12 Technological readiness in Europe

EU policy perspectives on Industry 4.0[1]

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12.1 Introduction

The new technological and innovative developments promised by the next industrial revolution come with their corollaries of optimistic and pessimistic scenarios for our societies. Today, public policy is still tackling digital transition issues; meanwhile, it is already acting on and anticipating the challenges and opportunities, and the risks and uncertainties, of the emerging Industry 4.0 (I4.0) paradigm. This chapter acknowledges these trends and provides an insider view on the background of the policy support given by the European Union (EU)[2] to the transition towards the new industrial age.

While the third production revolution brought its waves of innovations through a wider penetration of information and communications technology (ICT) and automation, I4.0 is expected to extend, accelerate, connect and scale up these disruptions and transformations, and to trigger a wider integration across domains and discoveries. It will enable this through the multiplication of interactions across the physical, digital and biological spheres (Schwab, 2016)[3] allowed by the convergence of new and emerging technologies and materials and the related technology-enhanced processes and systems, including 3D printing, the Internet of Things (IoT), big data and cloud computing, artificial intelligence (AI), advanced robotics, smart factories, precision farming and agriculture, fintech, neurotechnology, micro-engineering, predictive medicine, synthetic biology and predictive gene-based healthcare. The transformational and disruptive nature of the ongoing and upcoming technology-enabled or -pushed changes are already altering our learning, education, consumption, distribution, productive, financial, legal and governance systems (see e.g. Smit et al., 2016; Ulmann 2017; Craglia et al., 2018). They modify our established conceptions of privacy and ownership, work organisation, industries and competitive markets, and prompt the adoption of new business and governance models, as well as new collaborative and sharing practices.

From a policy perspective, these developments call for, amongst other things, adequate public anticipations and responses in terms of societal awareness raising and acceptance, learning and training, technology adoption and diffusion, support to production systems upgrading and value creation, data

security, and standards and regulatory frameworks across various industries and socio-economic domains. While they also entail a variety of opportunities to rethink public policy and its (participatory) processes, the (un)expected and unprecedented transformations of I4.0 are indeed already requiring more agile and anticipatory governance. At the EU level, I4.0 can be considered as a central component of innovation, industry and digital policies, even if in practice the responsibilities are distributed across EU-level institutions and the Member States with their governments and administrative bodies, institutions and agencies.

Setting up the foundations of the Europe 2020 Strategy[4] for smart, sustainable and inclusive growth, the EU has designed dedicated flagship initiatives – 'Innovation Union', 'An industrial policy for the globalisation era' and 'A digital agenda for Europe' flagships (European Commission, 2010a) – to strengthen the framework conditions and environment in the EU economy. Through these early broad and thematic policy initiatives, the Commission has put the development and adoption of emerging and digital technologies at the centre of its growth and modernisation agendas (European Commission, 2010b, 2010c, 2010d). Already, around a decade ago, the game-changing potential of key enabling technologies was underlined for the development of entirely new industries and as a response to societal challenges in areas relating, for instance, to energy, environment and resource scarcity (European Commission, 2009, 2010d). This study departs from these early initial policy steps and examines the main evolutions in the background and policy rationales for the support for the transition towards I.4.0 in Europe. The qualitative analysis mainly relies upon official European Commission communications[5] and EU reports as well as thematic national and regional strategies. It brings together an updated and structured picture of some of the rationales and directions of I4.0-enabling policies in the EU.

The remainder of the chapter is organised as follows. Section 12.2 describes the EU policy background and underlines the main related rationales for the support for the transition towards I4.0. Section 12.3 presents and compares the recently formulated I4.0 policy strategies at the national levels. Then selected regional strategies are discussed, focusing on the policy objectives and formulation as underlined in their innovation strategies for smart specialisation.

12.2 Industry 4.0: EU policy background and main rationales

12.2.1 EU policy background: an overview

The initial efforts to develop key enabling technologies (KETs)[6] and advanced manufacturing as engines of the EU's growth trajectory led to the identification of priority action lines for the EU's industrial policy and investments into new technologies. Building upon the 2010 communication (European Commission, 2010d), the policy proposals for *A Stronger European Industry for Growth and Economic Recovery* (European Commission, 2012) put forward six

fast-growing initial priority areas, including: markets for advanced manufacturing technologies for clean production; markets for key enabling technologies (micro- and nano-electronics, advanced materials, industrial biotechnology, photonics, nanotechnology and advanced manufacturing systems); bio-based product markets; sustainable industrial policy, construction and raw materials; clean vehicles and vessels; and smart grids (European Commission, 2012). These priority markets and technological areas constitute essential components of the industrial policy responses to the economic crisis and formed the basis for the development and modernisation of 'the industrial infrastructure needed for what has been identified as a new "Industrial Revolution"[7]' (ibid, p. 7). High in the concerns was thus the need to speed up investment in breakthrough technologies in fast-growing areas and to capitalize upon and exploit their transformative potential in order to reverse the manufacturing decline. Based on the works of dedicated tasks forces, further policy priorities along the initial areas were proposed for a *European Industrial Renaissance* (European Commission, 2014). These included, for instance, the implementation of knowledge and innovation communities, public–private partnerships (PPPs), the identification of projects of European interests, thematic initiatives, inter-regional cooperative efforts to realise joint investment projects, and dedicated funding schemes for enabling and industrial technologies and breakthrough advances, for instance, under the EU Horizon 2020 programme[8] (see also European Commission, 2015a for an early assessment of the European strategy for KETs).

In addition to the more supply-oriented initiatives, the Commission has gradually integrated a lead user market approach also enshrined in the strategy for the Digital Single Market (DSM)[9] (European Commission, 2015b, 2016a; Burh and Stehnken, 2018; Smit et al., 2016). Lead market strategies intend to stimulate the demand for adoption and diffusion of novel innovation designs (Beise and Cleff, 2004). The DSM communications recognise the multiple opportunities of digital technologies and the major challenges for *Digitising European Industry* deriving, for instance, from the large disparities across firms and European territories, the need for digitally skilled workers, an improved supply of digital consumer products and Web services, a critical mass of investments in digital innovation and infrastructure, and the importance of designing targeted policy actions in the field of data regulation and standardisation. On this latter point, five priority areas for standardisation have been selected focusing on 5G, cloud computing, the IoT, (big) data technologies and cyber-security (European Commission, 2016b) as the technology building blocks of the DSM.

Beyond the technological issues, the digital transition has wider social and economic implications and is changing the labour market conditions and the nature of work and skill mixes (e.g. digital and complementary entrepreneurial, engineering and power or soft skills – see Smit et al., 2016; Ulmann 2017). Acknowledging these structural changes, *A New Skills Agenda for Europe* underlined the main proposals to address the digital skills gaps in Europe and to encourage the development of digital skills strategies across Member States

(European Commission, 2016c). The many important challenges and opportunities of digital and key enabling technologies are again underlined in the successive and more recent communications on industry and innovation policies (see, for instance, European Commission, 2017a, 2018). These different proposals have paved the way and have contributed to the recent establishment of dedicated platforms (e.g. the European Platform of National Initiatives on Digitisation and digital industrial platforms). In parallel, key funding sources have been identified, for instance, from the European Fund for Strategic Investments,[10] Horizon 2020 as well as the European Structural and Investments Funds (ibid).[11]

The priority areas underlined in the previous communications also constituted important building blocks of the EU Regional and Cohesion Policy for the period 2014–2020. Within this policy framework, regions were required to design their Smart Specialisation Strategies[12] as an 'ex-ante conditionality' to access the European Regional Development Fund.[13] Smart specialisation strategies (S3) are socio-economic transformation agendas that aim at identifying priority research and innovation (R&I) investment domains in order to build up sustainable competitive advantages in the regional economies. As part of their smart specialisation strategies, regions were encouraged to collaborate through the Smart Specialisation Platform for Industrial Modernisation (S3P-Industry). Launched in 2016, S3P-Industry intended to facilitate the establishment of inter-regional partnerships and joint investment projects in areas relating to digital technologies and I4.0, and to reinforce the links among industrial value chains across Europe (Hegyi and Rakhmatullin, 2017).

The aim of this section has been to underline some of the fundamental orientations of the EU policy for industrial innovation and technological development. Taken together, EU official communications provide important conceptual pillars of the EU policy background for the digital era and for the transition towards I4.0. Besides, they make it possible to highlight common and consensual motivations across the different thematic policy intervention areas. The next section examines in further detail these key communications in order to put forward the broad policy rationales advanced to support the European digitalisation and industrial transition towards I4.0.

12.2.2 Broad policy rationales

Strengthening the manufacturing sector in the EU through the adoption of new technologies constitutes one of the fundamental rationales for I4.0-enabling policies. The role of the manufacturing sector in terms of direct and indirect jobs, export and private research, and innovation efforts in the EU economy has been acknowledged in successive communications from the European Commission. These latter policy documents have also made explicit the need to reverse manufacturing decline and to bring back to 20% the weight of industry in the EU's gross domestic product (GDP) by 2020. The 20% target has also been underlined in the political guidelines for the current European Commission

as a necessity in order to strengthen the EU's industrial base (Juncker, 2014). This objective raises major scale and policy challenges beyond the sole realm of innovation and industrial policies. One structural issue, as underlined by Berger (2014), resides in the current structure and de-industrialisation trends in EU, which do not leave much room for manoeuvre, also considering the decline of manufacturing (and the parallel rising value-added share of services) observed in other advanced and even emerging economies (Berger, 2014; European Parliamentary Research Service, 2015). Moreover, achieving the target requires coordination across a broader scope of policy areas such as energy, raw materials, capital, trade, education and training, business services, advanced technologies, standards, intellectual property (IP) and the single market in order to improve the overall framework conditions for industrial development (European Commission, 2012, 2014a; Veugelers, 2013; European Parliamentary Research Service, 2015). This means that continued enhanced coordination across the Commission's Directorates and Member States may well contribute to improving the general industrial environment in Europe with an industrial policy that can enhance the impact of targeted investment in new technologies for the advancement of manufacturing systems and the modernisation of industry.

In addition to its importance for economic growth, the manufacturing sector, and its role in research and development (R&D) and innovation, can provide both resources and potential solutions to tackle and address the societal challenges faced by the EU, such as health, climate change, food security and the development of a safe and secure society. A main rationale is that the adoption of I4.0 technologies can enable completely new kinds of better-quality and customised products and services across all economic sectors, while also allowing production to be more efficient from economic, social and environmental perspectives. Also, new and smart technologies are perceived as enablers for environmentally and socially sustainable manufacturing and for the set-up of economically and ecologically sustainable value chains across the EU. From the perspective of more integrated value chains in the EU, the single market is thus seen as pivotal, even vital, for a successful adoption and diffusion of new technological developments, and thus as a driver of the EU's industrial competitiveness (see, for instance, the industrial policy communication: European Commission, 2017a).[14] Yet, much is still to be done to advance or reinforce the lead in the global competition in green and clean technologies and smart manufacturing. Some of the answers will certainly lie in the EU strategic value chains that will be selected and supported and, eventually, in our ability to integrate and connect innovation systems and clusters across Europe, as well as to attenuate the (effects of) disparities that exist between regions, industries and firms (see European Commission, 2016a; Innobarometer,[15] Business Innovation Observatories, Digital Economy and Society Index (DESI)[16] in European Commission, 2017c; Digital Innovation Monitor[17] 2018 in European Commission, 2018a; and Vezzani et al., 2018 for comparisons of innovation performances in the EU).

By encouraging inter-regional collaborations and bottom-up initiatives for industrial modernisation, the Cohesion Policy's smart specialisation framework might actually hold some keys to unlock I4.0-enabled and sustainable cross-regional value chains in the EU. This also means that partnerships should be based on evidence-based matchings and assessments of related-industrial capabilities, skills and potential for critical mass, and that capacities for adequate monitoring and benchmarking need to be built up or reinforced. For the great diversity of European micro-firms and SMEs, important constraints on their transition towards I4.0 come from their awareness and understanding of the new model, of the benefits of absorption, the technology uncertainty, the costs of investment, economic impact assessments, issues around security, and the availability of I4.0 competences and skilled workers. At the same time, pressures to reinvent the ways in which firms deliver value to customers and markets and inter-connect through current and future value chains are no less important (Smit et al., 2016; Ulmann 2017). Nevertheless, hopes that I4.0 can allow the EU's industry to become attractive again for production and manufacturing activities are rising. In other words, advanced manufacturing technologies can be instrumental to aid reshoring in the EU (see Chapter 11 in this volume).

I4.0-oriented skills are required for the modernisation and digitalisation of EU industry. The skills shortage and mismatches in fields such as ICTs, green technologies, advanced industrial processes, fast-growing industries, science, technology, engineering and mathematics (STEM) subjects, research, creativity and entrepreneurship, and the importance of anticipating digital and I4.0-enabling skills needs are widely recognised in the EU policy background. In the ICT field in particular, it is estimated that Europe could have a major shortfall of ICT professionals in the short to medium term. Modernising the EU industrial skills bases and filling (digital) vacancies pose many imperatives for our traditional education systems, vocational education and training, as well as our lifelong learning frameworks and mechanisms. Especially in the transition towards I4.0, such investments should rely upon the development of dedicated tools to monitor and anticipate needs and mismatches at the EU, country, regional, local and industrial levels. Recent multi-stakeholder initiatives such as the 'Blueprint for Sectoral Cooperation on Skills'[18] and the 'Digital Skills and Jobs Coalition' are expected to contribute to address digital and sectoral skills mismatches in the EU (European Commission, 2016c). In addition to skills shortages, growing tensions are emerging within the exiting workforce due to the ongoing and pressing changes at both the organisational and factory-floor levels, leading, for instance, to complex imbalances between control, liability, flexibility, autonomy and empowerment, and to the greater human–machine interactions enabled by the adoption and diffusion of smarter technologies (see e.g. Craglia et al., 2018; Cirillo et al., 2018; UN DESA/DPAD, 2017). The scale and depth of these imbalances may differ greatly across industries and types of occupations (see e.g. Brynjolfsson et al., 2018; Frey and Osborne, 2017). These changes have come with the phenomena of polarisation, jobs creation, destruction and

transformation, and a series of labour market shocks, which call for enhanced skills planning capabilities and forward-looking governance mechanisms to anticipate, for instance, potential worker displacements due to the introduction of new production technologies and new labour rights in the digital economy. I4.0 technologies and processes also bring to the fore many legal and accountability concerns and would certainly require the setting-up of completely new forms of working and social contracts, which could account better for the socio-political aspects of digitalisation (European Parliamentary Research Service, 2014; Burh and Stehnken, 2018).

Timely regulation and standards for I4.0 technologies are critical for realising I4.0. 'A standard is a document, established by a consensus of subject matter experts and approved by a recognised body that provides guidance on the design, use or performance of materials, products, processes, services, systems or persons' (International Organization for Standardization [ISO]).[19] Standards are essential for the development and dissemination of new products and services, and enable comparability and inter-operability across firms, industries, regions and countries. Since the beginning of the decade, many EU-led initiatives[20] have been implemented jointly to foster the European Standardisation System (ESS) and the single market, as essential framework conditions for industrial innovation and enhanced competitiveness. In the I4.0 era, industry-wide adoption of standards is an even more critical requirement to facilitate the global networking of production and global functioning applications, and, above all, to allow for the realisation of economies of scale and productivity gains, as expected from the adoption of new advanced technologies (Smit et al., 2016). Moreover, anticipation in the area of standards can secure the digitalisation and modernisation of EU industries. According to a recent Joint Research Centre (JRC) study, broad thematic areas for standardisation include standards for integration, environmental sustainability, quality and performance, service standards and de-risking standards (Scapolo et al., 2015).

Regulation and anticipatory regulation help cope with the pace of change induced by the transition to I4.0. 'Anticipatory regulation is an emerging method of regulation that is proactive, iterative and responds to evolving markets' (NESTA, 2017). With faster technological change, the anticipation of regulation or de-regulation is necessary to limit technical (e.g. regarding open internet) and legal barriers (e.g. on the use and sharing of data; see also OECD, 2017) and also to address obsolete regulation, IP issues and their scope, the identification of final ownership and security of data, the liability for autonomous systems, cyber-security, and labour rights and workplace conditions. As already achieved in terms of data privacy regulation (the General Data Protection Regulation (GDPR); European Commission, 2016d), the EU is expected to become even more proactive considering the uncertainties related to smart technologies, their interactions with and effects on human beings, and the current and coming data-related concerns (see, for instance, Craglia et al., 2018 on AI-related challenges; and European Commission, 2018b for recent proposals on data and public information regulations by the Commission).

The EU has taken many initiatives to foster the DSM and to facilitate the uptake of new technologies and the generation of technology-enabled products, services and processes. Nevertheless, more action and greater investment will be required to enhance the coordination and the continuity of different national strategies and to better account for industry-region-specific contexts in order to enable an inclusive and sustainable transition towards I4.0. The next section touches upon such strategies at the national and regional levels and compares the different uptake of strategies focusing on the formulation of policy objectives in the transition towards I4.0.

12.3 Stimulating, accelerating and monitoring I4.0 in the EU

12.3.1 I4.0-enabling national initiatives in the EU

A number of EU Member States have designed a strategy to address the challenges of digitalisation and the transition towards I4.0. At the EU level, these strategies are monitored by the Digital Transformation Monitor (DTM), as part of the European Platform of National Initiatives. Launched at the beginning of 2017, the European Platform aims at facilitating more inclusive coordination and best practice exchanges for the achievement of the *Digitising European Industry* (see European Commission, 2016a). It also intends to stimulate collaborations and joint investments in order to reach the critical mass required to meet the goals set in terms of digitalisation of industry across Europe. As of October 2017, 15 Member States had already launched national initiatives for the digitisation of industry.[21] Seven more initiatives were under preparation. The DTM enables an EU-level monitoring of digital transformation in order to support a coordinated EU-wide effort. The Web platform provides statistics and information about initiatives for and the challenges related to digital transformation at the EU, national, sectoral and technological levels. As an integral element of the European Platform of National Initiatives on Digitising Industry, the DTM allows us to compare the framework conditions of national digital policies, for instance, through the Digital Transformation Scoreboard (2018) (DTS). The most recent DTM report covers a total of 19 strategies and programmes for digitalisation and relies mainly on desk research and interviews. The DTS provides Country Profile Reports (CPRs) for each Member State and offers a comparative overview in terms of framework conditions, main strengths and areas for improvement, as well as interesting policy practices.

In addition, the DTM makes available on the platform the documents of individual Member State, which present the main features of national initiatives, such as the policy levers, pillars and objectives, the budget and funding models, the strengths and weaknesses, the implementation strategy, the results achieved so far and uniqueness factors. Table 12.1 uses information from these documents in order to suggest a comparative overview of some of the national initiatives.[22] While these initiatives are collected under the thematic digital transformation,[23] many Member States actually refer more or less explicitly to I4.0.

As also underlined in the DTM analyses, the initiatives present many similarities in terms of policy objectives, but differ greatly, for instance, in terms of strategy design, focus, budget and related funding mechanisms, implementation approaches, coordination mechanisms and timing in terms of implementation and results achieved so far (Digital Transformation Scoreboard [2018] and national initiatives documents). Whilst such differences limit strict comparisons across national initiatives, they provide a relevant basis for benchmarking and experience exchanges.

Often initiated by the government or PPPs, many initiatives are now led or coordinated through multi-stakeholder partnerships with the close involvement of industry, academia and research. Indeed, a majority of national I4.0-enabling policies follow a bottom-up approach for the implementation of the initiatives. Moreover, the component 'awareness raising about I4.0, I4.0-related or digital technologies' is considered by many as critical to address the uncertainties associated with the emerging paradigm and to exploit the relevant opportunities offered by new technologies. As part of their strategies for digitalisation, many Member States and regions support the implementation of Digital Innovation Hubs (DIHs).[24] DIHs are one-stop-shops for SMEs, mid-caps and more mature or established companies, which provide a range of supporting services, including technology testing, financing advice, market intelligence, training, promotion and marketing, and networking opportunities. Two hundred hubs are already fully operational and about the same number are expected to be implemented. The WATIFY campaign[25] also complements the national and regional efforts, through awareness events, success story-telling and matchmaking events, in order to stimulate the modernisation of the EU industry, the technological transformation through digitisation and the uptake of advanced technologies. Working on different timescales, such national initiatives vary in terms of what they have achieved; indeed, whilst some Member States were actually still preparing implementation plans, others were already implementing their actions (e.g. the Czech Republic, Hungary, Slovakia and Slovenia; see Table 12.1). As initiatives differ in relation to the specific targets, their achievements also take different forms, such as network development, the number of supported, funded or awarded companies, identification of experts, R&I support (funding, programmes established), research cooperation and workers' training, depending, amongst other things, on the objectives and national specific contexts and industrial structures.

Furthermore, it is becoming apparent that Member States' initiatives and programmes also differ in terms of the weaknesses and threats of the initiatives adopted. Some initiatives show some weaknesses in relation to: the lack of a clear funding model or the lack or low level of public and or private funding; the definition of implementation plans and target setting; the low business culture and inadequate or costly internet and ICT infrastructure; bottlenecks in the deployment at the shop-floor level; the balance between small and large firms; or the definition of adequate company-level monitoring indicators. Threats also vary in terms of: regional inequalities; imbalances or divergence between

Table 12.1 Overview of selected national initiatives*

Countries	*Names of the initiatives (launch, adoption or official year of announcement)*	*Broad policy objectives (examples)*	*Main targets*	*Dedicated budgets (approximate)*
Austria	Plattform Industrie 4.0 (2015)	- Leverage multi-stakeholder interests - Accompany digitisation and provide knowledge and services on I4.0 - Define fields of action and advise policy makers - Develop joint strategies with high leverage on I4.0 - Steer regional, national and international activities - Enable exchanges of experience, best practices, data and studies	Companies, research, academia, policy makers, trade unions, employees' associations	€300,000 a year from founding members and €200,000 from fees (est. 2017)
Belgium	Made Different (launched in Flanders, 2013) Made Different-Digital Wallonia (launched in 2017)	- Foster move towards I4.0 - Support digital transformation of production and operational processes - Transform manufacturing into Factories of the Future	Manufacturing companies, esp. SMEs	No dedicated funding scheme, but availability of public grants
Czech Republic	Průmysl 4.0 (2016)	- Enhance competitiveness in the wake of I4.0 - Foster ability of companies to participate in GVCs - Improve manufacturing efficiency - Improve multi-stakeholder cooperation for the development of software solutions, patents, production lines and export know-how	Policy makers, private sector, R&D organisations, industry associations, academia	No additional budget earmarked

(*continued*)

Table 12.1 Cont.

Countries	*Names of the initiatives (launch, adoption or official year of announcement)*	*Broad policy objectives (examples)*	*Main targets*	*Dedicated budgets (approximate)*
Denmark	Manufacturing Academy of Denmark, MADE (2015)	- Increase competitiveness through industrial-based research in manufacturing - Strengthen Danish technical research community - Create an enabling ecosystem for research, innovation and knowledge sharing - Optimise education for manufacturing	Manufacturing SMEs, research and academia stakeholders	€50 million for 2014–2019 from participating companies, universities, associations, private foundations and public funds
France	Industries du Futur (2015)	- Developing cutting-edge technology - Business transformation - Upskilling the workforce - International cooperation on standards and alliances - Promotion of Industries du Futur	Industry and production SMEs, mid-tier companies and technology providers, academia and public bodies	Approx. €10 billion from public sources, including IftF funding from 2017 onwards, supported by private funding
Germany	Industrie 4.0 (2011)	- Technology deployment - Integration of cyber physical systems & IoT in industry processes - Enhance productivity, efficiency and flexibility of production processes	Manufacturing and production SMEs, entrepreneurs, large corporation, Policy makers	€200 million from public and contribution from industry
Hungary	IPAR 4.0 National Technology Platform (2016)	- Enhance information exchange and cooperation - Accelerate innovation in key areas of digitalisation and production - Innovative adaptation - Fasten responses to challenges and foster bold steps towards innovation	Policy makers, private sector, R&D organisations, industry associations, universities, social circles, businesses	In progress (incl. planned state support)

Italy	Industria 4.0 (2017)	- Innovative investment - Uptake of innovative technologies related to I4.0 - Development of skills with I4.0 education programmes	SMEs, micro-enterprises and large companies	>€18 billion for the period 2017–2020
Latvia	National Industrial Policy Guidelines 2014–2020	- Align workforce supply and education to the economy's needs - Foster manufacturing in industrialised areas and reduce energy costs - Improve financing availability - Promote an innovative environment and stimulate exports	National industry, managers, employees, students, clusters, etc.	Public funds (EU and national) amount to more than €6 billion for 2014–2020, complemented by private sector financing
Lithuania	Pramonė 4.0 (2017)	- Reinforce the competitiveness and productivity of the industry - Advance the integration of digital solutions and new technologies in the national industry	Industrial companies, enterprises and universities	€79.8 million foreseen for industry digitalisation in 2017–2020
Luxembourg	The Third Industrial Revolution Strategy Powered by Transformational Investments (initiated in 2015)	- Prepare the economy and society for megatrends and disruptions and for new economic models - Foster digital capabilities and competencies - Support firms and employees in the digital transition process	Public and private stakeholders, and specific industries	Project-based
Poland	Initiative for Polish Industry 4.0 – the Future Industry Platform (announced in 2016)	- Improve competitiveness of industry and establish conditions for I4.0 - Improve competitiveness of domestic machines, devices and software - Consolidate supply chains - Improve labour market attractiveness	Public and private stakeholders, esp. SMEs and domestic 4.0 solution suppliers, academia, research	In progress

(*continued*)

Table 12.1 Cont.

Countries	*Names of the initiatives (launch, adoption or official year of announcement)*	*Broad policy objectives (examples)*	*Main targets*	*Dedicated budgets (approximate)*
Portugal	Indústria 4.0 (2017)	- Provide industry with knowledge, information and tools for transformation and empower the national workforce - Enable conditions for the development of i4.0 start-ups and national technological solutions in an international context - Make Portugal an international hub	SMEs	€4.5 billion over four years
Slovakia	Smart Industry (2016)	- Bring company closer to I4.0 principles and thinking - Strengthen the economy and support the digital transformations of businesses	Industry, SMEs, R&D organisations, education providers and civil society	No additional budget earmarked
Slovenia	Slovenian Digital Coalition (2016)	- Foster development of the digital economy - Stimulate the creation of digital jobs - Support the exploitation of opportunities of ICT and internet	Civil society, public and private sector, industry	No dedicated budget
Spain	Industria Conectada 4.0 (2014)	- Increase the industrial added value and employment - Support the Spanish model for the industry of the future - Develop the local digital solutions - Develop differential competitive levers to promote industry and exports	Industrial enterprises, esp. SMEs and micro-enterprises	€97.5 million for project calls and related programmes, €68 million for ICT firms; €10 million for innovative clusters
Sweden	Produktion 2030 (2013)	- Modernise the industry base - Support sustainable production and customised, high-end industrial services - Upskill the workforce - Facilitate investments in production R&D	Research institutes, universities and companies/SMEs from industry and services	€25 million from VINNOVA 2013–2018 and €25 million from industry

The Netherlands	Smart Industry (2016)	- Catch up with I4.0 frontrunners - Support industry use of ICT and related opportunities - Strengthen knowledge, skills and ICT conditions - Enhance industry and manufacturing competitiveness	Business community with sectoral focus	€25 million for 2014–2017 complemented by industry co-financing
UK	High Value Manufacturing Catapult (HVMC) (2011)	- Accelerate new concepts to commercial reality and create sustainable high-value manufacturing - Innovation support improving manufacturing competitiveness - Innovation support for new sectors and markets - Target innovation support to SMEs - Support the development of the next-generation technologies to transform UK manufacturing	Business, industry and research organisations	€164 million from UK government on 2012–18 For 2015/16: €79.7 million commercial income vs. €61.3 million public funding and €62 million for collaborative R&D

Source: Elaborations from the 19 country documents available at https://ec.europa.eu/growth/tools-databases/dem/monitor/category/national-initiatives.

Note: Dates of the latest versions of websites range between January 2017 and May 2018.

relevant stakeholders' interests and involvement; the insufficient reach of micro-enterprises and small companies; decreasing mobilisation; mismatches between industry needs and qualifications; the discouraging effects of I4.0 complexity; instability of funding; social rejection; cyber-security-related threats; and political and economic instability.

12.3.2 The I4.0 in Research & Innovation Strategies for Smart Specialisation (RIS3)

Under the reformed cohesion policy for 2014–2020, several regions and Member States have designed their smart specialisation strategies as the basis for the identification of priority domains for R&I investments. S3 processes unfold into six fundamental steps, including an analysis of regional strengths, weaknesses and potential; a dedicated and inclusive governance; the adoption of a shared vision for local development; the identification and selection of priority R&I areas; the design of policy mixes; and the establishment of monitoring and evaluation frameworks (Foray et al., 2012). The priority or strategic domains can be reviewed and revised, and should help regions and countries to build up or reinforce competitive advantages through the development of unique innovation niches. Ideally, priorities should foster the development of new businesses and, eventually, block easy replication or imitation outside the region (European Parliamentary Research Service, 2018). The selection of strategic domains is based on bottom-up approaches and wide stakeholder involvement – the so-called Entrepreneurial Discovery Process (EDP). EDPs intend to be inclusive and participatory processes for decision making, which bring together business enterprises, government, research and academic institutions, and civil society/consumer groups in order to identify new domains for innovation and market opportunities (see, for instance Foray, 2015). The EDP features and the implementation strategies and approaches reflect the diversity of regional and national contexts, challenges and cultures, and the selected strategic domains (see Gianelle et al., 2016; OECD, 2013).

RIS3 strategies are monitored through the Smart Specialisation Platform, which aims at providing evidence-based advice and assistance for the design and implementation of the strategies. It offers, among other things, online inventory and benchmarking tools, technical reports and experts reviews. Since 2014, more than 100 S3 strategies have been developed and more than €40 billion (and more than €65 billion including national co-financing) have been allocated to regions for priority funding through the European Regional Development Fund (European Commission, 2017b). In practice, S3 strategies are implemented by the Operational Programmes (OPs).[26] Such OPs are plans in which Member States and/or regions detail how funding from the European Structural and Investment Funds will be spent during the programming period. The European Structural and Investment Funds include the European Regional Development Fund, the European Social Fund, the Cohesion Fund, the European Agricultural Fund for Rural Development, and the European Maritime and Fisheries Fund.

In order to stimulate and enhance the coordination for joint projects and investments for socio-economic transformation and modernisation, the Commission has set up the Thematic Smart Specialisation Platforms (or S3 Thematic Platforms)[27] in areas relating to energy (launched in 2015), agri-food and industrial modernisation (launched in 2016). Overall, the platforms involve over 120 regions and 28 inter-regional partnerships working together with the objective of realising joint investment projects (European Commission, 2017b). The platforms are meant to be developed and led by regions relying on wide stakeholder involvement, and new partnerships can be set up through expressions of interests on the thematic platforms. In particular, I4.0 technologies are expected to play a key role in industrial transitions and modernisation across EU regions. In terms of regional scope, the S3 Thematic Platform of Industrial Modernization is expected to be crucial for further I4.0-oriented transnational and inter-regional collaborations at different stages of the R&D and innovation value chains. From this perspective, the Vanguard Initiative is seen as inspirational to develop inter-territorial spaces and organisations to reinforce industrial modernisation across EU regions in priority areas or techno-industrial domains.[28]

Originally developed as a strategic development support tool, Eye@RIS3 provides information on the priorities, including their description, economic domains and scientific domains, and EU policy objectives.[29] Data and information come from national and regional public managers and from the European Commission staff, and are updated according to the outcomes of the (continuous) EDPs. Overall, KETs and Digital Agenda feature in at least one priority for more than half of the regions. Under the broad KETs category, sub-domains include, for instance, advanced manufacturing systems and materials and industrial biotechnology (see Hegyi and Rakhmatullin, 2017 for the main evolutions of the S3P-Industry). The S3P-Industry initiative, a multi-regional partnership on I4.0, explicitly aims at showing the benefit of I4.0 solutions and technologies to SMEs.[30] As a key component of the Digitising European Industry initiative, the DIHs are also actively involved in the S3 processes, either by leading a S3 priority area or by carrying more horizontal missions.[31] Additional support to the thematic platform is provided by the EU-funded ReConfirm project through evidence-based analyses for partnerships, collaboration labs and strategic workshops (matchmaking, roadmaps making assistance, etc.).

Table 12.2 presents selected information about RIS3 for some regions with different encoded policy objectives associated with the priorities or strategic domains selected by the Member States or regions. The search terms for the selection of regions included 'industry 4.0', 'industry 40, KETs', 'key enabling technologies' and '4.0 and digital technologies' in order to flag up examples of how 4.0-related technologies have been integrated into RIS3 designs.

More detailed information about each strategy is made available by the search and selection of the Member States or regions. The scope of this chapter unfortunately does not allow us to provide a comprehensive study of the variety of I4.0-related priorities and their different implementation stages at the

Table 12.2 Examples of I4.0-related policy objectives for selected RIS3 (Eye@RIS3)

NUTS ID	*Region/country name*	*Policy objectives related to priorities*	*Date source*
BE3	Walloon Region	D – Digital transformation, D.22 – Cleaner environment & efficient energy networks and low energy computing, D.25 – E-Commerce & SMEs online, D.26 – e-Government (e.g. e-Procurement, open data & sharing of public sector information), D.27 – e-Health (e.g. healthy ageing), D.28 – e-Inclusion (e.g. e-Skills, e-Learning), D.29 – ICT trust, cyber security & network security, D.30 – Intelligent inter-modal & sustainable urban areas (e.g. smart cities), D.33 – New media & easier access to cultural contents (e.g. heritage), D.35 – Robotics, autonomous and cyber physical systems (e.g. vehicles, embedded systems) J – Sustainable innovation, J.63 – Eco-innovations, J.66 – Smart green & integrated transport systems	Dec-14
DE3	Berlin	D – Digital transformation, D.19 – Artificial intelligence, cognitive systems, augmented and virtual reality, visualisation, simulation, gamification & interaction technologies, D.24 – Digitising Industry (Industry 4.0, smart and additive manufacturing) E – KETs, E.37 – Advanced manufacturing systems	Nov-13
DK04	Midtjylland	D – Digital transformation, D.24 – Digitising Industry (Industry 4.0, smart & additive manufacturing)	Jan-16
EL11	Anatoliki Makedonia, Thraki	D – Digital transformation, D.24 – Digitising Industry (Industry 4.0, smart and additive manufacturing) E – KETs, E.37 – Advanced manufacturing systems, E.38 – Advanced materials, E.39 – Industrial biotechnology, E.40 – Micro/Nano-electronics, E.41 – Nanotechnology, E.42 – Photonics	July-14
ES21	País Vasco	B – Blue growth, B.13 – Offshore mining, oil & gas E – KETs, E.37 – Advanced manufacturing systems, E.38 – Advanced materials	Dec-14
ES61	Andalucía*	A – Aeronautics & space, A.01 – Aeronautics, A.02 – Aeronautics & environment, A.03 – Bio fuels & energy efficiency, A.04 – Remotely piloted aircrafts, A.05 – Safety & security, A.06 – Space, A.07 – Transport & logistics	Jan-14
ITC4	Lombardia	E – KETs, E.37 – Advanced manufacturing systems	Oct-14

LU	Luxembourg	A – Aeronautics & space, A.06 – Space, A.07 – Transport & logistics D – Digital transformation, D.18 – Advanced or High performance computing, D.19 – AI, cognitive systems, augmented and virtual reality, visualisation, simulation, gamification & interaction technologies, D.20 – Big data, data mining, database management … D.25 – E-Commerce & SMEs online … D.35 – Robotics, autonomous & cyber physical systems (e.g. vehicles, embedded systems), D.36 – Smart system integration E – KETs, E.37 – Advanced manufacturing systems H – Service innovation, H.51 – New or improved organisational models, H.52 – New or improved service processes, H.53 – New or improved service products (commodities or public services)	Dec-17
PL22	Slaskie	E – KETs, E.37 – Advanced manufacturing systems, E.38 – Advanced materials	Dec-12
SI	Slovenia	D – Digital transformation, D.18 – Advanced or High performance computing, D.19 – Artificial intelligence, cognitive systems, augmented and virtual reality, visualisation, simulation, gamification & interaction technologies, D.20 – Big data, data mining, database management, ..., D.25 – E-Commerce & SMEs online, D.31 – Internet of Things (e.g. connected devices, sensors and actuators networks), D.35 – Robotics, autonomous and cyber-physical systems (e.g. vehicles, embedded systems), D.36 – Smart system integration E – KETs, E.37 – Advanced manufacturing systems	Sept-15

Source: Eye@RIS3 database, December 2018.

Notes:

* Information from Draft RIS3 Document or other (otherwise from final document)
Eye@RIS3 was fully upgraded in September 2018. Data are regularly updated based on inputs from European regional and national authorities and their stakeholders.

regional level.[32] Nevertheless, as for the national initiatives, it might still be too early a stage to assess the impact of dedicated efforts to support the transition towards I.4.0. But it may not be too late to provide evidence-based and multi-dimensional considerations of the I4.0 readiness of EU regions in order to anticipate, for instance, a territory-specific lack of adequate resources and cost-efficient infrastructure, or obstacles to partnership, or even cases of workforce and social rejections.

12.4 Conclusions

The EU has taken several important steps and has advanced on many fronts to stimulate, coordinate, monitor and strengthen framework conditions for the uptake of digital and enabling technologies in order to accompany the modernisation of its industrial bases and systems. Nevertheless, much remains to be done to ensure consistent and sustainable I4.0-driven or I4.0-enabled socio-economic and industrial transformations. Importantly, on the one hand, the imperatives of developing a critical mass do not relate solely to target funding or infrastructure, but also, and maybe more fundamentally, to the levels of awareness and readiness of our society and citizens in relation to I4.0 technologies and their transformational potential. On the other hand, the adoption and diffusion of new technologies and models should be fast-tracked in the majority of our regions in order to considerably reduce the territorial imbalances that can seriously undermine the inclusiveness and sustainability of such modernisation and transition paths.

From a governance and policy practitioner perspective, the level of horizontal and multi-level coordination required and the limited scope for experimentation and learning pose even more complex challenges in this transition period, especially when combined with the management of increasingly open and inter-connected territories. In this context, approaches such as smart specialisation can help to address these new challenges by offering renewed possibilities for evidence-informed collaborative innovation and industrial policy making. As underlined during the European Week of Regions and Cities,[33] critical to the success of these bottom-up initiatives are the territorial competences and assets needed to generate and sustain new dynamics for value creation and capture (Bailey et al., 2018), and the ability to match policy actions with territory-specific needs.

Notes

1 Disclaimer: the analyses presented in this chapter do not necessarily represent the views of the European Commission. Neither the European Commission nor anyone acting on its behalf can be held responsible for any use made thereof. The author would like to thank her colleagues Hegyi F., Rissola G. from the Smart Specialisation Platform, Tuebke A., Hervas F. from JRC-Unit B3 and Batalla Masana M. and Engelmann U. from DG GROW for their constructive comments and feedback on the chapter.

2 The EU is a union of 28 Member States and their citizens. Many institutions are involved in decision-making processes at the EU level, including the European Parliament (elected by EU's citizens), the European Council (heads of state or governments; see European Commission, 2018b), the Council or the Council of the European Union (representatives of governments) and the European Commission, which generally proposes new laws to be adopted by the Parliament and the Council. In this chapter, the focus is on the policy directions and proposals as reflected in the European Commission's communication and documents (see Publication Office of the European Union: https://publications.europa.eu/en/home).
3 See also at https://ec.europa.eu/digital-single-market/en/fourth-industrial-revolution.
4 The Europe 2020 Strategy is the EU's agenda for growth and jobs for the decade 2010–2020. It puts forward three priority dimensions, five headline targets and seven flagship initiatives.
5 The communications of the Commission refer here to the official documents, which provide the main rationales, levers and action lines, as well as the Commission's proposals regarding a given thematic and policy area or issue.
6 The European strategy for KETs combined the efforts of different Directorate-Generals (DGs) of the European Commission, including DG Research and Innovation, DG Communications Networks, Content and Technology, DG Regional Policy, DG Trade and DG Competition, under the political leadership of DG Internal Market, Industry, Entrepreneurship and SMEs. A high-level group on KETs is advising the European Commission on the implementation of KETs. For more about the European strategy for KETs, see https://ec.europa.eu/growth/industry/policy/key-enabling-technologies/european-strategy_en.
7 In reference to Rifkin (2011).
8 Horizon 2020 is the financial instrument of the Innovation Union flagship and constitutes the largest EU Research & Innovation programme ever, with about €80 billion of funding available between 2014 and 2020. The work programme for 2014–2015 included KETs pilot lines in areas identified by the High-Level Expert Group.
9 Digital Single Market – Policies: The Fourth Industrial Revolution, https://ec.europa.eu/digital-single-market/en/fourth-industrial-revolution.
10 The European Fund for Strategic Investment (EFSI) is one of the three pillars of the Investment Plan for Europe, which finances strategic investments in key areas such as infrastructure, R&I, education, renewable energy and energy efficiency, as well as risk finance for small and medium-sized enterprises (SMEs). For more details on this, see https://ec.europa.eu/commission/priorities/jobs-growth-and-investment/investment-plan-europe-juncker-plan/what-investment-plan-europe_en.
11 European Structural and Investment Funds: https://ec.europa.eu/info/funding-tenders/funding-opportunities/funding-programmes/overview-funding-programmes/european-structural-and-investment-funds_en. See also the early guidelines for enabling synergies between the funds at https://ec.europa.eu/regional_policy/sources/docgener/guides/synergy/synergies_en.pdf.
12 Smart Specialisation Platform: http://s3platform.jrc.ec.europa.eu.
13 Regulation EU 1301/2013. See also Foray et al (2012) for an official guide on smart specialisation strategies; and European Commission (2017b) for a recent communication on the regional policy.

14 Single Market Act I and Single Market Act II: http://ec.europa.eu/growth/single-market/smact_en.
15 Innobarometer and Business Innovation Observatory (DG GROW): http://ec.europa.eu/growth/industry/innovation/facts-figures_en.
16 Digital Economy and Society Index (DESI): https://ec.europa.eu/digital-single-market/en/desi.
17 Digital Transformation Monitor: https://ec.europa.eu/growth/tools-databases/dem/monitor.
18 Blueprint for Sectoral Cooperation on Skills: https://ec.europa.eu/social/main.jsp?catId=1415&langId=en.
19 https://www.iso.org/sites/ConsumersStandards/1_standards.html.
20 See European Commission (2016b) for ICT priority standards and the different EU initiatives in the area of standards at http://ec.europa.eu/growth/single-market/european-standards_en. See also the Vademecum at https://ec.europa.eu/growth/single-market/european-standards/vademecum_en, which compiles key documents from the European Commission on European standardisation policy and related practice. It provides guidance without having legal status.
21 See also a more detailed List of Active National Policy Initiatives for Digitisation of Industry at https://ec.europa.eu/futurium/en/system/files/ged/list_of_policy_initiatives_on_digitising_industry_across_eu_211117.pdf (last updated November 2017).
22 See https://ec.europa.eu/futurium/en/implementing-digitising-european-industry-actions/national-initiatives-digitising-industry.
23 In this chapter, policies for digital transformation are considered as I4.0-enabling policies. See Rifkin (2011) for conceptual discussions about the complementarity between I4.0 and Third Industrial Revolution paradigms in driving industrial transformation.
24 See https://ec.europa.eu/digital-single-market/en/news/digital-innovation-hubs-annual-event-2018. See also additional background information at https://ec.europa.eu/futurium/en/system/files/ged/digital_innovation_hubs_in_digital_europe_programme_final2_december.pdf.
25 https://ec.europa.eu/growth/tools-databases/dem/watify.
26 Operational Programmes adopted by the European Commission at the beginning of a programming period can be found at: https://ec.europa.eu/regional_policy/index.cfm/en/atlas/programmes.
27 Thematic Smart Specialisation Platforms: http://s3platform.jrc.ec.europa.eu/s3-thematic-platforms.
28 See https://www.s3vanguardinitiative.eu/
29 Eye@RIS3 database: http://s3platform.jrc.ec.europa.eu/eye-ris3.
30 Partnership webpage: http://s3platform.jrc.ec.europa.eu/eu/sme-integration-to-industry.
31 In practice, they can also result from an S3 process; see Rissola and Sörvik (2018) for dedicated cases studies on DIHs and S3. A catalogue of DIHs monitored by the S3 platform is available at: http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-catalogue.
32 See, for instance, Gianelle et al. (2016); European Parliamentary Research Service (2018).
33 See the reports and presentations of the workshop session on 'Thirty Years of EU Cohesion Policy: What Works? Where? for Whom?', co-organised by DG REGIO during the European Week of Regions and Cities 2018, at: https://europa.eu/regions-and-cities/programme/sessions/154_en.

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