European Commission

Quarterly R&I literature review 2022/Q1

The geopolitics of R&I

R&I PAPER SERIES
LITERATURE REVIEW

Research and Innovation

The geopolitics of R&I

European Commission
Directorate-General for Research and Innovation
Directorate G — Common Policy Centre
Unit G.1 — Common R&I Strategy & Foresight Service

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European Commission
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Manuscript completed in [March] [2022]

EUROPEAN COMMISSION

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Literature review

2022 Directorate-General for Research and Innovation EN

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INTRODUCTION

This literature review is developed by the 'Economics of R&I' team of the Chief Economist unit of DG Research and Innovation. It provides a brief summary of a selection of recent publications on R&I economics and policy. Contributors for this edition: Valentina Di Girolamo, Alessio Mitra, Océane Peiffer-Smadja, Julien Ravet (team leader).

Although innovative firms are typically better equipped to withstand the pressure of highly integrated global markets, the COVID-19 pandemic and the increasing uncertainties deriving from sudden changes in the geopolitical context (such as the Russia-Ukraine conflict) revealed several vulnerabilities for policymakers to tackle.

The globalisation process has enhanced the **interlinkages across global value chains** (GVCs), bringing about several benefits (such as the exploitation of the comparative advantage of international trades) as well as a number of new challenges (such as eased translation of local shocks into global shocks).

In this regard, innovation is not only linked to economic issues. Emerging technologies are becoming a key determinant of **international cooperation** and **competition**, also impacting geopolitical relationships.

Developing new and more sophisticated technologies is increasingly intertwined with the concepts of **resilience** and **technological sovereignty**, calling for new reflections on the role that R&I policy can play in determining interdependencies across countries.

Against this backdrop, EU R&I policy needs to incorporate a **new dimension**, related to **foreign** and **security issues.**

This literature review looks into the interlinkages between innovation and the international context, from **both empirical** and **theoretical perspectives**.

The selected papers cover a broad range of topics, from the changes occurred in GVCs and innovation processes, theoretical discussions underpinning the future of globalisation, to the geopolitical repercussions of the EU policy agenda.

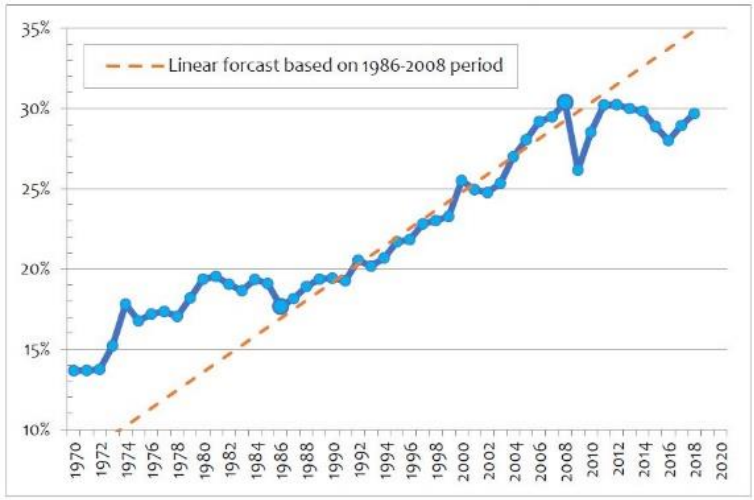
DE-GLOBALIZATION AND GLOBAL VALUE CHAINS

Antràs, P. (2020). De-globalisation? Global value chains in the post-COVID-19 age. National Bureau of Economic Research, No. w28115.

Messages	**1. Compared to the hyperglobalisation that occurred during the period 1986-2008, in the last decades globalisation has slowed down, yet not diminished. 2. Technological change is one of the drivers of such change in trajectory, with digital technologies likely fostering globalisation, and robotisation likely reducing it.**

The paper provides descriptive evidence on the evolution of globalisation and global value chains from 1986 to 2018. The author employs different aggregate macro indices to capture globalisation changes over time. Globalisation is observed to rapidly increase in the period 1986-2008, to then follow a steady, declining, or slowly increasing path, depending on the indicator used. The author describes different potential drivers of such global trends (digital technologies, robotisation, declining returns to R&D, trade liberalisation etc.).

Chart 1. World Trade over World GDP (1970-2018)



The author finds evidence that the global economy is facing a process of "slowbalisation", yet not "deglobalisation". This process started with the 2008 financial crisis followed by the great recession, well before the COVID-19 pandemic. In the aftermath of the 2008 crisis, world trade over world GDP dropped sharply, although the current figure shows that it has grown back to the pre-recession level. The author argues that such slowdown in the rate of globalization was inevitable, as the rapid expansion of trade openness experienced during the 1986-2008 was not sustainable.

The paper lists the ICT revolution, the trade liberalisation of the 90s, and the spread of capitalism as the main drivers of expanding global value chains from 1986 to 2008. Lower offshoring costs thanks to digital technologies, lower tariffs, and countries such as India, Russia and China entering global markets have enhanced globalisation. Yet, new technologies such as robotisation may be a substitute to offshoring, as they allow producing in the domestic market at low cost. At the same time, some other technologies such as digital platforms, blockchain and artificial intelligence may result in pro-globalization effects, by reducing transition and information costs for accessing GVCs.

EU SOFT POWER AND REGULATION STANDARDS

Bradford, A. (2020). The Brussels effect: How the European Union rules the world. Oxford University Press, USA.

Messages	**1. The EU is a soft powerhouse that shapes world markets through its regulations. 2. The EU has among the toughest regulations on everything from privacy, food safety, to the environment, as well as the second largest market in the world. 3. The strength that the EU has in soft powers, it lacks in hard power.**

The book argues against the idea that Europe international standing is in decline, overshadowed by the United States and China. On the contrary, it presents the EU as a soft powerhouse that shapes world markets through its regulations. To support such argument a wide set of detailed case studies of EU policies (spanning from food safety, data privacy to environmental protection) are presented.

The author finds that if a company wants to sell the same product everywhere, it is more economically convenient for the firm to meet the highest standard in the world, the ones decided in Brussels, rather than wasting money on having many different versions tailored for the various markets. The EU common market is the second largest market in the world (around a fifth of global GDP at market exchange rates). Discontinuing doing business in the European Union is too costly for companies, giving leverage to the European Union to impose strict quality standards.

The book provides various remarkable examples, such as the farmers in Nebraska that started producing pesticide-free products to meet EU standards. Big tech companies (such as Google, Microsoft, Apple and Facebook) comply with EU antitrust and privacy regulations, also for users outside the EU. Countries across Africa, Asia, and Latin America starting following EU data protection standards. Many other countries adopted REACH-like and RoHS-like legislation on chemical production safety standards for human health and the environment.

The success of the "Brussels effect" is mainly explained by the EU common market dimension and the EU institutions' legislative abilities. Yet, the permanence of such effect may be challenged in the future by technological change. Indeed, with the spread of new technologies such as Artificial Intelligence, 3D printing etc., it may become harder to develop compelling regulations, without leaving the European Union behind in term of breakthrough innovations.

WHAT IS TECHNOLOGY SOVEREIGNTY?

Edler J., Blind K., Kroll H. and Schuber T. (2021), Technology Sovereignty as an Emerging Frame for Innovation Policy – Defining Rationales, Ends and Means, Fraunhofer ISI Discussion Papers Innovation Systems and Policy Analysis No. 70.

Messages	**1. Technology sovereignty is not an end in itself, but a means to achieve the central objectives of innovation policy. 2. Sovereignty as a normative ideal risks moving the discourse towards autarky and protectionism. 3. Future policies will have to aim at establishing an equilibrium between sovereignty and openness.**

The notion of technology sovereignty has recently gained prominence in national and international debates, including at European level, as an additional rationale for innovation policy. In the paper, the authors propose and justify a concise yet nuanced concept of technology sovereignty to contribute to and clarify this debate.

The authors define technology sovereignty as "*the ability of a state or a federation of states to provide the technologies it deems critical for its welfare, competitiveness, and ability to act, and to be able to develop these or source them from other economic areas without one-sided structural dependency*". In the paper, they offer a balanced perspective of a nation's legitimate interest in ascertaining the availability of and access to technologies on the one hand, and the dangers posed by autarky and protectionism on the other hand, despite the overwhelming body of evidence on the overall superiority of rules-based systems and international openness in science and technology.

Future policies will have to aim at establishing an equilibrium between sovereignty and openness. The authors propose three policies to accomplish this: (i) new forms of strategic intelligence and foresight to understand the need for action to secure technology sovereignty and how to achieve it; (ii) mobilisation of a set of traditional STI policies that have specific importance in the context of technology sovereignty, such as investing in research or developing competences and up-to-date infrastructures (in particular in the digital domain); (iii) a set of policies specifically targeted at securing technology sovereignty, such as international standardisation (to prevent a proprietary monopolisation of technologies), strong regulatory frameworks, complementary competition, trade and investment policies and strengthening international institutions to safeguard rule-based trade and competition.

The innovation policy of the future will have to be developed in a complex triangle of transformation policies, competitiveness policies and technology sovereignty considerations. A new balanced innovation policy must protect international welfare gains through free trade and division of labour from short-sighted technology sovereignty policies driven by domestic interest groups.

THE NEED FOR 'REGLOBALISATION'

Dixson-Declève, S., Bria, F., Charveriat, C., et al. (2021), Transformation post-COVID: global value chains: harnessing innovation to protect and transform the backbone of global trade, Publications Office, 2021.

Messages	**1. The governance of most global value chains show several signs of failure to protect, prepare and transform our economy. 2. Diversification and the reduction of dependency on single sources of supply have emerged as an imperative for the recovery. 3. A transformative approach calls for supporting a reglobalisation.**

This paper was produced by the ESIR high-level expert group, which provides evidence-based policy advice to the European Commission on how to develop a forward-looking and transformative research and innovation policy. In this paper, the authors examine how we can protect, prepare, and transform EU industry and harness innovation to make global value chains (GVCs) more resilient.

The constant quest for efficiency and cost-cutting has ended up depriving GVCs of the redundancy they need to be resilient and help the world face unexpected events. The governance of most GVCs had already shown the signs of a "triple failure" before COVID-19, i.e. failures to (i) protect workers, the environment, and the economy; (ii) prepare the economy for unforeseen disruptions; (iii) transform the paradigm of GVCs towards sustainable practices.

The polarisation of the global economy and the extraction of value typical of the digitalisation process have been exacerbated by the pandemic. GVCs not only became more global in recent decades, but they also became increasingly dependent on key exporting economies like China. While reshoring production would not necessarily guarantee an increase in the resilience of value chains, the issue of diversification and the reduction of dependency on single sources of supply has emerged as an imperative for the post-pandemic recovery.

The paper provides several recommendations, supporting a vision of "reglobalisation", rather than one of "de-globalisation". These include focusing on sustainability by incentivising environmental, social and governance practices along the value chain; setting green and fair conditions for companies' bailouts and support; rethinking the trade-off between resilience and efficiency (which tends to shift towards efficiency in a temporary context of apparent prosperity); going from single to multiple sources of supply to minimise supply chain risk in critical GVCs; combining global trade with more robust regional value chains, especially for critical infrastructure; embedding sustainable GVCs in global and bilateral trade agreements; investing in R&I as it is fundamental for the resilience and transformation of value chains.

GLOBAL VALUE CHAIN AND FIRMS INNOVATION

Reddy, K., Chundakkadan, R., & Sasidharan, S. (2021). Firm innovation and global value chain participation. Small Business Economics, 57(4), 1995-2015.

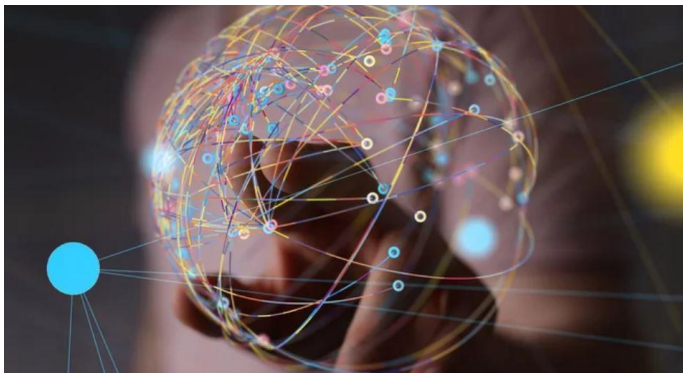
Messages	**1. Innovation positively impacts on firms' participation in GVCs. 2. Progressive improvement in firms' capacity to innovate are essential to increase companies' GVC participation.**

The paper investigates the relationship between firms' innovation capabilities and their participation in Global Value Chains (GVCs). In doing so, the authors rely on firm-level data retrieved from the World Bank Enterprise Survey (WBES), covering both the manufacturing and service sector. The dataset covers 90 countries over the period 2006-2017.

The empirical analysis is carried out using a probit regression model with GVC participation as the outcome variable and innovation as the main regressor of interest. Innovative firms are identified as companies that have introduced a new product on the market, differentiating between new-to-the-market innovations (radical innovation) and incremental innovation. Firms participating in GVCs are defined as carrying out export and/or import activities with international quality certificates. As a robustness check, the authors also use an alternative definition, looking at companies that import and export simultaneously.

The results point to a positive and significant relationship between innovation and GVC participation, and suggest that larger and older firms are more likely to participate in GVCs. When differentiating between radical and incremental innovation, the paper provides interesting insights. First, the probability for firms to participate in GVCs increases as they start to innovate. Second, the probability further increases as firms shift from incremental to radical innovation.

The paper provides further support to the notion that firms' innovative capacity has the potential to significantly alter the way firms behave in the international market. Furthermore, given the higher participation observed for large and medium-sized companies as compared to small ones, the results confirm that policy initiatives aiming at enhancing small firms' capacity to climb up the innovation ladder are essential to enable greater integration into GVCs, thereby boosting economic growth.



RENEWABLE ENERGY AND GEOPOLITICS

Sattich, T. et al. (2021). Renewable energy in EU-China relations: Policy interdependence and its geopolitical implications. Energy Policy, 156, 112456.

Messages	**1. Policy interdependence in the field of renewable energy (RE) plays an important role in determining EU-China geopolitical relations. 2. Different RE policies are strongly intertwined, and symmetric and asymmetric interdependences translate into political alignment and increasing competition, respectively.**

The paper investigates the role played by renewable energy (RE) in the geopolitical relations between the EU and China. Emphasizing the importance of renewable energy, and energy policy in general, in shaping international relations and geopolitical balance, the authors adopt a theoretical approach to analyse whether renewable energy initiatives implemented in the EU and China have contributed to enhance their geopolitical cooperation, or have represented a source of dispute.

Table 1
Interdependence and political interaction.

	Asymmetric	Symmetric
Strong interdependence	**Political approach:** Competitive geopolitics, conflict over trade and investment **Outcome:** Power struggles	**Political approach:** Cooperative global governance **Outcome:** World market, institution building
Weak interdependence	**Political approach:** Competitive geopolitics, conflict over trade and investment **Outcome:** Sporadic disruptions	**Political approach:** Cooperative global governance **Outcome:** Unrelated and uneventful coexistence

The paper develops a theoretical framework drawing on the concept of policy interdependence, which looks at the potential effects that policy choices made by external actors can have on a country's domestic policy. In doing so, the paper relies on the so-called "process theory", an analytical approach explaining a given outcome based on event sequences, as well as on the timing and combination of event chains. In this regard, the authors disentangle RE policy in four areas (climate, energy, industry, trade and investment), and use data on institutionalised dialogues, and non-institutionalised policy interactions to extrapolate information on the timing and geopolitical context of the different policy initiatives.

Overall, the analysis suggests that policy interdependence in the field of RE has important implications for EU-China relations. The role of RE in determining the trajectory of EU-China political interactions varies across different policy sub-areas, entailing different degrees of convergence. The authors observe increasing linkages between EU and Chinese climate policy, which are also reflected in the area of energy policy related to RE. Particularly relevant is the degree of interdependence observed in scientific research activities linked to climate-related subjects (including energy), which have created space for increasing cooperation. Nevertheless, although EU and China appear aligned in terms of overall climate and energy objectives related to RE, divergences remain as regards the policy instruments implemented, especially in areas concerning industry, trade and investment. Domestic industrial measures implemented in the two economies have been typically followed by defensive counter-moves on the other side, indicating the presence of increasing levels of competition and rivalry in these fields.

GREEN DEAL AND GEOPOLITICS

Leonard, Mark; Pisani-Ferry, Jean; Shapiro, Jeremy; Tagliapietra, Simone; Wolff, Guntram B. (2021) : The geopolitics of the European Green Deal, Bruegel Policy Contribution, No. 2021/04, Bruegel, Brussels

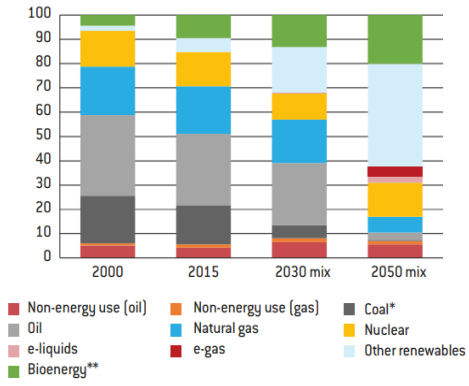
Messages	**1. The successful implementation of the EU Green Deal will significantly change EU's energy system composition 2. Changes in EU's energy trading volumes will produce important geopolitical repercussions, re-defining both EU international relations as well as the energy security strategy.**

Using data on the EU energy system, the paper investigates the geopolitical implications of the European Green Deal, accounting for intended and unintended consequences of its implementation. The achievement of EU's environmental goals will drastically change the current composition of the EU energy system by 2050. EU imports of coal, oil and gas are expected to decrease respectively by 71-77%, 23-25% and 13-19%, over the period 2015-2030. A further shrinkage in the trading volume of these commodities will occur after 2030, when oil and natural gas imports are expected to go down by 78-79% and 58-67%, respectively, compared to the 2015 levels. As a result of these changes in EU energy trading activities, four types of geopolitical implications are identified in the analysis.

First, the EU decarbonisation process will have relevant impacts on oil and gas-producing countries in the EU neighbourhood, leading to a decrease in investments in fossil fuel infrastructures. Nevertheless, some of the energy suppliers to the EU are expected to benefit from the EU Green Deal implementation during the transition phase towards carbon-neutrality. This is particularly relevant for Russia, main supplier of natural gas, which is likely to see its exports increase in the 2030 timeframe, as natural gas will be largely used as main transitional energy source [Note: paper published in 2021].

A second important implication concerns the effects the implementation of the Green Deal will have on the global market, where significant oil price reductions are expected as a result of the new trade balances. Third, the EU Green Deal is expected to solve EU's energy security problems related to the highly dependent relation between the EU and its current main energy suppliers (notably, Russia). However, other security concerns could arise in relation to the increasing need for critical raw materials necessary for the manufacturing of several green technologies, which risks making the EU strongly dependent on other international partners, first of all China.

Figure 1: EU energy mix evolution (55 percent lower emissions in 2030 compared to 1990 and climate neutrality in 2050)



Source: Bruegel/ECFR based on European Commission (2020). Note: among the various scenarios consistent with EU climate targets used by the European Commission, we picked the MIX scenario. E-liquids and e-gas are synthetic fuels, resulting from the combination of green hydrogen produced by electrolysis of water with renewable electricity and CO2 captured either from a concentrated source or from the air. Bioenergy includes solid biomass, liquid biofuels, biogas, waste.

RENEWABLE ENERGY AND GEOPOLITICAL RISK

Su, C. W., Khan, K., Umar, M., & Zhang, W. (2021). Does renewable energy redefine geopolitical risks? Energy Policy, 158

Messages	**1. Increases in renewable energy production will reshape global geopolitics, by reducing the relative weight of geopolitics dependencies associated with fossil fuels. 2. The relationship between geopolitical risk and renewable energy can be both positive and negative, depending on the period of observation. 3. Renewable energy can reduce geopolitical risk by freeing countries from dependencies on import of gas and oil.**

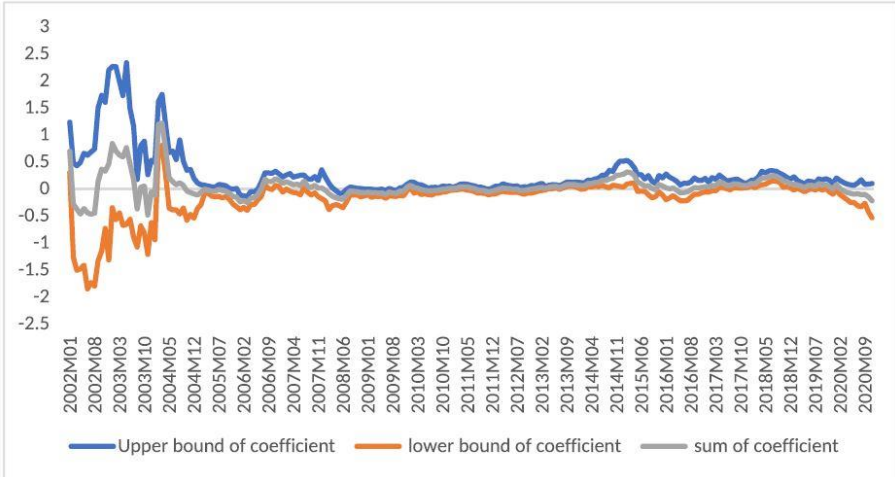
The paper provides evidence on the relationship between geopolitical risk and adoption of renewable energy. The authors employ an index of geopolitical risk (which includes wars, terrorist attacks, and interstate conflicts) and the sum of wind, solar and hydropower (measured in TeraWatt Hours) from 2000 to 2020.

No significant relationship between geopolitical risk and adoption of renewable energy is found over the entire sample. However, by investigating the relationship with a rolling window causality test, it is uncovered that such relationship exists in different subsets, changing sign depending on the time period (and the events that took place in that period).

As an example, the 2006 dispute between Russia and Ukraine strengthened the EU interest in renewable energy to minimize the gas dependency on Russia. Some EU Member States strongly pursued the development of renewable energy, while others diversified their energy supplies in order to avoid disruptions caused by geopolitical risk.

An opposite example is the failure in 2013 of the Desertec project on the renewable energy grid in the Middle East and North Africa (aiming to increase energy supplies to Europe via solar power plants in the Sahara Desert), due to the geopolitical turmoil caused by the Arab Spring in the region.

The authors suggest that greater investments in renewable energy technologies can make countries major economic players in the future, while mitigating the economic consequences of climate change, and reducing conflicts deriving from energy dependencies.



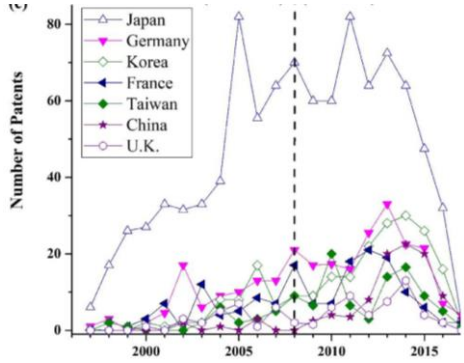
TECHNOLOGY COMPETITIVENESS AND IOT

Ahn S-L. (2020) Three characteristics of technology competition by IoT-driven digitization. Technological Forecasting and Social Change. Volume 157, August 2020

Messages	**1. Internet of Things (IoT) driven digitization is characterized by a rapid innovation cycle. 2. The U.S. is the global leader in terms of IoT patents.**

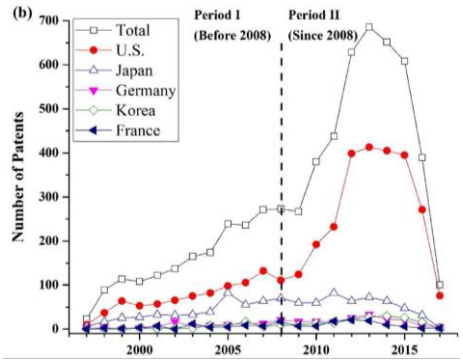
This paper investigates the changes in the technological competitiveness of countries induced by Internet of Things (IoT)-driven digitization.

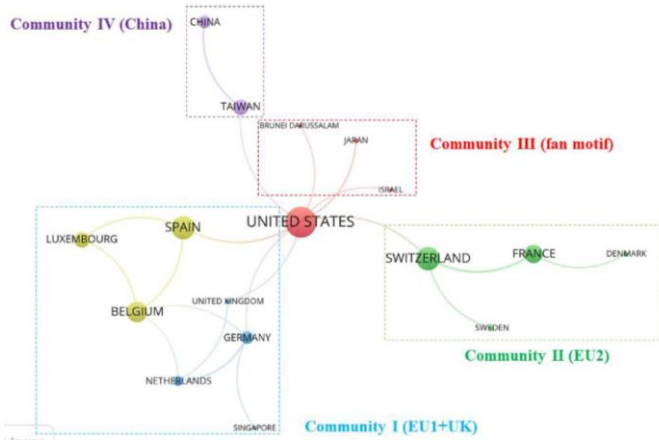
The author uses international patent data covering the 1997-2017 period. It selects technologies most related to the IoT and builds different indicators for a selected set of countries.



The paper finds that IoT-driven digitization is characterized by a rapid innovation cycle, which implies the lifetime of knowledge is short in IoT-driven innovation. He demonstrates that the U.S. leads IoT-driven digitization with a widening gap and that the gaps among countries other than the U.S. have narrowed over time. After 2008, Asian and European countries' innovation activities in IoT-driven digitization have been more significant but the gap with the U.S. has still widened.

The analysis of joint patenting activity shows that, prior to 2008, based on the applicants' nationality, there was no clear cooperative network structure. However, after 2008, different clusters of international collaboration communities have started to emerge. The U.S. has become the country leading the change in the global value chain of patents for IoT-driven digitization. In Europe, there are two international hubs: Switzerland-France and Spain-Belgium-Germany. The authors conclude that network effect of IoT-driven digitization could have a significant impact on the technological competitiveness of countries.





TECHNOLOGY SPECIALISATION AND 5G

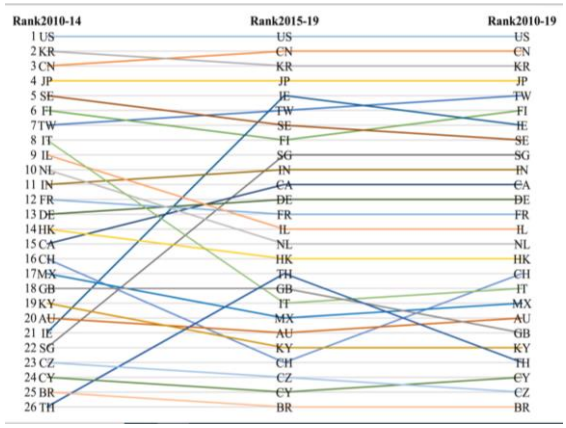
Parcu P.L., Innocenti N., Carrozza C. (2021). Ubiquitous technologies and 5G development. Who is leading the race? Telecommunications Policy

Messages	**1. The US is in the first position for 5G as it is specialized in the rarest technologies related to 5G, followed by Korea and China 2. European countries appear to be less diversified and specialized in more common technologies 3. Strengthening cooperation between EU countries is critical to compete with US and Asia.**

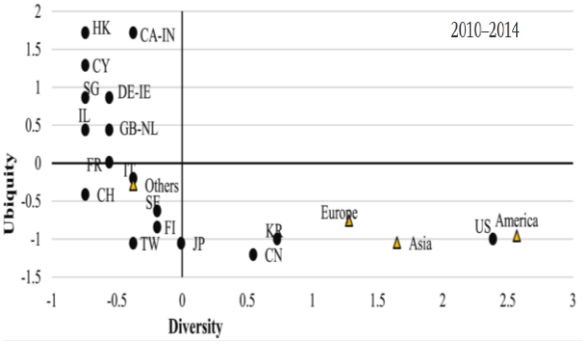
This paper investigates technology specialisations in 5G development in different regions and countries.
The authors use patents related to 5G technology from the U.S. Patent and Trademark Office (USTPO) and the European Patent Office (EPO) filed between 2010 and 2019. The authors compute the diversity (how many different technological specialisations there are in the basket of each country) and the ubiquity (how rare are these specialisations on average) of the countries considered. All the countries in the lower right quadrant (i.e. high diversification and low ubiquity) can be considered leaders in the 5G technology.

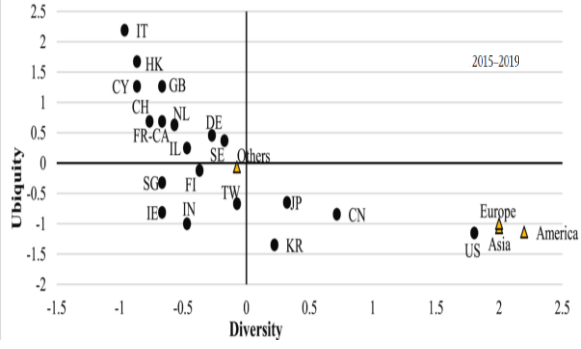
They find that the first position is covered by the US in the 2010-2014 and 2015-2019 periods, while the second position during 2010-2014 was occupied by Korea, which however later lost ground in favour of China. European countries appear to be less diversified and, in general, specialised in technologies that are more common.

During the 2010-2014 period, Europe, as a region, was lagging behind, but in the second period (2015-2019), it was able to bridge the gap reaching values almost identical to Asia.



The technologies and the specialisations needed to develop 5G are in the hands of a few countries around the globe. Single European countries, taken in isolation, are not among those leading players. However, Europe, considered as a whole, competes well with the US and Asia in terms of patented innovations, suggesting the economic and strategic relevance of strengthening cooperation within the EU.





ECONOMIC COMPLEXITY THEORY AND APPLICATIONS

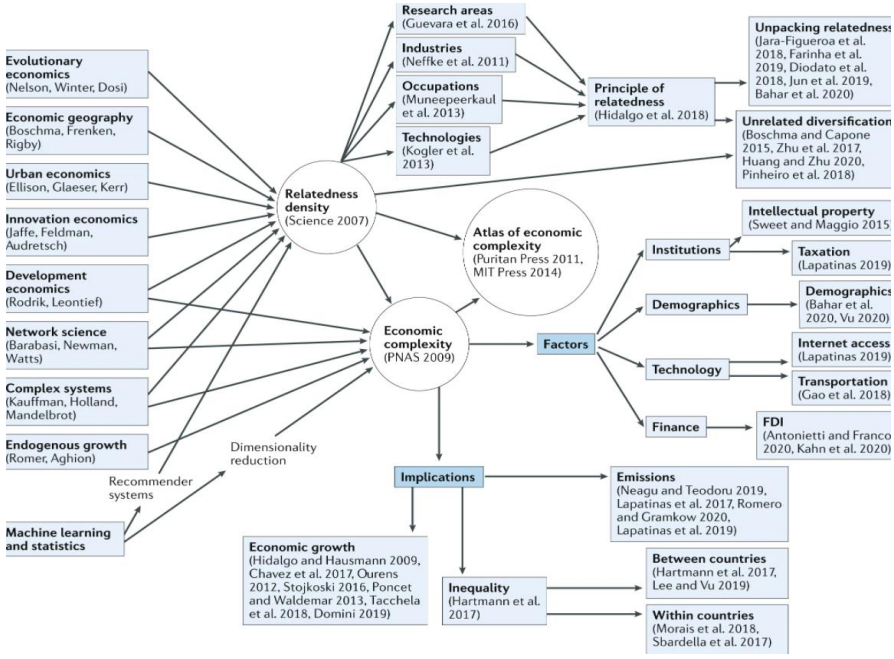
Hidalgo, C. A. (2021). Economic complexity theory and applications. Nature Reviews Physics, 3(2), 92-113.

Messages	**1. Economic complexity is a powerful tool that can be used to construct predictors of a location's diversification and development potential. 2. The use of economic complexity has accelerated in the past decade related with the emergence of AI techniques in research.**

This paper explores the economic complexity theory, which has attracted attention in the research community during the last decade, and its applications.

Like traditional approaches to economics, economic complexity focuses on the duality between economic inputs and outputs. But, unlike traditional approaches, which either aggregate output (as gross domestic product (GDP) does) assume the nature of inputs (such as capital, labour and knowledge) or model micro-data based on theoretical hypothesis, economic complexity methods embrace fine-grained data on thousands of economic activities to learn both abstract factors of production and the way they combine into thousands of outputs without pre-imposed structures. This is made possible by applying machine learning techniques to data on the geography of activities, such as product exports, employment by industry or patents by technology. It provides a powerful tool that can be used to construct predictors of a location's diversification and development potential.

The acceleration of the study of economic complexity during the past decade coincides with the rise of machine learning and AI. Metrics of economic complexity have been used to formalize the impact of economic structures in outcomes such as economic growth, income inequality, greenhouse emissions, employment and the spatial concentration of economic activities.



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