Policy Report

An industrial policy for EU New Manufacturing

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Executive Summary

This report uses a number of key cross cutting themes identified through the course of the MAKERS project, in highlighting current issues that need to be addressed in order to further facilitate and promote the uptake, implementation and dissemination of Industry 4.0 technologies and practices: New Smart Specialisation; Public/Private financial support; Global Value chains and reshoring; Awareness, readiness and infrastructure; Skills and capacity building; and Sustainability.

Drawing on this, the report identifies a need for policies to address a range of issues, including, inter alia, the need for: new skills to be developed and constant re-skilling and up-skilling processes as Industry 4.0 progresses; enabling SMEs to have access to funding and finance to embrace digital technologies; recognising and exploiting possibilities to reposition firms, industries and regions on new parts of the global value chain as the value added of manufacturing changes over time; seizing re-shoring opportunities as relocalisation opportunities open up – involving policies to rebuild supply chains in Europe; infrastructure investment to embrace new technologies (e.g. 5G) and so on as part of an holistic regional industrial policy.

In so doing, the report stresses that Industry 4.0 will play out differently across sectors and regions, and this will have implications for the focus of and the innovation aspirations of EU industrial and cohesion policy. The integration of sectors with new technologies will be fundamental in allowing the former to be truly transformed in the light of the new technologies. A transformative industrial policy needs therefore to ‘join up’ technologies, sectors and places. The challenge for the new round of RIS3 will be to acknowledge the transformative necessity of policy intervention as against a more incremental upgrading.
1 Introduction

This paper is part of the MAKERS project, stemming from work undertaken as part of Work Package 8. It consists of policy recommendations deriving from research across MAKERS Work Packages 1 to 7. The aim of Work Package 8 is to provide policy-makers and major stakeholders with a broader overview of what is needed at the European policy level to support and enable a so-called ‘manufacturing renaissance’. The paper covers three sections: (1) a synthesis of policy implications derived from MAKERS deliverables and a review of the broader literature; (2) proposals for a new comprehensive policy to support ‘smart manufacturing’, (3) a Case Study of the readiness for, and awareness of, manufacturing firms in the Veneto region in Italy to transition to Industry 4.0 principles.

The research team consisted of partners from across the MAKERS project who contributed in terms of key policy implications and recommendations from MAKERS work packages. The findings of this paper were discussed and validated by MAKERS participants as the MAKERS academia-business-policy forum in Venice (25-26th October 2018).

We have used a four-stage approach in constructing this report:

A Literature Review- the existing literature on Industry 4.0 and policy implications has been reviewed by the research team. This literature reviewed consisted of: Industry and Government reports, reports by think tanks, trade bodies, firms and unions, and academic studies and scholarly articles.

Synthesis of policy implications- a synthesis of policy implications and recommendations was carried out by the research team. This combined policy implications and recommendations provided by MAKERS partners coming out of their relevant Work Packages and deliverables with key points from the wider literature. Policy implications and recommendations were also validated by partners at the MAKERS academia-business-policy forum in Venice (25-26th October 2018).
A survey was conducted through Unioncamere Veneto (UCV), drawing on the design of an existing MAKERS survey which had been piloted jointly during secondments at UCV by the University of Birmingham and Lund University’s Centre for Innovation and Research and Competence Centre. The survey was undertaken with manufacturing companies in the Veneto region of Italy. The focus of the survey was to: (1) gain a broad overview of awareness of organisations to Industry 4.0 technologies, current patterns of adoption and expected adoption of industry 4.0 technologies; (2) identify the main barriers organisations have in implementing industry 4.0 technologies; and (3) identify policy areas organisations view as key enablers in promoting and enabling the adoption of industry 4.0 technologies.

A semi-structured interview was carried out with an official from DG Growth to gain the viewpoint of the European Commission on the current state of Industry 4.0 developments in member states, and to consider the effectiveness of current policy initiatives, as well as how the European Commission is preparing organisations and people for the level of disruption Industry 4.0+ is expected to generate.

2 New Smart Specialisation

A key policy area identified in the MAKER’S project is the need to re-think the EU’s current ‘Smart Specialisation’ approach. Smart specialisation was introduced in the 2000s as a new way of tackling regional development (Foray, David and Hall, 2009). Foray (2015a) proposed that “the notion of smart specialisation described the capacity of an economic system (a region for example) to generate new specialities through the discovery of resources and competences in these domains” (p.1). Smart specialisation has been at the forefront of EU regional and cohesion policies in recent years and has been implemented though the Research Innovation Strategies for Smart Specialisation (RIS3) in the 2013-20 funding round. A key feature of Smart specialisation is that it is a regional policy framework
that concentrates public resources in knowledge and human capital in particular activities with the aim of strengthening the comparative advantage of regions and countries in new or existing areas (European Commission 2011). Smart specialisation focuses on research and development, innovation, the identification of potential mismatches between regional skills, capabilities and the demand requirements of the region in the medium or long term (McCann and Ortega-Argiles, 2013). The advent of the ‘fourth industrial revolution’ means that policymakers need to rethink their current approaches to smart specialisation. The wave of new technological developments brought about as part of the fourth industrial revolution is arguably driving a shift in our techno-socio-economic paradigm (Perez, 2010). These technologies are expected to change the organisation of production inside and between firms, as well as the balance between capital and labour, fundamentally changing the workplace, the physical environment as well as the way we live our lives. The scale and speed of the challenges posed by the ‘fourth technological revolution’ brings into focus both the need for - and possibilities for - a broader canvass on which to draw transformative industrial and regional policies approaches. The MAKERS project has identified the need for a new approach to ‘Smart Specialisation’ which places a greater emphasis on shifting the focus from individual firms in a single industry to groups of firms that offer the potential for growth across a set of related industries (WP4.2/3). The MAKERS project has identified three key areas that policy needs to address within the current smart specialisation approach: (1) the co-ordination of policies; (2) a focus on combining regions; and (3) the development of new business models.

Co-ordination of policies

A key MAKERS policy recommendation is the need for smart specialisation policies to be viewed as a set of processes, rather than a collection of policies. The current nature of the European Commission and its departmental structure is viewed by many as a major limiting factor in the further development of Industry 4.0 (Unido 2018). There is need for common a strategy to be developed at a European level promoting universally recognising standards
and regulations, and the development of educational strategies that promote the
development of specific skills and abilities that are required across the general population.
The first issue around developing and co-ordinating strategies at the European level is the
complexity around mobilising and aligning various policy-makers and stakeholders in order
to develop a narrative to elicit information and disseminate common practices. A key policy
recommendation here is the need for the development of a multi-level governance structure
that incorporates national, regional and global policy makers and stakeholders, in a bid to
find and build complementarities between different policy arenas. Secondly there is a need
for smart specialisation and innovation policies to better align with the political arena at
European level, to clarify the regulations that will facilitate standardisation of practices such
as data access, data interoperability and data protection (WP3 WP.4).

Combining regions

A key feature of smart specialisation is the emphasis placed on exploiting related variety,
building regional embeddedness and enabling strategic diversification, focusing on the need
for regional actors (government, firms, universities, research institutions) to collaborate in
identifying the current starting point for the region in terms of skills, technologies and
institutional governance and then to build on these capabilities rather than trying to start
‘from scratch’ (WP.2). This approach sees the capacity of territories to root their economic
activity in the local institutional fabric as being central to their economic success, through
the generation, acquisition and exchange of knowledge (WP.2, WP3). An issue around the
current approach to smart specialisation is a lack of emphasis on linkages and co-ordination
between regional, national and international innovation and knowledge networks. A key
characteristic of the fourth industrial revolution is the connectivity it affords to organisations
and consumers alike, allowing organisations to operate on a ‘glocalized’ level. But a key
point to note is that regional sources of information are not sufficient, therefore the
development of capabilities will need to take on multi-governance structures. Global,
national and regional co-ordination is required to create the mechanisms required to
facilitate the transfer of regional, national and international knowledge, technologies and expertise, and to facilitate its diffusion, allowing regions to leverage their local capabilities in upgrading (Vezzani et al., 2017; Kotnik and Petrin 2017; Radosevic and Stancova 2015).

There is some recognition of this at the European level. As a DG Growth Official noted when interviewed for this Report (2018):

“the EU is struggling to better coordinate innovation policies at all levels i.e. regional, national and European and combine them where needed. This is one of the main challenges for the EU and is a key factor in the success of EU itself.” A key policy recommendation is that policy-makers need to further promote the development of linkages between governments, firms, universities and research institutions, but also put in place mechanisms to facilitate regions to join national and international innovation and knowledge networks”.

New Business Models

A key feature of smart specialisation is the concept of an “entrepreneurial discovery process.” The entrepreneurial discovery process is an inclusive, bottom-up process in which both the private and public sector (policy-makers, businesses, academia, etc.) engage in a process of discovery with the aim of producing information about potential new activities, identifying potential opportunities that emerge through this interaction, while policy-makers assess outcomes and ways to facilitate the realisation of this potential (European Commission, 2017). The current entrepreneurial discovery process (although making some headway through initiatives such as 'The Vanguard initiative for New Growth through Smart Specialisation' which seeks to facilitate the creation of partnerships to support innovative SMEs and regional innovation ecosystems) has come under criticism due to weak monitoring and governance, which has often resulted in an excessive focus on existing sectoral strengths in a geographic area and on projects focusing on short term returns, rather than promoting the discovery and development of new opportunities (Smit et al., 2016). A second key criticism identified was the lack of linkages between actors involved within the entrepreneurial discovery process, often resulting in differing stakeholder opinions
on regional strengths and opportunities (Radosevic and Stancova 2015). Thirdly, the process of entrepreneurial discovery can be weakened by a lack of linkages and stakeholder participation; the current lack of engagement of business and other stakeholders has resulted in the entrepreneurial discovery process being led predominantly by members of the research community resulting in information externalities (Mieszkowski and Kardas 2015). A key policy recommendation here is the need to for policies to better encourage the active participation of different actors through creating platforms that encourage and facilitate intra- and inter- regional interactions between different stakeholders to facilitate the identification and dissemination of Industry 4.0 developments.

3 Public/Private financial support

The points noted above are especially pertinent given that the rapid pace of technological and other changes inherent in the Fourth Industrial Revolution posing considerable uncertainty and risks for firms and governments alike (Andreoni and Chang, 2016). Managing these risks and uncertainties requires the pooling of resources, risk-sharing, and the use of joint support services and infrastructures. Public and private sector financial support will be a key enabling factor in building awareness and promoting the dissemination of technologies within sectors and regions. Financial interventions must form part of a more holistic industrial strategy for stimulating business investment and new firm formation to rebuild national value and safeguard the competitiveness of manufacturing ecosystems. The MAKERS project has identified that small and medium-sized enterprises (SMEs) are somewhat excluded in the terms of Industry 4.0 developments, technologies and incentives. Policy and in particular financial support need to better address this issue of financial inclusion for SMEs in a bid to create an inclusive growth environment. SMEs often are excluded from the immediate uptake of new technologies primarily due to uncertainty around the impacts of technologies, and initial investments required in acquiring, adopting,
implementing and training employees in the use of such technologies. For instance, even in Germany (a leader in manufacturing), only an estimated one in five companies use interconnected IT systems to control their production processes, although almost half intend to do so (Davis, 2015). In terms of policy recommendations, the MAKERS project has identified four key areas that policy needs to address to better facilitate the development and adoption of emerging technologies: (1) Financial support for R&D emerging technologies; (2) Public Procurement; (3) Cross sectoral Investments; and (4) Financial Support for organisations bringing manufacturing back manufacturing.

There is some recognition of such issues at the European level. As a DG Growth Official noted when interviewed:

“to support firms in adopting new technologies and SMEs in particular, is to provide them with the kind of services – most of them free of charge - that are specifically created to help SMEs identify the best EU incentives at their disposal: i.e. coaching schemes, for example are at a firm’s disposal providing them support in better defining their “innovation management” actions. This service is meant to help SMEs; (1) to adapt themselves to changing markets, (2) to help them identify the most suitable commercial partners or to show them how to sell their products internationally. We are continuously assessing and adapting our action, so we are always in the process of delivering and shaping best policies and solutions ever for supporting EU companies to be competitive, including in the global market”.

Financial support for R&D emerging technologies

A key policy requirement is the need for the continued investment by public and private sector organisations in R&D for emerging technologies. As mentioned above technological change and adoption is fraught with uncertainties, in particular Industry 4.0 technologies which have been viewed by many critics as too expensive, too unreliable and oversized, and the Industry 4.0 approach as being driven largely by equipment producers rather than consumer demand (Davis 2015).
The European Commission has attempted to build awareness of the impacts of emerging Industry 4.0 trends to create an inclusive growth environment: one such attempt is the Horizon 2020 (H2020) programme which the MAKERS project is itself part of. The H2020 programme is providing around €80 billion for research and innovation, including support for developing key enabling technologies. The research programme will also finance prototypes and demonstration projects, with the aim of raising awareness of organisations to the potential implications that emerging Industry 4.0 technologies will have on re-shaping manufacturing and current value chains. Although steps have been taken to build awareness and finance R&D, the mechanisms employed by policy and institutions vary vastly across nations and sectors. According to Hundley et al (2003), the EU overall lacks risk capital that allow new and innovative firms’ formation especially at times of high risk such as when technology is changing; this goes hand in hand with an overall greater risk aversion than the US for instance (ibid). This MAKERS Policy report argues that more can be done in regard to making finance available for both private and public sector R&D projects, and a greater emphasis needs to be placed on collaborative research that aims to build awareness of organizations in emerging technologies within a national and regional context. This can be in part be accomplished by affording regional and national innovation networks some degree of autonomy in identifying the specific needs of regions and making finances available through Regional Innovation Systems (RIS) and National Innovation Systems (NIS), universities, incubators etc to address these needs (WP.2.1/2 WP3.1).

Public Procurement

Another key policy area identified as part of MAKERS is the need for public procurement to take on a more active role as an enabling factor in the dissemination and adoption of technologies. Public Procurement is viewed as a counterbalance to market failures that are hindering innovation, by enlarging the market for technologies and services, ensuring and encouraging further R&D by creating the momentum and market required (Edquist and Zabala-Iturriagagoitia, 2012). For instance, the H2020 project has identified and
encouraged public procurement as one of the key market-based policy instruments for smart, sustainable and inclusive growth (European Commission, 2010). The MAKERS project has identified two further areas which policy needs to further address: (1) procurement policy needs to promote the development of standards, thus promoting awareness and diffusion; and (2) procurement policy needs to enable interactions with potential users and suppliers to facilitate the exchange of knowledge and identification of issues, which is currently limiting uptake (WP.2.1/2, WP3.1, WP4.2/3).

Cross sectoral Investments

Throughout the MAKERS project it has been identified that skills will play a fundamental role in determining the uptake and dissemination of Industry 4.0 technologies. There is a need for policy to adapt to the changing environment due to emerging technologies. According to the Aulbur and Bigghe (2016), the rapid rate of technological development within manufacturing is increasingly leading to a skills mismatch, with many manufacturing companies viewing the lack of talent and skills as a major barrier limiting their ability to implement such technologies. The UK Commission for Employment and Skills (2015), for example, identified emerging technologies and the mismatch of skills as a major cost factor hampering the growth and adoption of emerging Industry 4.0 technologies. The MAKERS project has stressed the need for skills within Industry 4.0 to be viewed as a long-term strategy; policy-makers need to foster a lifelong learning approach to building and developing skills required by industries in order to encourage the continued development and adoption of Industry 4.0 technologies. Key policy requirements identified included the need for financial support to be put in place to help private sector organisations nurture, train and continually retrain employees as technologies further develop. In this regard, firstly, financial incentives need to take on a collaborative approach where private and public sector organisations identify the specific skills requirements of regions and sectors and work together to develop the relevant skills required. Secondly, support should be geared towards a regional context through centres of excellence, universities, innovation hubs, incubators
and so on, as the requirements for specific skills are highly localized (WP.2.1/2 WP3.1 WP4.2/3).

**Financial Support for organisations bringing manufacturing back**

The fourth industrial revolution presents huge opportunities for EU member states to ‘repopulate’ manufacturing ecosystems to complement the fact that Global Value Chains (GVCs) will further shift, develop and diversify as the fourth industrial revolution plays out. Policy-makers need to recognize that in order for a reshoring of manufacturing to be effective within an Industry 4.0 setting, policies need to create an inclusive ecosystem where private sector organisations are not supported via subsidies or incentives to relocate labour intensive-activities activities (these will anyway be susceptible to wage rate and exchange rate shifts and are footloose in nature as relative unit labour costs shift) (WP4.2/3; Bailey et al, 2018). Instead policy needs to prioritise and provide access to funding that supports services and infrastructures, the availability of skills across the spectrum, innovation capacity and support for the supply chain base (Bailey and De Propris, 2014). Lastly policy needs to put in place financial incentives that facilitate R&D-intensive activities that are producing non-standardized products (Bailey et al, 2018).

**4 Global Value Chains and Reshoring**

The Fourth industrial revolution and the expected disruptive change this brings will redefine global value chains. The MAKERS project has identified five key impacts that emerging industry 4.0 trends will likely have in this regards: (1) technological upgrading of value chains, (2) shorter value chains, (3) reshoring production to domestic economies, (4) small scale smart production mixing digital and artisan competences; and (5) close to market production - see Figure 1.

On the first point, emerging Industry 4.0 technologies will create great opportunities for path creation, renewal and extension for organisations. This is in part fuelled by the nature of
change that Industry 4.0 presents whereby technologies are not specific to any sector - instead they can be applied across different industries and sectors. Take for instance the emergence of firms such firms as Google or Apple who cater to billions of users; they are increasingly leveraging their digital capabilities to enter different value chains such as driverless vehicles and personal mobility services.

On the latter point, Industry 4.0 technologies are set to redefine global value as digital capabilities are brought to the forefront of decision making and planning; technologies such as connected devices and big data analytics are increasingly placing greater emphasis on consumers as major actors within the value chain, with consumer data increasingly becoming accessible as technologies develop. Organisations are becoming increasingly aware of the value of this data, presenting organisations with the ability to monetise this data by providing a more personalised product offering (Deloitte 2016).

In regard to (2) shorter value chains and (3) reshoring production to domestic economy, the continued development and adoption of digital technologies will fundamentally alter the way products and processes are developed. The development of digital technologies such as virtual reality will fundamentally alter the way products and process are developed, whereby different actors within the value chain need no longer be restricted by geographic location; instead product development, production processes, planning, and monitoring can be carried out through a cyber physical system, affording manufacturers a greater degree of flexibility regarding manufacturing locations and promoting the co-location of production and consumption (Laplume et al., 2016). Technologies such as additive manufacturing further afford manufacturers flexibility in picking and choosing production locations. As Oettmeier and Hofmann (2016) have noted, additive manufacturing takes the complexity away from manufacturers switching production locations, as conventional manufacturing considerations - i.e., the use of specialist machinery and local labour costs - become less of a determining factor for location. Instead the size and demand of local markets will likely become a greater influencing factor. Although additive manufacturing is predicted to
redefine conventional manufacturing methods and reorganise global production patterns, there is still a long way to go as Ford (2014) has noted in that major obstacles remain for the diffusion of additive manufacturing in the form of costs associated with technologies. These include initial investment costs, and requirements for specialist skills and lower production volumes, resulting in additive manufacturing currently being used mainly in small scale, highly customised and complex production.

Figure 1 Value chain upgrading and new development paths

In regard to policy recommendations, the MAKERS project has identified four key areas that policy needs to work on to better prepare organisations for anticipated changes in the distribution of GVCs and facilitate and encourage the reshoring of production: (1) the development of European and international standards; (2) the development and adoption of smart and agile production systems; (3) the strengthening and development of regional clusters and supply base; and (4) the development of specialists skills.
National and International Standards

A key area that policy needs to address is the lack of standardisation of digital and communication technologies. The development of standards is a crucial determining factor in the diffusion and development of technologies within industries. The continued rise in connected devices/equipment, and increased interactions between humans and machines requires standardisation for a successful implementation of technologies across nations and industries. The development of standards will make it easier for companies to connect their existing and new equipment, regardless of their manufacturer/service provider, reducing complexities associated with acquiring new technologies. Therefore, it is imperative that policy makers address the increasing need to create a European standard and encourage the development and alignment of international standards to European standards by making suppliers and consumers aware of the requirements so as to access the European market. Policy-makers will need to work closely with both private and public sector organisations and research institutes in identifying and monitoring the development of global standards and requirements regarding European standards.

Smart and agile production systems

As discussed earlier, the development of smart and agile production systems will have fundamental impacts in re-shaping and re-organising GVC. Therefore, policy-makers must address the need to promote the continued development of technologies such as additive manufacturing and develop corresponding digital capabilities. The development and adoption of smart and agile productions systems must be approached from an interdisciplinary view point, whereby policy-makers work together with a range of value chain actors to identify, develop and disseminate smart agile technologies and practices. A similar approach to the Swedish approach (identified in MAKERS WP.2) could usefully be adopted whereby policy-makers work closely with research institutes and private sector actors in developing, identifying and showcasing the benefits of adopting new technologies and production methods.
Strengthening and developing regional clusters and the supply base

Clusters are characterized by ‘coopetition’ whereby firms within a cluster co-operate and compete simultaneously. A large literature discusses the benefits that clusters bring to firms and regions, the main points being the ability of clusters to network along the value chain, whereby various regional, national and international stakeholders such as MNE’s and local firms, universities, public and private sector research institutes come together to create synergies through interlinked activities, resulting in economic advantage. (Barrios 2002; Crozett et al 2003). The fourth industrial revolution is characterised by conditions that are in a sense intrinsic to cluster strengths, i.e., interconnectivity, co-operation, shared standards etc (Steiner, 1998). Throughout the MAKERS project it has been stressed how innovation is fundamentally a collective process requiring constant interactions between value chain actors; take for example the Swedish case study (WP.2) whereby close interactions and collaboration between local firms, policy-makers and the University of Borås were fundamental in developing and strengthening of the textiles cluster. A further point identified within the MAKERS project is the need for policy to address the growing need to facilitate organisations to join existing co-operative networks and clusters (WP.1/2). Therefore, a key policy requirement to strengthen and grow existing clusters - and facilitate the growth of new clusters - is the need to facilitate linkages between existing value change actors and networks but also new value chain actors. This can be accomplished by policy-makers working closely with both private and public sector research institutes as well as encouraging cross-disciplinary research and communication, through adopting open innovation practices (WP.4.2/3; WP1; WP2).

Developing Specialist Skills

Developing specialist skills is a fundamental requirement to promote readiness for and awareness of the expected impacts that the fourth industry revolution will bring for GVCs. Developing the specialist skills required to facilitate the adoption and implementation of Industry 4.0 technologies and practices is dependent on both public and private sector
dialogue. As identified in WP2.2/3, the development of the skills required within regional clusters is highly dependent on the wider regional context and need identifying through close linkages between industry, higher education and local government. Therefore, the need for policy-makers to actively promote dialogue and elicit information will become a far greater factor in determining the success of regional clusters in adapting to the changes presented by the fourth industrial revolution. This is in line with modern conceptions of industrial policy as a process of discovery (Rodrik, 2008). A key policy recommendation is the need for policy-makers to better monitor Industry 4.0 developments and build capacity in these developments; this can be done through working together and creating partnerships with universities, training providers and firms, in order to create training programmes that are relevant for, and required by, regional actors with aim of strengthening and further developing regional clusters (WP.2.1/2 WP.4.2/3).

In regard to reshoring, policy-makers need to focus on facilitating the development of skills and capabilities for the next generation of production process and products rather than focusing on bringing ‘old’ manufacturing back (W4.1). As De Backer et al. (2016), Bailey and De Propris (2014) and Bailey et al (2018) have identified, reshoring is unlikely to re-create large numbers of manufacturing jobs and certainly not low-skilled jobs that have been offshored or outsourced abroad; therefore policy needs to focus on retraining and re-equipping people with the relevant skills in order to facilitate and encourage the reshoring of manufacturing (WP4.1/2).

5 Awareness, Readiness and Infrastructure

Physical infrastructural capabilities are a crucial enabling factor in raising awareness and improving readiness and adoption of emerging Industry 4.0 trends and technologies. Das (2017) defined Physical infrastructure as the basic physical structures required for an economy to function and survive, such as transportation networks, a power grid, sewerage
and waste disposal systems. The MAKERS project has looked beyond the basic physical structure required and focused on the wider infrastructural requirements required in order to identify and build readiness for organisations in the context of emerging Industry 4.0 trends and technologies. The effective development of policy is highly dependent upon private-public sector dialogue in order to identify opportunities and challenges faced by organisations; as noted this in line with modern conceptions of industrial policy as a collaborative process of discovery of information (Bailey and De Propris, 2014).

MAKERS partners recognised the work of the European Commission in this area: “despite the number of obstacles on the path to paving the way of a comprehensive industrial policy for manufacturing, the EU Commission put in place a lot of measures and incentives for the adoption of new technologies. (MAKERS Partner, 2018).

And as a DG Growth Official noted when interviewed (2018):

"the best measures to improve firm’s capacity to adopt new technologies are those that combine different types of actions, starting with fiscal and financial incentives, co-ordinated at regional, national and EU level. As the EU Commission, we are always committed to bridging the gap between firm needs and expectations to a real trading environment. For this reason, a number of initiatives have been set up, among others, for raising awareness about the availability of EU funding (both grants and financial instruments) and improving access to finance for SMEs…"

Nevertheless, the adoption of Industry 4.0 technologies and practices is seen by many organisations as a huge risk, due to the speed of technological change and the risk associated with untested technologies; managing these risks calls for the pooling of resources and risk-sharing and this requires a greater level of joint support services and the development of collaborative ecosystems engaging both public and private sector organisations. Hindering factors limiting the creation of such an ecosystem include current disparities in the quality and content of innovation and education systems. The EU has made some progress in aligning the content and quality of qualifications to enable frictionless labour mobility across EU member states. This has been primarily accomplished by favouring the conservation of national and regional institutional set ups and policy
frameworks that reflect the peculiarity of member states, resulting in a mechanism for
cchange varying between policy domains. This MAKERS report stresses the need for
innovation and education systems to be positioned within a multi-level governance
framework that is able to integrate regionally, nationally and globally. On this, Bachtler et al
(2017) highlight, for example, ‘living-labs’ where multinational companies and start-ups can
interact and benefit from each other’s competencies - see Figure 2.

A further point identified by the MAKERS project is the need for policy to take on ‘a
transformative place-based’ industrial policy, where local and national innovation systems
develop and adopt technologies that transform sectors, markets and supply chains – also
see Figure 2.

Figure 2 Multi Level Structure
The MAKERS project has identified the need for tangible, intangible and incentive infrastructures to be better aligned in order to promote awareness and facilitate the building of capabilities of organisations within regions (WP3.1). Tangible infrastructures include infrastructure projects that build digital capabilities such as fibre optics networks, 5G networks, physical spaces such as innovation hubs, research centres etc. Other tangible infrastructure projects will extend in a number of directions as Industry 4.0 technologies impact on different sectors; for example it, could extend to a charging station network to encourage the transition to electric vehicles, and transport bridges to better link regions and clusters (WP3.1). On the flip side, intangible infrastructure places a greater emphasis on enabling and encouraging linkages within industries and organisations facilitating the transfer of knowledge between sectors, organisations and territories. A key feature of intangible infrastructures is that they facilitate the identification of needs of regions, organisations etc and provide a platform to disseminate and encourage the adoption of Industry 4.0 technologies and trends (WP3.1 WP1.1 WP2.1.2). Incentive infrastructures lie between both tangible and intangible structures, acting as facilitators and accelerators for the implementation of both tangible and intangible structures, through funding projects that have been identified and incorporated in both tangible and intangible infrastructure projects (WP3.1, WP1.1, WP2.1.2).

The alignment of Intangible and tangible infrastructure projects is highly dependent on interdisciplinary collaboration and linkages where policy-makers have to nurture and engage within ecosystems of open, interconnected networks of stakeholders, co-operating to a much greater extent through strategic partnerships (Bachtler et al, 2017). Such ecosystems will be more dependent on their business environments to source knowledge regionally, nationally and internationally (Ammermann, 2015). As the OECD (2016) has noted, “pieces of knowledge required come from various actors and activities are rarely available inside a single organisation… it is important therefore to support the generation, diffusion and use of many sorts of knowledge and types of collaboration” (OECD, 2016; 68). A key requirement of the development of such ecosystems is the need for well-developed institutions capable
of nurturing collaboration and networks both regionally and internationally (Amison and Bailey 2014) and in industrial policy terms in bringing actors together in the knowledge discovery process. Policy-makers and research institutes, both private and public organisations within industries and regions, need to work together to create this inclusive ecosystem in which the motto ‘we are open for business’ is the baseline for upgrading local business environments (WP4.2/3, WP2.1/2). It essential that the development of policy takes on three key dimensions; regional, national and global to facilitate the development of such ecosystems mentioned above and encourage stakeholder collaboration and knowledge flows between different value chain actors.

**Regional strategy**

A requirement of regional strategy is that it needs to take on the role of a facilitator rather than an observer (WP2.1/2). Regional strategies need to ensure that local linkages are developed and maintained, and that knowledge and expertise gained from insertion in global value chains (as well as Global Innovation Networks (GINs), NISs and RISs) are available to regional stakeholders and feed back into the local area.

Regional strategies need to foster close collaborations between local stakeholders with the aim of utilising local knowledge and expertise allowing for the further development of local competences. Collaboration and linkages developed within a regional context can allow for the development of capabilities and skills while also facilitating the diffusion and adoption of knowledge and technologies (see the Swedish approach collaboration with University of Borås - WP2.1/2). As noted, the development of skills is highly dependent on the regional context and the development of these skills should be identified within a regional context through close collaboration and linkages between industry, higher education and local government (WP2.1/2).

**Global Strategies**
Global strategy should primarily focus on the attraction of investment and collaboration with Multinational Corporations and global research institutes. This may be accomplished through the adoption of open innovation practices (WP2.1/2).

**National strategies**

National strategies should focus on the identification of emerging technologies and trends through interactions with and between GINs, NISs, and RISs (WP2.1/2). The interactions between these will allow for the strengthening of national research capabilities and awareness (WP2.1/2). National Strategies must put mechanisms in place so as to better understand and compare the impacts of Industry 4.0 on sectors and industries; this can be accomplished through promoting further applied research by competence centres and research institutes at a global, national and regional level (WP1.1).

**Digital Infrastructure**

A key requirement for the transition of industry towards Industry 4.0 is the development, implementation and adoption of technologies. As WP3 identified, the successful implementation of digital technologies is largely dependent of the development of digital infrastructures. The development of infrastructure is viewed as a catalyst for promoting development and enhancing the impact of policy interventions. It is therefore imperative that policy-makers bring the agenda of digital infrastructure to the forefront of policy discussions and development. As identified in previous work packages and throughout the literature, a central component of the fourth industrial revolution is digital capabilities; the digitisation of the environment in which organisations operate is set to fundamentally alter the market place, creating and destroying markets as well as jobs. The current level of digital capabilities and infrastructure vary vastly between regions and nations, which is creating a so called ‘digital divide’ (OECD, 2001). There are many factors that can cause digital divides, and these include differences in human capital, human capital development, infrastructural
capabilities, institutional set-ups and policy, and access to finance and culture (including attitudes to risk and failure) (Hundley et al 2003). A key point identified by the MAKERS project is the need for policy to address the growing demands by business and society as whole for digital infrastructures as well as helping reduce current digital disparities within European regions.

The first point to note here is the need for high speed and reliable communication access to users such as 5G infrastructures, and the development of high speed and reliable internet infrastructures (WP.1, WP.3). It is estimated that by 2025 internet traffic is set to be 95 times higher than it was as in 2005, and mobile data traffic is expected to increase by 25 to 42 per cent year on year (Gov 2018). This increase in demand is in part fuelled by the current shift in the organisational and societal environment afforded by the increasing interconnectivity between organisations, consumers and connected devices (WP.1). The increasing interconnectivity between users and devices has resulted in the increased development of new business models and new value chain actors, resulting in a steady increase in virtual, global market and workplaces (Lakner et al., 2015). The MAKERS project has identified three key dimensions that policy MAKERS need to consider in the development of digital infrastructure projects.

Firstly, as a base-level policy, there is a need for policy interventions to de-risk the creation of digital infrastructures through making finances available to both facilitate experimentation and testing, and to promote the implementation of digital infrastructures. This will require a greater degree of both private and public sector co-operation to reach the desired scale. Secondly policies need to ensure that the digital infrastructures are able to support the rapid increase in traffic and can also handle further increases that are expected. Here, digital infrastructures must provide coverage that has sufficient capacity to ensure data can flow at the volume, speed and reliability that is demanded by businesses and society, while simultaneously ensuring that access and costs are balanced so as to be accessible to everyone (WP.1, WP.3).
Thirdly there is a need for policies to be to co-ordinated at a European level, to ensure that there is interoperability of interfaces, facilitating the creation of an inclusive growth environment. Co-ordination at the European level is also needed in order to promote the development of international standards, as discussed earlier in the paper (see smart specialisation) (WP.2.WP.4).

Fourthly, the development of digital infrastructures needs to coincide with the development of “digital education” infrastructures that embed the development of digital skills within education systems. Policies must take a pro-active approach in developing the required skills within a multi-level governance structure, where policy interventions are developed and co-ordinated at a national and European level ensuring labour mobility and an inclusive environment ensuring as many people as possible can participate in the ‘digital economy’ (WP.1, WP.2, WP.3, WP.4). We turn to skills next.

6 Skills and Capacity Building

Linking to section 5 above, the development of skills and capacity building is a key determinant in the successful transition of manufacturers to smart manufacturing; it is therefore imperative that policy-makers prioritise this (WP.1, WP.2, WP.3, WP.4). The BRICS Business Council (2016) states that the rapid rate of technological development in manufacturing is increasingly leading to a skills mismatch, with many manufacturing companies viewing the lack of talent and skills as a detrimental barrier limiting their ability to implement industry 4.0 technologies and practices. The fourth industrial revolution is set to redefine conventional approaches to skills development; skills requirements will vary according to regions and sectors. A recent report by the Manpower group (2017) found that skills cycles are becoming shorter, and that 65% of jobs are yet to exist. It notes a current unsustainable trend of employers being talent consumers rather than builders. Similarly, Frey and Osbourne (2013) found that 47% of jobs within advanced economies are set to be automated, resulting in a decline in routine and labour intensive tasks. The continued prevalence of digital technologies within workplaces is dramatically altering the demand for
skills by organizations, with employers requiring professional and operational staff to have wider knowledge and understanding of different technologies and production methods (UK Commission for employment and skills 2015). Related to this, Lakner et al., (2015) note that the continued adoption of digital technologies within organisations is increasingly promoting integration and collaboration with various supply chain actors, resulting in the creation of global work places, where employees come from a range cultures, languages and countries, and must collaborate and work together in the development of products and production process.

The MAKERS project has identified four key strategies that can facilitate and prepare organisations for the changes that will occur: (1) Up-skilling, when the existing workforce is trained in carrying out tasks differently, e.g. working with robots, this can be undertaken in house or through external training centres; (2) Re-skilling, as noted above Industry 4.0 will result in job displacement - some jobs will no longer exist therefore people will need to be given new skills that are required by industries; (3) providing a continuous learning environment - the nature of change presented by industry 4.0 means that skills need to be continually developed in conjunction with technological developments; and (4) adopting a more organic organisational structure that actively promotes interactions and communication within organisations, as well as encouraging flexibility and adaptability within the workforce.

In terms of policy implications, Industry 4.0 as noted above is set to both destroy jobs as well as create new ones. This raises a profound risk of labour market polarisation, and there will be a need not only to develop the skills required for Industry 4.0 to be applied within industries, but also the need for policy-makers to foster a lifelong approach to skills and capacity building (WP.4.1). It is therefore imperative that policy-makers not only identify the required skills but also provide the infrastructure to train and continually retrain people as to facilitate and build awareness in the continued development of industry 4.0 technologies.
and practices (WP.2/3). The MAKERS project has identified three policy instruments in this regard:

**Education and training systems**

Education and training systems will play a crucial role in building the skills readiness of the labour force within Europe. As mentioned above, the current pace of technological change and the resulting mismatch is a major hindering factor in the adoption and development of industry 4.0 technologies and practices. A recent survey by Deloitte (2016) found that by 2030 the demand for STEM subject knowledge is predicted to increase by eight percent in importance for the average UK worker, to meet this increase in demand the UK would need to add a further four and a half million STEM enabled professionals. At the same time, employers are increasingly requiring employees to have soft skills, such as interpersonal, leadership, problem solving skills, knowledge of foreign languages and flexibility in terms of willingness to learn and adapt to new technologies (Deloitte 2016).

In terms of policy recommendations, policy-makers need to take a long-term approach to building skills, rather than just focusing on STEM skills; policy needs to emphasise the need for people to gain a more balanced set of skills, incorporating both subject and technical knowledge as well as emphasising the need for more social and soft skills (WP3.1, WP4.1, WP.2). Another key policy recommendation is the need for policy to promote and facilitate employees taking a more proactive approach to skills development and viewing the development of their own skills as a continual lifelong requirement. It is therefore imperative that policy-makers and private sector organisations work together to create an environment that facilitates the continual upskilling of employees through making professional development programmes readily available to employees. A final point raised in the MAKERS project is the need for policy to emphasise the development of new managerial skills. Managerial skills are a key enabler in the diffusion of knowledge and practices within organisations, therefore policy should emphasise the need for managers within organisations to develop skills.
Promotion Diverse Forms of Work

The fourth industrial revolution presents organisations with a need for specialist skills, which may be difficult to find, and for many organisations (in particular SMEs) too costly to develop in house given the need for such skills to be specific to certain technologies and projects etc (McKinsey 2018). Development of and access to specialist skills will be a fundamental factor in the adoption of Industry 4.0 technologies and practices amongst organizations, in particular by SMEs. The increasing demand for specialist skills is increasingly leading to organisations acquiring relevant skills through temporary contracts and on a project basis, leading to a rise in what is known as the ‘gig economy’. A key feature of a gig economy is the ability it affords organisations to access ‘just in time’ skills (Valerio 2016); employees are acquired under ‘flexible’ arrangements as ‘independent contractors’ or ‘consultants,’ working only to complete a particular task or for a pre-defined time (Friedman 2014). The continued development of digital technologies has encouraged the emergence of platforms such as Topcoder, Expert360 and Kaggle that facilitate and connect employers with the specialist skills required (Friedman 2014). The ‘gig economy’ has experienced rapid growth in recent years: take for instance the United States in 2016, where 35 per cent of its workforce was made up of self-employed freelance employees, who collectively earned $1 trillion, with estimates suggesting by 2027 more than half the US workforce will be made up of freelance, employees. Similarly, the number of freelance employees within the European Union (EU-28) doubled between 2000 and 2014, making them the fastest growing group in the European labour market (Morgan Stanley 2018).

A key policy recommendation identified within the MAKERS project is the need for policy to facilitate and promote the development of open, dynamic labour markets that encourage a range of work contracts to make specialist skills accessible to the masses. The creation of such markets will need to develop in conjunction with new labour market regulations at national and global levels that govern and protect employees operating within such
environments; (Friedman 2014) identified that a ‘gig economy’ opens up employees to exploitation by shifting the burden of economic risk onto workers.

**Collaborative approach to skills and capacity building**

The successful identification and development of skills must be a collaborative process whereby policy-makers, research institutes and private sector organisations work together to identify upcoming trends as well as the specific requirements for industry (WP2). Therefore, policy must take on three key dimensions - global, national and regional - to better identify skills scarcity and skills gaps (WP2, WP3). Regional policy should aim to put structures in place to encourage dialogue with regional actors as well as working with regional educational institutes to create programmes that develop the skills required within specific regions. National policy should encourage a platform were information gathered from within regional networks, as well emerging skills requirements identified from international interactions, are combined in order to develop programmes that promote the development of skills that can be applied across regions and nations, as well as building capacity for future needs (WP1, WP3). A final point identified was the need for policy to take on a global approach to developing skills; as mentioned above the workplace is increasing becoming digitised and the emergence of global workplaces are on the rise (Lakner et al, 2015), therefore policies need to be put in place at a European level that enable the recognition of professional skills that are developed during the course of an employee’s employment globally.

### 7 Sustainability

A key area explored in the MAKERS project has been the notion of a circular economy. A Circular Economy can be defined as any business model strategies that aim to slow, close, and narrow resource loops (Bocken et al. 2016). A circular economy moves away from a
conventional linear economic model based on ‘take-make-consume-throw away’ pattern; instead a circular economy is based on sharing, leasing, reuse, repair, refurbishment and recycling (European Commission 2016). A key characteristic of a circular economy is the emphasis on selling utilisation, rather than ownership as the most suitable business model within a circular economy, as it will allow organisations to profit without externalising the cost of waste (Stahel 1982). A recent report by PwC (2017) found an increasing trend where consumers are increasingly shying away from owning products, preferring access to and the use of products over ownership. The automotive sector has been at the forefront of the shift in consumer behaviour. For example, car ‘ownership’ in the UK is at the highest level ever with 76% owning (including leasing) vehicles, but the number of miles driven each year has declined by around 20% from its peak in 1995 (Ofgem 2015). Instead there has been a steady rise in the use of ride hailing apps and car clubs. Uber, for example, has over 40,000 drivers and 3.5 million users in London alone. Similarly car clubs have seen a sharp increase in demand; in 2008 car club memberships amounted to 32,000 but by 2018 membership had risen to over 245,000 members with evidence suggesting car club users prefer access over ownership.

The fourth industrial revolution is seen as key enabler in the development of a circular economy and the MAKERS project has identified three key enabling technologies that present major opportunities for industries to transform conventional business models into forms that are better aligned with circular economy principles.

**Internet of things**

The Internet of things (IoT) presents business with unparalleled access to devices, whereby they can monitor the performance, condition and location of devices (Beukel 2017). MAKERS Work Package 4 (WP.4) used a case study of the automotive industry and how technologies such as the IOT in conjunction with infrastructural developments may promote this transition into a circular economy by highlighting the transition from ICE (Internal Combustion Engine) to ACE (Autonomous Connected Electric) vehicles, whereby the
requirements of consumers to own a vehicle are no longer a determining factor. Instead, mobility as a service is the desired goal, encouraging the development of completely new business models whereby the emphasis will no longer placed on the physical resource of a ‘vehicle’ but is instead on providing consumers with a ‘mobility’ service. There are numerous more examples of how the continued development of the IOT is encouraging a circular economy, such as the rise of platforms like Airbnb or blabacar, which promote the sharing and reusing of resources (Beukel 2017).

Additive Manufacturing & Automation

The continued adoption and development of additive manufacturing and automation technologies will present organisations with major opportunities to develop a glocalized value chain, reduce manufacturing waste and equipment redundancy, and minimise transportation and warehousing requirements (Beukel 2017; Rosen 2014; McKinsey 2017). Firstly, additive manufacturing and automation in conjunction with IoT presents organisations with the opportunity to operate a highly glocalized value chain, whereby product design and R&D can be undertaken on a global scale, and production can be carried out closer to the end consumers as there is less requirement for physical equipment, thereby allowing manufacturers the freedom to pick and choose production locations without incurring associated set-up costs (Rosen 2014; McKinsey 2017). Secondly additive manufacturing will potentially present organizations with opportunities to reduce requirements for warehousing space and associated costs and waste, as products and components can be stored virtually and produced according to requirements at a location close to the end consumer (Christopher and Ryals 2014; Sedgwick 2016).

In terms of policy recommendations, the MAKERS project has identified a number of key areas that policy needs to address in order to promote the development of a circular
Overcoming a lack of direction

A lack of clear strategic direction by policy-makers is seen as a key hindering factor in the development of a circular economy, the MAKERS project has found. Take for instance the case study of the automotive industry utilised in WP4. A key factor limiting the pace of the transition of the automotive industry from ICE to ACE is uncertainty over the regulatory framework and policy approach; note for example, a recent shift by the UK government in reducing the incentives offered to consumers for electric vehicles when numerous studies have indicated that government incentives, and infrastructural projects are a major influencing factor in the uptake of electric vehicles (Burden and Bailey, 2019). This can be seen as a lack of commitment by governments in facilitating the uptake of sustainable alternatives (BEIS Committee report 2018). The case of Hong Kong is an extreme example of how a lack of governmental commitment can either promote or hinder the adoption of new products, where electric vehicles sales fell from over 2000 vehicles sold in 2016 to just 89 after government incentives were removed (Ofgem 2018). A second point identified was the lack of consistency in policy to match apparent objectives set by governments. For example, there has been a recent push by policy-makers in promoting a circular economy as part of the EU’s circular economy package announced in 2018, but policies still place a strong focus on recycling with a far weaker focus on re-use. Policies remain heavily skewed towards making organisations meet recycling targets which are measured by volume and weight, an approach which has been argued to discourage the re-use of goods as producers are obliged by legislation to meet their recycling targets or make up the difference, resulting in perfectly reusable resources being recycled to meet targets (tech UK 2015).

A key policy recommendation is that policy needs to further develop ‘shared goals’ that helps steer stakeholders in the adoption of circular economy practices through identifying areas that require funding and making them available. Policies need to ensure consistency through
working closely with industry in identifying issues with regards to current policy targets and objects.

Building stakeholder awareness

A second key policy area identified within the MAKERS project was the need for policy to promote awareness of circular economy concepts and disseminate the benefits of a circular economy. Stakeholder awareness is seen as key determining factor in the current uptake of circular practices; many consumers view the lack of ownership, and the perception that remanufactured goods are somewhat below par in regards to performance as major factors limiting the growth of circular economy (Bardhi and Eckhardt 2012; Catulli et al. 2016; Abbey et al. 2015). Therefore, policy needs to address this growing issue by instigating social incentives that encourage a shift of social norms, with the aim of changing consumer perceptions as to what is considered socially acceptable (Techuk 2015). Policies need to work in close collaboration with educational facilities and business in order to promote and implement social incentives.

New Business Models

Another area identified by the MAKERS project is the need for policies to promote the development of new business models in the context of a circular economy. Policy needs to work with organisations to promote the incorporation of a service delivery business model, as well as conventional product based ones. The service delivery model has been widely practiced within the B2B sector for a while now, but the development of B2C is still in its infancy, therefore policy needs to nurture and promote the continued development of this sector by helping organisations view their products as resources. The aim is to provide a functional service whereby organisations retain the ownership of their products and, where possible act as service providers selling the use of products, not their one-way consumption. Secondly policy needs to promote the inclusion of circular practices within the early stages of production, planning and product development through setting regulatory requirements.
that promote the development of products that have the end of life provisions built into them, such as plans for disablement, re-use, re-manufacture and recycling of products. This transformation will require both private sector co-operation as well as public sector financial support in helping organisations develop the relevant skills and knowledge required in such practices.

Infrastructure

The current infrastructure in place is seen as major limiting factor in the development of a circular economy, therefore a key area which policy needs to address is the development of reverse logistic infrastructures (WEF 2014). Reverse logistics is the process of moving goods from their point of consumption to a consolidation point for the purpose of capturing value or proper disposal (Rogers and Tibben-lebke, 1998). Reverse logistics include the collection of goods, transportation to a central location, and sorting according to the ultimate destination, i.e. remanufacturing, refurbishing, reusing or recycling (Lambert et al., 2011).

The current state of reverse logistic infrastructures within European nations is at its infancy with the costs associated with reverse logistics usually higher than the residual value of the goods. In part this is due to a lack of scale and the costs associated with collecting and sorting often being far too high, due to geographic dispersion (WEF 2014). Therefore policies need to address this issue in order to facilitate the development of a circular economy. A key recommendation is that policy needs to facilitate the building of this reverse logistic infrastructure through providing and encouraging the development of local and national structures to enable the collection of goods at the end of their life through local and national consolidation centres where products can be sorted and re-disturbed to suppliers/manufactures and recyclers. This approach has many hurdles as identified by Sehgel (2008), due to the complexities in identifying products and matching them with suppliers,
but the advent of the fourth industrial revolution may help overcome this hurdle. This approach will need to be developed in conjunction with manufacturers and retailers for it to be feasible, and the reverse logistic requirements of products must be imbedded at the product development stage.

8 Case Study: Industry 4.0 take up in the Veneto Region

The MAKERS project conducted a survey of 1829 companies spread across twelve major industries, through regional chambers of commerce in the Veneto region of Italy, in order to assess organisations’ awareness of and readiness for Industry 4.0 technologies. The survey also sought to identify key barriers to uptake as well as how organisations would like policy-makers to assist in the implementation of Industry 4.0 technologies. Figure 3 shows the survey sample by sector (see Table 1 in Appendix for sector key).

Case Study: Awareness and Intentions
To assess awareness and intentions we asked participants:

*Which of the following technologies is your organization using or planning to use in the next 1-2 years? (See Table 2).*

Our survey found 74 per cent of all respondents had no plans to invest in at least one the technologies presented to them, with participants from the food, drink, tobacco, and textile sectors running at over 80 percent. Of the participants which had acquired the listed technologies, on average 30 per cent of the respondents had acquired the technology without help with financial support from the Italian government’s *Industry 4.0 Plan*. Only 16 per cent of participants who had recently acquired the listed technologies had acquired the technology through the help of *Industry 4.0 Plan* financial support, with the rubber/plastic, Metals/ Fabricated metal, and machinery and equipment sectors showing higher take up of support, with for 23, 21, 18 per cent each respectively. The survey found that 38 per cent of all participants expect to acquire at least one the technologies presented to them but have yet to acquire or introduce them within their organisation - see Figure 4.

**Figure 4: Respondents’ awareness and intentions**
Of the technologies presented, cyber security was viewed by participants as a key technology with 52 per cent of participants expected to acquire cyber security technology in the near future. Other key technologies included: internal integration systems (30 per cent), horizontal and vertical integration systems (36 per cent), renewable components (27 per cent), advance manufacturing and cloud services (20 per cent) - See Figure 5 (and Table 2 in the Appendix).

The survey highlighted notable disparities in the acquisition of technologies between those acquired with and without the help of the Italian government’s Industry 4.0 Plan financial support. Key areas identified were the acquisition of advanced manufacturing technologies (such as co-bots) with 64 per cent of participants having acquired advanced manufacturing technologies with support; in contrast 61 per cent of participants that acquired technologies such as cyber security (which was identified as a major area where organisations plan to invest) acquired the technology without the help of support. More broadly, the survey has identified a general mismatch of technologies that are perceived by organisations as areas in which they plan to invest in the future and the acquisition of technologies aided through Italy’s Industry 4.0 Plan financial support - See figure 6.
Figure 3 Technology acquisition

Figure 4 Technology acquisition by sector
Our survey found a general trend amongst sectors suggesting that technologies acquired without the help of Industry 4.0 Plan financial support outpace the acquisition of technologies acquired with the help of Industry 4.0 Plan financial support. There is also a positive trend across all sectors in terms of planned investment in Industry 4.0 technologies - see figure 7.

Case Study: Barriers to technology adoption

To assess the barriers for the adoption of industry 4.0 technologies we asked participants: *What are the main difficulties in the implementation of these technologies?*

Our survey found that the 67% of respondents viewed initial costs of investments as a major barrier in the implementation of technologies, with a lack of skills and demand accounting for 38% percent, and complexity around product diversification accounting for 36 per cent - see Figure 8 (and Table 3 in the Appendix).

Case Study: Policy initiatives for technology adoption
We asked participants:

*What policy initiatives would your business like to see implemented to help you adopt the technologies linked to Industry 4.0?*

Our survey found 71 per cent of respondents viewed access to funding as a key factor here, with 66 per cent viewing training and up skilling as requiring policy initiatives, with 49 per cent viewing access to technical knowledge and 40 per cent viewing the sharing of knowledge as key policy areas that need strengthening so as to enable organisations to adopt and implement industry 4.0 technologies - see Figure 9 (and Table 4 in the Appendix)

![Figure 6 Policy initiatives for adoption of technologies](image)

**Case Study: Summary**

Our Survey has highlighted some of the disparities in communication between private and public sector organisations, with current policy initiatives and access to funding not necessarily coinciding with the demands of organisations in the region. The survey has highlighted the need for better coordination between industry 4.0 policies to meet the demands of organisations within the region and to better promote and enable the adoption of Industry 4.0 technologies.

**9 Conclusion and Recommendations**
Industry 4.0 will play out differently across sectors and regions, this will have implications for the focus of and the innovation aspirations of EU industrial and cohesion policy. The integration of sectors with new technologies will be fundamental in allowing the former to be truly transformed in the light of the new technologies. A transformative industrial policy needs therefore to ‘join up’ technologies, sectors and places. The challenge for the new round of RIS3 will be to acknowledge the transformative necessity of policy intervention as against a more incremental upgrading.

A transformative industrial policy needs to think beyond sectors alone, and rather identify, nurture and diffuse the key cross-cutting technologies (e.g. digitalisation, internet of things, robotics and artificial intelligence) that have an enabling role across manufacturing and services. Policy interventions should form part of a more holistic industrial strategy for stimulating business investment and new firm formation to rebuild value creation and capture, and safeguard manufacturing ecosystem competitiveness. Policy needs to take this on board, for example in private-public-sector dialogue to identify opportunities to re-join supply chain functions. This would be in line with modern conceptions of industrial policy as a collaborative process of discovery of information involving the public and private sector.

Linked to this, industrial strategy needs to recognise and exploit such technologies by making them accessible to businesses in different regions. Furthermore, a transformative industrial strategy needs to be developed both nationally and regionally in a holistic sense (for example on skills, access to finance, clusters, supply chains and innovation) so as to enable policy to be better suited to the distinctive characteristics and advantages of different scales.

This could entail examining what might a regional industrial strategy might look like, identifying sectoral trends, analysing emerging strengths and opportunities identified, and
carrying out analysis of the export potential of key sectors in which the region already holds emergent strengths and which can be built on in a ‘smart specialisation’ sense.

The latter requires regionally-based industrial development strategies promoting ‘related diversification’ capitalising Industry 4.0. Such strategies need to recognise (i) the need to bring together different but related activities in a region via cross cutting Industry 4.0 technology platforms (such as via Living Labs or digital demonstration hubs) and (ii) the differing potentials of regions to diversify, due to different industrial, knowledge and institutional structures linked to specific regional historical trajectories. Rather than ‘starting from scratch’ or applying ‘one size fits all policies’, regional industrial strategies for Industry 4.0 instead require tailor-made policy actions embedded in, and linked to the specific needs and available resources of regions, starting with the existing knowledge and institutional base in that region. These need to capitalise on region-specific assets, rather than attempting to replicate and apply policies that may have worked in quite different places.

However, to transform the region’s potential based on ‘unrelated variety’, and to broaden and renew the region’s industrial structure by helping it branch into new related activities, policy could encourage crossovers between manufacturing (and service) industries and between manufacturing and new technologies. This could come via knowledge transfer mechanisms that connect related and unrelated industries, such as by: (i) enhancing entrepreneurship from unrelated industries (targeting such entrepreneurs would not only increase the likelihood of successful policy, but could also contribute to regional diversification); (ii) encouraging labour mobility between related and unrelated industries, as it transfers knowledge between industries and may lead to new ‘recombinations’ of knowledge (such labour mobility could also increase the level of human capital, as firms and employees learn from experience in related sectors and in turn helps regional resilience as workers can move between sectors); (iii) promoting exposure to new technologies via
institutional intermediaries and (iv) supporting collective research collaboration with partners from related and unrelated competences (ibid).

Other elements would involve, inter alia, the need for: new skills to be developed and constant re-skilling and up-skilling processes as Industry 4.0 progresses; enabling SMEs to have access to funding and finance to embrace digital technologies; recognising and exploiting possibilities to reposition firms, industries and regions on new parts of the global value chain as the value added of manufacturing changes over time; seizing re-shoring opportunities as relocalisation opportunities open up – involving policies to rebuild supply chains in Europe; infrastructure investment to embrace new technologies (e.g. 5G) and so on as part of an holistic regional industrial policy.
Makers Work Packages

WP.1


WP.2


WP.3


WP.4


WP.5


WP.6


WP. 7

Further MAKERS Publications


References


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Appendix

Table 1 Sectors

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<thead>
<tr>
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<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>Foodstuff, drink sectors &amp; tobacco</td>
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<tr>
<td>2</td>
<td>Textile sector, clothing and footwear</td>
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<tr>
<td>3</td>
<td>Woody articles and furniture</td>
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<tr>
<td>4</td>
<td>paper products, publishing and printing</td>
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<td>5</td>
<td>Rubber/plastic</td>
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<td>6</td>
<td>Marble, glass, ceramic and other minerals</td>
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<td>7</td>
<td>Metals and fabricated metal products</td>
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<td>8</td>
<td>Machinery and equipment</td>
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<td>9</td>
<td>Electric/electronic machinery</td>
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<td>10</td>
<td>Means of transport</td>
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<td>11</td>
<td>Jewellery and goldsmith</td>
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<td>12</td>
<td>Glasses sector</td>
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<tr>
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<td>other manufacturing companies</td>
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Table 2 Technologies

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<th>Technologies</th>
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<tr>
<td>vD1.1</td>
<td>Advance manufacturing – Cooperative robots</td>
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<td>vD1.2</td>
<td>Additive manufacturing processes – 3D printing</td>
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<td>vD1.3</td>
<td>Wireless sensor Networks</td>
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<td>vD1.4</td>
<td>Cloud services – Iaas, Paas, SaaS, &amp; Raas</td>
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<td>Augmented reality – Interactive interfaces</td>
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<td>vD1.6</td>
<td>Simulation – Digital twin and Virtual Reality</td>
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<td>Cyber security – Network protection services</td>
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<td>Internal integration</td>
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<td>vD1.9</td>
<td>Horizontal/vertical system integration</td>
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<td>Renewable components and materials</td>
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<td>Nano or Bio Tech</td>
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<td>Big Data and analysis</td>
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<td>Table 3 Barrier to adoption</td>
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<tr>
<td><strong>Barriers to implementation of technologies</strong></td>
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<tr>
<td>vD2.1 Initial cost of investment</td>
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<tr>
<td>vD2.2 Access to credit</td>
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<tr>
<td>vD2.3 Access to information related to the above technologies</td>
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<td>vD2.4 Access to external consultants and Knowledge</td>
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<tr>
<td>vD2.5 Lack of Management support</td>
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<td>vD2.6 Lack of skills in human resources</td>
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<td>vD2.7 Usability and problems of human-machine interface</td>
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<tr>
<td>vD2.8 Ability to correctly interpret data during decision making</td>
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<td>vD2.9 Standardization of communication protocols</td>
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<td>vD2.10 Cyber security and network protection</td>
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<td>vD2.11 Lack of demand by Buyers and Customers</td>
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<tr>
<td>vD2.12 Complexity in terms of product diversification</td>
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<tr>
<td>vD3.1 Access to market knowledge</td>
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<td>vD3.8 Regulation</td>
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Table 4 Policy Initiatives

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