

INDUSTRIAL INNOVATION FOR TRANSFORMATION: NEW SCIENCE & POLICY INSIGHTS

Key messages

- This article introduces the main challenges, the latest scientific evidence and policy issues, and the science and policy areas for industrial innovation to be further developed, and the role of industrial innovation in sustainability and prosperity in Europe.
- New innovations and integrated production structures need updated management practices. Territorial and economic disparities and the performance heterogeneity of firms depend on the differences in innovation diffusion and adoption rates.
- Mixed consequences on the labour force and structural inequalities arise out of advanced digitalisation, while sustainable technologies may have a significant positive impact on employment and industrial composition.
- Disruptive transformative EU policies should be set up to trigger the exploration of innovation with the highest possible economic, social, and employment returns. These should also be able to attract industrial investment.

1. Introduction

The EU economic and policy actors recognise the crucial role of corporate R&D and innovation in driving sustainable development and socio-economic transformations. In fact, at the global level industries are undergoing profound structural transformations due to technological, business, and social innovations that challenge the traditional policy focus on industrial competitiveness and the 'silos' approaches to industrial innovation policy.

As innovation continues to transform industries and society, there is renewed attention on industrial innovation policies. Furthermore, key related aspects are already emphasised in the new political orientation of European Commission's President von der Leyen in her recent publication "Political guidelines for the next European Commission 2019-2024".

In support of the EU industrial research and innovation policy agenda, the European Commission's Joint Research Centre (JRC) and the Organisation for Economic Cooperation and Development (OECD) co-organised the 7th European Conference on Corporate R&D and Innovation (CONCORDi 2019) on 25-27 September, 2019.

The policy brief presented here draws on the results of this conference and introduces recent novel scientific evidence and policy issues affecting industrial innovation and its role in sustainability and prosperity in Europe.

2. Science and policy addressing the main transformation challenges

Innovation systems are complex, characterised by various layers of interactions between heterogeneous agents from various domains: science, technology, production, consumption, and government. To build sustainable competitiveness and in bringing prosperity to European Member States, science, technology, and innovation (STI) policy issues need to be tackled from different angles.

Systemic challenges

Many disruptive factors are driving the socio-economic transformation of industries and territories. Digitalisation, new technologies, new business models, major industrial transitions in energy and transport systems, and historical shifts in social and demographic patterns call for more comprehensive policies. The transformation of EU industry requires profit, investment, and employment incentives to be aligned with pressing environmental and social needs. For instance, while Artificial Intelligence (AI) technologies have a wide range of applications across various domains, concerns such as their diffusion, accessibility, and their impact on jobs and employment should be dealt with carefully.

New technological drivers for competitiveness

EU industrial competitiveness largely depends on the integration of direct and indirect effects of innovation. The former directly translate into productivity gains

while the latter do so indirectly through the improvement and diffusion of innovative capacity.

In fact, various disruptive technologies currently drive the socio-economic transformation of industries and territories. The digitalisation of consumption and production, artificial intelligence, and new platform technologies are driving change, and at the same time new business models are enabling major transitions in methods of delivery for products and services, and the organisation of energy and transport systems. This transformation requires additional investment and policy support.

Sustainable and social imperatives, and responsible research and innovation

As underlined in the UN Agenda 2030 and the Addis Ababa Action Plan, new business drivers and models as well as novel policy actions are required that embrace the multiple dimensions of sustainability (biodiversity, climate change, Circular Economy¹) and responsibility. This perspective also recognises a transversal role for innovation, which is not only considered to be a Sustainable Development Goal (SDG), but also a key enabler in achieving all other SDGs by promoting responsible research and innovation.

While AI technology has a wide range of beneficial applications in various domains, for example, its diffusion, accessibility, and impact on jobs and employment needs to be considered carefully. Indeed, the societal implications of technological change are often insufficiently understood.

EU industrial innovation competitiveness already contributes to developing sustainable development processes by direct and indirect productivity-enhancing impacts (e.g. innovative capacity and diffusion, employment, and economic value). What is more, corporate R&D and innovation consequently play an essential role in building the EU's sustainable competitiveness and in bringing prosperity to the EU and its Member States in the future.

Human resource challenges

The impact of industrial innovation on employment is expected to be both uneven and large. Furthermore, internal demand dynamics, wages disparities between territories, the need for (new) skills, and the risks of job polarisation are topics of great societal importance in this process. Strengthening the links between innovation and industrial policies becomes

essential for long-term employment and healthy business dynamics. Indeed, human resources underpin all thriving innovation systems.

Yet, there is a mismatch between the education and training system and the industrial and science and innovation system in Europe that needs to be addressed urgently including in view of our ambitions for prosperous and sustainable development.

Territorial Challenges

Industrial specialisations and opportunities for structural change differ substantially across and within territories in the EU — countries and regions. Territories face place-specific challenges of balancing both the “local” and “global” dimensions of industrial R&D&I processes. On the one hand, leading firms rely on dispersed networks of actors and places at the global scale in organising their knowledge creation and innovation activities. On the other hand, evidence from economic geography shows that knowledge-intensive business activities tend to concentrate in local innovation systems characterised by strong positive feedback, virtuous cycles of high performance, and high investments. Together, these trends can further accentuate the divergences between leading, intermediate, and lagging actors and territories².

3. New science for policy insights

New technologies, structural change, and industrial transformation

Both manufacturing and service industries are facing production, productivity, and globalisation challenges driven by solutions based on radical innovation. Several countries have created policies to steer the development of Industry 4.0 and foster the adoption of digital technologies such as the “High-Tech Strategy 2020” in Germany (where the concept of Industry 4.0 was born), “Advanced Manufacturing Partnership” in the United States, and “Made in China 2025”. However, the adoption of these technologies is challenging for many firms and regions, mainly SMEs and productivity laggards. There is an increasing need for new management practices to fully embrace and reap the benefits of industry 4.0, moving toward a more integrated and digitalised productive structure.

Recent (new) scientific results (CONCORDi 2019) point out that despite convergent tendencies, the

¹ An economic system aimed at eliminating waste and the continual use of resources.

² Specific territorial places characterised by higher levels of innovation and entrepreneurship often account for more and better innovation outcomes. Furthermore, there is a higher positive spillover effect in specific territorial places with a large number of innovation-intensive companies such as knowledge-intensive hubs.

deployment of industrial robots in Europe is deeply embedded in the path-dependent industrial dynamics and developmental differences, and robot-based automation seems to strengthen the pre-existing territorial-economic disparities.

The latest robotic technologies are likely to displace labour in areas like manufacturing, logistics, healthcare, and routinised conceptual professions. However, there are considerable differences between countries in the intensity of robot usage, and also in terms of diversity of applications. A trade-off emerges between displacement of certain tasks and job creating complementarities in others. In addition, at firm level there are significant differences between digital and non-digital companies, with the former more likely to innovate, increase employment, or enjoy greater market power. This is particularly true in the service sector where adoption of digital technologies is linked to service innovation.

The new JRC-OECD report³ launched at the Conference confirmed that the 2000 world corporate top R&D investors are shaping the future of technology and AI.⁴ With regard to AI related developments, firms in the ICT sector located in Japan, China, and Korea take the lead while European companies rank higher in terms of basic research in the field. The analysis also shows the pervasiveness of AI related technologies and their fast diffusion in non-ICT related sectors.

Large Multi-National Corporations (MNCs) play a role in the setting up and shaping of different types of global value chains (GVCs). Understanding the geographical dimension of the innovation process is key given that participation in GVCs shapes industrial structure at the local level. The geographical dimension is also essential in the process of creating and disseminating AI-related knowledge.

Industrial innovation and socio-economic transformation

The acceleration of technological change, urbanisation, an aging society, and increased global connections impact on the European socio-economic model significantly. As a consequence, this model faces several challenges: regional disparities, skills erosion, job losses, increasing inequality, and environmental degradation. Therefore, the policy focus is shifting from purely economic growth to the broader concept of prosperity, which embraces sustainability objectives and puts employment and

participation in the job market at the forefront of socio-economic policies.

Scientific evidence presented during CONCORDi 2019 points to four messages relevant to policy:

- Firstly, R&D&I, the digital transformation, and the pervasive diffusion of AI have mixed consequences on the labour force and structural inequalities. Some forms of innovation seem to favour employment and wages growth while others lead to the loss of jobs. In fact, the effects of innovation and digitalisation are highly heterogeneous, varying across firms and sectors, and may have positive indirect effects through the emergence of new sectors, new forms of production and products, and new complementarities between AI applications and human tasks.
- Secondly, sustainable technologies may have a significant impact on employment and industrial composition, and the related specialisation in environmental technologies by EU regions may increase the labour market participation rate and investment in R&D and human capital.
- Thirdly, the transition to a Circular Economy calls for the development of the so-called “industrial symbiosis”: the mutually beneficial exchange of waste and by-products between geographically close agents.
- Fourthly, policies should foster sectors and firms where labour-friendly product innovation is more prominent while safety nets and life-long learning programmes should be designed for those traditional and low-tech sectors where job losses due to automation are likely to be concentrated.

Intangibles and diffusion of technology for transformation

Technological diffusion relates to both geographical diffusion and to diffusion from firm to firm as well as from technology to related fields. The deeply intertwined nature of technologies and other external factors make measuring the diffusion of technology a difficult endeavour. Several new measurements of technology diffusion were presented during CONCORDi 2019.

The most measurements are based on trade (e.g. the use of technologies embodied in intermediate goods), spillovers (patent citations, the choice of location of multinational corporation R&D facilities, impact of R&D on total factor productivity) and distance to frontier measurements (technology flows from leading firms to lagging firms). Trademarks look promising as a proxy for innovation in services.

³ See Dennis H., *et al.* (2019)

⁴ They own almost two third of patents filed at the largest IP offices worldwide.

Furthermore, as most measuring strategies lack the measurement of technology adoption, surveys may provide more insights provided they contain technology-specific information.

Many policy relevant take-away messages emerged regarding the barriers to technological diffusion and the policies aimed at overcoming them. On the one hand, technology diffusion is strongly affected by regulatory frameworks. Improved regulations such as capital, product, and labour market regulations might improve the process of lagging firms catching up. On the other hand, many policy instruments fail to consider the absorption capacity dimension of firms and regions, and the complementary nature of organisational capabilities.

If the policy issues are to be tackled empirically, two related questions need to be answered: *How to trigger private investments in new technologies? How to encourage private firms to contribute to the collective exploration of new innovation pathways?*

4. Evidence required for transformative industrial innovation policy

The 7th edition of CONCORDi underlined important evidence-for-policy gaps. These gaps are in part linked to the previously introduced challenges as well as to the evidence and main messages presented at the Conference by both academia and policy-makers.

Technology & sustainability strategy

The EU depends on access to critical technologies from other countries in the world and needs to improve its assessment capabilities in order to identify R&D investments gaps, drivers, and barriers. Moreover, the social, economic, political, and environmental impacts of the EU's multi-technological dependence should be investigated further.

The above is important evidence for enabling appropriate selection of technologies relevant to achieving sustainable competitiveness and socio-economic prosperity. For this purpose, measuring the levels of intangibles or complementary assets becomes even more important.

Industrial innovation and company value chains

The contribution of digital technologies and digital economies to growth in global and EU value added and productivity needs to be monitored accurately.

Reaching the critical masses of investment (human capital, financial capital, and infrastructure, etc.)

would require the identification of appropriate industrial innovation partnerships in priority technological areas and industrial activities.

The impact of this partnership will also depend on the innovation diffusion patterns, the enabling public facilities and actors, and on the spatial and economic impacts of strong-networked firms. These dimensions should be analysed further.

A better understanding of the factors (public policies, regulation, tax systems among others) which prevent SMEs accessing the benefits of digitalisation would help policy-makers to take appropriate actions to facilitate market entry and innovation by SMEs.

The human side of sustainable transformations

The ongoing technological and socio-economic transformation may create new jobs. Indeed, advanced industrial innovation triggers a "creative-destruction" process revealing the redundancy of old investments and professions.

Policy-makers should rely on sound evidence for how to improve incorporation of socio-economic aspects in industrial innovation and transformation strategies, that is, relating to quality of life and well-being.

Furthermore, so that industrial innovation targeting the three sustainability dimensions (economic, social and environmental) can be enabled, the capabilities and skills required by different types of actors need to be understood better and probably need extending.

Data and measurements for policy

To be able to measure the issues related to industrial innovation and the main challenges in the socio-economic transformation,⁵ the EU should equip itself with an appropriate statistical and analytical framework of new and open access data and standard analytical methodologies⁶.

⁵ Four examples:

- a) How do we measure digital goods in National Accounts? When measuring the complete implications of the internet revolution on productivity, do we fully take account of user time in the production of services from these goods? e.g., time spent fixing security problems that prevent access, time spent on websites for purchase of travel, government services, etc.
- b) What are the most appropriate ways of measuring and modelling the external costs of industrial innovation, and the attendant environmental and social benefits of particular directions of transformation?
- c) How to cope with the still scarce evidence on the links between innovation, structural change, and inclusive growth, even more so for developing countries?
- d) How to cope with the need for better data to link ex-ante effort to performance in policy-making?

⁶ For example, the use of text data and machine learning (AI) which provide high dimensional data, and focusing on prediction rather than causal inference.

New policy experimentation and evaluation

New policies should be designed to stimulate critical investment in innovations that benefit developing economies and local/global competitiveness and sustainability.

It would be worth exploring different (new) policy measures which enable the EU and its Members States to take advantage of the economies of scale and large EU market as “a springboard” to the global market.

New policy approaches, such as mission-oriented innovation policy, should be carefully investigated and tested, and should be coherent with the pre-existing policy instruments.

5. Recent relevant EU policy avenues

Industrial innovation for competitive and sustainable transformation presents a great many opportunities and challenges. Gauging the appropriate policy response is crucial and requires careful analysis of policy support programmes and actions.

This section comes from a policy panel composed of several European Commission policy services representing the following Directorate-Generals: *Economic and Financial; Research and Innovation; Communications Networks, Content and Technology; and Regional and Urban Policy.*

The main policy areas highlighted were: i) Productivity slowdown and, in particular, the diffusion of technology versus pushing the technological frontier; ii) Business creation and growth; iii) New efficient ways to stimulate innovation; iv) Investment in human capital; and v) Competition and uneven distribution of wealth.

The importance of improved regulatory frameworks, access to venture capital, and initiatives to strengthen human capital (European Social Funds, Skills Agenda, and Skills Intelligence) for stimulating both innovation and business environment. In addition, country-specific recommendations and national productivity boards⁷ will help individual countries to analyse specific economic productivity and competitiveness developments and challenges.

"Co-creation" has a key role for achieving Responsible Research and Innovation (RRI). Co-creation means collective responsibility for Horizon Europe in which multiple actors and stakeholders will focus on shared objectives. The key action areas of RTD to achieving

RRI are investment in R&D, improved regulation through co-creation, and identification of national strategies and advisory boards.

Furthermore, one important EU objective is to close the digital skills gaps across Europe. Through its "Digital Skills and Jobs Coalition" action, the European Commission seeks to reduce these gaps further by fostering the sharing, replication, and upscaling of best practices in areas such as training and enhanced matching for digital jobs, increasing certification and awareness. Major initiatives such as the EU's Digitising European Industry Strategy launched in 2016, Digital Innovation Hubs (DIHs) and Digital Europe have been designed to enable digital transformations that create greater value in Europe. Affecting the development of a Digital Single Market, these policy initiatives and the new programming – i.e. Creative Europe (2020), new Digital Europe, Horizon Europe, InvestEU – are expected to unlock even more of the EU's digital potential.

Moreover, another crucial EU objective is the promotion of an innovative and smart economic transformation through the EU Cohesion policy. In this policy framework, support to national and regional smart specialisation strategies (and their revisions) has been gradually extended: (i) to enhance innovation diffusion, R&I capabilities, and the uptake of advanced technologies; (ii) to establish competent institutions and bodies for the design, implementation, and monitoring; (iii) to develop skills for industrial transitions and entrepreneurship; (iv) Digitalisation, service accessibility, and infrastructure investments; (v) SMEs growth and competitiveness; and (vi) the facilitating role of the public sector in the Entrepreneurial Discovery Processes (EDPs).

6. Concluding remarks

CONCORDi 2019 paved the way to policy-relevant research avenues: a research agenda shared by the international community of practitioners and academics dealing with the economics of industrial innovation and related policy issues.

The increasingly cross-disciplinary nature of the economics of industrial innovation calls for new statistical norms, new data, complex analytical methods, and radically new policy designs that are able to consider the multi-dimensional (geographical, institutional, sectoral) aspects of the development of industrial innovation for transformation in Europe.

Therefore, considering the scarce financial and environmental resources and the need to match

⁷ https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/national-productivity-boards_en

industrial competitiveness and sustainability, *new (disruptive) policies for transformation* should be set up. The objective is to get private European companies to explore new innovations with the highest expected social returns.

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⁸ See CONCORDi 2019 programme and presentation materials at the following webpage: <https://iri.jrc.ec.europa.eu/concordi-2019>

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