourcing, Upskilling, Dual track systems and Lifelong learning policies.

Developing a data driven skills assessment: The need of skills for future technologies can be efficiently assessed by leveraging on Big Data and AI technologies.

Creating a regional market: Creating a market which supports stakeholder engagement in providing for skills development of the workforce.

Financial incentives: Develop incentives for corporates and territories in designing and establishing vocational trainings for the workforce.

Communication: Supporting stakeholders in communicating and advertising training initiatives for meeting future skills demand.

Digital and physical infrastructure for "*Learning Factories*": A clear model for learning factories must be deployed, such as in Germany with the "Learning Factories 4.0".

Agility in mind: The approach towards the skills agenda must be able to adapt to the changing circumstances of new technology developments and the market requirements.

Locally-driven, not centrally-driven: Allow room for territorial differences and not impose an overarching one-fits-all concept upon all individual cases.

Governments can encourage investments in data which will have positive spillovers across industries while addressing the low appropriation of returns to data-sharing. As discussed previously, access and availability of relevant data for new data-driven solutions remains a crucial challenge in the industrial B2B domain.

The combination of intellectual property rights (IPR), licenses and alternative incentive mechanisms should have **international and national guidelines for IPR** to spur data-sharing and to create the required levels of **trust**. The increasing role of software in production gives IPRs - in particular copyright; a strategic importance.

Promoting open standards in APIs would boost interoperability and reuse of data and digital services, while enhancing competition among service providers.

Data governance frameworks should be developed. A balance is needed between openness (and the social benefits from access to and the reuse of data, and the legitimate concerns of those whose privacy and IPRs may be negatively affected.

Policymakers need to be attentive to the procedures for allocating funds for public research; the balance between support for applied and basic research; a variety of institutional features and incentives which shape open science; the frameworks that provide incentives for firms, public researchers and public research institutes to commercialize research, while protecting the public interest; the development of well-designed public-private partnerships.

Foresight in science and technology is needed to understand the landscape. Better anticipation of trends could clearly assist policy development and the allocation of research funds and other resources.

Policymakers need to engage in long-term thinking. A good example, is the German Industrie 4.0-model.

Governments need to address privacy concerns. Comprehensive data collection enabled by the IoT can erode privacy. Promoting privacy-enhancing technologies and the empowerment of individuals through more transparent data processing, and data portability should be considered.

Cross-cutting policy considerations. The range of relevant policy issues is broad, which highlights the need for policy coordination.

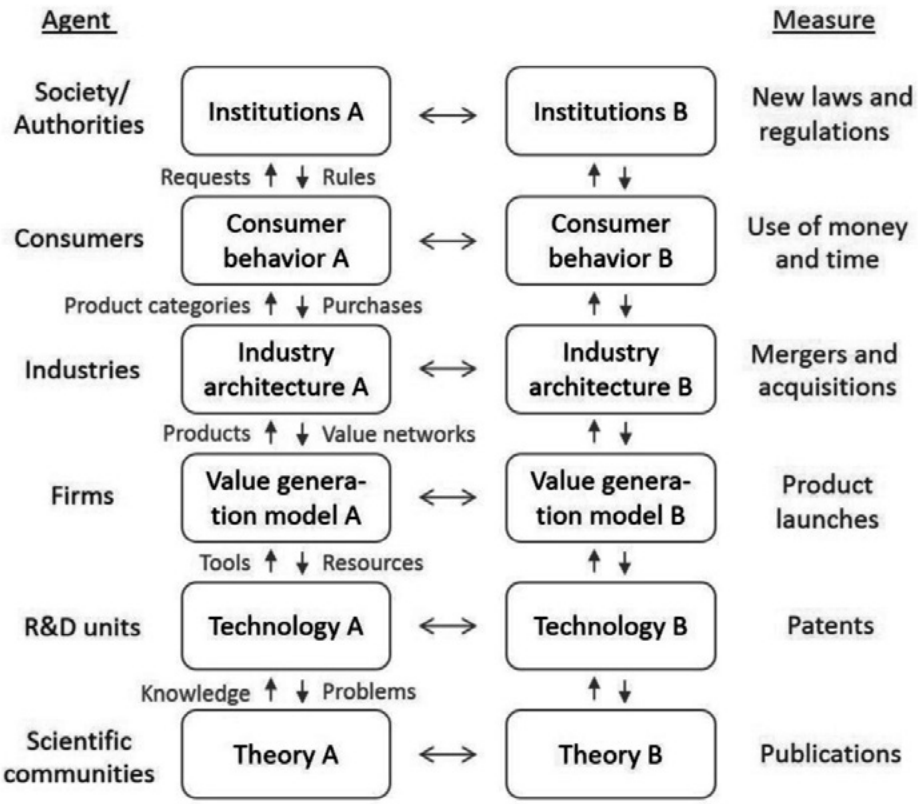
Business role

As the private sector is embracing digital technologies for foreseen new growth opportunities and optimization of their existing businesses, they are faced with a two-fold challenge.

- First, digitalization of business is about accelerating technological change in the existing business. This requires deploying new technology solutions, building new metrics for measuring the progress and at best sharing best practices within the company and its ecosystem to optimize the results.

- Second, transforming the existing business culture with (digital) intelligent tools-enabled ways of working, incentivizing the required internal changes and educating their existing and future workforce proves a far harder challenge to master.

Here in lies a key demand for increased public-private sector planning and co-operation to foster digital economy jointly. To succeed in this joint work a vision-driven, instead of a technology-driven national development plan is required. The below picture describes the complexities for businesses in digital transformation.



Source: Aalto University, Dept. Computer Sciences, 2018

Define Corporate Skills Strategies: Define their own strategy for skills, including the sourcing and upskilling strategy through internal means.

New University Partnership Models: Engage in dialogues and form new partnerships with universities for innovative educational programs.

Apply Innovative Data Driven Skills Assessment Tools: The need of skills for future technologies can be efficiently assessed by leveraging on Big Data and AI technologies.

Facilitating SME Inclusion: Promote and facilitate SMEs by granting access to corporate academies and curricula.

Workforce mobilization: Mobilizing, incentivizing and sensitizing the workforce about their responsibility in their individual lifelong skills journey.

Third party financing: Financing upskilling projects through third party finance schemes.

Innovative Learning Factory infrastructures: Promote and develop new innovative infrastructures for Learning Factories.

Educational role

Territorial skills strategy: Adapt the strategy of the university to the skills agenda of the territory**.**

Cooperative world class skills curricula: Facilitate the transition from theoretical knowledge to practical skills by cooperative programs together with corporates, which include globally recognized certifications.

Accelerated skills acquisition methodology: Innovative approaches for digitally enhanced learning.

Agility tool: The approach towards the vision must be able to adapt to the changing circumstances of new technology developments by deploying an agility tool.

Communication: Communicate the skills strategy and align with all university members.

Rapid technological change could challenge **the adequacy of skills and training systems to match demand and supply for new skills** (although digital technology could of course play a role in augmenting skills supply, for instance through Massive Open Online Courses or MOOCS)

The increasing complexity of some scientific equipment also demands the use of **multiple skill types**. But some education systems and individual institutions may not be responding as well as is needed.

Practices adopted across research institutions, teams and departments - private and public – which enable **interdisciplinary education and research**.

Policymakers could seek to replicate, where appropriate, the approaches of institutions successful in fostering interdisciplinary research.

Developing a high level of **generic skills throughout the population** will also be important. Generic skills such as literacy, numeracy and problem-solving provide a foundation for the acquisition of technology-specific skills (whatever those technology-specific skills turn out to be in future). Good generic skills help to *'future proof'* human capital.

Supporting firm-level training and life-long learning; and, ensuring that any barriers to women's participation in science, technology, engineering and mathematics are removed.

Citizen role

Individual responsibility: Promote individual responsibility in the lifelong upskilling journey systems.

Internal/external mobility: Enable and empower individuals to pursue new placements internally and externally.

Reward systems: Give the individual a reason to believe and to take part in training programs.

Practical skills: Facilitate the transition from theoretical knowledge to practical skills including globally recognized certifications.

9. Conclusions

In 2016, *Foreign Affairs*-journal published an article *"human work in the robotic age"* by two McAfee and Brynjolfsson, where the role of the national government was theoretically simplified to two options

1. fostering a strong, flexible experimentation culture for faster innovation

2. implementing status quo-prone policies protecting the established players and markets.

As seen in this study, European regional and national policymakers have adopted the former option.

This means a balanced public policy approach ranging from new or modified legislation to address the new demands for business environment to actively supporting the adoption of new digital solutions at the firm-level via ecosystems.

As the digital markets for industrial tools and services are in emerging, to succeed in shaping the sectoral digital transformation efforts, it is imperative to look at the existing industrial processes, production logic and business networks to understand the real organizational demand for change. As mentioned, there is no single answer how to address change.

However, examples, such as the cases around the Industrie 4.0-comcept, provide the most efficient ways to induce change fitted to the local conditions, characteristics and ecosystems.

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