GLOBAL VALUE CHAINS AND INNOVATION NETWORKS IN THE FOURTH INDUSTRIAL ERA

This policy brief provides insights into several issues from a policy perspective that are closely related to the implementation of I4.0 in the European context of digitalisation.

The successful implementation of Industry 4.0 (I4.0) within the European Union (EU) should build upon existing global innovation networks (GINs) and global value chains (GVCs) and the ecosystem of EU firms, especially in the manufacturing industry where I4.0 could play an important role.

Due to the large share of small and medium-sized enterprises (SMEs) that define the EUs competitiveness, it is vital to integrate I4.0 by ensuring these companies can benefit from their efforts in implementing it and create and offer value.

It is important to address training, requalification and workers' concerns about I4.0 in order to support its implementation while maintaining the EU social model.

Harnessing the EU's strength in industrial application, while bearing in mind its lag in traditional ICT industries, could make I4.0 a viable policy option ensuring future leadership of the European economy, if certain factors discussed in this policy brief are included in future industrial policies.

1. Main issues and policy context

Industry 4.0 (I4.0) represents the digitally enabled, horizontal and vertical interconnection of industrial manufacturing in real time. This transformation will affect business models, innovation activities, knowledge management and will accelerate transformative processes within companies. It will require an appropriate mindset and change management process, as well as a workforce that is prepared for this transformation. Especially in traditional industrial sectors, I4.0 will lead to data-driven capabilities and the continuing servitisation of traditional business models. In manufacturing industry circles, the term I4.0 is increasingly used to describe a digital and technological process that transforms society as a whole. The current pandemic is underlining the need for digitalisation and highlighting technological priorities such as robotisation and cloud computing. This requires new modes of production, work and knowledge management. Within supply chains, transformations are expected to supplier networks, with innovation emerging across entire ecosystems, and with a focus on resilience and on recovery from the pandemic. These transformations require, among other things, new ways of collaboration in I4.0. This offers significant opportunities for the EU in 'reshoring' (or backshoring or maintaining) manufacturing within the EU, which is well-positioned in terms of technologies, skills and knowledge within a strong existing ecosystem of companies in the manufacturing industry. With regard to manufacturing, the aspects of supply chain security, open strategic autonomy, flexibilisation and repurposing of manufacturing have an impact on the I4.0 approach, including in relation to production in Europe and reshoring.

The European economy has two characteristics that distinguish it from, for instance, the USA or China. Firstly, in terms of specialisation, the European economy is largely dependent on its industrial and manufacturing sector. Moreover, it is highly fragmented and dependent on SMEs, meaning that implementation of I4.0 will be more diverse as many players have different requirements, making it difficult to collaborate across global innovation networks (GINs) and global value chains (GVCs) towards I4.0. By contrast, purely software or data-driven industry sectors have not gained as much importance in Europe as in the USA or China. Hence, driving I4.0 in the traditional manufacturing sector is of high economic and social importance for Europe. While the USA or China may be more advanced in software and data capabilities, and have produced many leading players in the fields of ICT and artificial intelligence (AI), the industrial application of I4.0 requires unique knowledge that is available in Europe, but this must be harnessed through appropriate policy-making to realise this transformation.

Secondly, the European economy is largely dependent on SMEs active in the sectors in which it specialises, resulting in a fragmented and highly focused landscape of industrial and manufacturing clusters and ecosystems. This fragmentation may have brought significant advantages in specialisation, but it makes data exchange across supply chains even more challenging. This derives from several factors, such as

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concerns about data privacy and data security, and major efforts to exchange data without knowing who can use and benefit from the data generated across the supply chain. In particular, and in addition to technological challenges, managerial complexity is augmented by having many stakeholders in a supply chain. Furthermore, SMEs typically have a different mindset to large companies and possess limited resources, calling for policy that addresses their special requirements and for design of appropriate integration strategies.

Current understanding focuses on technological applications within (smart) factories, but interconnection across the supply chain brings several challenges: SMEs, along with workers, need to be integrated into I4.0 to implement the concept successfully. This policy brief will specifically deal with the following issues that arise in the implementation of I4.0:

- How does I4.0 influence GVCs and GINs, especially from the perspective of SMEs?
- What are the implications of I4.0 for work organisation and job markets?
- How are business models transformed and knowledge-based services created through I4.0?

These three topics are further discussed from a policy perspective, highlighting recommendations for action in order to support GVCs and GINs on their path towards I4.0. Likewise, policy recommendations are presented that consider the transformations in work organisation, job markets and business models.

2. Overview of previous literature: the implications of Industry 4.0 for new models of production and work organisation

Current literature on the implications of I4.0 for new models of production and work organisation can be summarised under the following main themes:

- I4.0 will lead to changes in corporate strategic approaches and the organisational models underlying production, innovation and work systems. These changes are expected to lead to increasing geographical distribution of production and innovation resources, reflecting novel dynamics in GVCs and GINs (Dachs et al., 2019; Dosso et al., 2017; Dröll and Polizzi, 2018; Ramirez, 2018).
- Skill- and routine-biased technological changes and job polarisation are predicted as greater automation (e.g. through robotisation) and digitalisation will potentially displace low-skilled and routine jobs. At the same time, it will also increase demand for high-skilled workers (software and data experts, engineers, etc.), leading to a simultaneous increase in employment at both the highest and lowest occupational levels, and a decrease in middle-skilled occupations (Cséfalvay and Gkotsis, 2020; Frey and Osborne, 2014; Okazawa, 2013).
- The transition to I4.0 affects the way firms create value (internal performance of tasks, relations with suppliers and other business partners), how they capture value (monetisation of the offer) and how they offer value (for instance, servitisation or more integrated or bundled products and services). This transformation requires adequate skills to move towards data-driven business models, also integrating knowledge-intensive services (Müller et al., 2018a).

I4.0 is seen as both offering high potential for the manufacturing industry to participate in the digital transformation, and at the same time producing significant challenges. In addition to technological considerations, there is increasing discussion of topics from a managerial and social perspective in relation to implementation of I4.0. From a managerial perspective, topics include the digital transformation of business models in traditional manufacturing industries, the question of data ownership when data is shared in digital clouds, and changing bargaining powers when new players enter the market (Birkel et al., 2019; European Commission, 2018; Müller et al., 2018b).

From a social perspective, central requirements include integrating the existing workforce through requalification, new qualifications and appropriate job profiles, and addressing workers' fears and concerns. While academia, practitioners and politicians increasingly regard these challenges from the perspective of industrial enterprises, their embeddedness in GINs, GVCs and ecosystems should be regarded in more detail. In particular, the role of SMEs is little understood, in terms of both managerial and social challenges in the context of I4.0 (Müller et al., 2018a; Müller and Voigt, 2018). In response, SMEs need to be included within existing industrial initiatives to support I4.0, for instance through provision of affordable, secure and decentralised data spaces, training and requalification of the existing workforce, and business models that include SMEs as parts of GINs and GVCs.

3. Global corporate value chains and innovation networks in the fourth industrial era: lessons from the GLORIA workshop

This policy brief provides insights on topics relevant to I4.0 implementation in Europe, with respect to the

aforementioned gaps in current dominant perspectives in I4.0 discussions. These insights are based on a collection of research and policy activities, ranging from our GLORIA workshop on GVCs and GINs in the fourth industrial era to more recent and ongoing work also touching on this subject, often in relation to changing working environments, robotisation and organisation of innovative activities, closely related to the European Digital Strategy[1] and Made in Europe[2].

Understanding GINs and GVCs for I4.0

As mentioned, value chains and ecosystems are of great importance to the European economy. However, their fragmented and heterogeneous nature, including both SMEs and large firms, currently makes it difficult to understand and appropriately support each of the members within GINs and GVCs in working towards I4.0. Furthermore, there is insufficient understanding of the role of other players, such as universities and research and technology organisations. Hence, in order to support research and development and innovation (R&D&I) activities for GINs and GVCs in moving towards I4.0, and to strengthen European GINs and GVCs in relation to industrial competitors, this must be better understood.

There is a need to obtain more fine-grained data from GINs and GVCs and understand the interplay of different actors working towards I4.0, in order to promote its implementation in Europe and understand which players require what kind of support. In particular, we need to better understand how to support SMEs in this process, and how to enable cross-company data exchange and collaboration on I4.0, as described in the following section. Furthermore, public-private partnerships (PPPs) and collaboration between industry, universities and policies, with a focus on supporting R&D&I and strategically important patents, represent measures to support GINs and GVCs on their path towards I4.0 faster and in a more targeted way than currently possible. For instance, large automotive companies perform a decreasing share of value-added processes, which are increasingly done by the smaller supply companies in GINs. In Europe, ICT patents are mainly concentrated in the central EU, together with Scandinavian regions and some regions in France and the UK. Eastern and southern regions tend to show lower levels of patenting activity per capita. However, when looking at the patenting of innovative products that incorporate ICT patents, we see a much more dispersed map. It turns out that a higher share of ICT patents is associated with lower shares of ICT-combined patents. Regions specialised in ICT development rely more on international collaborations/spill overs.

Enabling cross-company collaboration and data exchange in GINs and GVCs for I4.0

For GINs and GVCs to successfully move towards I4.0, their members must collaborate across company borders and across company departments. In particular, the former requires companies to share data with each other by digital means. This raises the question of who makes the efforts in this data sharing – which often includes various data types and standards across multiple stakeholders – and who gets the benefits. So far, the benefits often accrue to the (mostly large) companies that have direct contact with the end customer. However, the efforts are made by suppliers in a multi-tier supply chain, often encompassing SMEs. SMEs fear that they will offer too much transparency to their customers but not profit from the benefits, while making major efforts to meet technical requirements in terms of standardisation, data quality and data transmission. Hence, SMEs must be supported on their path towards I4.0, also recognising their specific characteristics such as low bargaining power, lack of skills for digitisation, lack of benefits from I4.0, and limited resources. Their limited resources and skills and lack of benefits often exclude SMEs from innovations towards I4.0, which threatens their overall competitiveness.

To counteract the challenges for SMEs in relation to I4.0, two main courses of action can be recommended. Firstly, policy-makers can create initiatives that share knowledge and examples of best practice, and provide support for the interplay of SMEs and large firms within GINs and GVCs. Often, such initiatives can help to break patterns of existing dependencies, bargaining power and distrust to form more collaborative GINs and GVCs. Secondly, SMEs can be supported specifically in technology implementation and skill development, or at the level of GINs and GVCs by providing means of secure data exchange, data storage and benefits generated from data-driven business models. Hence, recommended policy is to create local-based and specific, but regionally and globally relevant, clusters of expertise for further development of GINs and GVCs in the age of I4.0. In particular, a prime recommendation for action here is to give SMEs access to funds and connect them with universities and research institutions, as both areas often currently hamper their implementation of I4.0.

[1] See https://ec.europa.eu/digital-single-market/en/content/european-digital-strategy

[2] See https://ec.europa.eu/info/publications/made-europe_en

Furthermore, since I4.0 involves vertical and horizontal integration, i.e. within an organisation and across value chains, a key barrier towards SMEs' implementation of I4.0 is the issue of data exchange. While larger companies are better set up for the I4.0 initiatives and for pushing its implementation, smaller companies need to make comparatively much higher effort for data integration. In addition, a very high risk is perceived in that only the largest actors in a value chain, or those closest to the customer, retain any economic benefit from data sharing. As SMEs are irreplaceable for industrial value creation in Europe, they must be better supported in moving towards I4.0, bearing in mind their role in GINs and GVCs and their specific characteristics.

In turn, GINs and GVCs must be informed about the challenges faced by SMEs in the first place. In many instances, clear communication must be established between several actors, including SMEs. Different actors in GINs and GVCs should be brought together through a neutral platform, such as policy, industrial associations or research institutions. Together, they can work on approaches to share the benefits of larger players in GINs and GVCs with SMEs, who are necessary to provide their data, but who cannot or will not do this if they are not supported and benefits are not passed on to them. Again, SMEs can be supported individually on a technology or skill level, or broader initiatives can be formed to ensure data transmission and data storage across GINs and GVCs. As a neutral player, and together with universities and research institutions, the often dependence-based behaviour within GINs and GVCs can be formed into an ecosystem mindset.

Additionally, and regardless of whether an SME is involved, it remains unclear who is the owner of data and who can benefit from it. Both questions can be supported by policy, ensuring a dependable legal framework and highlighting the mutual benefits and interdependencies of GINs and GVCs.

Designing industrial policy towards reshoring through I4.0

Regarding reshoring, it was observed that the cost differential between offshoring and reshoring has been closing in recent years. Through I4.0, cost-based offshoring out of the EU is expected to reduce, replaced by more competitive, digital industrial value creation within the EU. This is because new I4.0 technologies and concepts allow more productive and flexible manufacturing within Europe. However, the policy challenge is twofold: more technologically advanced countries face a trade-off between the job losses in low-skilled activities that may be caused by new technologies such as robot deployment and the relatively small increase in higher-skilled jobs, and the significant productivity gains made feasible through reshoring to factories with I4.0-integrated technologies. By contrast, countries that are currently excluded from these technologies must confront the problem that reshoring industrial production from less developed countries to developed economies might block the way for integration and upgrading (Cséfalvay and Gkotsis, 2020). Hence, I4.0 can be seen as a chance not only to maintain Europe's competitiveness in industrial manufacturing, but to bring back production once offshored outside Europe. However, we must understand the actual motives for backshoring, and that backshoring not within the EU, but to the EU, can be established. I4.0 might also serve as a complementary driver to maintain innovation activities within the EU instead of offshoring these to other regions. Although industry specificities apply, technologically advanced manufacturing such as I4.0 also attracts innovation activities, that in turn enhance the attractiveness as a location for companies (VDI Technologiezentrum and IDEA Consult, 2019). Policy is required to better investigate this topic, also from the perspective of GINs and GVCs, and to bring GIN and GVC players, along with universities and research institutions, together in initiatives and associations that aim for better mutual understanding, drivers and causes, and support measures. Furthermore, it is recommended to support reshoring activities by supporting the required technology investments.

4. Policy Conclusions

This section summarises the main policy conclusions from the GLORIA workshop.

First, in terms of the geographic dimension, **there is a need for better understanding of the actors in GINs/GVCs, and for finer-grained data**. Policy support requires a finer mapping of R&D&I activities across strategic value chains in order to increase the effectiveness of (industrial) innovation policy, also in light of its implications for the (co)location and relocation of companies' R&D&I and production in the EU. Such data can help in addressing the different regional capabilities needed. While the EU missed the first 'ICT revolution', it can benefit from the application of those technologies for the digital transformation in industry. This implies further strengthening of technology-specific capabilities of regions in relation to targeted strategic value chains. Some European countries are developing strong partnerships to further develop their expertise in the I4.0 domain. Corrocher et

al. (2020) provide evidence of Chinese-German collaboration in the development of technologies for the smart factory, which points to great opportunities for integration of the EU into international I4.0 GVCs. At the same time, however, this might lead to increasing regional disparities and issues relating to technological competitiveness within the EU (Weresa, 2019).

Second, regarding implementation of I4.0 and Workforce 4.0 (W4.0) at the company level, the issue of data sharing and who benefits from it has been highlighted. It was also noted that not all participants in GVCs/GINs are similarly vulnerable to substitution: the more individual companies are focused on advanced products and process innovation, the less vulnerable they become. Recent evidence at both the country and firm levels also points to important productivity gains for companies developing I4.0-related technologies in new domains, such as AI and the latest developments in wireless technology (i.e. 5G) (Venturini, 2019; Benassi et al., 2020). The largest share of these gains is likely to be appropriated by established companies, thus pointing to an uneven distribution of value added across the value chain and across company types, with related problems of dominant positions. Also for this reason, the EU has an important eventual role in pushing towards suitable framework conditions, and ways to organise and share data in a way that deepens the EU social model.

Third, the critical role of upskilling and retraining of the workforce was underlined, both at company and at country level. Examples were mentioned of Chinese companies leapfrogging from I2.0 to I4.0. This was not attributed to lower labour costs per se, but rather a high capacity to prepare the workforce to integrate into advanced GVCs and GINs, combined with high flexibility in the company business models. Therefore, the role and impact of I4.0 are a function of the current level of technological maturity: in more advanced countries with higher wages, I4.0 can lead to job displacement via outsourcing or automation, whereas in low-wage countries it can be used to upgrade global integration into GVCs/GINs. The impact of W4.0 on the workforce is thus directly related to the skill level; it only represents an improvement for the highest skilled. Stricter employment policies might incentivise companies to invest in education and increase human capital without job displacement. Growth at high skill levels can be expected in the long run rather than the short, and in new occupations directly related to the digital transformation.

It was highlighted that we should be aware in discussions that looking at the new labour market through the eyes of the old labour market might miss the target. To meet the expectations of both society and companies, **new ways of work need to be found that maintain overall decent working conditions and a fair level playing field, assure minimum social standards and avoid social dumping**. This has become even more apparent during the pandemic.

Finally, more advanced companies tend to have higher levels of backshoring, because higher automation brings higher productivity and flexibility, which allows more local manufacturing activities close to key markets and customers. In addition to an outsourcing trend, a development towards reshoring can be observed. Recent reshoring evidence from Austria and Germany points to the fact that this often happens within the firm and the (macro-)regional level. More important than labour costs are production flexibility, quality and workflow coordination issues. Much backshoring in Europe currently happens from within the EU, often from Eastern Europe, and mainly in the ICT and automobile sectors, thus not recovering activities in sectors such as textiles or food. **However, new production technologies, such as additive manufacturing beyond prototyping, might trigger reshoring in other sectors than those currently observed**. More data would be required to understand which functions are locally bound and which tradeable. Regulation and work within public-private partnerships were also outlined as policy measures successfully addressing the challenges of I4.0/W4.0, as they create networks, trust and validation. It was mentioned that the high dynamics of I4.0/W4.0 realities provide a challenge to agile regulation. **Other recommendations include integrating other players such as universities, research and technology organisations, and forming initiatives supported by policy across GINs and GVCs into ecosystems**.

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