Anno LIV, 2020, 1 *Economia & Lavoro* *Thirty Years, pp. 67-88*

INNOVATION POLICY GOVERNANCE AND DYNAMIC CAPABILITIES IN THE PUBLIC SECTOR: CHALLENGES FOR ESTONIA AND OTHER CEE COUNTRIES IN THE CONTEXT OF INDUSTRY 4.0

by Kadri Ukrainski

The components of any national innovation system (NSI) – institutions and organisations – need appropriate alignment to enhance innovation and the dynamic development of any country. Many authors have claimed that the countries of Central and Eastern Europe (CEE) have recently slowed down in their development. The reasons include weak reforms and deficiencies of their NSI, pointing to NSI rigidity, misalignment of institutions, overly strong FDI-dependence, and poor governance quality. This article combines the concepts of NSI and the dynamic capabilities of governments as coordinators of the knowledge economy conditions in the NSI. By using selected empirical examples from CEE on micro-level stimuli for knowledge production and diffusion (which both are the core processes of the NSI), the article outlines the challenges for CEE countries' governments, including, (among others) operating through demand as well as supply-side factors on the NSI, enhancing interactivity (in 'real time'), aligning incentives for different types of NSI actors, aligning micro, meso, and macro levels (local, regional, national, and global systems of innovation), and acquiring policy capabilities to make connections through policy learning.

Keywords: national systems of innovation, dynamic capabilities of governments, knowledge economy, Central and Eastern Europe.

Le componenti di qualsiasi sistema nazionale di innovazione (SNI) – le istituzioni e le organizzazioni – necessitano di essere allineate correttamente al fine di potenziare l'innovazione e lo sviluppo dinamico dei vari Paesi. Da più parti si sostiene che, di recente, lo sviluppo dei Paesi dell'Europa centrale e orientale ha subito un rallentamento. Le ragioni addotte includono l'adozione di riforme deboli e la presenza di carenze nei loro SNI, quali la rigidità dei sistemi stessi, il disallineamento delle istituzioni, un'eccessiva dipendenza dagli IDE, e una governance mediocre. Il presente contributo combina i concetti di SNI e di capacità dinamiche dei governi in quanto "coordinatori" delle condizioni dell'economia della conoscenza all'interno dei SNI. Ricorrendo a una selezione di esempi empirici provenienti dai Paesi dell'Europa centrale e orientale e riguardanti gli stimoli a livello micro per la produzione e la diffusione di conoscenza (che rappresentano i processi principali del SNI), l'articolo delinea quelle che sono le sfide cui i governi di questi Paesi si trovano di fronte: tra le altre, il fatto di dover intervenire sul SNI agendo sia sui fattori dal lato della domanda sia su quelli dal lato dell'offerta, nonché il fatto di dover aumentare l'interattività (in "tempo reale"), allineare gli incentivi rivolti a differenti tipologie di attori del SNI, allineare i livelli micro, meso e macro (in altre parole, i sistemi di innovazione a livello locale, regionale, nazionale e globale), e acquisire capacità a livello di policy al fine di stabilire collegamenti attraverso l'apprendimento delle politiche.

Parole chiave: sistemi nazionali di innovazione, capacità dinamiche dei governi, economia della conoscenza, Europea centrale e orientale.

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Codici JEL / JEL codes: O31, O33, O38.

ISSN 0012-978X

1. Introduction

Several earlier studies reveal how Central and Eastern Europe (CEE) countries develop quite different patterns while shifting from completely different systems of former communist regimes. They cannot emulate the models of industrialised countries as the technologies, and the global challenges entailed (not only related to Industry 4.0), are new; moreover, meeting them successfully would imply both successful management and forward-looking innovation and social policy (Hirsch-Kreinsen, 2016).

Innovation policy belongs to the broadly defined area of industrial policy, including trade and competition policy. In its broad meaning, industrial policy is considered as the overall ensemble of policies that directly and indirectly affect industrial performance through the impact on microeconomic variables. While these different aspects are closely interlinked, innovation policy has become the dominant, if not the major, dimension of industrial policy today (Chaminade and Edquist, 2010).

In this regard, Industry 4.0 is a much narrower concept that does not mean only technology (i.e. knowledge), but rather communicates an envisioned state of manufacturing. Therefore, it can be understood as a policy-driven innovation discourse (Reischauer, 2018) often labelled as "Fourth Industrial Revolution" or "Industry 4.0". It encompasses the adoption of digitisation techniques and processes (digitalisation, cloud computing, Internet of Things, IoT, and big data) to gain competitiveness on international markets (Castelo-Branco *et al.*, 2019). It is still in a state of being a "promising technology", which has a quite ambivalent character, meaning that digital technology will bring definite technological, economic, and social advantages, but still needs a higher degree of societal acceptance (Hirsch-Kreinsen, 2016). In this respect, the capability of governments to address multi-dimensional economic and innovation policy instruments, also wider socio-economic issues related to Industry 4.0, becomes crucial. These are, for example, internet-based concentrations of power, data protection, and ethical and moral responsibilities for "machine-made decisions", etc. (Hirsch-Kreinsen, 2016).

Lundvall and Borras (2005) link the core of national systems of innovation (NSI) in terms of science and technology policy to more comprehensive innovation policy related to establishing knowledge-based economies, which are "directly based on the production, distribution and use of knowledge and information" (OECD, 1996, p. 7). This article uses the frame of NSI, as well as the literature of dynamic capabilities in the public sector, to discuss the requirements that Industry 4.0 technology is placing on national governments in CEE countries.

In academic literature as well as in practice, a knowledge-based economy primarily refers to the research-intensive branches of the economy. This definition is too narrow since it ignores the universal set of problems accompanying the implementation of knowledge, as well as the significance of experiential knowledge. The latter is very important, for instance, in traditional branches of the economy and (public-sector) services considered middle and low-tech (Cooke, 2008). Capabilities of public sectors are essential as coordinators of the knowledge economy conditions – funding, competition, and cross-border (macro-regional) strategies and commitments (Galgóczi and Drahokoupil, 2017). Although generic ICT is at the core of the Industry 4.0 concept, the "digital divide" separating catching-up countries from the advanced ones is not large compared with more general gaps in learning and competence building, "the learning divide" (Lundvall, 2007). This view matches well with the idea of dynamic capabilities of agents involved in NSI (a concept first developed by Sen, 1988).

2. The role of governance in the varieties of NSI

The national innovation system in its broader meaning has been conceptualised to include all parts and aspects of the economic structure and institutional setup affecting learning, searching for, and exploring knowledge (i.e. the production system, the marketing system, and the finance system present themselves as subsystems) (Lundvall, 1992, p. 12). A narrower definition is applied by Nelson (1993), referring specifically to the R&D system, including links between research institutions, firms, and government in the area of R&D. How successfully these subsystems operate depends on the governance of the whole system referring to the "processes of interaction and decision-making among the actors involved leading to the creation, reinforcement, or reproduction of social norms and institutions" (Hufty, 2011, p. 405).

Recent approaches to technological change in society (e.g. deep transitions) (Schot and Kanger, 2016) therefore formulate the need for deeper and more versatile technological change in society to move towards the path of sustainable and equitable income distribution. They emphasise that, in order to move to a viable development model, it is no longer enough to "optimise" old systems, but more profound system-level change is required (Schot and Kanger, 2016), which in our interpretation also means quite different incentives for innovation. The weakness of systems with stronger state lead or control is the relative rigidity resulting from the close interconnectedness (or even locking) between system participants, requiring relatively high external pressures and time to trigger the change process (Boyer, 1999, p. 132). In CEE countries, the innovation systems are impacted strongly by the EU via funding and legal coordination (Farkas, 2011). On the other hand, these economies are overly dependent on the division of labour and investments of multinational groups, and are therefore strongly coordinated externally (Nölke and Vliegenthart, 2009). CEE countries are still in the process of developing their institutional infrastructure of research and education sectors, technology and innovation, production systems, and labour market and financial system institutions, which are fragmented and misaligned (also called "patchwork capitalism" by Rapacki and Czerniak, 2018).

Governance is separately discussed as determining the functionality of the system in the interplay with the existing structure of that system. Governance impacts the system through regulatory, market, normative, and cognitive mechanisms (Hillman *et al.*, 2011). The question of "how to govern" entails the focus of governance on the supply or demand side, or both. "What to govern" reflects the target of governance determining the functionality pattern (key innovation processes), but also the coverage of subsectors. The key processes include the development and spread of knowledge, influence on the direction of the search for innovations, entrepreneurial experimentation, market formation, legitimation, resource mobilisation, and the development of positive externalities (Hillman *et al.*, 2011). The extent to which the desired functionality of the system is achieved depends on the adjacent regimes determined by the environmental conditions. We can empirically analyse how the environment influences governance arrangements, and how they are aligned with the regimes of the sub-systems involved (Hillman *et al.*, 2011). This impact is created not only by public policy instruments, but also by different regimes under which governance itself operates (e.g. policy-making routines based on ministries, open call-based funding systems, etc.) and by the alignment of regimes under which sub-systems operate, e.g. alignment of different technological systems to public research specialisation, etc. (Breschi *et al.*, 2000). Typically, the regimes are defined via public governance routines incorporating a bundle of governance instruments encompassing rules, norms, and procedures (the latter also regulating behaviour and controlling outcomes) (Krasner, 1982). At the same time, similar regimes are described in the case of the private sector as regimes collecting routines, rules, and procedures in global networks (Haufler, 2004). The Organisation for Economic Co-operation and Development (OECD) (OECD, 2015) limits science, technology, and innovation governance to "the set of publicly defined institutional arrangements, including incentive structures and norms, that shape the ways in which various public and private actors involved in socioeconomic development interact when allocating and managing resources for innovation". These arrangements affect how public and private-sector actors co-evolve in distributing and managing the resources necessary for innovation. This is a narrower approach than the one typically used (e.g. de la Mothe, 2001), but it is needed for analytical purposes that disentangle the policy coordination impact from the mutual effects of the other actors in the system.

The role of institutions, and their ability to change become crucial in case of rapid change. Economic and technological changes do not occur in isolation from social and institutional transformations, which are represented by regimes in this model. As argued by Zysman (1996), distinctive institutional structures in different countries stemming from historically determined political and economic development define the choices that are available to individual actors (individuals, firms, and organisations) in responding to new economic or technological trends. The institutions are essential to accumulating the acquired knowledge and skills into collectives of workers organised into organisations (Wolfe and Gertler, 2002). As discussed by Hodgson (1993), habits and routines within organisations constitute an important mechanism for preserving and transmitting skills and technological learning within the organisation. Universities and public research organisations as knowledge providers follow certain routines that can be too rigid. Inability to relinquish old routines can pose the risk of an irrational lock-in of resources. Similarly, Gertler (1993) illustrates the great difficulties that manufacturers in old, mature industrial regions have in accepting new technologies. Whether institutions within a country or a region can support or hinder learning comes to be of crucial importance. The systemic problems of any NSI can be divided into: the presence or capabilities of the actors; the presence or quality of the institutional setup and of the infrastructure; and the interactions between these factors (Wieczoreck and Hekkert, 2012).

3. Dynamic capabilities of governments, and the premise of Industry 4.0

Economic agents will allocate resources on the exploration and development of innovations if they know or believe in the existence of some sort of unexploited opportunities, and that there will be a market for such new products or processes, and some (economic) net benefit from such innovations (Dosi, 1988, p. 1120). The Industry 4.0[1] concept has been compiled with respect to the perspectives of the manufacturing sector in relation to advancing the dynamic (or "real-time") innovative capabilities of firms.

[1] Compagnucci *et al.* and Pelle *et al.* in this monographic section introduce the technological changes related to Industry 4.0.

Following the Schumpeterian tradition, Pisano and Teece (1995, p. 1) have conceptualised the capabilities as responses of strategic management to the dynamic environment in terms of "adapting, integrating, re-configuring internal and external organisational skills, resources, and functional competencies toward changing environment".

The innovative capabilities of governments intersect with the innovation processes of firms – when looking at the feedback channels of a learning-based model of innovation (Caraça *et al.*, 2009) – via different channels:

– innovation in the public sector itself as a producer of (public and semi-public) goods and services (perhaps a more technological view on innovation); and

– innovation policy, i.e. how the public sector influences innovation processes of the private sector via policies and institutions it creates in general (so-called "framework conditions"), but also, more specifically, what stimuli (e.g. a specific R&D grant system it provides) for both, the science and technology systems.

As with firms, the capabilities of all kinds of different public bodies and organisations, i.e. the capabilities of agents who are forming the core of NSI (e.g. universities, governmental units at different levels, etc.) can be identified (von Tunzelmann *et al.*, 2010). These are (according to Windrum, 2008) expressed in products (services) or processes, more specifically in service innovation (in the meaning of new services or of improvement of an existing service), service delivery innovation (new or altered ways of supplying services), and administrative and organisational innovation (changes in organisational structures and routines), but also in policies and strategies. The latter can imply conceptual innovation (development of new views, and challenge of existing assumptions), policy innovation (changes in thinking or behavioural intentions, also stimuli), and systemic innovation (new or improved ways of interacting with other organisations and sources of knowledge) (Windrum, 2008). Von Tunzelmann *et al.* (2010) also conceptualise these capabilities on regional, national, and global level in products, processes, and policies and strategies. The innovative capabilities of governments are elsewhere seen (according to Kattel and Mazzucato, 2018): state (steering) capabilities to achieve desired outcomes and legitimacy; policy capabilities to coordinate different aims and instruments and to achieve policy coherence; and administrative capabilities to align technical, planning, and administrative capabilities.

In their discussion, Kattel and Mazzucato (2018) propose to synthesise the concept of dynamic capabilities with the Weberian-tradition of administrative capacities. These can be identified on three levels: individual, organisational, and network – the individual level consisting of the capabilities of individuals and their relationships (Gieske *et al.*, 2016). In the context of Industry 4.0, the skills of both private and public managers become extremely relevant in adopting new technology, as knowledge, skills, work orientations, and work virtues of the management and staff influence different aspects of restructuring and transforming (public) production and service delivery (Hakkarinen *et al.*, 2001). The theoretical, technical (digital), but also practical knowledge of new technology contributes to the introduction of ICT in the public sector, but also helps to deal with the increased uncertainty and risk situations caused by technical integration.

The organisational level comprises the organisational policies, rules, routines, and strategies, but also managerial activities that determine the organisational behaviour (Gieske *et al.*, 2016). The main challenge of the innovation policy lies in the aligned coordination of individual public offices or aggregates of different public offices (such as regional administrations), where different non-market coordination and regulation mechanisms can be used (Friedrich *et al.*, 2014). The network level incorporates inter-organisational arrangements, network collaboration, and institutional rules that shape the cooperation of actors within a certain wider socio-technical regime (Gieske *et al.*, 2016). As societies become more open, public-sector officials need to achieve integrated solutions not only across different ministries and agencies, but also by incorporating wider sets of stakeholders internationally. This is also the case with CEE countries in the context of a deepening and widening EU integration. Different professional skills (multi-skilling), international and social skills, but also management skills (especially knowledge management) become more relevant (Hakkarainen *et al.*, 2001). These skills may help to integrate tasks better and to de-specialise, but also work more efficiently in groups, and interact better within and between (international) working groups, with suppliers and clients (citizens) in their home country (Hakkarainen *et al.*, 2001).

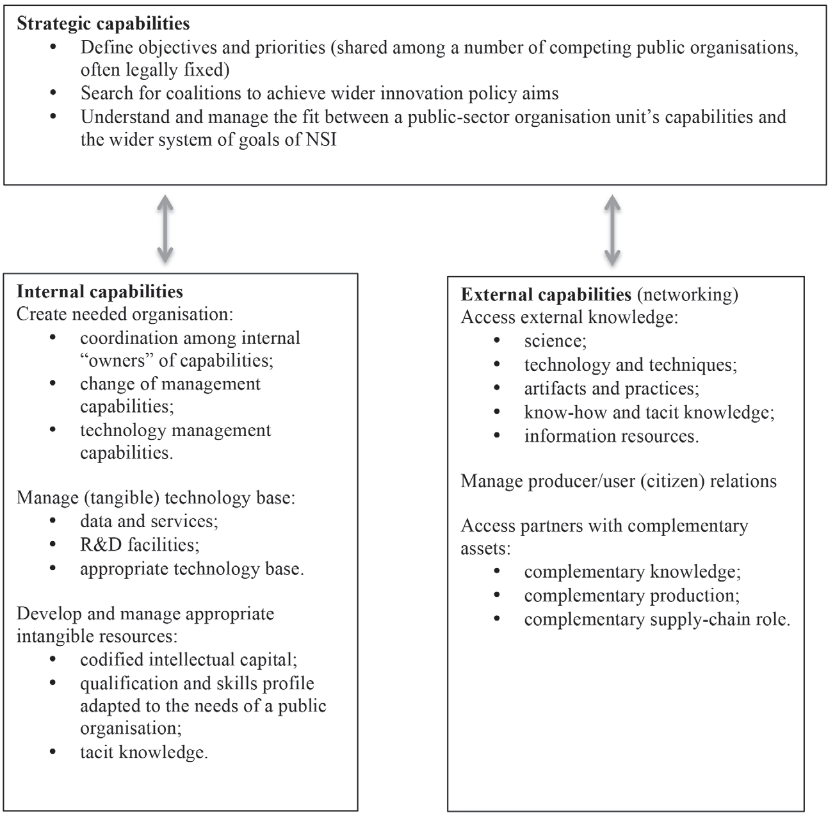
The abovementioned skills become increasingly relevant as the globalisation of production and markets occurs (especially when the sectors where public-sector firms are more active become more globalised, e.g. energy, transportation, etc.). However, these skills also became more relevant with increasing flat hierarchies, decentralisation, and increased information exchange concentrated more at the operational level (Hakkarainen *et al.*, 2001). In the long run, it is also a matter of "competitiveness" or "survival" of individual units, as leadership enables better coordination and steering of autonomous workgroups, and new work virtues contribute to reliability and trust among citizens. The capabilities of the innovation policy encompass the processes related to how the public sector innovates internally in becoming an agent of change, which in turn generates its appropriate policy-generation capabilities (Kattel and Mazzucato, 2018).

Innovation in the public sector on a public-office level is often related to technological (ICT-related) or other process improvements enabling the supply of more or higher-quality services at lower costs. However, as is the case with private firms, the ability to appropriate the outside knowledge and innovation (denoted as "absorptive capacity" by Cohen and Levinthal, 1990) is dependent on the internal knowledge and capabilities (including own R&D), and, together with the spill-overs of the knowledge pool within and outside of the administrative sector, the available (technological) knowledge is formed. A very important aspect of this model is how the incentives for R&D and building up the absorptive capacity are dependent on the technological opportunities, the appropriability of gains, but also the interdependence of competing administrations (in case of public offices, also alternative service providers, as there exists horizontal competition between the offices).

According to Nooteboom (2012), the absorptive capacity complemented with the expressive capacity, which is triggering understanding on the 'receiver side', is forming the collaborative capacity, which can be increased by learning from cooperation experience, and can in turn further lower cooperation costs. Cooperation is more difficult between partners with more considerable cognitive distances (which can be empirically assessed by organisational data and technological profiles, cf. Nooteboom *et al.*, 2007); however, larger cognitive distance involves potentially greater novelty value from cooperation. Different international and organisational contexts only add to the R&D cooperation complexities (Nooteboom, 2012).

Considering the discussion above, the popular conceptualisation of capabilities of firms by Arnold and Thuriaux (1997) can be adapted to the public sector with the purpose of empirically analysing it in individual public-sector units, as well as to the whole NSI level. The capabilities of individual public-sector organisations can be analysed by framing them into strategic, internal, and external capabilities, which need to be aligned in real time to produce the desired effects (figure 1).

Figure 1. Innovation capabilities of public-sector organisations



Source: adapted from Arnold and Thuriaux (1997).

Considering the innovation policy, it is extremely difficult to imagine the capabilities to perform a strategically successful innovation policy without having strong internal and external capabilities of public administrations, as specialised services, policy learning from other countries, etc. would not work well enough. For example, when analysing innovation policies in the broader set of transition countries (including CEE countries), Veugelers and Schweiger (2016) find surprisingly similar policies, implying that policy mixes are insufficiently tailored to local conditions. The policies focus on creative capabilities and not on absorptive capabilities because the governments are trying to emulate advanced countries by attempting to develop high-tech industries instead of local competitive advantages. This reflects weaknesses in both strategic and external capabilities. The

CEE countries have been characterised by the misalignment of innovation capabilities of firms and research-performing institutions (e.g. weak absorptive capacities of firms, and weak applied research in the public science system) and by the lack of skills in terms of commercialisation of research results. Governments with weak strategic development capabilities only worsen the situation by setting formal goals that emulate those of Western countries (Havas *et al.*, 2015).

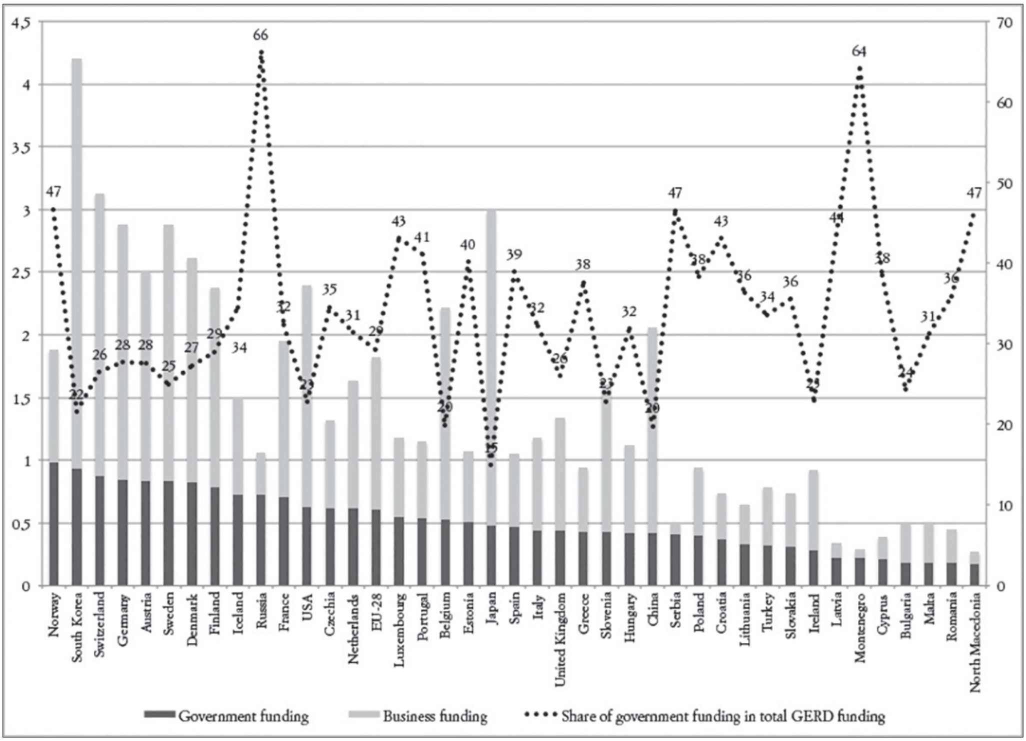
Furthermore, when solving various social and environmental challenges, more emphasis needs to be placed on the experimentation with niche solutions enabling socio-technical systems to change, and tilting the institutional and regulatory regime field towards a transformative change of these socio-technical systems (Schot and Kanger, 2016). The solutions in innovation policy are dynamically emerging, and need to be co-designed through dialogue between multiple actors. As Kattel and Mazzucato (2018) discuss, innovation policy needs to shift from the support-and-measure approach to the lead-and-learn approach, which poses serious challenges to public sectors in CEE countries on both the system and organisation levels.

By this shift, the real-time alignment of strategic, internal, and external capabilities is critical in different policy areas. Earlier research has found that strong innovation capabilities and well-functioning governance systems are behind sound economic development (Fagerberg and Shrolec, 2008). The governance quality in CEE countries has been estimated to be at a medium or low level compared with other countries in the EU (Rapacki and Czerniak, 2018), perhaps little better in Estonia (Farkas, 2019). Surprisingly, the analysis of Industry 4.0 readiness by Castelo-Branco *et al.* (2019) reaches very different results, placing France and Italy among weak countries in terms of infrastructure and big data maturity, and Germany, Sweden, and Denmark among weak countries in terms of infrastructure for Industry 4.0. Although the authors bring out the incomplete nature of the available data on these issues (several essential dimensions of Industry 4.0 seem to be left out), this raises the question of how the innovation systems are related to the adoption of Industry 4.0.

4. Internal capabilities and readiness for Industry 4.0

Any system can be evaluated by two components: performance and results. It is quite challenging to assess the functioning of innovation systems in countries at different development levels (Cirillo *et al.*, 2019), as well as to evaluate separately specific technology-related capabilities in different countries. In reviewing different possibilities, Archibugi and Coco (2005) maintain that the generation capacity of technology and innovation can be measured by R&D expenditure, which is a comparable indicator across countries and over time, and outlines the role of the public sector in the knowledge generation processes. In transition countries, a critical role is played by how the public sector initiates and reforms these processes in science and education, as well as by how it supports the private sector also during transition, when many private production structures and networks were altered. An alternative indicator related to the number of patents is equally not meaningful for individual CEE countries (Borrás, 2019).

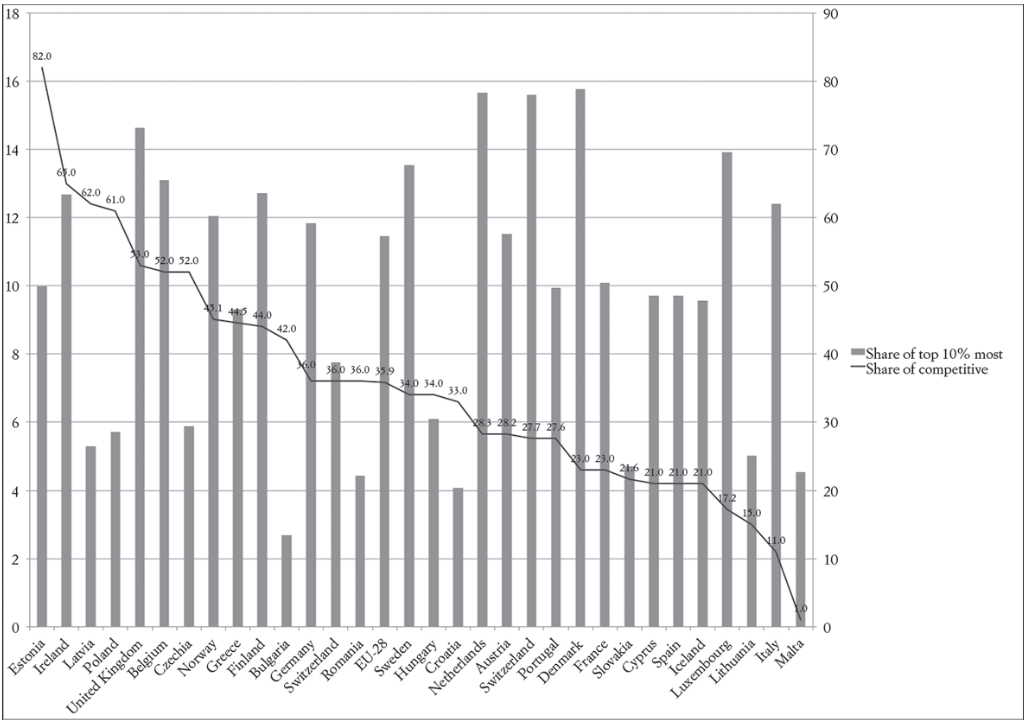
Figure 2. R&D funding in 2017 by government and private sectors (percentage of GDP, left axis), and share of public-sector funding in the gross domestic expenditure on R&D (GERD) (percentage, right axis)



Source: author's calculations based on Eurostat data.

The long-term trend of R&D expenditure growth stagnated during the recent financial crisis, when both government and business investments started to decline (OECD, 2017). Among the EU-13, Poland and Lithuania have managed to increase their investments in R&D, while in Estonia and Latvia (but also, for example, in Finland), a decline after the crisis is evident. The historic levels of investment in those countries have not yet been achieved. Figure 2 shows that the government's role in funding R&D activities is higher in CEE counties (as is the case with France – among the old EU Member States – and Norway), remaining in most cases above 30% of GERD. Still, the capabilities to invest are twice as low as in the EU-28 average, remaining well below 1% of GDP (exceptions are Czechia, Hungary, Poland, and Estonia). Although CEE countries' general dependence on the European Structural and Investment Funds (ESIF) is widely recognised, the learning aspects of this open method of coordination within the EU can only occur if EU Member States' governments possess different kinds of organisational capacity, or some degree of knowledge and expertise (Borrás, 2019). This also determines the dynamism and capabilities of the research sectors funded by ESIF.

Figure 3. Share of the world top 10% most cited publications indexed in the Web of Science database (left axis, 2016), and percentage of project funding (right axis, 2014)



Source: Eurostat.[2]

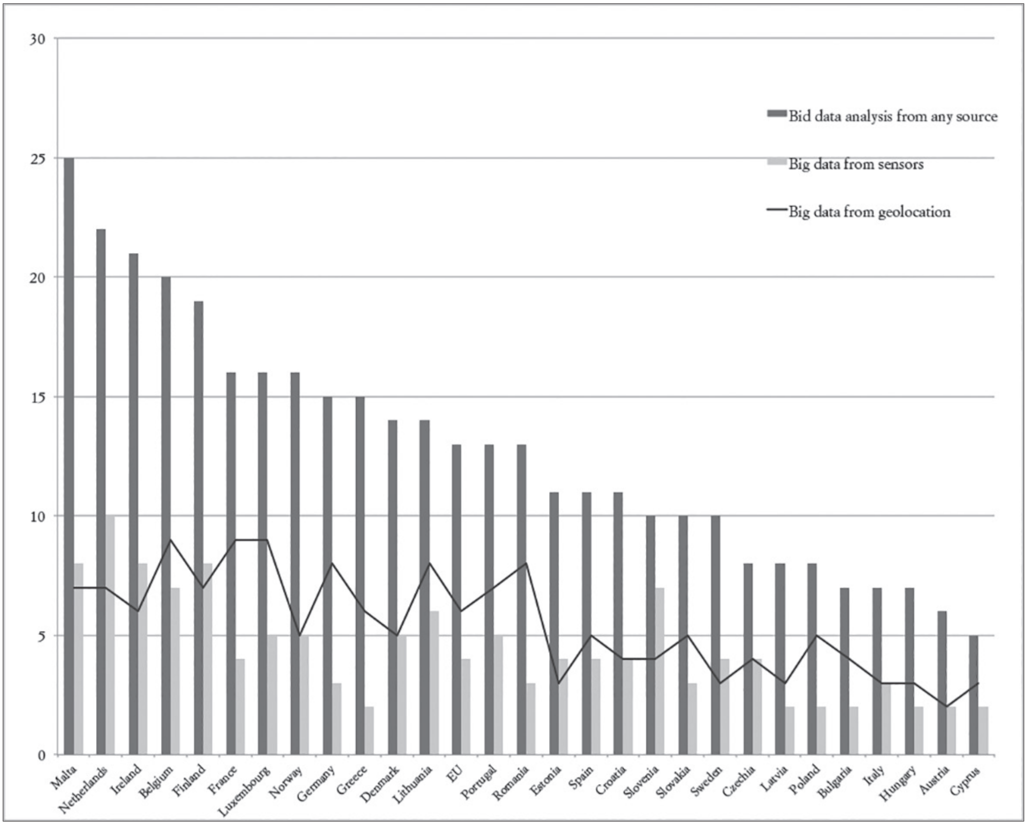
The widespread conception that CEE countries are converging towards a western-style model had already been challenged by Lepori *et al.* (2009), and it can be said that more recently, in a number of countries, the reforms have slowed down (this is related to the broader policy context). On the other hand, some countries have perhaps gone too far in competitive research funding mechanisms (Estonia, but also Latvia and Poland, figure 3). As discussed by Masso and Ukrainski (2009), an overly high degree of competition exerts adverse effects in academic sectors, an effect found also by Aghion *et al.* (2005) in the case of innovation. This illustrates the capabilities of the public sector, notably ministries and intermediary organisations responsible for research funding within NSI. Ukrainski *et al.* (2016) also show that, by concentrating the stimuli very narrowly on some single activities or indicators in the context of generally weakly developed institutions (as is the case with Estonia and Ukraine), it is possible to achieve extremely high values of the indicators without balanced NSI development. Therefore, the crucial aspect is how the interplay

[2] The values for the countries missing in the Eurostat database are added from the PREF Study (https://rio.jrc.ec.europa.eu/en/library/pref-study-%e2%80%93-analysis-national-public-research-funding), and calculated by the author using the data from the Latvian Ministry of Education and Science (https://rio.jrc.ec.europa.eu/en/file/10425/download?token=ssrpjhqs).

of funding and other stimuli, e.g. performance indicators of ESIF-based funding used by governments to steer the activities, would help to overcome more complex challenges in CEE countries in benefitting from new technologies.

According to Kagermann *et al.* (2013), different areas that are key for the digital transformation of the industry are related to the infrastructure (e.g. comprehensive broadband supply), and require substantial investments. However, a study on the firms in Denmark (Kromann and Sorensen, 2015) found that firms invest little in automation because it brings along small productivity gains (1.7% annually). Firms often lack the skills and resources even to analyse the feasibility and the different needs and possibilities for automation. Interestingly, better access to finance limits the adoption of automation, while exposure to international competition from China spurs it.

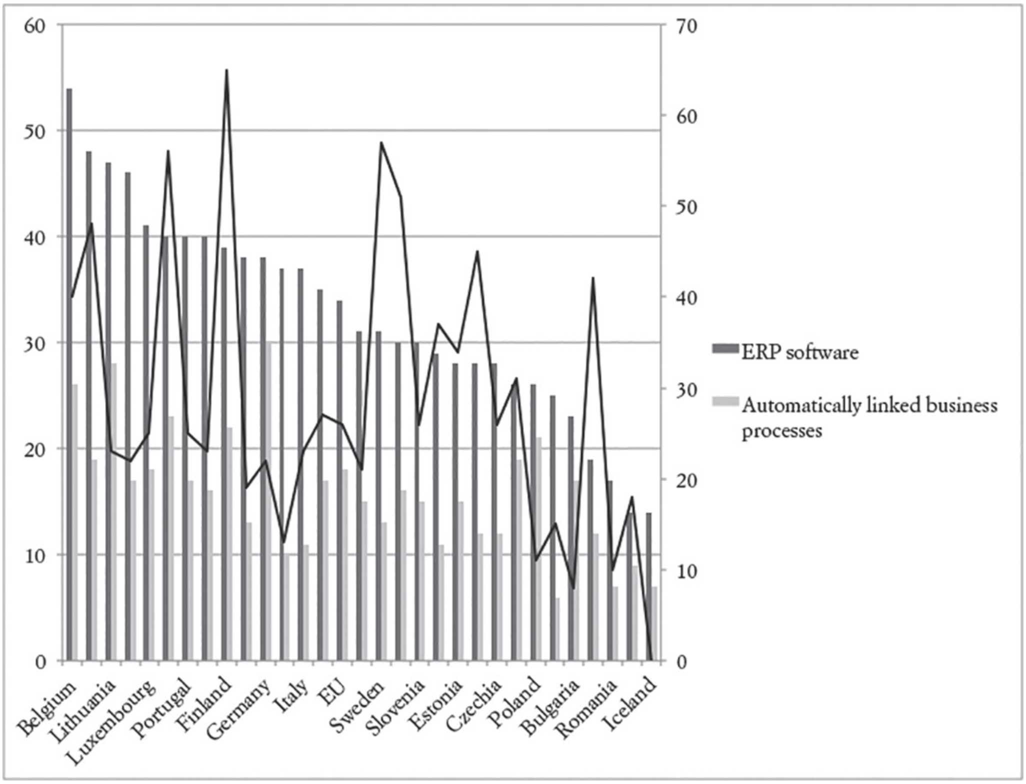
Figure 4. Share of big data analysis obtained from any source, from sensors, and from geolocation data



Source: Eurostat.

The use of digital technology is still quite modest in all EU countries. Figure 4 shows that, in most countries, the share of companies using big data analysis from any source remains below 15%, and cloud-computing services seem to be widely used only in some advanced countries. Conversely, the use of enterprise resource planning (ERP) software is still more prevalent (figure 5). CEE countries, especially Lithuania, Poland, and Croatia, feature levels of adoption of business processes automatically linked to their customers and suppliers quite comparable to the more advanced countries.

Figure 5. Share of companies using ERP software, having automatically linked business processes to their suppliers or customers, and buying cloud computing services over the internet



Source: Eurostat.

Digitalisation requires managers' skills regarding automation and robotics, process optimisation techniques, as well as up-to-date methods of managing supply chains, logistics, data analysis, etc. Merely investing in broadband coverage is insufficient. R&D-related stimuli for firms to upgrade within global value chains are mostly external to CEE firms, as partners drive their upgrading through production and delivery terms and conditions (Karo *et al.*, 2018). It is surprising that older studies (such as Swaan, 1999) that focused on capabilities, tacit knowledge, and systemic change in the Hungarian industry concluded similarly that individual and organisational capabilities depend upon cooperation between international market leaders (foreign direct investment, FDI) and domestic actors, which is rather atypical for post-socialist economies.

The wider changes in the external environment (demand), as well as in the labour markets (competition, quality, price, and immigration policy), add indirect pressures. However, internal stimuli remain weak and not "systemically created". Swaan (1999) argues that the formal education system can enhance organisational and market capabilities, which are mastered in practice by following the examples of others (important tacit knowledge component), and that these examples have been largely absent in post-socialist economies in the early years of transition. The literature seems to point to similar conclusions in more recent years. Work organisation and design, training, and ongoing professional development require more attention to absorption and adoption, as well as to development of human capital in NSI (Veugelers and Schweiger, 2018). It still seems that companies in CEE countries show quite low levels of technology related to Industry 4.0. According to Eurostat data, the use of robots and 3D printing possibilities remain within the EU average (7% and 4%, respectively), hardly an indicator of widespread use. Castelo-Branco *et al.* (2019) have also concluded that the bulk of countries are still performing around average levels.

5. External capabilities

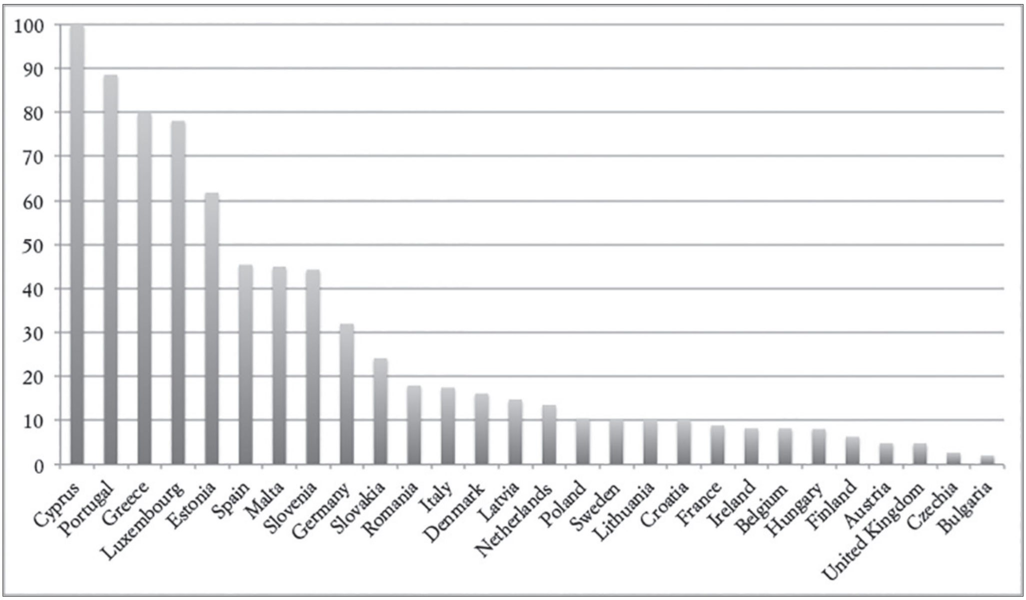
Small countries seek expertise through international networks, which is necessary for scientists in those countries to avoid insulation in increasingly specialised fields of science (Luukkonen *et al.*, 1992). Therefore, small countries often try to integrate into international cooperation networks also more widely, which can compromise the depth of integration. For mostly small CEE countries, the integration (versus isolation) patterns remain relevant in their research policy agenda. The dichotomy of the usual comparison between EU-13 and EU-15 countries can somewhat simplify the reality.

It has been argued that low participation of EU-13 countries in Horizon 2020 (H2020) – this is the main driving programme of external cooperation in the EU) is evident, despite their increasing research capabilities and their increasing co-publication rates with old EU Member States (Makkonen and Mitze, 2015). The main reasons have been found in static network patterns (Tijssen, 2008) and in geographical, cultural, institutional, and technological barriers (Schrengell and Lata, 2011). The most important reasons are evident at organisational-level capabilities (although the underlying reasons can often be systemic): information and language barriers; lack of professional contacts and research networks; lack of leading universities and research organisations acting as leaders in proposals; limited understanding of the framework programmes (FPs); weak training in preparing successful proposals; insufficient motivation to participate in FPs; lack of practice in project management; little experience in cross-country cooperation; generally low focus on R&D in policy and in business; and few options for exploitation of research results at national level (Ukrainski *et al.*, 2018).

FP funding seems to replace the resources from other (mainly national) funding sources in old EU Member States, while it tends to compensate for the less developed infrastructure in CEE countries; a viable option is thus being found for increasing regional innovativeness in these regions in combination with other policies (Varga and Sebestyén 2016). EU-13 countries finance 22-24% of their R&D expenditure from abroad, compared with 11-13% of the EU-15. Within the funding-from-abroad category, H2020 plays a varying role, being larger in Southern and smaller EU Member States, but also in EU-13 countries (figure 6). Even very practical and administration-related barriers show the lower capabilities of governments in CEE countries (Ukrainski *et al.*, 2017 and 2018).

Additionally, ESIF reflect CEE countries' dependence on additional and conditional investments. For example, Serbanica and Constantin (2018) analyse the cohesion policy, and find that Romania and Bulgaria devote about 15% of cohesion policy funds to enterprise and innovation-related objectives, while Slovenia and Estonia spend over 30% for the same purposes. Since those investments enter the domestic funding indicators, the relative dependence on external (EU) funding, but also competition-based project funding and related bureaucratic compliance procedures, are even higher.

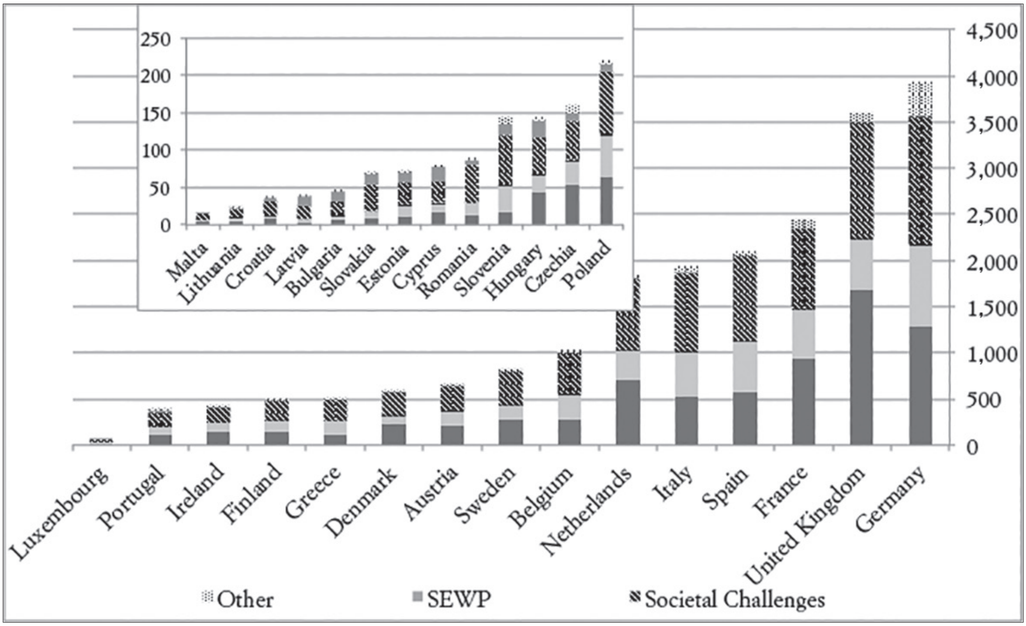
Figure 6. H2020 as a proportion of intramural business R&D expenditure funded abroad



Source: author's calculations based on Eurostat data.

H2020 has been more focused on firms and public-sector participants compared with its predecessor (Seventh Framework Programme, FP7). The different capabilities of the various EU Member States' governments in the participation in H2020 become more evident if one looks at the individual instruments within the programme (figure 7). CEE countries receive less funding in total than most leading countries receive from Industrial Leadership (especially in relation to Industry 4.0 topics) alone.

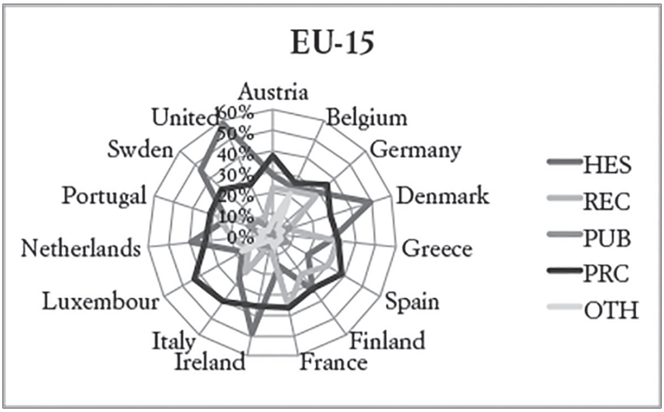
Figure 7. European Commission's contributions by H2020 thematic pillar (in million euro)

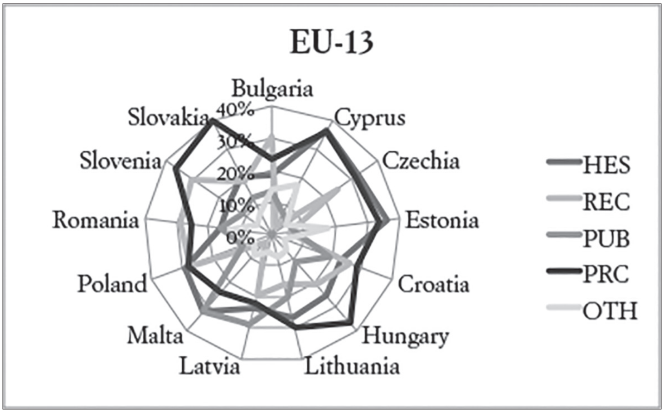


Key: SEWP: Spreading excellence and widening participation.
Note: cut-off date of eCorda data: 28 February 2017.
Source: author's calculations based on eCorda.

Across H2020, 39% of participants have come from the higher education sector, 16% from research institutes, 9% from the public sector, and 31% from private firms, whereas 5% are other participants (figure 8). The relevance of the higher education sector is lower than the average in CEE countries (from 34% in Estonia, to 17% in Romania), while it is higher among the more innovative countries (49% in Denmark, 46% in Sweden, and 58% in the United Kingdom). The context specificity of the respective NIS can explain these differences: for instance, while the Estonian system is dominated by universities and private firms, in Poland public research institutes are relevant actors. However, the public sector and other sectors generally seem to have lower participation ratios (except for Latvia, where among a generally lower participation, the public sector seems more active). Of course, one has to take into account that there are very few actors in smaller countries. The potential to enhance the capabilities in terms of application for H2020 in CEE countries is quite limited, inasmuch as they already have much higher activity levels compared with strong innovators. Simply, there are relatively few researchers in enterprises and in the public and third sectors in those countries.

Figure 8. Average shares of total funding benefitted by different types of actors in H2020 projects





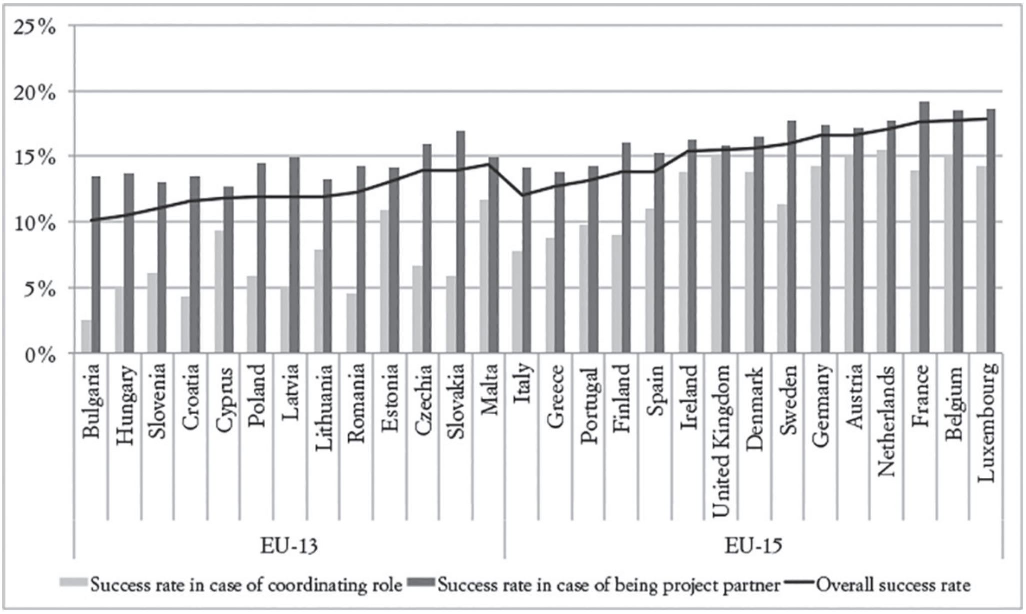
Key: HES: higher education sector; REC: research institutes; PUB: public sector; PRC: private firms; and OTH: other participants.
Source: author's calculations based on eCorda.

One has to explain the surprisingly similar shares of private companies in EU-15 vis-à-vis EU-13 countries. Many of these cases represent funding instruments, where an SME is the sole beneficiary, not involving any larger consortia that would require wider international capabilities and networks. Ukrainski *et al.* (2019) show that, in complex and network-based instruments, EU-13 countries are especially poorly represented, showing governments' low external capabilities, for example in public procurement of innovation, pre-commercial procurement, and joint technology initiatives (which are related to strategic technologies such as those linked to Industry 4.0).

6. Strategic capabilities

External capabilities are linked to the strategic ones if one considers the search for strategic coalition to achieve different innovation policy aims. Figure 9 illustrates that the success rates of CEE participants in H2020 as project coordinators are low, around 5% or less (except for Estonia); in most advanced countries, these rates are three times as high.

Figure 9. Success rates of H2020 applications by the applicant's role (coordinator or participant)

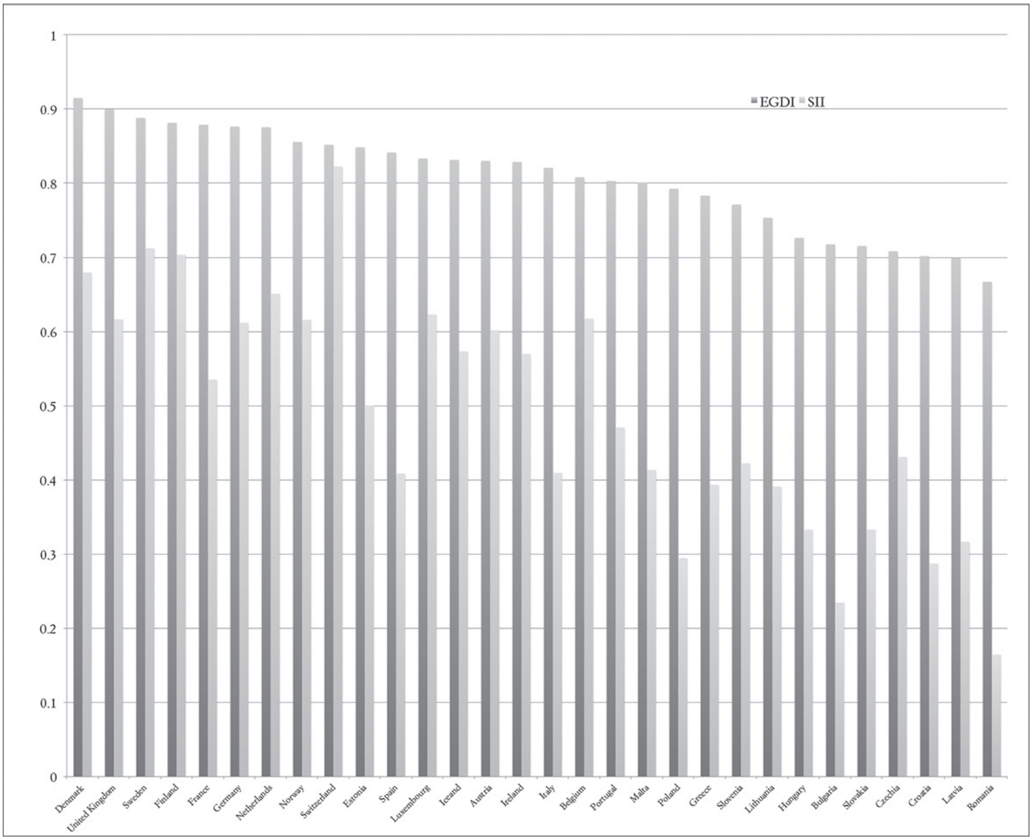


Source: author's calculations based on the ECorda.

Here, the challenges for CEE countries are related to the generally poor coordination capabilities (Farkas, 2019), but also to the (path-dependent) dominance of the public sector in NSI. As the H2020 moved towards greater involvement of different stakeholders (most notably firms, but also public-sector organisations as users of innovation), fragmented NSI hinder also this kind of strategic knowledge-gathering and creation via networks.

As the whole EU performs comparatively well economically, different patterns of innovation activities of individual countries can still be found. Most of CEE countries fall in two lower groups in SII (modest and moderate innovators), except for Estonia, which belongs to the strong innovators' group. In the Global Innovation Index (GII) (2019), all the three Baltic States belong to the strong innovators' group. However, EGDI shows a much lower variability (figure 10).

Figure 10. Summary Innovation Index (SII) of the European Innovation Scoreboard database (2019), and E-Government Development Index (EDGI) (2018)



Source: European Innovation Scoreboard (2019) and United Nations e-Government Survey (2018).

For Industry 4.0, the regulatory framework, standardisation, open standards, and safety and security become strategically relevant (Kagermann *et al.*, 2013). Shifting innovation policy instruments from direct financial aid to demand-side policies would accelerate catching-up processes and address specific bottlenecks in the demand for Industry 4.0 in CEE countries (Muscio *et al.*, 2015). However, governments' capabilities to apply such instruments more extensively seem rather weak. This also concerns the Industry 4.0 demonstration projects, which would illuminate the benefits of this approach. Edler (2009) finds that demand-side instruments would be especially relevant for public services as triggers of catching-up processes. As innovation policy mixes are often not transparent, regular evaluations are needed, but also the balance of vertical and horizontal policies, which can be in turn handicapped by weak institutions (Veugelersa and Schweiger, 2018).

7. Conclusion and discussion

Industry 4.0 is seen as a potential solution to at least some of the challenges facing CEE countries attempting to overcome the middle-income trap. This is also pointing policy-wise to the country-specific (as opposed to the uniform) needs in terms of innovation policy formation in CEE countries (for example, in designing next-period ESIF conditions). It is possible in some NSI aspects to separate the weaker-performing CEE countries from the stronger ones. Based on the comparison of individual indicators across countries, it seems that the stronger countries are clustered together in terms of NSI outputs (such as top-level publications).

This brings to the fore the issues encountered by (not only) CEE countries in terms of interactive and dynamic capabilities of governments addressing the challenges to operate through demand as well as supply-side factors, including better balance and integration of macroeconomic and overwhelmingly micro-based innovation policies (e.g. in ESIF), tailoring these to the country-specific needs. There seems to be a persistent challenge for CEE countries to enhance interactivity and to promote it in "real time", for example in terms of changing context on varying export market conditions, R&D funding environments (such as H2020), and fast-developing technological opportunities (such as Industry 4.0). Regional and national innovation systems seem not to be supported dynamically by appropriate policies (Veugelers and Schweiger, 2018): it is necessary to align innovation policy mixes in real time, supporting the joint advancement of all types of actors, but also coordinating a better response to the micro, meso, and macro-level changes (local, regional, national, and global innovation systems). The need for better capabilities of governments to enhance policy generation capabilities in terms of making connections, through 'policy learning' (internal, external, and strategic), seems critical to catching up with the leading countries.

Interestingly enough, the success indicators of Industry 4.0 adoption are not in line with the NSI characterisations of CEE countries; it has to be concluded that, judging from the measurable indicators, the backlog of CEE countries is much smaller compared with the broader NSI. In some specific software or business process integration with partners, some CEE countries are performing relatively better. However, these indicators mostly describe the input side of Industry 4.0, while the output side is incorporated into the more comprehensive (summary) innovation indices, which are overpowered by the inefficiencies in the NSI. The analysis showed that managing complex systems, and achieving resource efficiency remain the central challenge for CEE countries.

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