JCMS JOURNAL OF COMMON MARKET STUDIES

UACES

JCMS 2022 Volume 60. Number 4. pp. 926–944 DOI: 10.1111/jcms.13291

Regional Technological Capabilities and the Access to H2020 Funds

DANIELE ARCHIBUGI,[1,2] RINALDO EVANGELISTA[3] and ANTONIO VEZZANI[4]
[1]Irpps-Cnr, Rome [2]University of London, Birkbeck College, London [3]School of Law, University of Camerino, Camerino [4]Department of Economics, Roma Tre University, Rome

Abstract

This contribution provides fresh evidence on the factors facilitating the access to H2020 funds by EU regions focusing on the role played by pre-existing technological endowments. The empirical analysis aims at assessing if, and the extent to which, the regional distribution of such resources strictly reflects the technological capabilities of regions (with the risk of a perpetuation or even a deepening of pre-existing technological gaps) or, alternatively, whether a rebalancing allocation mechanism (able to mitigate technological asymmetries) is at work. We show that an overall rebalancing effect of H2020 seems to dominate thanks to the 'collaborative-inclusive logic' of the Research and Innovation Actions (RIA) and the Innovation Actions (IA). The latter have been able to more than compensate the 'elitarian' nature of the other two pillars of H2020, namely the European Research Council (ERC) and the Marie Skłodowska-Curie Actions.

Keywords: regional innovation; patents; EC Framework Programme; Horizon 2020

Introduction: The Distribution of Technological Competences in Europe as a Challenge for EU Policies

Building a cohesive and competitive Europe has represented for several decades one of the most challenging and ambitious goals of our continental policy institutions, and one which is still far from being reached (Monfort, 2020). The EU productive and technological landscape is in fact characterized by the permanence of strong spatial asymmetries and polarizing forces, such as agglomeration economies, operating not only at the country level but also at a subnational scale (Evangelista *et al*., 2016; Iammarino *et al*., 2019). In this framework, new regional players have emerged since the 2004 EU enlargement, which brought new opportunities for firms located in Eastern regions to be integrated within continental and global value chains but also the emergence of new peripheries (Stöllinger, 2016; Gros, 2018).

In the current policy debate regarding the EU cohesion target two key converging points seem to emerge:

1 Regions rather than countries, should become the key spatial and socio-economic domains and targets of cohesion policies (Boschma and Frenken, 2011; European Commission, 2011a; Rodriguez-Pose, 2018);
2 Research and innovation are the key ingredients and leverages of any strategy pursuing a sustainable and inclusive growth in the EU (European Commission, 2011b).

To what extent is the current EU policy framework consistent with, and able to address, the two points listed above?

On the one hand, the main policy scheme for EU cohesion operating at a regional scale – the Structural and Investment Funds – only to a limited extent allocates resources to R&D and innovation (Medve-Bálint, 2018). On the other hand, the role of EU policies explicitly devoted to support science and technology (S&T) need to be assessed to check if they really contribute to the cohesion target. In fact, existing EU S&T policies might have a twofold effect on cohesion. Competitive S&T schemes may end up favouring areas of excellence and leading players and regions since they aim to strength the role of EU innovation system in the global arena. However, the explicit collaborative setting of part of such policies, aiming at the creation of an integrated European Research Area, may complement cohesion policies in reducing regional gaps. It is a typical case in which public policies may lead to (unintended) contrasting results.

Policies that ex-post provide opposite outcomes might still be valuable, provided they are informed by an overall common strategy. This potential duality applies also to the European Commission's Horizon 2020 Programme (H2020), the EU's flagship instrument for science and technology policy. There is very limited empirical evidence on the role played by S&T EU policies in favouring technological convergence or, vice versa, technological polarization. Filling this gap in the literature is a major endeavour that would require tackling the issue from different perspectives, even focusing on one specific policy instrument, as the H2020 considered in this work. Some preliminary insights can be drawn from the analysis of the H2020 funds allocation across EU territories.

The aim of this paper is to explore the rationale behind the regional allocation of H2020 funds, focussing on the role played by the pre-existing technological capabilities of regions, along with other possible factors, in facilitating (or hampering) their participation to the EU S&T programme. Due to the lack of evidence on the impact of the H2020 we are confident that the evidence presented in this work will also allow drawing some indications on the potential role that this policy scheme might play in the future (for example in its updated version, the Horizon Europe 2021–27) with respect to the target of building a cohesive S&T European system.

The empirical analysis is based on two main data sources: REGPAT and CORDIS. REGPAT is a patent database developed by the OECD allowing to identify the location of inventive activities at a regional level. The regional distribution of H2020 funds will be analysed using data provided by the Community Research and Development Information Service (CORDIS) of the EU. It is worth stressing that the use of H2020 data presents two advantages with respect to previous data on the EU Framework Programmes (FPs) implementing the Innovation Union: (i) for the first time it provides a breakdown of the financed budget at the level of project partners (previously the whole budget was associated to the project coordinator limiting the analyses to the counting of projects); (ii) it allows to take into account the different schemes composing the H2020, and in particular the role of the European Research Council (ERC), which represents a novelty in the EU policy framework. In fact, ERC is explicitly focused on the support of frontier research and excellence, abandoning the idea of research consortia and networks that have traditionally characterized the previous FPs. We consider for the first time the ERC, as part of H2020, also for its possible role for the EU regional cohesion.

The paper is structured as follows. First, we discuss the policy context and the relevant literature. Second, we present the characteristics and logic of the different pillars of the H2020 programme. Third, we provide a brief description of the dataset and the methodology used and a descriptive analysis of the level and dynamics of the concentration of technological activities and innovation gaps in the EU at a regional level. Fourth, we assess the extent to which the regional allocation of H2020 funds is related to the technological capability of regions along with other relevant potential factors facilitating the access to such policy scheme. Finally, we conclude with some policy implications.

I. Policy Context and Relevant Literature

Technological capacities in the EU are far from being evenly distributed across industries, firms and even more at a spatial level (Meliciani, 2015). This is due to various factors, the most important being the cumulative nature of innovation and learning processes, and the localized character of spillovers, externalities and systemic interactions in the process of generation and economic exploitation of technology (Evangelista *et al*., 2002). These features produce long-lasting spatial technological asymmetries that can, in absence of corrective mechanisms, produce not-reversible processes of polarization, agglomeration and clustering (Von Lyncker and Thoennessen, 2017; Bruszt and Vukov, 2018). In the case of EU, its productive and technological landscape has strong spatial asymmetries and polarizing forces operating not only at country level but also at a subnational scale.

Systematic and up-dated analyses on the level and dynamics of technological polarization in the EU at regional level are still limited. Paci and Usai (2000), analysing the main regional differences in a restricted number of EU countries in (labour) productivity and technological intensity (patents per employee), have found a higher level of regional concentration for innovative activities than for labour productivity. Moreno *et al*. (2006), looking at the 1994–96 and 1999–2001 periods, have shown that innovations have been spreading to regions in Southern Europe (Spain and the South of Italy especially) and in the Scandinavian countries but also that this process has not been homogenous. Archibugi and Filippetti (2011) have shown that the 2008 financial crisis halted the convergence process in innovation across countries. A more recent study (Evangelista *et al*., 2016) has confirmed that the distribution of technological capabilities in EU regions is much more concentrated than that of gross domestic product (GDP). Similarly, Döpke *et al*. (2017) using a set of regional quality-of-life indicators have shown that the EU regional inequality in ‘well-being’ is lower than the regional inequality in real GDP per capita.

There is also a wealth of exercises which have tried to profile EU regions on a variety of indicators of innovation capabilities (see for example Navarro *et al*., 2009; Verspagen, 2010; Hollanders *et al*., 2020) with the idea of broadening the measurement of innovation beyond technological based indicators and build regional taxonomies as in the case of the EU regional innovation scoreboard (European Commission, 2019). In general, the resulting geographical patterns emerging in these studies are quite similar to those emerging when considering only the patenting activities (Paci and Usai, 2000), which supports our methodological choice to focus on patents as an indicator of the technological capabilities of regions when looking to their capacity to access H2020 funds.

Despite the different methodologies used, the above-mentioned studies provide converging evidence on the permanence of strong technological asymmetries in the EU, and this despite the presence of policies specifically aiming at increasing the cohesion of EU territories. This raises doubts on the effectiveness of such policies and the instruments used to foster the level of cohesion.

Indeed, the evidence on the effectiveness of cohesion policies is by no means conclusive (Lains, 2019) and their positive effects on regional growth may be hampered by an unfavourable industrial structure, the lack of R&D capabilities in the receiving regions (Cappelen *et al*., 2003), and by poor administrative and political governance; factors needed to take advantage of the availability of structural and cohesion funds (Incaltarau *et al*., 2019). The role played by deficiencies in the regional administrative capacity in determining an effective implementation of EU supporting schemes is an emerging theme in the cohesion literature (Ederveen *et al*., 2006; Terracciano and Graziano, 2016). In fact, only territories with a high institutional quality have been capable of triggering positive effects from these policies (Rodríguez-Pose and Garcilazo, 2015). The specific tools and areas of intervention of these policies represent another critical issue. Medve-Bálint (2018), investigating the spending patterns of the Southern and the Eastern members states in two recent programming cycles (2007–13 and 2014–20), reveals that physical infrastructure investments where often prioritized over long-term growth-generating R&D and that the allocation of EU funds do not entirely reflect domestic development needs.

All-in-all, the effectiveness of cohesion policies is limited by the insufficient financial commitment, their poor implementation at the local level, and the prioritization of large-scale infrastructure projects that are politically appealing rather than those with longer-term impact like building applicable R&D infrastructure (Rhodes *et al*., 2019). Crescenzi and Giua (2016) suggest that bottom-up policies might not always be the best approach to boost territorial cohesion, and top-down policies might be more effective especially in the case of regions with a weaker socio-economic environment. The rational is that 'the complexity of the programming of bottom-up interventions might lead to a concentration of the benefits in stronger areas' (Crescenzi and Giua, 2016; p. 13) and that policy coordination increases the returns from cohesion policies.

The Role and Effectiveness of S&T Policies

Since the release of the Lisbon Strategy in 2000, fostering science, technology, innovation, and human capital have been considered key ingredients and leverages of any strategy aiming at achieving a cohesive and competitive European Union (Archibugi and Lundvall, 2002; Lorenz and Lundvall, 2006). Regions rather than countries have steadily increased their relevance as key spatial and socio-economic units as well as policy targets of both cohesion and S&T policies (Boschma and Frenken, 2011; European Commission, 2011a). In the most recent years, regional innovation strategies for smart specialization (such as the RIS3 approach to the European Regional Development Fund) have become a key component of the EU Cohesion Policy supporting the thematic concentration of resources and reinforcing the strategic programming and performance orientation of policy action (European Commission, 2011a). More precisely, the RIS3 initiative encourages regions and cities from different EU Member States to strengthen their technological bases, and to collaborate and learn from each other through joint programmes, projects and networks with concrete impacts on every aspect of economic life.

Despite the great emphasis given to technology, innovation and human capital as the key drivers and sources of economic growth, studies on the actual regional allocation of resources deriving from EU S&T policies are limited. Even more neglected has been so far the issue concerning the role played by EU S&T policies in influencing the dynamics of regional technological gaps in Europe. There are however few recent exceptions. The micro-level study by Fattorini *et al*. (2019) finds that the European development funds supporting direct investments in R&D at regional level are associated with the improvement of firms' productivity, while funding designed to support overall business are not. Muscio and Ciffolilli (2020) use regional data from the 7th European Framework Programme to investigate the factors underlying the capacity of regions to participate to Industry 4.0 related projects. Their results suggest that regional economic competitiveness matters, and that network participation is particularly relevant for less developed regions.

As a matter of fact, most of the literature on the EU Framework Programmes rely on the collaborative design of these funds to explore the effectiveness of EU network policies (Breschi and Cusmano, 2004), their contribution in favouring interdisciplinary research (Bruce *et al*., 2004), the role of collaborative network properties in generating and diffusing knowledge (Breschi *et al*., 2009), or the factors leading to regional R&D collaborations (Amoroso *et al*., 2018). All-in-all, these studies suggest that EU policies may have favoured the integration of the European research around poles of highly connected actors (places), but it may have been less successful in integrating different research areas, such as natural and social sciences. In addition, the beneficial effect of network participation seems to be particularly relevant for less endowed regions.

Following up this last stream of literature, our contribution aims at providing fresh evidence on the factors facilitating the access to H2020 funds by EU regions focussing on the role played by their pre-existing technological endowments. More in particular, our empirical analysis aims at assessing if, and the extent to which, the regional distribution of such resources strictly reflects the technological capabilities of regions (with the risk of perpetuating or even exacerbating pre-existing gaps) or, alternatively, if a rebalancing allocation mechanism able to mitigate technological asymmetries is at work. The empirical exercise proposed in this contribution should take into due account the specific characteristics and logic of different funding schemes of the H2020 programme, and the ways in which the design of such schemes could affect the accessibility to such funds by regions endowed with different S&T capabilities.

II. The Characteristics and Logic of the Different H2020 Funding Schemes

Horizon 2020 is the key tool of the EU Innovation Union flagship initiative under the 2014–2020 multiannual financial framework, which brought together various research and innovation initiatives[1] under the same umbrella to pursue an inclusive approach with the aim of integrating research and innovation across Europe (European

[1]The Framework Programme for Research, the innovation related activities of the Competitiveness and Innovation Framework Programme and the European Institute of Innovation and Technology.

Commission, 2011b). The H2020 is organized around different pillars and objectives, mapping into actions (the actual funding schemes) and the fund allocation is managed directly by the EU; each funding scheme is governed by specific rules that may lead to a differentiated distributional effect on EU organizations and the territories hosting them.

Table 1 summarizes the main features of four key funding schemes of H2020: the European Research Council (ERC), the Marie Skłodowska-Curie Actions (MSCA), the Research and Innovation Actions (RIA) and the Innovation Actions (IA). All together these four actions account for about 80 per cent of the total H2020 budget, almost 30 per cent are channelled through the first two actions and more than 50 per cent through RIA and IA. In the last column we also report the share of each scheme with respect to the whole H2020 budget and to the total number of projects funded. The differences between the two percentage figures highlight the heterogenous average size of projects across the four H2020 schemes. For example, the MSCA accounts for about 32 per cent of the total H2020 funded projects, which correspond to about 10 per cent of the total H2020 budget; this is due to the relatively small average size of the project funded under this specific scheme.

The European Research Council is a relatively recent body within the EU research and innovation panorama. Established in 2007 with the FP7 (the 2007–14 funding period), it was the first scheme allowing the support of research projects by single researchers or teams with the idea of fostering scientific excellence (European Commission, 2007). Indeed, up to the FP7, collaboration among researchers/teams was the main purpose of the European Research and Innovation funds, with the idea of creating an integrated research area in the EU. Under the H2020 the ERC was entitled with a budget of €13 billion – about 18.7 per cent of the overall budget – to foster frontier research within the pillar ‘Excellent Science’; for the first time we explore its relationship with technological capabilities at the regional level.

It is reasonable to expect that the emphasis on excellence of the ERC may render particularly difficult accessing these funds by regions less endowed of knowledge capabilities, while the lack of a collaborative design may also hinder the inclusion and the diffusion of knowledge toward lagging regions. Therefore, the funding scheme is likely to be the least aligned to the goals of EU cohesion policies.

Also, the MSCA operates under the pillar of ‘Excellence Science’ to distribute highly competitive and prestigious research and innovation awards, allowing for career development and further training of researchers at all career stages through mobility to a hosting institution. The probability for a university to host MSCA grantees significantly increases in relation to its research performance and international orientation, despite some top universities have so far hosted fewer grantees than expected (Falk and Hagsten, 2020). Moreover, the MSCA sustains the diffusion of knowledge toward a series of programmes supporting research networks, staff exchange, and the promotion of research results to the public. Similarly, to the ERC, we can expect that the excellence goal of this policy scheme may favour better endowed regions; however, the collaborative setting of some parts of this fund and the declared objective of favouring knowledge diffusion may soften its possible contribution to knowledge polarization.

Finally, the RIA and IA support basic and applied research to foster the development of new knowledge addressing the so-called societal challenges with the former slightly more oriented toward the earliest phases of the research and development process.

Table 1: An Overview of the Main H2020 Actions

Action	*Eligibility Criteria*	*Funding*	*Activities*	*Target*	*% of H2020* *(% in sample)* *[% of projects]*
European Research Council (ERC)	Based on experience & scientific track record, which depend on the type of grant: ● Starting ● Consolidator ● Advanced ● Proof of concept ● Synergy	EU funding rate 100%	Funding researchers looking to set up or consolidate their own independent research team or programme, as well as to already established research leaders. The ERC awards funding for a period of up five or six years.	(frontier) Research	19% *(19%)* [21%]
Marie Skłodowska-Curie Actions (MSCA)	Single researchers (but involving two institutions) or research networks, depending on the action	*EU funding rate 100%*	They encourage mobility, collaboration and sharing of ideas between disciplines and back initiatives that break down barriers between academia, industry and business (a small share is dedicated to public events promoting science).	Mobility Collaboration Networking Dissemination	9% *(10%)* [32%]
Research & innovation actions (RIA)	At least 3 legal entities, independent of each other and established in different countries	*EU funding rate 100%*	Activities aiming to establish new knowledge and/or to explore the feasibility of a new or improved technology, product, process, service or solution.	Research Development	*(38%)* [14%]
Innovation actions (IA)	At least 3 legal entities, independent of each other and established in different countries	*EU funding rate 70% (non-profits funded 100%)*	Activities directly aiming at producing plans and arrangements or designs for new, altered or improved products, processes or services.	Research Development Pre-production	*(18%)* [7%]

Note: We report the actual shares only for ERC and MSCA, because for these funding schemes the correspondence between H2020 budget and structure is straightforward (see https://ec.europa.eu/research/participants/docs/h2020-funding-guide/grants/applying-for-funding/find-a-call/h2020-structure-and-budget_en.htm#SO_widen). We check for consistency comparing budget figures with allocation of funds across EU regions as reported in our sample.

However, for the evaluation of both types of actions patents were conceived as a key performance indicator (European Commission, 2011b), reflecting a possible bias toward technological innovation in the policy design.

While the ERC and MSCA strongly stress the concept of scientific excellence, the RIA and IA actions are competitive funds reflecting the original collaborative logic of the Framework Programmes. From the one hand, we should expect that the competitive logic of these funds is reflected in a higher capability of more endowed regions to access them. From the other hand, the collaborative logic aiming at integrating more peripherical regions to develop an integrated research area may act as a counterweight. Therefore, the role of RIA and IA in contributing or mitigating knowledge polarization is ex-ante more ambiguous.

III. Data and Descriptive Evidence

As already anticipated, the technological capacity of EU regions is analysed using REGPAT, a patent database that allows to identify the location of inventive activities. We focus on the inventor residence to analyse the technological capacity of European regions since this helps identifying the area where technological activities are carried out and knowledge and competences accumulated. The analysis is carried out manly at the NUTS2 (and NUTS1 level in the case of few very small countries).[2]

For the patent activities of EU regions, the descriptive analysis focuses on the 2001–16 period and, as usual when working at the regional level, data are averaged on sub-periods: 2001–04; 2005–08; 2009–12; 2003–16. This choice reduces to the minimum the annual variability of the underlying data (particularly strong for patent data in the smallest units of analysis) and allows to better describe the overall changes occurred during the period considered.

The regional distribution of H2020 funds is analysed using data provided by CORDIS. This is the primary information source for projects funded by the EU FP for research and innovation (FP1 to Horizon 2020). For the first time, the Horizon 2020 data provide information on the budgetary allocation of funds among different partners of a project. We exploit this information to allocate funding across the EU territories and have a more detailed information than the simple counting of projects allowed by data on previous FPs. Data on H2020 funds refer to the 2015–19 period.

Consistently with other works, and for presentation purposes, we present some descriptive statistics aggregating data at the level of macro regional groups: North Europe (Sweden, Norway, Finland and Denmark), Central Europe (Austria, Belgium, Germany, France, Ireland, Luxembourg, Netherlands, UK), South Europe (Greece, Italy, Malta, Portugal, Spain) and East Europe (Bulgaria, Czech Republic, Croatia, Estonia, Hungary, Lithuania, Poland, Romania, Slovakia, Slovenia). Finally, we link past technological capabilities of regions (2010–14) to the H2020 funds received between 2015 and 2019, controlling for country specificities. This will allow us to assess to what extent and how the distribution of (access to) funds across regions is dependent on the technological capabilities of regions, possibly triggering processes of (increasing) accumulation or diffusion of knowledge capabilities.

[2]In particular, these countries are Cyprus, Estonia, Latvia, Lithuania, Luxembourg, and Malta.

Technological Gaps and the Distribution of H2020 Funds across EU Regions

In this section we provide a synthetic overview on the level and dynamics of the spatial concentration of technological activities in the EU area as well as preliminary descriptive evidence on the regional allocation of H2020 funds.

The first part of Table 2 shows the Gini coefficients computed on the number of patent applications and GDP levels across the 281 EU NUTS2 regions in four distinct sub-periods (2001–04; 2005–08; 2009–12; 2013–16). The Gini index for GDP is shown in the table as a benchmark to compare the relevance and dynamics of technological concentration in the EU area compared to the concentration of economic activities. The level and dynamics of the Gini coefficients computed on patent counts shows a strong uneven distribution of technological capacities, which is always higher than that of GDP. Over time, there is a small decrease in the level of technological inequality. The second part of Table 2 reports the concentration of technological activities and GDP in the top 10 regions. In the first period (2001–04), ten regions concentrate a share of overall EU patents nearly double compared to GDP. However, the share of patents of the top 10 regions has decreased consistently (from 35.4 per cent to 29.9 per cent), while the share of GDP has remained substantially stable over the 2001–16 period.

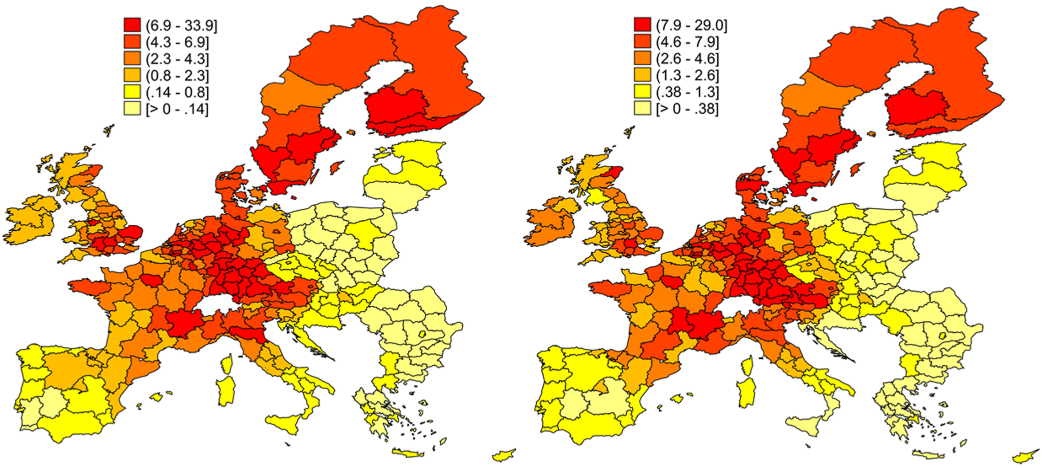
The importance of regional and country specific factors in explaining technological asymmetries in the EU surfaces clearly emerge looking at Figure 1, reporting the level of patent intensity (number of patents per capita) of EU NUTS2 regions respectively in 2001–04 and 2013–16. The figure shows strong macro-regional differences in the patent intensity and a certain degree of technological heterogeneity within most EU countries. The highest levels of patents per capita are found in the North and Central Europe but this area also extends to the North of Italy, while a more uneven regional pattern is found in France. The least innovative regions are located in Eastern and Southern Europe. A comparison of the two maps shows a high degree of stability of the EU technological landscape with the persistence of very large gaps between the lowest and highest performing macro-regional areas of EU. In synthesis, despite a timid process of a catching up process in many traditionally backward regions lead by the growth East European regions and Portugal, not much has changed between 2001 and 2016 in the EU spatial

Table 2: Technological and GDP Concentration in the EU

	2001–2004	*2005–2008*	*2009–2012*	*2013–2016*
Gini coefficients				
GDP	0.51	0.49	0.49	0.49
Patents	0.72	0.70	0.69	0.68
Share of top 10 EU regions				
GDP	18.9%	18.9%	19.3%	19.1%
Patents	35.4%	32.6%	31.0%	29.9%

Note: For some countries (CY, EE, LT, LU, LV, MT) NUTS2 level data are not available, for these countries NUTS1 figures are used. *Source*: Authors' computations on REGPAT (version 2019a) and Eurostat data.

Figure 1: Patents per 10,000 habitants: 2001–04 (left) and 2013–16 (right). [Colour figure can be viewed at wileyonlinelibrary.com]



Source: Authors' computations on Regpat 2019a data.

Table 3: Shares of H2020 Budget and Patents by Country Group

Group	*H2020*	*ERC*	*MCSA*	*RIA*	*IA*	*Patents*
North EU	9.1%	8.7%	9.9%	8.2%	8.9%	9.8%
Central EU	60.6%	74.1%	60.5%	60.5%	54.9%	76.2%
South EU	23.3%	13.8%	21.7%	25.1%	29.7%	10.8%
East EU	7.0%	3.4%	7.7%	6.0%	6.5%	3.1%
Total	100%	100%	100%	100%	100%	100.0%

Note: H2020 funds refer to budget allocated between 2015 and 2019, for comparison purposes we also report the share of patents during the 2013–2016 period. *Source: Authors' computations on Regpat 2019a and H2020 data*.

technological landscape, with Figure 1 reflecting the well-known structural dualism within the broad EU area.[3]

The permanence of significant technological gaps across EU regions rises important policy issues regarding the allocation logic of resources supporting S&T activities, in particular with reference to the H2020 funds: (a) To what extent the technological asymmetries described in this section could affect the regional distribution of H2020 funds? (b) To what extent could a policy instrument such as H2020 modify the regional distribution of regional technological capabilities, enlarging or contributing to closing the technological gaps in the EU? While it is too early to empirically assess the impact of H2020 on the technological asymmetries across EU regions, in the following section we will shed some

[3]In the 2013–16 period the average patent per capita (weighted by population) in Central EU regions is (still) about 11 times higher than in Eastern EU ones. A less static picture emerges when looking at the rates of change, with most East European (and Portugal) regions showing a good dynamism as a result of a rapid integration of these regions into the EU intellectual property rights system and in the Mittel European (Germany centred) production system.

light on point (a) through an econometric analysis. Here we start addressing this issue on a pure descriptive ground confronting (in Table 3) the budget allocation of H2020 funds across the main EU country groups during the period 2015–19 and the shares of patents accounted for by the same country groups during the 2013–16 period.

Table 3 shows that the distribution of H2020 budget across country groups does not match closely that of patents. Southern and Eastern EU countries receive a share of H2020 budget that is about twice than that of patents. In other words, these areas have access to a higher share of funds with respect what one would expect in the case the allocation of funds had followed a pure competitive (or excellence) logic based on regional knowledge capabilities.

In fact, among the four specific actions, the ERC is the only one that tends to replicate the technological asymmetries of European areas discussed above. In the regression analysis we will explore these relationships exploiting regional-level information.

IV. Regional Technological Capabilities and Access to H2020 Funds. An Econometric Analysis

In this section we move to the key empirical target of the paper assessing if, and the extent to which, the regional distribution of H2020 funds reflects the level of the technological capabilities of regions while controlling for other potential factors influencing the access to such policy scheme. We carry out this analysis using a multivariate regression framework with the following specification:

$$\log\left(h2020_{i,\,2015-2019} + 1\right) = a + \beta \log\left(patents_{i,\,2010-2014} + 1\right) + controls + \mu_c + u_i \tag{1}$$

where i indicates a generic EU NUTS2 region. In other words, we estimate the logarithmic relationship between H2020 funds received by a region and its technological capabilities observed before the starting of the H2020 funding allocation. Once assessed the relationship for the overall H2020, we explore possible specificities across the different funding schemes composing it.

We use a log–log specification to directly estimate the elasticity — the relationship between percentage changes — of H2020 with respect to patents. Where the estimated β is equal to 1, then a 1 per cent increase in the technological capabilities of a region is reflected in the same increase of H2020 funds. With $\beta > 1$ the H2020 would increase more than patents, (over)prizing regions endowed with higher technological capabilities, $\beta < 1$ would instead signal that the allocation of H2020 funds increases less than proportionally with respect to the technological capability of regions implying that a sort of equalizing effect is at work.

We enrich the basic specification with a series of controls to account for possibly confounding factors and correctly identify the relationship at stake. Country specificities are likely to play an important role facilitating or hampering the access by regions to H2020 funds. We therefore include a list of dummy variables to control for country specific fixed effects (μ_c). Moreover, we cluster the standard errors at the country level to account for the fact that regions from the same country cannot be considered as independent observations (errors are likely to be correlated). In this way we control for possible differences in the strength and quality of the national innovation systems in which regions are embedded, and that can have a role in determining the capacity of regions to access H2020 funds beside their pure technological capabilities. Once controlling for the fact that observations are clustered within countries, we are quite confident that the country fixed effects will reflect – at least to some extent – the integration-collaborative logic guiding most of the EU funding schemes.

We control for the agglomeration economies affecting innovation and the localized knowledge spillovers including the logarithm of a region population density. We also include a dummy variable for capital regions to capture the fact that in many countries capital regions outperform other areas from a scientific and innovative viewpoint (Paunov *et al*., 2019) and have been among the areas driving regional competitiveness in the EU (European Commission, 2017). The strong presence in these regions of public services and most national higher-level knowledge-based functions (Mayer *et al*., 2017) could again represent an important comparative advantage in the participation to EU S&T competitive policy schemes and more specifically to the access to H2020 funds. Finally, we include the logarithm of the regional GDP per capita to capture those factors contributing to the strength of the regional system beyond strict technological capabilities, such as the strength of the scientific infrastructure as well as the organizational capabilities or soft types of innovation, making them more resilient (Filippetti *et al*., 2020).[4]

For each region patents, population density and GDP per capita are averaged over the five years (2010–14) preceding the begin of allocation of the H2020 funds (2015–19). We first run our set of regressions on the overall H2020 funds accessed by EU regions, and then test the full specification on different H2020 policy schemes (ERC, MSCA, RIA and IA) to explore possible specificities of the relationship between technological capabilities and access to funds.

Regression Results

In Table 4 we report the results of our least square estimations. In the first column we report the estimation of equation 1, excluding the control variables (population density, capital region and GDP per capita). The coefficient attached to *patents* turns out to be positive but not statistically different from 1 (see also the results of the test reported in the middle of the table), a result consistent with the idea that the EU distributes competitive research and innovation funds proportional to the knowledge capabilities of regions.

This result holds true also when adding the control variables. The coefficient attached to population density is positive and statistically significant, suggesting that agglomeration economies and localized spillovers have positive effects on the capability of regions to access H2020 funds (with a 1 per cent increase in population density leading to an increase of funds of 0.22 per cent). The coefficient attached to capital regions is also positive and significant, suggesting that the presence of a critical mass of S&T and public infrastructures in regions hosting large capital urban areas may be an asset to access H2020 funds. Interestingly, the coefficient attached to GDP per capita is not statistically

[4]We have also considered the European Quality of Government Index developed by the University of Gothenburg to control for the role of regional institutional quality in accessing H2020 funds. However, the variable was never significant and the regression statistics in general worse than those we get when not including it in the analysis. This result suggests that differences in institutional quality does not seem to matter when considering H2020 (and controlling for other factors).

Table 4: H2020 Funds at Regional Level, OLS Estimations. *Dependent Variable: Log of Funds in the 2015–19 Period (versus 2010–14 Variables)*

	H2020	*H2020*	*ERC*	*MSCA*	*RIA*	*IA*
Patents (log)	1.077***	0.888***	3.305***	1.605***	1.057***	0.919***
	(0.0597)	*(0.0683)*	*(0.296)*	*(0.276)*	*(0.193)*	*(0.135)*
Population density (log)		0.218**	1.003**	0.0283	0.193*	0.0923
		(0.0936)	*(0.403)*	*(0.319)*	*(0.110)*	*(0.134)*
Capital region		0.674***	2.355	1.543*	0.672**	0.668**
		(0.183)	*(1.622)*	*(0.758)*	*(0.324)*	*(0.312)*
GDP per capita (log)		0.143	−2.257	−0.950	0.417	0.512
		(0.318)	*(1.696)*	*(1.061)*	*(0.449)*	*(0.394)*
Country fixed effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Constant	12.99***	10.89***	−6.096	7.896**	8.005***	8.341***
	(0.347)	*(0.857)*	*(5.029)*	*(3.277)*	*(1.754)*	*(1.497)*
Test beta patents = 1	0.271	0.112	0.000***	0.038**	0.770	0.553
Observations	259	259	259	259	259	259
Adj. *R*-squared	0.715	0.741	0.508	0.330	0.564	0.516
RMSE	0.933	0.877	5.423	3.269	1.759	1.661

Note: Standard errors clustered at country level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The *t*-tests reject the hypothesis of unitary elasticity of funds versus patents only for the regressions on ERC and MSCA. Moran tests on the error terms of the regressions do not provide evidence of spatial dependence. For example, in the H2020 regression the Moran test using a contiguity spatial weighting matrix provides a *p*-value of 0.617, while a joint test using a contiguity and a distance matrix provides a *p*-value of 0.098.

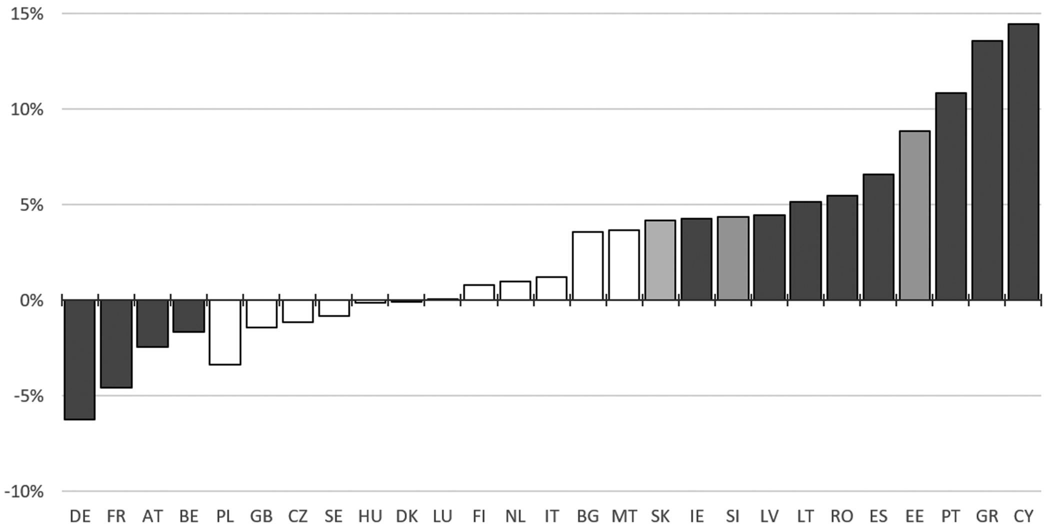
significative, suggesting that population density and capital regions have more 'explanatory power' than the overall quality of the regional system proxied by the GDP per capita.

How to reconcile the unitary elasticity of H2020 funds to patents with the fact that the former seems to be less concentrated than the latter, favouring regions from Eastern and Southern countries (see Table 3)? The response to this question can be provided looking at the country fixed effects reported in Figure 2. The Figure seems to confirm the presence of a rebalancing rational of H2020 with respect to the existing macro-regional technological asymmetries shown in previous sections. In fact, Figure 2 shows that once controlling for technological and other capabilities, regions from Germany, France, Austria and Belgium receive, on average, less funds than others (up to 5 per cent relative to the sample average), while regions located in countries listed on the right part of the figure receive 'a premium' of up to about 15 per cent.

All-in-all these results suggest that, while respecting a competitive (technologically based) logic, the H2020 funds have been able to not let behind regions located in least technological advanced countries. The objective to create an integrate research area through a collaborative design of the funding scheme may have helped balancing the distribution of funds, prevailing on the possible polarizing effect deriving from agglomeration economies and the existing technological asymmetries.

We have nonetheless argued that the different H2020 actions, given their different rational and design, could differ in terms of their potential 'polarizing' or 'balancing' effects on the EU technological landscape. The results of the estimates on the ERC, MSCA, RIA and IA actions confirm this hypothesis. For the two schemes operating under the scientific excellence pillar the coefficient attached to patents is statistically greater than 1. For the ERC, the coefficient is particularly large, suggesting that an increase of the regional

Figure 2: Patents per 10,000 habitants: 2001–04 (left) and 2013–16 (right).



Source: Authors' computations on Regpat 2019a data.

technological capabilities is matched by a threefold increase of funds' availability. It is also worth noticing that the coefficient attached to population density is large and significant for the regression on ERC while small or not significant for the other funds, suggesting that the focus on excellence may particularly favour densely populated urban areas. For the RIA and IA, the results are in line with the main regressions; the coefficients attached to *patents* are not statistically different from 1.[5]

The inspection of the H2020–patent relationship across different funding schemes provides therefore evidence of a possible heterogeneous role of the different EU research and innovation schemes with respect to the regional convergence/polarization issue. Indeed, policy schemes aiming at prizing excellence (as in the case of the ERC action) seem to exacerbate the differences in the knowledge capabilities of regions, possibly contributing to the process of polarization between European regions.

Conclusions and Policy Implications

The paper has confirmed that regional unbalances in technological capabilities in the EU are severe and that such asymmetries have decreased only to a limited extent over the period covered by this study (2001–16). This raises legitimate doubts on the effectiveness of the EU cohesion policies and on the space that in such polices have instruments supporting the scientific and technological basis of backward regions.

[5]An inspection of the country fixed effects, not reported for reasons of space, reveals that RIA and IA match closely those reported in Figure 2 (correlation: 0.77 and 0.92) Differently, the country fixed effects for ERC and MSCA show less clear patterns (correlation: 0.49 and 0.66). Finally, we should also point out that the number of regions accessing ERC funds in our sample is much lower than that accessing the other funds considered, further reinforcing the idea of a concentration of funds in the most technologically endowed regions. We have also run a specification including patents at country level instead of country fixed effects to check whether more innovative countries receive (on average) fewer funds. The results shows that this holds true in all the regressions, reinforcing idea of a redistributive mechanism is at work in H2020.

The bulk of EU S&T policies do not operate at a regional scale nor are designed to address the cohesion issue. Nonetheless they might have an impact on the level of scientific and technological cohesion of EU. While it is too early to assess the impact of the H2020, we have tried to shed light on this topic by highlighting the different logic of the main H2020 pillars and by empirically investigating the relationship between the access to these funds and the technological capabilities of EU regions. In particular, we have assessed whether the regional distribution of H2020 funds reflects (with a sort of proportional law) the technological capabilities of regions — with the associated risk of perpetuating or even exacerbating pre-existing technological gaps — or, alternatively, if some kind of rebalancing mechanism to mitigate technological asymmetries is at work.

Regarding the allocative ex-ante rationale of H2020 we have discussed the differences among different pillars, pursuing different objectives, and the specific rules that may lead to a differentiated distributional effect on EU organizations and territories. While the ERC and MSCA strongly stress the concept of scientific excellence, the RIA and IA actions are competitive funds reflecting the original collaborative logic of the Framework Programmes and requiring an inclusive participation.

The econometric exercise confirms that the access to H2020 is first and foremost proportional to the level of technological development of a region, which is consistent with the competitive logic of EU S&T policies. Moreover, agglomeration effects and public infrastructures facilitate the access to H2020 funds. However, our empirical exercise also reveals the presence of a rebalancing mechanism in the regional allocation of H2020: regions located in less developed countries tend to get a share of H2020 funds that is higher to that implied by their technological capabilities. This rebalancing mechanism has much to do with the 'collaborative-inclusive logic' characterizing the policy design of RIA e IA that seem to prevail on the more 'elitarian' nature of the ERC and MSCA pillars where access to funds increases more than proportionally with technological capabilities.

It is also likely that such rebalancing mechanism will continue to operate in the next future through the new Horizon Europe programme (covering the period 2021–27). However, the actual contribution of such policy scheme to the EU cohesion target is likely to be rather limited, and not able to offset the stickiness of the technological gaps across EU regions. This pessimistic view stems from the high level of technological asymmetries documented and to the internal contradictory logic of the H2020 that continues to pursue two apparently contrasting objectives: on the one hand, fostering the EU technological capabilities and areas of excellence to compete with established countries such as the United States and Japan, and with emerging ones such as China; on the other hand, guaranteeing the integration of the EU research systems, possibly reducing technological disparities across EU and thus favouring cohesion. The two objectives are somehow in conflict since the first may require a further agglomeration of competences in the already strongest areas of EU (to compete with Silicon Valley, Toyota and Samsung towns or Shenzhen) while the second aims to nurture capabilities also in less developed regions.

It is true that H2020 is one of the world largest public schemes supporting the development of new knowledge. But the yearly funds available through H2020 are not comparable to what one of the top corporations spends in a year: while the yearly budget of H2020 was about 11 billion euros, in 2019 large corporations such as Alphabet (23 billion euros), Microsoft (17.5), Huawei (16.7), Samsung (15.5), Apple (14.4) or Volkswagen

(14.3) alone spent larger amounts in R&D (Grassano *et al*., 2020; Archibugi and Mariella, 2021).

Having said that, our analysis suggests that policy schemes such as H2020 (or the new Horizon EU) have at least the potential to contain a further increase in gaps across EU territories. On the ground of this evidence, we welcome the fact that the next Recovery Fund, has not been funded by downsizing the next Framework Programme 2021–27, Horizon Europe. Still, we wonder if the resources available will be sufficient to satisfy the two main goals of fostering EU excellence in innovation and to help cohesion in science and technology. The fact that, in the past, the instrument has shown a certain efficacy in both respects may be a good reason to further increase its budget in the future. In time of resource scarcity, it could be eventually envisaged a reallocation of part of the cohesion funds to those S&T schemes characterized by a 'collaborative-inclusive logic' rather than trying to increase the share of cohesion funds dedicated to innovation; this would level-off the institutional disparities that are at the root of the different performances across regions.

Acknowledgments

We wish to thank a grant of the School of Business, Economics and Informatics of Birkbeck, University of London, and the financial support of PRIN (Projects of National Interests promoted by the Italian Ministry for University and Research) Innovation and Global Challenges Prot. 20177J2LS9. Many thanks also to Marion Frenz, Mara Giua and Fabrizio Tuzi for early comments on this research.

Correspondence:
Antonio Vezzani
Roma Tre University
Italy
email: antonio.vezzani@uniroma3.it

References

Amoroso, S., Coad, A. and Grassano, N. (2018) 'European R&D Networks: A Snapshot from the 7th EU Framework Programme'. *Economics of Innovation and New Technology*, Vol. 27, No. 5–6, pp. 404–19. https://doi.org/10.1080/10438599.2017.1374037

Archibugi, D. and Filippetti, A. (2011) 'Is the Economic Crisis impairing Convergence in Innovation Performance across Europe?' *JCMS: Journal of Common Market Studies*, Vol. 49, No. 6, pp. 1153–82. https://doi.org/10.1111/j.1468-5965.2011.02191.x

Archibugi, D. and Lundvall, B.Å. (eds) (2002) *The Globalizing Learning Economy* (Oxford: Oxford University Press).

Archibugi, D. and Mariella, V. (2021) 'Is a European Recovery Possible without High-tech Public Corporations?' *Intereconomics*, Vol. 56, No. 3, pp. 160–6. https://doi.org/10.1007/s10272-021-0973-x

Boschma, R.A. and Frenken, K. (2011) 'Technological Relatedness and Regional Branching'. In Bathlet, H., Feldman, M. P. and Kogler, D. F. (eds) *Dynamic Geographies of Knowledge Creation and Innovation* (London: Taylor & Francis/Routledge), pp. 64–81.

Breschi, S., Cassi, L., Malerba, F. and Vonortas, N.S. (2009) 'Networked Research: European Policy Intervention in ICTs'. *Technology Analysis & Strategic Management*, Vol. 21, No. 7, pp. 833–57. https://doi.org/10.1080/09537320903182314

Breschi, S. and Cusmano, L. (2004) 'Unveiling the Texture of a European Research Area: Emergence of Oligarchic Networks Under EU Framework Programmes'. *International Journal* *of Technology Management*, Vol. 27, No. 8, pp. 747–72. https://doi.org/10.1504/IJTM.2004.004992

Bruce, A., Lyall, C., Tait, J. and Williams, R. (2004) 'Interdisciplinary Integration in Europe: The Case of the Fifth Framework Programme'. *Futures*, Vol. 36, No. 4, pp. 457–70. https://doi.org/10.1016/j.futures.2003.10.003

Bruszt, L. and Vukov, V. (2018) 'Governing Market Integration and Development – Lessons from Europe's Eastern and Southern Peripheries: Introduction to the Special Issue'. *Studies in Comparative International Development*, Vol. 53, pp. 153–68. https://doi.org/10.1007/s12116-018-9264-3

Cappelen, A., Castellacci, F., Fagerberg, J. and Verspagen, B. (2003) 'The Impact of EU Regional Support on Growth and Convergence in the European Union'. *Journal of Common Market Studies*, Vol. 41, No. 4, pp. 621–44. https://doi.org/10.1111/1468-5965.00438

Crescenzi, R. and Giua, M. (2016) 'The EU Cohesion Policy in Context: Does a Bottom-Up Approach Work in All Regions?' *Environment and Planning A: Economy and Space*, Vol. 48, No. 11, pp. 2340–57. https://doi.org/10.1177/0308518X16658291

Döpke, J., Knabe, A., Lang, C. and Maschke, P. (2017) 'Multidimensional Well-being and Regional Disparities in Europe'. *Journal of Common Market Studies*, Vol. 55, No. 5, pp. 1026–44.

Ederveen, S., de Groot, H. and Nahuis, R. (2006) 'Fertile Soil for Structural Funds? A Panel Data Analysis of the Conditional Effectiveness of European Cohesion Policy'. *Kyklos*, Vol. 59, pp. 17–42. https://doi.org/10.1111/j.1467-6435.2006.00318.x

European Commission (2007) *FP7 in Brief. How to Get Involved in the EU 7th Framework Programme for Research* (Luxembourg: Office for Official Publications of the European Communities).

European Commission (2011a) *Cohesion Policy 2014–2020: Investing in Growth and Jobs* (Luxembourg: DG-Regional Policy, Publications Office of the European Union).

European Commission (2011b) Proposal for a Council Decision establishing the Specific Programme Implementing Horizon 2020 – The Framework Programme for Research and Innovation (2014–2020). COM(2011) 811 final.

European Commission (2017) *My Region, My Europe, Our Future. Seventh Report on Economic, Social and Territorial Cohesion* (Luxembourg: Publications Office of the European Union).

European Commission (2019) *Regional Innovation Scoreboard* (Luxembourg: Publications Office of the European Union).

Evangelista, R., Iammarino, S., Mastrostefano, V. and Silvani, A. (2002) 'Looking for Regional Systems of Innovation: Evidence from the Italian Innovation Survey'. *Regional Studies*, Vol. 36, No. 2, pp. 173–86. https://doi.org/10.1080/00343400220121963

Evangelista, R., Meliciani, V. and Vezzani, A. (2016) 'The Distribution of Technological Activities in Europe: A Regional Perspective'. Joint Research Centre (Seville site) (Luxembourg: Publications Office of the European Union).

Falk, M.T. and Hagsten, E. (2020) 'Potential of European Universities as Marie Curie Grantee Hosts'. *Higher Education*, Vol. 81, pp. 1–18. https://doi.org/10.1007/s10734-020-00540-3

Fattorini, L., Ghodsi, M. and Rungi, A. (2019) 'Cohesion Policy Meets Heterogeneous Firms'. *Journal of Common Market Studies*, Vol. 58, No. 4, pp. 803–17.

Filippetti, A., Gkotsis, P., Vezzani, A. and Zinilli, A. (2020) 'Are Innovative Regions more Resilient? Evidence from Europe in 2008–2016'. *Economia Politica*, Vol. 37, No. 3, pp. 807–32. https://doi.org/10.1007/s40888-020-00195-4

Grassano, N., Hernandez Guevara, H., Tuebke, A., Amoroso, S., Dosso, M., Georgakaki, A. and Pasimeni, F. (2020) *The 2020 EU Industrial R&D Investment Scoreboard* (Luxembourg: Publications Office of the European Union).

Gros, D. (2018). 'Convergence in the European Union: Inside and Outside the Euro'. Presentation at the Informal meeting of Economic and Financial Affairs Ministers, Sofia, 27–8 April 2018 (Brussels: CEPS).

Hollanders, H., Es-Sadki, N., Merkelbach, I. and Khalilova, A. (2020) *European Innovation Scoreboard 2020* (Luxembourg: Publications Office of the European Union).

Iammarino, S., Rodríguez-Pose, A. and Storper, M. (2019) 'Regional Inequality in Europe: Evidence, Theory and Policy Implications'. *Journal of Economic Geography*, Vol. 19, No. 2, pp. 273–98. https://doi.org/10.1093/jeg/lby021

Incaltarau, C., Pascariu, G.C. and Surubaru, N.C. (2019) 'Evaluating the Determinants of EU Funds Absorption across Old and New Member States – the Role of Administrative Capacity and Political Governance'. *Journal of Common Market Studies*, Vol. 58, No. 4, pp. 941–61.

Lains, P. (2019) 'Convergence, Divergence, and Policy: Portugal in the European Union'. *West European Politics*, Vol. 42, No. 5, pp. 1094–14. https://doi.org/10.1080/01402382.2018.1522833

Lorenz, E. and Lundvall, B.-Å. (2006) *How Europe's Economies Learn. Coordinating Competing Models* (Oxford: Oxford University Press).

Mayer, H., Sager, F., Kaufmann, D. and Warland, M. (2017) *The Political Economy of Capital Cities* (London: Routledge).

Medve-Bálint, G. (2018) 'The Cohesion Policy on the EU's Eastern and Southern Periphery: Misallocated Funds?' *Studies in Comparative International Development*, Vol. 53, No. 2, pp. 218–38.

Meliciani, V. (2015) *Regional Disparities in the Enlarged European Union: Geography, Innovation and Structural Change* (London: Routledge).

Monfort, P. (2020) 'Convergence of EU Regions Redux. Recent Trends in Regional Disparities'. EU Directorate-General for Regional and Urban Policy WP 02/2020 (Luxembourg: Publications Office of the European Union).

Moreno, R., Paci, R. and Usai, S. (2006) 'Innovation Clusters in the European Regions'. *European Planning Studies*, Vol. 14, No. 9, pp. 1235–63. https://doi.org/10.1080/09654310600933330

Muscio, A. and Ciffolilli, A. (2020) 'What Drives the Capacity to Integrate Industry 4.0 Technologies? Evidence from European R&D Projects'. *Economics of Innovation and New Technology*, Vol. 29, No. 2, pp. 169–83.

Navarro, M., Gibaja, J.J., Bilbao-Osorio, B. and Aguado, R. (2009) 'Patterns of Innovation in EU-25 Regions: A Typology and Policy Recommendations'. *Environment and Planning. C, Government & Policy*, Vol. 27, No. 5, pp. 815–40. https://doi.org/10.1068/c0884r

Paci, R. and Usai, S. (2000) 'Technological Enclaves and Industrial Districts. An Analysis of the Regional Distribution of Innovative Activity in Europe'. *Regional Studies*, Vol. 34, pp. 97–114. https://doi.org/10.1080/00343400050006032

Paunov, C., Guellec, D., El-Mallakh, N., Planes-Satorra, S. and Nüse, L. (2019) 'On the Concentration of Innovation in Top Cities in the Digital Age'. OECD Science, Technology and Industry Policy Paper No. 85. https://doi.org/10.1787/f184732a-en

Rhodes, M.J., Epstein, R. and Börzel, T.A. (2019) 'Introduction: Peripheries in Competition? Political and Economic Development in the EU'. *West European Politics*, Vol. 42, No. 5, pp. 927–40. https://doi.org/10.1080/01402382.2019.1609195

Rodriguez-Pose, A. (2018) 'The Revenge of the Places that Don't Matter (and What to do about it)'. *Cambridge Journal of Regions, Economy and Society*, Vol. 11, No. 1, pp. 189–209.

Rodríguez-Pose, A. and Garcilazo, E. (2015) 'Quality of government and the returns of investment: Examining the impact of cohesion expenditure in European regions'. *Regional Studies*, Vol. 49, No. 8, pp. 1274–90. https://doi.org/10.1080/00343404.2015.1007933

Stöllinger, R. (2016) 'Structural Change and Global Value Chains in the EU'. *Empirica*, Vol. 43, No. 4, pp. 801–29. https://doi.org/10.1007/s10663-016-9349-z

Terracciano, B. and Graziano, P.R. (2016) 'EU Cohesion Policy Implementation and Administrative Capacities: Insights from Italian Regions'. *Regional & Federal Studies*, Vol. 26, No. 3, pp. 293–320. https://doi.org/10.1080/13597566.2016.1200033

Verspagen, B. (2010) 'The Spatial Hierarchy of Technological Change and Economic Development in Europe'. *Annals of Regional Science*, Vol. 45, No. 1, pp. 109–32. https://doi.org/10.1007/s00168-009-0293-8

Von Lyncker, K. and Thoennessen, R. (2017) 'Regional Club Convergence in the EU: Evidence from a Panel Data Analysis'. *Empirical Economics*, Vol. 52, No. 2, pp. 525–53. https://doi.org/10.1007/s00181-016-1096-2