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Mobilising European Structural and Investment Funds and Horizon 2020 in support of innovation in less developed regions

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Abstract

How can EU policies support the development of innovation capabilities in less developed regions? This note examines the mobilisation of the EU's two major innovation support instruments: the European Structural and Investment Funds (ESIF) and Horizon 2020 (H2020). Using data from Eurostat and European Commission administrative data on ESIF and H2020 funding, we observe a number of salient patterns. While newer member states benefit from higher research and innovation allocations from ESIF, participation in H2020 remains a formidable challenge. Across Europe we find that H2020 participation is closely associated with a number of proxies of the development of national and regional innovation systems. With few exceptions (most notably Slovenia and the Czech Republic) newer member states are characterised by lower overall R&D intensity, their research and innovation systems are less internationalised and most R&D is performed by public research institutions rather than businesses. Based on a review of literature on the determinants of participation in the H2020 (and its predecessor Framework Programmes), the history of today's advanced innovation systems and a consideration of the objectives of, modes of intervention of and possible complementarities between ESIF and H2020 we single out international collaboration and business innovation capabilities as important instrumental objectives for development-minded policy.

Executive Summary

How can EU policies support the development of innovation capabilities in less developed regions? This note examines the mobilisation of the EU's two major innovation support instruments: the European Structural and Investment Funds (ESIF) and Horizon 2020 (H2020). ESIF – with its focus on productivity and income convergence and attendant support to broad-based innovation investments - is more relevant to regions with low innovation capabilities whereas H2020 – with its focus on precompetitive research of global significance – becomes progressively more relevant to regions with higher innovation capabilities. In principle, both ESIF and H2020 are open to all regions. However, take-up of ESIF for innovation and participation in H2020 are very unequally distributed across regions with similar capability deficits. Unequal distribution is not merely confined to partly inevitable territorial disparities within countries but, importantly, is also evident across national borders. Regions in Central and Eastern Europe - largely new member states - and also Southern Europe appear to be particularly affected.

Participation in H2020 is often singled out as a particularly pressing problem in less developed regions. In addition to much-needed resources from its sizeable budget, H2020 provides unparalleled opportunities to participants from less developed regions to engage with international scientific and technological networks and address research questions of global economic significance. To understand possible reasons for low participation, we review literature on the determinants of success in H2020 and predecessor Framework Programmes for Research and Technological Development (FP). We find that prior participation in the FP, networks and collaboration, organisational characteristics, and importantly, national system and funding structures all combine to construct the scientific excellence that the FP/H2020 is known to select for. Additionally, FP/H2020 participation may reflect self-selection, whereby either very weak participants, or very strong ones, who can tap on alternative funding sources, choose not to participate. H2020 presupposes a minimum level of research and innovation capability necessary to engage with global research questions of economic significance. However, less developed regions are typically characterised by weak business innovation capabilities and by public research institutions and tertiary and vocational education that struggle to keep up with the demands of international science or globalised industry.

We recall the policy objectives of ESIF and H2020 and examine their potential impacts in terms of regional innovation capability accumulation. Taking cues from the economic history of advanced innovation systems, we highlight the central role of business innovation capabilities in the long-run development of thriving innovation systems. ESIF can help prop up capabilities in less developed regions with weak innovation systems until such time as they can participate more fully in H2020. In support of this goal ESIF innovation investments can be focused on two specific instrumental objectives: to support the internationalisation of public research on the one hand, and to support the development of business innovation capabilities on the other.

As discussed elsewhere (e.g. see European Commission, 2014) mobilising ESIF for innovation is largely down to administrative capacities to orient, coordinate, programme and implement innovation projects. RIS3 provides a new framework for this kind of mobilisation to happen. However, even with RIS3 and the mobilisation of sizeable ESIF resources for innovation, accumulation of the necessary innovation capability within both the business sector and the wider innovation system takes time and is not guaranteed. The risk of insufficiently tailored policy mixes is well recognised but not always addressed. This may materialise, for instance, with too little support

for broad-based innovation, including non-R&D innovation activities in design, marketing, engineering, training, information technology and management that are important for new-to-the-firm and new-to-the-industry innovation, and which, on the long run, can be a stepstone to and complementary to R&D. Poor tailoring may manifest in insufficient attention to the types (e.g. organisational and marketing versus technological innovation) and modes of innovation (e.g. in-house broad-based innovation activities versus collaborative research) that are most relevant to businesses in the region.

We explore some potential complementarities between ESIF and H2020 at the level of policies. At least conceptually, the ways in which the two instruments impact on capability accumulation can overlap and reinforce one another. In developing systems that are of primary interest to cohesion policy, the two instruments complement each other in a stepwise manner, with ESIF investments helping build the scientific excellence required to further benefit from H2020. However, a range of obstacles can stand in the way of harnessing complementarities. At the level of policies (as distinct from projects), these can include the absence of long-term planning horizons, the absence of the necessary governance infrastructure and reforms required and the lack of suitable policies for capability development that are in keeping with stage of the innovation system's development.

A key issue appears to be that administrative rules and procedures for ESIF and H2020 are not always compatible. Rules may also require adaptation to the economic and institutional realities of newer member states. Other important barriers include the absence of national sources of funding to pick up those parts of the innovation value chain not supported by EU funds and, crucially, the absence of a critical mass of R&D-performing businesses, which appear to be important in steering public research and skills provision and are in any case necessary if H2020 participation is to have local economic impact. Along with opportunities to harness complementarities, possible and anecdotally reported undesirable outcomes deserving further study are identified such as long-term dependence on funding from European sources and substitution between ESIF and H2020.

We then examine some salient structural features of EU innovation systems, drawing from statistical information on R&D expenditures (most notably the shares of public and business innovation within the national aggregate) and administrative information regarding participation in ESIF and H2020 at the national and regional level. With few exceptions (most notably Slovenia and the Czech Republic) newer member states are characterised by lower overall R&D intensity. Most R&D is performed by public research institutions rather than businesses, and ESIF research and innovation allocations account for a larger share of GDP (around 0.4% for Poland, Slovakia, Lithuania and Latvia and as much as 0.6% for Estonia). In contrast, with some exceptions (most notably Slovenia and Estonia), the countries where H2020 funding accounts for a greater share of GDP, tend to be older member states, with higher overall R&D intensities, and in which businesses perform most R&D. Newer member states appear to be less well integrated into international scientific networks, as suggested by the overall lower shares of international co-publications. At the national level, and among the variables considered, international co-publications, followed by business R&D intensity are the variables most closely associated with H2020 participation.

The regional picture is more nuanced. Among the 20 member states for which our data permit us to examine sub-national variance (usually at the NUTS2 level) we observe greater within-country differences in regional allocation of funding (defined as the percentile difference between the region

with the national minimum and the region with the national maximum) for H2020 than for ESIF. Greece, followed by Spain, Belgium and Italy are the countries with the greatest intra-national regional differences in H2020. Poland, Portugal and Hungary are the countries with the greatest intra-national regional differences in ESIF funds. Finally, capital regions tend to attract more H2020 funding, which underscores the importance of co-location for innovation activity of this kind.

We finally identify some salient characteristics of regions that stand to benefit from greater participation in H2020. We examine 200 EU regions for which data are available in terms of their participation in ESIF, H2020 and their R&D intensity, the latter being an important indicator of overall innovation capability. As a result of this analysis we divide all EU regions into three groups: lagging, transition and better-performing regions. “Lagging regions” are regions with low R&D intensity (less than 1 per cent of GDP) and a ratio of H2020 to ESIF funding below 1. They tend to be concentrated in newer member states and also in Southern Europe. “Intermediary regions” comprises of regions with a notable R&D intensity (at least 1 per cent of GDP) and a ratio of H2020 to ESIF funding below 1. Intermediary regions could be of particular interest to policy, as their participation in H2020 is below that expected from their overall R&D intensity, and may be where the largest policy gains can be had at short order. “Better-performing regions” exhibit both a notable share of R&D and a high (greater than 1) ratio of H2020 to ESIF funding. Lagging and Transition regions will inevitably have to ensure that ESIF funding is channelled in support of innovation capability accumulation. Support for both the internationalisation of public research and the development of business innovation capabilities seem relevant to most regions in these groups and offer fruitful directions for future European policy. However, the precise targets for policy attention are likely to differ between countries and regions and will require context-specific analysis.

Keywords: Synergies, Horizon 2020, ESIF, Innovation,

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Contents

1 Introduction

Innovation policy is central to tackling the multifaceted challenges facing Europe's regions, among others: sluggish economic growth, globalisation, demographic changes and climate change. Regions with incomes per capita below the EU average or with sluggish economic growth in particular, are finding it difficult to benefit from either national and EU innovation policy frameworks and instruments. Territorially differentiated, inclusive, and appropriately sequenced responses supporting broad-based and progressively more ambitious innovation seem necessary. Research and Innovation Smart Specialisation Strategies (RIS3) provide a framework that facilitates long-term planning and resource mobilisation.

The creation of synergies between the two main sources of EU funding dedicated to research and innovation - the European Structural and Investment Funds (ESIF) and Horizon 2020 (H2020) - is an important challenge in the implementation of RIS3. Harnessing synergies is a challenge in more ways than one. Until now the bulk of the discussion has been about synergies at the level of projects – that is, *combining* different instruments to ensure that scale and scope economies are achieved (European Commission, 2014)[1]. However, *synergies at level of policies* - and of appropriate adaptations to the national and regional policy mix in particular - have not been investigated. As we discuss in this report, synergies at the level of policies imply territorial tailoring of instruments, sequencing between them, and their meaningful embedding into long-term RIS3 processes.

This report provides an overview of mobilisation of ESIF and H2020 at the regional level and examines some of its aggregate patterns. Specifically, we examine mobilisation experience against the following questions:

- What are the possible complementarities, at the level of policies rather than projects, between ESIF and H2020?
- What are the main structural features of EU innovation systems at the national and regional levels and how do they shape the mobilisation of ESIF and H2020 funds?
- What are the roles of EU, national and regional policies in bringing about meaningful change in the innovation systems of regions with different capability deficits?

The overarching objective is to articulate possible directions[2] for policies that strengthen innovation capabilities and outcomes in the less developed regions of Europe. To this end we investigate in particular how ESIF and H2020 can be used in a mutually reinforcing fashion and identify instrumental policy objectives. The report is structured as follows.

As H2020 participation is identified as a particularly pressing problem in less developed regions, we begin with a brief review of the determinants of participation in the FP, showing that prior

[1] This discussion elsewhere focuses on complementarities (or synergies) in the narrow sense of combining funding from various instruments to maximise the overall amount devoted to a particular project, theme or priority (or support different parts of). However, unexploited scale economies are not always a problem, and may not be the key bottleneck preventing capability accumulation and development. For this reason we consider here complementarities at the level of the policy mix, which is combining specialised instruments and their various support mechanisms to achieve long-term, aggregate policy objectives, such as to build business innovation capabilities, to foster scientific excellence and internationalisation, university-industry interaction etc. This perspective brings issues related to sequencing and to focusing resources to binding constraints for aggregate development to the fore.

[2] This overview would also help inform two EC initiatives co-implemented by DG REGIO and JRC, namely: S2E and RIS3 Support to Lagging Regions, to better define their future activities.

participation in the FP, networks and collaboration, organisational characteristics, and importantly, national system and funding structures all combine to construct the scientific-excellence that the FP is known to select for. Additionally, FP participation may reflect self-selection, whereby either very weak participants, or very strong ones, who can tap on alternative funding sources, choose not to participate. We provide an overview of the rationales for synergies between ESIF and H2020 at the level of policies and consider how ESIF can support the development of scientific excellence, and, importantly, innovation capabilities more generally, particularly in the business sector. We argue that business innovation capabilities are of central importance in the long-term development of regional innovation systems and deserve closer attention.

Drawing from administrative data on pre-allocated and place-based ESIF and spatially-blind and competitive H2020 funding, we show the extent of mobilisation across EU member states and their within-country variation. We observe that funding mobilisation in each instrument is broadly shaped by structural features of national research and innovation systems, such as the presence of capital or metropolitan regions, international cooperation and the share of business R&D funding and performance.

Finally, we show that the relative mobilisation of ESIF and H2020 across 200 European regions is closely associated with their R&D intensity, which we take as a proxy of the overall development of their innovation system. We then classify each region and provide some initial thoughts on the kinds of policies what would be most appropriate in each type.

2 What determines H2020 funding mobilisation? A review of the literature

Take-up of ESIF for innovation and participation in H2020 are distributed very unequally across regions with similar capability deficits. Unequal distribution is not merely confined to partly inevitable territorial disparities within countries but, importantly, is also evident across national borders. Regions in Central and Eastern Europe - largely new member states - and also Southern Europe appear to be particularly affected. Whereas, mobilising ESIF for innovation is largely down to administrative capacities to orient, coordinate, programme and implement innovation projects (European Commission, 2014; Gianelle et al., 2016; Boden et al., 2016), success in the FP is a multifaceted challenge.

Participation in H2020 is often singled out as a particularly pressing problem in less developed regions. Given the disparities in scientific and technological capabilities between EU member states, the take up of Framework Programme funding in the EU is skewed towards member states that joined the EU before 2004 (Annerberg et al, 2010; European Commission, 2017). This is especially problematic from a development perspective, as in addition to much-needed resources from its sizeable budget, H2020 provides unparalleled opportunities to participants from less developed regions to engage with international scientific and technological networks and address research questions of global significance.

A number of studies have shown success in the FP is overwhelmingly determined by participant attributes that can be good proxies of scientific excellence – such as the number of publications and the average number of citations (Geuna, 1998; Henriques et al., 2009). However, scientific excellence, both in its construction where it previously did not exist and in its visible manifestations such as high-impact publications, is both an economic and a social process. Learning and improved human capital are natural outcomes of sustained international collaboration. But familiarity among research teams who have previously worked together, manifesting in lower coordination costs, may also result in biases. The award of research funding is not always a natural process by which the best researchers cumulate advantages based on the quality of their ideas (Viner et al., 2004). Rather, it can be a cumulative-causation process, whereby initial success becomes a self-perpetuating phenomenon, rather than one invigorated by competition.

Prior participation in the Framework Programme

The so-called "Matthew effect" in science refers to the phenomenon of research groups that have been successful in obtaining external funding having a greater chance of producing publishable research that in turn improves the chance of getting further funds in the future (Geuna, 1996). More specifically, it has been argued that overall research output has an effect on participation in FP (Ukrainski, 2014). Furthermore, an important factor in relation to the successful application for external funding is whether there have been collaborative relationships prior to the award of funding (Defazio et al., 2009). Along with the low level of FP participation it can be demonstrated that less developed regions have a low level of overall international co-publication intensity (Harrap and Doussineau, 2017). This implies good prior performance is an advantage in obtaining funding as such an institution is seen as less risky than one that has never been funded (Geuna, 1996).

Such success due to prior participation means that the universities and research institutes with high reputations become more connected and central to a network through repeated participation in EU Framework Programmes (FPs) (Protogerou et al., 2010). Such selection mechanisms mean that early entrants have advantages in terms of repeated participations (Geuna, 1998; Heller-Schuh et al., 2011), as they achieve a more central position in the FP networks that confer further advantages in terms of FP participation. It follows that the lack of prior participation puts institutions from the EU13 at a disadvantage. The role of prior participation is also evident with regards to business participation in the FP. A recent study for the European Commission (Open Evidence and Ernst and Young, 2016) found that lack of necessary skills and networks is a major barrier to business participation in the FP, particularly in new member states.

Pre-existing research networks and collaboration structures

Participation in FPs is concentrated in a highly clustered small group of institutions with high reputations (Lepori et al., 2015). While such small world networks are efficient for the transmission of knowledge, it can be difficult for new entrants to join and are therefore less effective for fostering integration (Heller-Schuh et al., 2011). A study of the area of information society technologies (Protogerou et al., 2010) suggests that the instruments of the FPs consolidate the position of incumbent core network actors while not allowing for promising peripheral organisations to assume more central roles.

The choice of consortium partners for a FP proposal could have important consequences for project participation. To minimise cultural issues and geographic constraints, there can be a tendency to maintain well-known individual and team-level links (Okubo and Zitt, 2004). Makkonen and Mitze (2016) have shown that while there was an increase in co-publication intensities between old and new member states, following the latter's accession to the EU, the increase between new member states was more significant.

Co-publication analysis also indicates that the new member states collaborate strongly together and this is replicated in FP participation, although some countries become less peripheral in their FP participation (Harrap and Doussineau, 2017). This indicates that the prior performance of a consortium influences the FP success of new members. This is also influenced by prior links in a researcher's wider international collaboration networks.

FP networks show a stable core with a large number of projects with the same partners. Around this core there are some highly frequent participants as well as others that participate more rarely. These latter organisations will rarely join the core (Breschi and Malerba, 2009). It is further argued that research priorities and network organisation are defined by the core and that they demonstrate a tendency towards resistance to change. A counter argument is that the core co-regional pairs that co-publish frequently do not receive a disproportionate amount of funding from FP as it is distributed equally based on past scientific performance (Hoekman et al., 2013). This issue of performance and reputation is an important factor as it is a horizontal issue pertinent to the national system and characteristics of the organisation.

National or regional R&I system characteristics

One characteristic that appears particularly important is the degree of internationalisation in the national R&I system. A high degree of international openness, as reflected in international mobility,

participation in transnational research teams and cross-border co-authorship, can have positive effects on the capacity of researchers to apply to international programmes such as the FP (Dinges and Lepori, 2006; Langfeldt et al., 2012).

The relationship between internationalisation and the performance of the science system runs both ways. A recent study of the mobility of scientists shows that the attraction of a country is not systematically based on obtaining greater funding than their origin: High quality in the performance of a national science system is important and research excellence initiatives have an influence (Cuntz, 2016). Furthermore, open science systems with more researchers coming in and going out produce higher impact research (Wagner and Jonkers, 2017). These are, collectively, strong indications of the interactive relationship between an internationally open system, research quality and attractiveness to researchers.

While R&D intensity can indicate the regional presence of research-active organisations that can potentially participate in the FP, it is not just overall R&D intensity that matters but its composition too. As also shown in Section 4 of this report, countries with a higher share of R&D performed and funded by *businesses* typically perform better in the FP, in view of the instrument's focus on the pre-competitive stage of research. For instance, a study of the extent of university-industry R&D collaboration in the FP by Azagra-Caro et al. (2013) found that much of the observed variance across European regions could be explained by the incidence of business R&D in the region. It is likely that it is not business R&D performance in the region *per se* that is important for FP participation, but what it signifies: sizeable business R&D investments are only possible when a constellation of problems in the innovation system have been effectively tackled, including the appropriate framework conditions for investment, the supply of adequate relevant skills and successful reform of public research so that it is synergetic and responsive to the demands of industry.

Organisational characteristics

International reputation has a strong influence on the extent of FP participation (Henriques, et al, 2009; Lepori et al., 2015; Defazio et al., 2009). Prestigious institutions become better connected and more central in the network leading to repeat participation in the FP (Protogerou et al., 2010). The expectation that reputation improves the chances of a successful bid encourages applicants to act strategically in their selection of partners. This behaviour further fans the cumulative causation relationship between first-entry, high scientific research quality, high reputation and potential for repeat participation. The corollary is that newer participants have a higher chance of being left out. The lack of international reputation is an important barrier for new entrants to overcome. This is typically the case in new EU member states, where there are smaller numbers of world class institutions with the required reputation (Annerberg, et al., 2010).

The size of the institution can also be a factor as large institutions may be better able to support and manage complex international collaboration projects (Geuna, 1996; Lepori et al., 2015). A common issue, anecdotally reported at S2E National Events,[3] was the lack of expertise and experience in the proposal writing stage and the implementation of transnational collaborative projects (Özbolat and Harrap, forthcoming). Larger institutions, particularly those in older EU member states, may have greater resources to establish support mechanisms.

[3] Details on all 13 National Events including the Joint Statements issued by S2E and national authorities after the event can be found at: http://s3platform.jrc.ec.europa.eu/national-events

A recent study by Enger and Castellacci (2016) considers the decision to actually submit a proposal; the stage during which some potential participants may opt not to participate (so-called self-selection). Using a dataset comprising the entire population of research organisations in Norway, Enger and Castellacci (2016) find that, in addition to the importance of prior participation, access to national funding schemes that are complementary to the FP is an important determinant. The challenge in the design of national funding schemes is to ensure that they complement and not substitute the FP, as unconditional availability of more dependable national funds may also mean there is less need to apply to competitive and therefore uncertain funding streams such as H2020.

3 ESIF and H2020: Policy objectives and potential complementarities from a development perspective

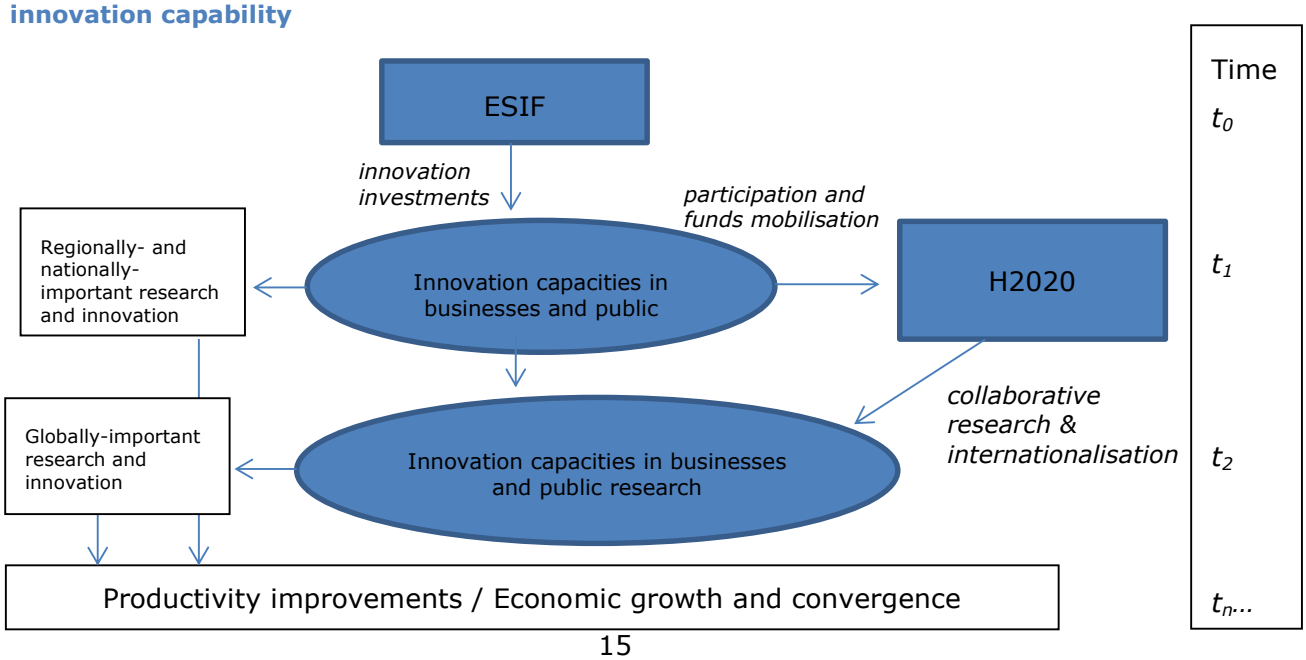
Policy complementarities for development

Enhancing the global competiveness of European industry on the one hand and supporting the convergence of productivity and income levels between European regions on the other, are the overarching economic objectives of EU research and innovation policies and EU regional development policies respectively (Guzzetti, 1995; Tondl, 1995; Chorafakis and Pontikakis, 2010). In keeping with these distinct objectives, historically the two sets of policies have followed their own development paths. This is evident in their main instruments:

- the Framework Programme, known in its current iteration as the EUR 80 billion-plus "Horizon 2020" programme (H2020), which has spearheaded support for precompetitive research of global significance (chiefly in the form of centrally-administered and competitively-awarded funding for mainly collaborative research projects); and
- the European Structural and Investment Funds (ESIF), which have supported productivity and income convergence across EU regions and countries by way of (targeted support for EU-funded but nationally-administered) investments.

The recognition that the two objectives of competitiveness and cohesion can be mutually reinforcing is motivating an active search for overlaps and complementarities between the two sets of policies and their instruments. In principle, ESIF can be complementary to H2020 in several ways. In weaker innovation systems that are of primary interest to cohesion policy, the two instruments complement each other in a stepwise manner. First, ESIF can support the initiation of innovation activities and accumulation of innovation capabilities, both in public research and education and in businesses. Then, as innovation capabilities accumulate in firms, and public research capacities are upgraded, weaker innovation systems progressively become better able to engage with H2020, access its networks and conduct research of global significance (see simplified diagram in Figure 1). In this stylised sequence, ESIF is much like the scaffolding meant to prop up a structure during its construction; and, although this is not always appreciated, just like the scaffolding, its gradual withdrawal is part of the plan.

Figure 1: The role of ESIF and H2020 in regionally, nationally and globally significant innovation capability



Complementarities also exist because each of the two instruments can support the policy objectives of the other. H2020 obviously supports cohesion by linking research teams across European borders and facilitating learning. However, its main role in capability accumulation arguably comes by way of its ability to "raise the bar". By supporting research questions of global significance, H2020 tends to raise the bar of quality and impact at that level (Henriques et al., 2009). Even before doing so directly, it can chart the way for the necessary reforms and steering of capabilities development that lead to convergence not just of capacities but also of outcomes. ESIF, courtesy of supporting less developed systems, is liable to support a wide range of sectors, technologies, firms and products. Other things being equal, over the long-run ESIF may contribute to the development of a more populous and, importantly, diverse pool of globally innovative European companies. These are just the obvious complementarities at the level of countries and regions which is where most important innovation policy decisions take place. At the level of projects (or collections of projects tackling a particular challenge), the gamut of complementarities and potential for improvement is likely greater still[4].

Obstacles to complementarities

However, a number of obstacles can stand in the way of realising such complementarities. The inability to plan strategically has been a chief obstacle. The absence of a framework for long-term planning in regional (and some cases national) innovation policy has prevented the strategic use of funds and of the necessary governance and institutional reforms demanded at various stages of an innovation system's development. The policy idea of Smart Specialisation Strategies (RIS3) has come as a response to the need for long-term planning. RIS3 is now helping extend planning horizons and unite previously disparate funds and instruments, although much progress remains to be made, especially in less developed regions and in countries with little experience in innovation policy. RIS3 provides an opportunity to harness these complementarities by embedding ESIF and H2020 into the region's long-term strategy. But this opportunity is not always recognised and the potential links often remain unexploited in a region's strategy and attendant policy interventions. Failing to harness these complementarities within the RIS3 process raises the risk of the use of ESIF for innovation in ways that do not support meaningful capability accumulation, for instance, by failing to upgrade and internationalise public research institutions or by failing to engage with a broad-base of the region's business sector or failing to attenuate territorial imbalances[5].

A key issue appears to be whether there are elements in the design of ESIF and H2020 that prevent such complementarities, including mismatches in administrative rules and procedures (see European Commission, 2014) and possible lack of adaptation to the economic and institutional realities of newer member states. Other important barriers include the absence of national sources of funding to develop complementary lines of research and to pick up those parts of the innovation value chain not supported by EU funds and, crucially, the absence of a critical mass of R&D-performing businesses, necessary if H2020 participation is to have an economic impact in the region.

[4] See the S2E Joint Statements (http://s3platform.jrc.ec.europa.eu/national-events) and Examples of Synergies (http://s3platform.jrc.ec.europa.eu/synergies-examples) for possible project complementarities

[5] Another possible, but not necessarily likely, outcome of the inability to plan strategically is the use of ESIF to postpone (if not prevent) the necessary changes by providing a dependable source of financing that sustains outmoded modes of governance and institutions (and attendant orientations and functions of innovations systems). For example, readily available ESIF funding may be acting as a substitute for H2020 funding, which in developing regions may remove the incentive to reform and the opportunities to learn and improve.

Business innovation capabilities as an instrumental development objective

In a broader sense, identifying exactly how ESIF and H2020 can complement each other, requires an understanding of what kind of innovation capabilities are central to productivity and income improvements and how they accumulate over time. This understanding can be greatly enhanced by studying the developmental paths of what are today advanced innovation systems. The most striking feature of advanced innovation systems is the central role of the business sector (Bell, 2009). In thriving innovation systems, most R&D is both financed and performed by businesses. Public research systems are, of course, central to advancing the frontiers of knowledge and as such are necessary pillars of the innovation system, but most economically useful innovation takes place within firms. The path to both economic convergence and competitiveness therefore inevitably crosses from the accumulation of business innovation capabilities.

This is why focusing on the smaller subset of policies designed to strengthen business innovation capabilities may be a way to enhance the impact of and complementarities between ESIF and H2020. Historically, in what are now developed innovation systems, business innovation capabilities are accumulated over long periods of time as a function of the systematic carrying out of innovation activities internal to firms. These capabilities can be initiated (or "bootstrapped" e.g. with the insertion of a first engineer or a first researcher into a company) where they do not exist, stimulated (with innovation vouchers, prizes etc.) and supported in many ways, including by way of targeted public investments in human resources, by supporting innovation activities within firms that are complementary to R&D (see practical policy directions in Arnold and Thuriaux, 1997; Bell, 2009; Cirera et al., 2017) and by way of collaborative research and innovation projects with universities and public research organisations (Hanna et al., 1995, p. 80; Arnold and Thuriaux, 1997; Bell, 2009; OECD, 2014). It would seem therefore that, in addition to national innovation policies, EU investments in innovation capacities as supported by ESIF, and in collaborative R&D projects as supported by H2020 can play an important role in the accumulation of business innovation capabilities.

Empirical literature suggests that differences in business innovation capabilities lie behind the variable outcomes of most measurable dimensions of economically useful innovation: the rate of product and process innovation and its economic impact (Frenz and Ietto-Gillier, 2009; Varga et al. 2014), the extent and quality of university-industry interaction (Azagra-Caro et al., 2013) and even the ability of innovation systems to diversify into new sectors (Smith et al., 2005; Bell, 2009). In view of this evidence, in the analysis that follows we treat business innovation capabilities not just as an instrumental objective of both competitiveness and cohesion policies but also as a defining characteristic of regional and national innovation systems in the EU and major differentiator of their experiences and needs with respect to both ESIF and H2020.

4 Mobilisation of ESIF and H2020 across the EU

Several aspects related to success in FP/H2020 have been discussed in the previous sections. Many of these success factors have so far been primarily described at the level of the research performing organisation, but there are also aspects affecting participation that relate to aggregate features of the innovation system, at both the national and regional levels.

In this section we attempt to make sense of structural features of European innovation systems and the ways in which they shape FP and ESIF mobilisation. Some of the key features examined include: overall R&D investments; the weight of business in the funding and performance of R&D; and the internationalisation of research, with its implications for other aspects such as access to networks and consortia building.

Research and innovation funding by source

Two sets of data were extracted from the JRC R&I regional viewer[6]: the total of H2020 allocations up to July 2017 by NUTS2 region and planned ESIF investments in RTDI relevant categories of intervention[7]. Yearly averages were calculated for each region and were then aggregated to obtain the yearly average funding[8] at the national level.

Table 1 provides an overview of R&D expenditures among EU member states, ranked by R&D intensity [i.e. Gross domestic expenditure on R&D (GERD) as a percentage of GDP]. With few exceptions (most notably Slovenia and the Czech Republic, and to a lesser extent Estonia and Hungary), new member states are concentrated towards the bottom of this ranking. The picture is not too dissimilar for the Business Enterprise Sector (BES) investments as a proportion of GDP.

[6] http://s3platform.jrc.ec.europa.eu/synergies-tool

[7] 002 - Research and innovation processes in large enterprises; 056 – Investment in infrastructure, capacities and equipment in SMEs; 057 – Investment in infrastructure, capacities and equipment in large enterprises; 058 – Research and innovation infrastructures (public); 059 – Research and innovation infrastructures (private, including science parks); 060 - research and innovation activities in public research centres; 061 – Research and innovation activities in private research centres; 062 – Technology transfer and university-enterprise cooperation; 063 – Cluster support and business networks; 064 – Research and innovation processes in SMEs (including vouchers); 065 – Research and innovation processes, technology transfer in low carbon economy; 066 – Advanced support services for SMEs and groups of SMEs; 067 – SME business development, support to entrepreneurship and incubation; 073 – Support to social enterprises (SMEs); 101 – Cross financing under the ERDF: support to ESF type actions.

[8] The economic indicators for research and innovation investments were extracted from the EUROSTAT website (January 2018). The EUROSTAT indicators for research and development (R&D) include statistics on expenditure, personnel and government budget allocations for R&D. Data used related to performing sector and the source of the funding. Data for the year 2015 were used except where all the data were not available, then the next most complete year was used. This is indicated in the tables and charts. By way of a caveat, it should be noted that the H2020 funds are actually allocated whereas the ESIF data used are only for planned investments. However, data from the 2013 Annual Implementation Report for the period 2007-2013 show that absorption was generally over 90% (except for developing human potential). While there were variations between countries the rate is generally high and should increase as the funds are allocated post 2013. This provides some reassurance that planned amounts can be a reasonable estimation of investments for the 2014-2020 programming period.

Table 1: RTDI investments as a percentage of GDP (2015)

Country	GERD % of GDP (1)	BES % of GDP (2)	Public GERD % of GDP*** (3)	ESIF % of GDP (4)	H2020 % of GDP (5)	Spread between H2020 and ESIF intensity (5)-(4)
SE**	3.310	1.870	0.967	0.018	0.062	0.044
AT	3.050	1.520	1.012	0.012	0.063	0.050
DK	2.960	1.760	0.869	0.010	0.070	0.060
DE	2.920	1.910	0.814	0.022	0.042	0.019
FI	2.900	1.590	0.845	0.034	0.081	0.047
BE	2.470	1.440	0.604	0.015	0.085	0.070
FR*	2.230	1.240	0.794	0.014	0.037	0.023
SI	2.200	1.520	0.444	0.293	0.120	-0.173
NL	2.000	0.970	0.667	0.011	0.088	0.077
CZ	1.930	0.670	0.635	0.257	0.030	-0.228
UK	1.670	0.820	0.486	0.014	0.045	0.031
EE	1.490	0.610	0.693	0.654	0.118	-0.537
HU	1.360	0.680	0.472	0.324	0.045	-0.279
IT	1.340	0.670	0.523	0.042	0.038	-0.004
LU	1.270	0.600	0.627	0.003	0.039	0.035
PT	1.240	0.530	0.605	0.318	0.069	-0.249
ES	1.220	0.560	0.552	0.073	0.065	-0.008
IE	1.200	0.580	0.328	0.010	0.051	0.042
SK	1.180	0.290	0.414	0.362	0.027	-0.335
LT	1.040	0.300	0.383	0.381	0.024	-0.357
PL	1.000	0.390	0.442	0.453	0.016	-0.437
EL	0.970	0.300	0.537	0.111	0.093	-0.019
BG	0.960	0.340	0.196	0.208	0.033	-0.174
HR	0.840	0.390	0.323	0.277	0.028	-0.250
MT	0.770	0.350	0.262	0.121	0.052	-0.069
LV	0.630	0.130	0.218	0.393	0.048	-0.344
RO	0.490	0.180	0.212	0.102	0.017	-0.085
CY	0.480	0.100	0.271	0.062	0.145	0.083

*GDP (2014)

** GDP (2013)

***it is not known whether public funding for RTDI as extracted from EUROSTAT would include structural funds or not. It depends whether the authority reporting the statistics has the ability to track the funds. However, there is no crossover between BES, ESIF and H2020 intensities

As far as Gross Expenditure on R&D (GERD) by the government and higher education sectors is concerned, particularly low levels (below 0.35% of GDP) are evident in six new member states (Croatia, Cyprus, Malta, Latvia, Romania, and Bulgaria). ESIF research and innovation related investments, however, account for a higher share of GDP in new member states. This is hardly surprising for a cohesion instrument meant to facilitate development. However the figures also highlight possible mobilisation challenges for ESIF – up to the time covered by our data – particularly for Romania.

By contrast, H2020 tends to account for a higher share of GDP in older member states, which on the whole tend to spend more on R&D in general, and more of it is performed by businesses. High R&D

intensities, to a large extent supported by businesses are the hallmark of dynamic, developed innovation systems, thriving on virtuous cycles of innovation investments, synergies between public and private R&D activities, higher revenues and productivity improvements due to innovation, and further innovation investments.

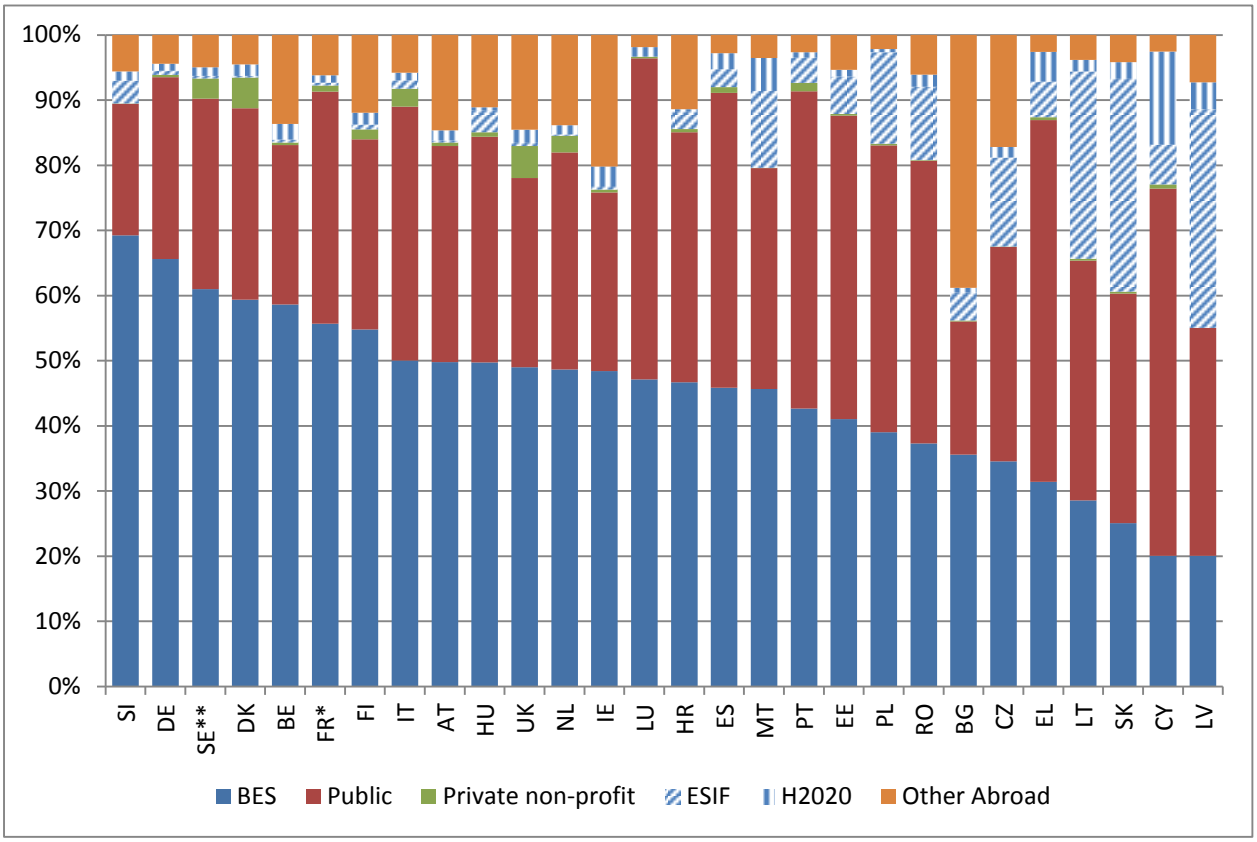
As mentioned above, Slovenia, Estonia and the Czech Republic are exceptions among new member states. The three countries are among the highest R&I investors, a relatively high share of their national research effort is performed by businesses and are also among the biggest ESIF beneficiaries. In particular, Estonia stands out as it mobilises a significant amount of ESIF in R&I (around one billion for the 2014-2020 period) but is also a good performer in Horizon 2020 based on H2020 funding as a percentage of GDP.

The role of business R&D

It can be argued that business funding is an appropriate summary indicator of a productive innovation system. When business funding flows into public research it is because there is an expectation it will lead to economically useful innovation – which on the whole corresponds to public research systems which are both well-funded through other sources and rigorously steered and governed (OECD, 2005: pp. 16-20; also see OECD, 2011 for recent trends in the governance of public research in advanced innovation systems). Like other indicators of business investment, business funding of R&D tends to be higher in countries with legal institutions that protect the rights of investors and with effective public policy and governance (Guellec and van Pottelsberghe, 2000; Brown et al., 2017). On the whole, countries where businesses are willing to fund the bulk of the national R&D effort (irrespective of whether performed in-house, or by external R&D services suppliers such as universities and PROs) are those who have managed to instigate virtuous cycles between resources for innovation, profitable innovation and more resources for innovation. As a result they manage to mobilise more resources to innovation overall.

For these reasons, the share of GERD funded by business can be a revealing indicator of the development of a national innovation system. Figure 2 presents the share of different institutional funders of R&I (businesses, government, private non-profit and funding from abroad) in the national total (GERD), with member states ranked according to the share of business funding. It is immediately striking that countries in which businesses finance the bulk of the national R&D effort are those with the most dynamic innovation systems (as attested, for example, by the latest European Innovation Scoreboard: EIS, 2018), and broadly coincide with those that achieve the highest overall R&D intensities too.

Figure 2: Sources of RTDI funds in EU – 2015 (*2014, **2013)



Where does EU funding fit into this picture? To answer this question additional estimates are necessary. Eurostat R&D statistics report funding sourced by the various institutional funders within the country and from abroad, including a dedicated category for EU funding "Abroad - European Commission" (ABR_EC). We have further distinguished the broad Eurostat category "Funding from Abroad – European Commission" into H2020 and ESIF funding, by multiplying the level of funding reported by Eurostat by the share of H2020 and ESIF in the sum total of our administrative-data derived indicators. This comes with the caveat that while the distinction between business and public funds is clear and certain, we cannot be sure that the same is true of the distinction between national and EU funds, the latter of which may on occasion have been (mis)classified as coming from national sources[9]. This suggests that ESIF in particular and likely H2020 may be underrepresented[10]. Presenting ESIF and H2020 in comparison to other sources of R&D funding has the advantage of appreciating their relative importance for individual countries, within a framework that is consistent with formal R&D statistics.

[9] According to the Frascati Manual 2015 publicly-financed GERD should contain only national resources (and therefore exclude ESIF and H2020 funding). According to EUROSTAT (in a bilateral email exchange on 15/03/2018), if however, the reporting unit is not capable of tracing the source of funds correctly EU funds may be (mis)classified under the national or regional authority. As far as national accounts are concerned, according to Eurostat (in a bilateral email exchange on 7/11/2018) ESIF funds would be recorded as a transfer from the "Rest of the World".

[10] An *ex post* verification of the estimated levels of H2020 funding using this method compared to nearest available year estimates of levels of H2020 funding available from alternative sources shows that this method and the alternatives are within the same order of magnitude (average percentile differences less than 50%) and exhibit a high cross-country correlation (Pearson's R=0.9)

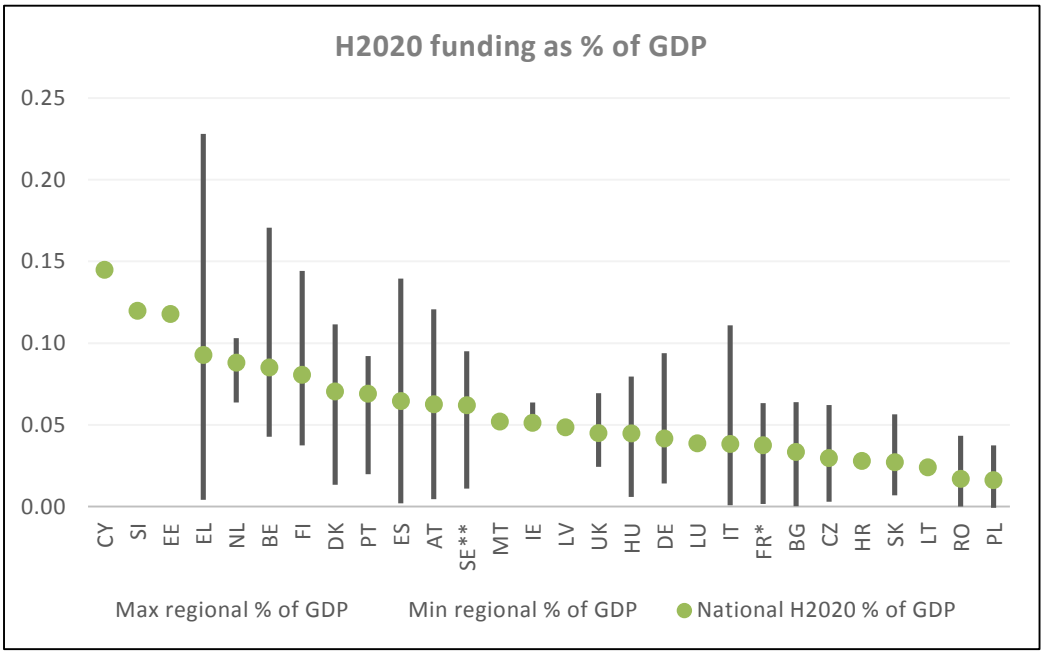
With respect to EU funding, Figure 2 shows that low shares of business funding correspond to high dependence on ESIF. Countries with weaker innovation systems (in terms of both R&D intensity and share of business sector in total R&D) tend to be the ones in which the largest proportion of R&D funding comes from the EU (including H2020 and ESIF) – new member states in particular but also Greece. Only SI goes against this pattern among new member states, and is indeed the country with the highest share of BERD in the EU.

Regional variations

The national structure of funding provides an important reflection of the national research and innovation system. However, there can be significant variation between the different regions in a country. These are politically important, especially given the impulse given to the regional dimension of innovation policy by RIS3.

Figures 3 and 4 present H2020 and ESIF intensities for each country respectively, showing the national average (as the dot) as well as the maximum and minimum regional intensities (corresponding to either extremity of the vertical lines). There are eight smaller countries[11] where the NUTS2 accounts for the whole country or have been treated as one territory due to their size. This constraint confines our examination of sub-national variance to 20 EU member states only. We use mostly the NUTS2 and in some cases NUTS1 level of territorial aggregation (see Methodological Notes in section 5 for a fuller explanation).

Figure 3: H2020 funding intensity showing national average and regional max/min

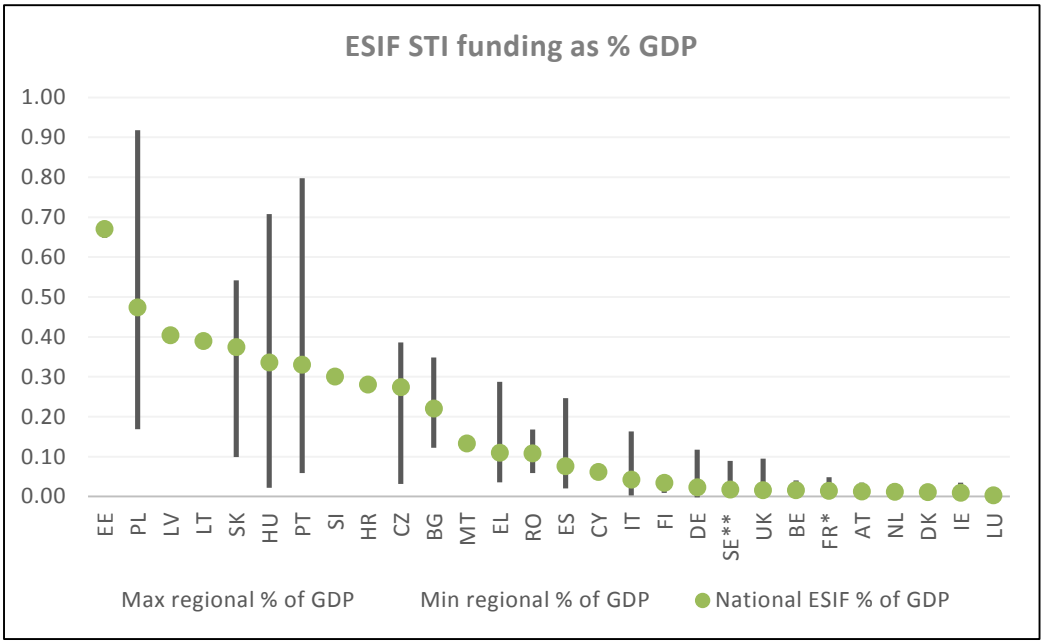


Greece, followed by Spain, Belgium and Italy are the countries with the greatest variations between regions in H2020. In the case of ESIF, the largest variations between regions are in Poland, Portugal and Hungary. We observe greater differences in regional allocation of funding (defined as the

[11] Croatia, Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, Slovenia

difference between the region with the national minimum and the region with the national maximum) for H2020 than for ESIF.

Figure 4: ESIF STI funding intensity showing national average and regional max/min



It is also possible to distinguish between capital regions, metropolitan regions and other regions. The NUTS3 level is used to identify capital and metropolitan regions, the latter being either a NUTS3 region on its own right or a combination of NUTS 3 regions which represent all agglomerations of at least 250 000 inhabitants[12]. Of the 20 countries with regional variance, 14 of those with maximum H2020 intensity contain capital regions, three have metropolitan regions and three do not contain any metropolitan region (EL, IT and SE). For the minimum intensity regions 11 are metropolitan and nine are other regions. Capital regions tend to attract more H2020 funding, which underscores the importance of co-location for innovation activity of this kind. It also suggests that the magnitude of the development challenge for lagging regional innovation systems is proportional to existing economic disparities within countries, which should serve to temper expectations about what is feasible within politically-relevant timeframes.

Structure of research and innovation system: international engagement

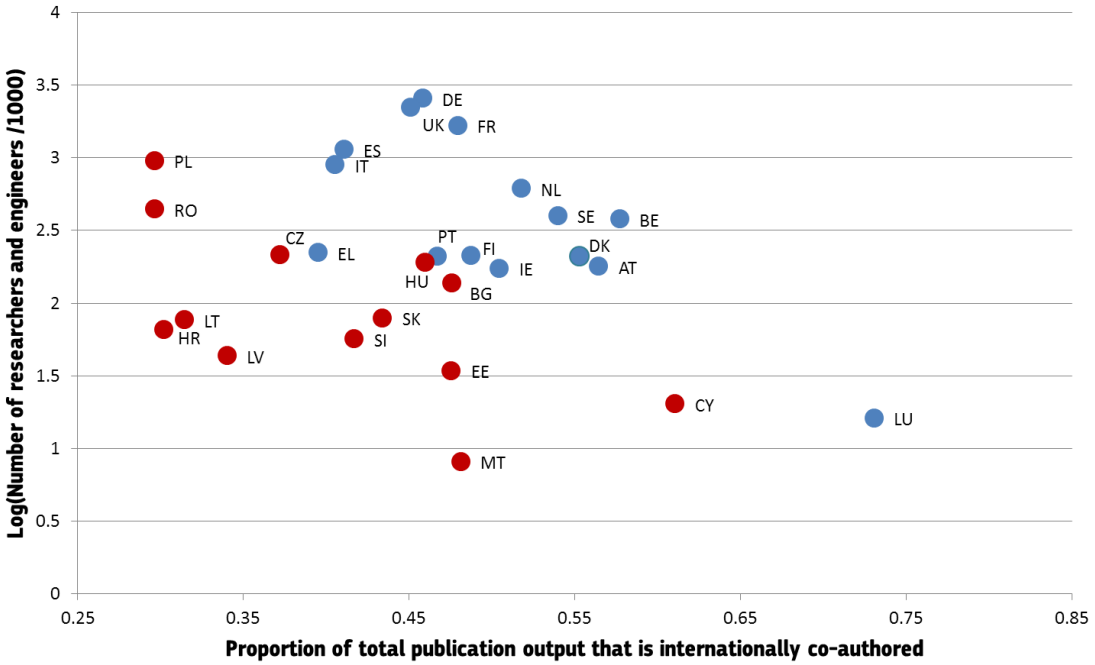
The review of determinants for H2020 participation in Section 2 highlighted the role of access to and integration into international research networks. International engagement stands to improve the innovative performance of a country or region. Furthermore, trans-regional and international cooperation is also an important dimension of smart specialisation. New member states have a strong dependence on foreign direct investment (FDI) and global value chains and yet their Research and Innovation Strategies for Smart Specialisation (RIS3) are not internationalised (Radosevic and Stancova, 2015). However, while networks and knowledge flows are considered important for the innovation performance of countries and regions (Runiewicz-Wardyn, 2013) it should be

[12] http://ec.europa.eu/eurostat/web/metropolitan-regions/background

remembered that just connecting internationally is not enough: knowledge spillovers may not happen in the absence of a minimum necessary level of innovation capabilities in the region (Miguélez and Moreno, 2015).

Figure 5 plots the proportion of internationally co-authored papers[13] against the number of researchers and engineers in each EU member states (using EUROSTAT data). The horizontal axis shows the proportion of international co-publications over the country's total publication output in the time period. Figure 5 shows that EU member states tend to follow the well-known pattern of smaller countries being engaged in international collaboration more than larger countries (Schubert and Braun, 1990; Leclerc and Gagné, 1994). However, it is noticeable that while both old and new member states follow this pattern, new member states (in red) as a group are less internationally engaged. The lower proportions of international co-authorship are dominated by new member states, suggesting that they are not as extensively linked in international research as other EU countries. Lack of international connectedness is itself both a cause and an effect of difficulties in participating in H2020[14], but probably goes well beyond it.

Figure 5: International co-authorship against number of researchers and engineers in a country[15]



Source: Harrap and Doussineau (2017)

A concerted policy to open up of research and innovation systems in new member states and favour internationalisation, should not just support participation in joint research projects, but also include

[13] This data was extracted from Scopus. The time frame for extracted publications was 2007-2013. The analysis was restricted to articles, conference papers, book chapters and books. International collaboration is inferred when the authors' affiliation addresses are in two or more different countries. The co-authorship can be attributed to a country (or region) through whole counting where every country with a contributing author is counted (Leydesdorff and Wagner, 2008). In fractional counting the country is assigned a fraction of the paper. In our case, as our interest is primarily with the presence or absence of an international link (rather than the volume of authorship), the whole counting approach is appropriate.

[14] It is indicative that in pairwise correlations between H2020 funding intensity, and a handful of national innovation indicators (such as overall R&D intensity, public R&D intensity, business R&D intensity, and co-publications) the share of international co-publications, followed by business R&D intensity, were the two variables with the highest correlation coefficient (0.44 and 0.21 respectively).

[15] Extracted from Scopus and restricted to articles, conference papers, book chapters and books.

initiatives catering to the entire chain of knowledge generation and circulation, including training and human resource mobility initiatives, the harnessing of diaspora networks, and greater participation in international funding consortia.

5 H2020 mobilisation relative to ESIF: regional patterns and groupings

In this section we attempt to characterise EU regions according to their levels of R&D intensity, on the one hand and the relative weight of H2020 versus ESIF funding on the other. This mapping can highlight some common trends, allowing us to group regions, relate these to possible needs and may thus allow policy makers at both the EU and the national levels to better tailor support for innovation in those territories. More tailored support to regional authorities would facilitate the identification of good practices and their possible transfer between similar regions.

Regional innovation systems vary enormously and are themselves parts of broader national and sectoral innovation systems with distinct trajectories and needs for support. On the basis of prior literature that underscores the role of scientific excellence, internationalisation, business innovation activity and also complementarities between national funding sources and H2020 participation (see section 2), we anticipate that the better a research system is performing on these counts, the more funding it can obtain from H2020. Focusing on the specific objective of enhancing the participation of regions with weak innovation capabilities in H2020, our attention can be profitably focused on those regions where relatively small changes in research and innovation policies can have large impacts. At either extremity, there are of course systems with weak innovation capabilities in both the public and the business sector and systems with generally strong innovation capabilities, underpinned by scientific excellence. Of particular interest here are the various types of other systems in between these two extremes. These include systems with relatively strong public research but only moderate or weak business innovation capabilities (e.g. EL, PT, and CY) and systems which have managed to mobilise considerable resources for research and innovation but have not yet managed to translate these into improvements in scientific excellence or economically useful innovation. The latter group includes a handful of countries, mostly in Central and Eastern Europe which have relatively recently secured large business investments in innovation, primarily as a by-product of FDI, and stand to gain the most from further participation in H2020.

Methodological notes

Territories taken into account

In the interest of policy relevance, to the extent that available statistics permit, the territorial level assigned corresponds to either the political or the administrative level. In total, the analysis covers 200 NUTS2 and NUTS1 territorial entities, including country-level "regions" (e.g. CY, MT, LU). This reflects the diversity of territorial organisation in the EU and the level of regional policy making in each member state[16].

Chosen data and indicators for analysis

For each region, three types of information help us to position EU regions:

1. GERD relative to regional GDP. The latest available indicators (2015) are taken from Eurostat.
2. The total planned amount of ESIF dedicated to Research and innovation at regional level for the period 2014-2020. The planned investments in European Structural and Investment Funds (ESIF) concerns only funding clearly earmarked for research and innovation, activities.

[16] Country codes and NUTS level taken into consideration for this analysis: AT=2; BE=1; BG=2; CY=1 (country level); CZ=2; DE=1; DK=2;EE=1 (country level); EL=2; ES=2; FI=2; FR=2; HR=1 (country level); HU=2; IE=2; LT=1 (country level); LV=1 (country level); MT=1 (country level); NL=1; PL=2; PT=2; RO=2; SE=2; SI=1 (country level); SK=2; UK=1

Of the funds that make up ESIF[17], these are mostly from the European Regional Development Fund (ERDF), followed by the European Social Fund (ESF) and the Cohesion Fund in decreasing proportions. The territorial level (NUTS level) used depends on the availability of data from regional operational programmes (OP) and also the national operational programmes. The share of each region in national OPs has been estimated by taking into account the population size of the regions and their development stage. Data depicted here are thus estimations of planned investments and do not reflect final investment figures. A broad definition of research and innovation activities takes into account categories of intervention both within and outside the Thematic Objective 1 specifically devoted to them. Infrastructures, support to SMEs and social innovation are also considered covering in total 15 categories of intervention related to Research and innovation (see list in annex 1).

3. The total amount of Horizon 2020 funding captured by beneficiaries in the regions[18].

Chosen thresholds for grouping regions

Any attempt to group dissimilar entities entails an element of arbitrariness and the present exercise is no exception. In terms of regional R&D intensity, a chief consideration for determining a threshold is to set it at a level that is indicative of a regional innovation system of intermediate capability. That is, an innovation system that has already made some notable progress in mobilising R&D resources, including private funds, and therefore stands a reasonable chance of progressing to the more systematic, interactive, and ambitious innovation activity that can facilitate meaningful participation in H2020[19]. Lacking any other yardstick, and for simplicity's sake, we set the threshold for the level of research investment at 1% of GDP. This threshold is far from the EU average of 2.3% (Eurostat, 2015) and even further from the Barcelona objective of 3%[20]. However it is not entirely arbitrary. With only a handful of rather uncharacteristic exceptions, the vast majority of regions (about fifty) with H2020-intensive EU innovation support, spend at least 1% of their GDP on R&D (Figure 1). Additionally, as most EU regions cluster around this value, it is not irrelevant or unrealistically beyond reach, as a target to aspire to. It therefore seems a fitting threshold for something like *a minimum of overall R&D activity* necessary for the region to stand a reasonable chance of graduating to H2020-intensive EU support.

We also set the reference point for the ratio H2020/ESIF to 1. The level of parity between H2020 and ESIF funds has a more straightforward interpretation. If the ratio is inferior to 1, it means the region in question is capturing less H2020 funding than it is allocating ESIF, which would be expected in

[17] There are five European Structural and Investment Funds: European regional development fund (ERDF); European social fund (ESF); Cohesion fund (CF); European agricultural fund for rural development (EAFRD); and European maritime and fisheries fund (EMFF).

[18] The regionalisation of data may be affected by a headquarter effect (HQE) in some Member States (particularly in France, Italy and Spain) due to the difference between the (physical) location of the actual research performer and the (legal) location of the beneficiaries' headquarter (this problem affects in particular large public research organisations). Data for France, Italy and Spain have been corrected to control for the actual regional location of Horizon 2020 beneficiaries. The period covered by Horizon 2020 indicators goes from 2014 onwards to June 2017

[19] A single indicator, such as R&D intensity, can of course be only very imperfectly suggestive of the diverse and multifaceted research and innovation activity and implied capability. Implicit in its use here is the, not entirely unjustified assumption (see, among others, Bell, 2009) that it correlates with a broad swathe of complementary innovation investments, activities and capabilities that are strictly not covered by the narrow definition of R&D.

[20] The Barcelona European Council's objective to raise overall R&D investment to 3% of GDP. See http://ec.europa.eu/invest-in-research/action/history_en.htm.

regions of low innovation capability. If the ratio is above 1, it means the region in question is capturing more in H2020 than the funding it allocates through ESIF[21], as would be expected of regions of higher innovation capability, particularly capital regions and other regions encompassing large cities.

Resulting groups of regions

Figure 6 plots data for EU regions along two axes:

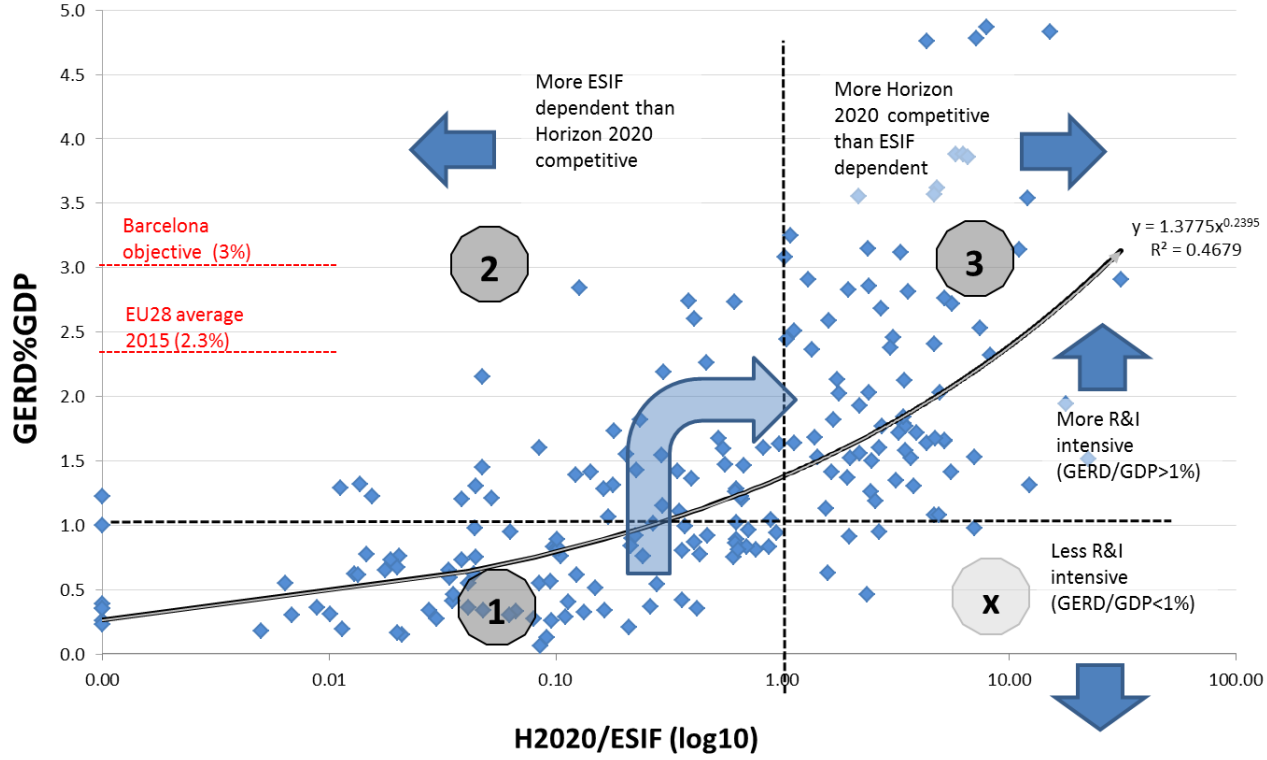
- a horizontal axis with R&D intensity, which we take as a summary measure of the overall research and innovation effort of each region (in public organisations and in businesses) and;
- a vertical axis showing the ratio between the amount of Horizon 2020 funding and the amount of ESIF funding on R&I by each region (henceforth the H2020-to-ESIF ratio) [22].

It is immediately apparent that there is a moderate correlation between R&D intensity and H2020-intensive EU support. Regions where R&D accounts for a more significant share of economic activity tend to be more successful in attracting H2020 funding, as reflected in the path of the continuous regression line. R&D intensity alone explains about 47% of observed differences in the H2020-to-ESIF ratio.

[21] On R&D intensity dimension (vertical axis), if x<1 then 'b' else 'a'. On the ratio H2020/ESIF dimension (horizontal axis), if y<1 then 'b' else 'a'

[22] More specifically, the horizontal axis corresponds to regional R&D intensity from Eurostat (2015), i.e. GERD(regio)/GDP(regio) and the vertical axis corresponds to the (log of) the ratio H2020/ESIF: (total H2020 funding captured at regional annualised)/(total ESIF allocated to R&I annualised).

Figure 6: Three main areas defining EU regions according to R&I spending and their use of EU funding



Taking into account the abovementioned thresholds, at least three[23] policy-relevant groups of EU regions with similar EU fund mobilisation experience for a given R&D intensity can be defined.

- Group 1: the "Lagging R&I regions" - area defined by low R&D intensity with higher ESIF dependence and lower capacities to capture H2020 funding.
- Group 2: the "Intermediary R&I regions" - area defined by a higher R&I intensity combined higher ESIF dependence and lower capacities to capture H2020 funding
- Group 3: the "Better-performing R&I regions" - area with higher R&D intensity combined with lower ESIF dependence.

Figure 6 points to a notional development path, whereby regions gradually progress from group 1, to group 2, through to group 3 as a function of the overall development of their innovation systems – loosely proxied here by R&D intensity. Of course actual development paths, and the policies needed to support them, are not going to be as straightforward. Yet broad tendencies such as these are indicative of the expected progression and relative weights of the two funding streams as a function of capability accumulation and are broadly suggestive of the workings of a methodical process of cumulative capability accumulation, such as described in Figure 1.

The number of Lagging and Better-performing R&I regions comprising groups 1 and 3 is approximately the same (77 versus 74 regions) but there are other important differences (see Table 2 below). In terms of population, Better-performing R&I regions are twice as large as the Lagging regions, suggesting that urban areas may be more represented in Better-performing regions than in

[23] The remaining quadrant (a possible Group 4) only gathers 5 atypical regions with a low R&I intensity but with good performance in H2020 compared the ESIF planning. However, the small number and diverse development and policy trajectories of these regions, preclude a meaningful grouping.

other areas. The overall amount of economic activity is an important delineator too. In terms of the size of their economies, as measured by GDP, Better-performing regions are about 3 times larger than Intermediary regions and 6 times larger than Lagging regions. However, these differences are particularly pronounced when considering R&D expenditures. The combined GERD of Better-performing regions is 4.5 times larger than Intermediary regions and 23 times larger than Lagging regions.

Table 2: Main characteristics of the 4 groupings of regions

	Number of Regions	%	Population (2015)	%	GDP (2015) Meur	%	Est. GERD in Meur	%
Area 1 'Lagging' regions	77	38.5%	118 548 493	23.4%	1 639 158	11.3%	11 152	3.8%
Area 2 'Intermediary' regions	44	22.0%	100 063 078	19.8%	2 091 122	14.4%	31 909	10.8%
Area 3 'Performing' regions	74	37.0%	272 429 984	53.8%	10 093 166	69.3%	245 553	83.0%
Area x regions	*5*	*2.5%*	*15 120 349*	*3.0%*	*742 928*	*5.1%*	*7 064*	*2.4%*
Total	200	100.0%	506 161 904	100.0%	14 566 374	100.0%	295 679	100.0%

Source: Eurostat. Own calculation

Figure 7 identifies all regions included in the analysis with their NUTS2 codes and Figure 8 places each regional grouping on a map. The discussion that follows examines each regional grouping separately.

Figure 7: EU regions according to their R&D intensity and participation in H2020 and planned ESIF allocation

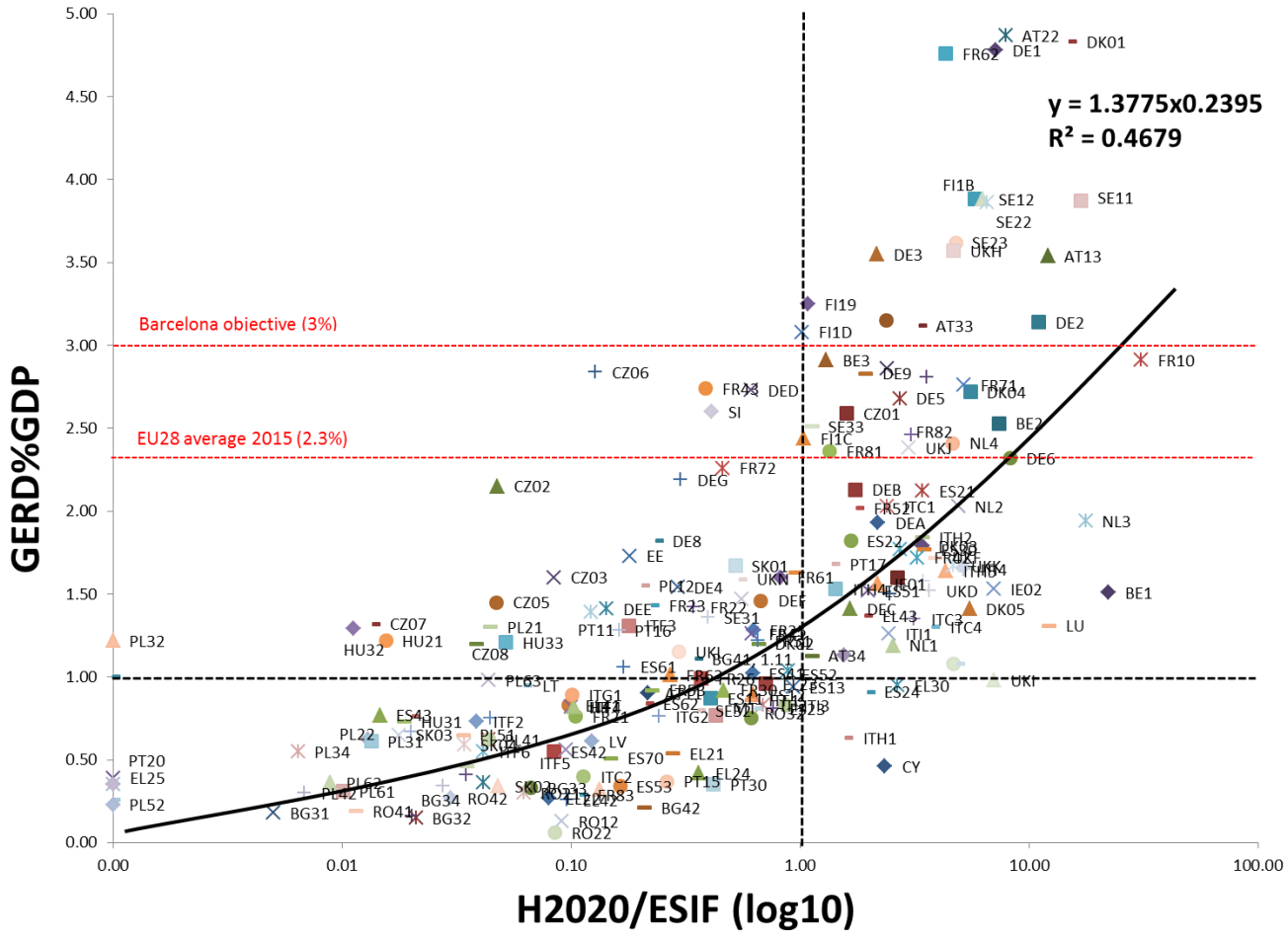
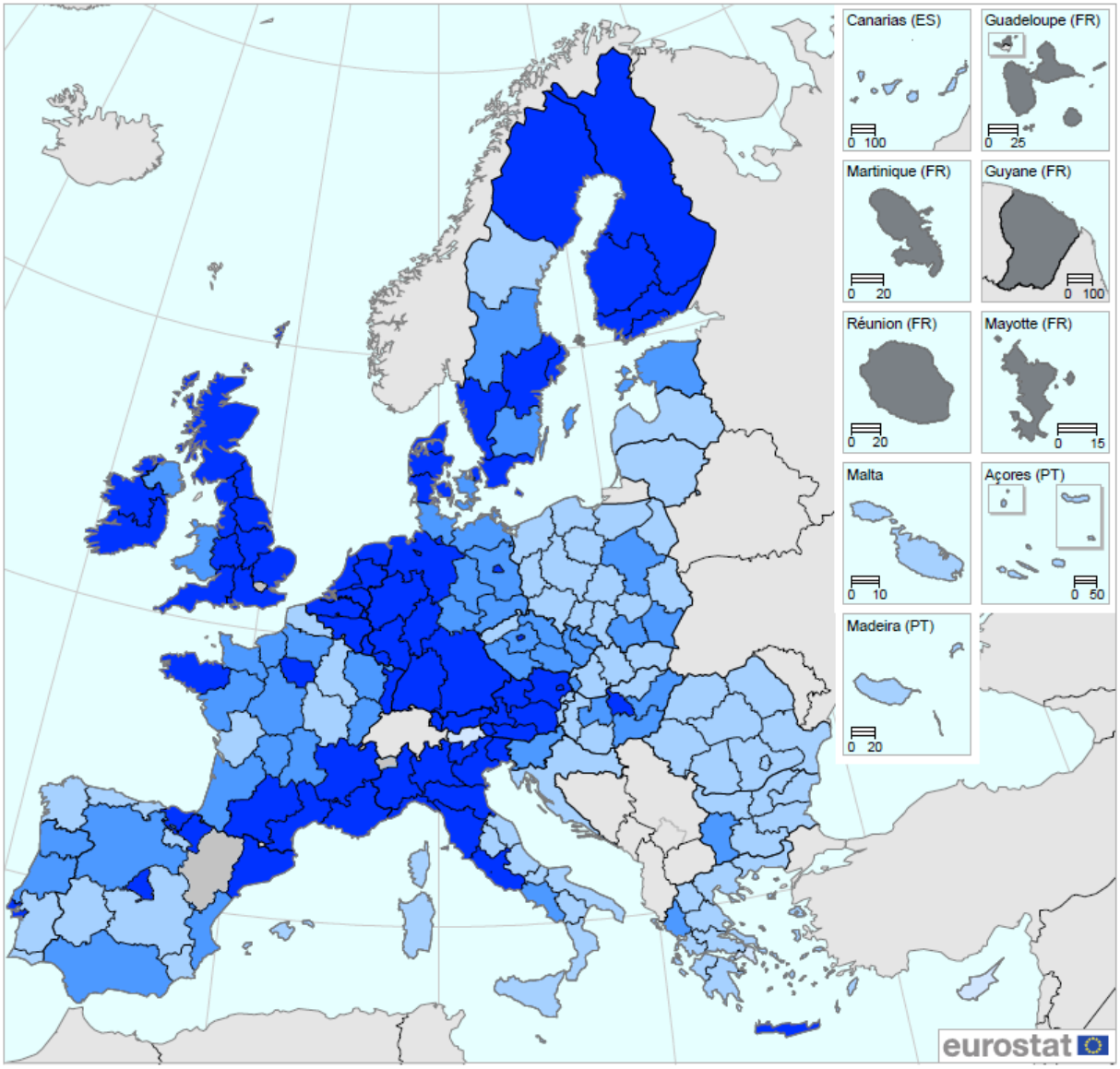


Figure 8: Geographical distribution of the identified groups



Group 1: Lagging R&I regions: Higher ESIF allocation than H2020 funding and low R&I intensity

This group of regions is the most numerous, comprising 38.5% of the 200 EU28 regions considered but represent 23.4% of population, 11.3% of GDP and only 3.8% of R&D expenditure. These regions allocate the highest share of ESIF to R&I. At the same time their performance in H2020 is generally low. This group is made of mostly new member states (outside of capital regions): PL, CZ, HU, SK, LV, and LT. The only exception is Portugal: almost all Portuguese Regions are also in this group. A first interpretation could be: Group 1 regions have research and innovation capabilities but are lagging

behind in terms of performance in competitive programmes such as Horizon 2020 due to lack of broad innovation capabilities and even possible competition between ESIF funding and H2020 (which is anecdotally reported in S2E national events but not yet demonstrated). Except Portugal, RIS3 strategies are designed at the national level and TO1 is managed partially (for Poland) or totally at the national level (CZ, HU, SK). As this is a group with many regions, further work may be useful in identifying further subgroups, to better discriminate regions and better shape policy directions.

Table 3: Lagging R&I regions: Higher ESIF allocation than H2020 funding and low R&I intensity

Group 1 ESIF allocation > H2020 funding R&I intensity <1 77 Regions (38.5%) 23.4 % of the EU population 11.3% the EU GDP 3.8% of EU R&D expenditure	AT11	Burgenland	ITF5	Basilicata
	BG31	Severozapaden	ITF6	Calabria
	BG32	Severen Tsentralen	ITG1	Sicilia
	BG33	Severoiztochen	ITG2	Sardegna
	BG34	Yugoiztochen	ITI2	Umbria
	BG42	Yuzhen Tsentralen	ITI3	Marche
	CZ04	Severozapad	LT	Lietuva
	EL11	Anatoliki Makedonia	LV	Latvija
	EL12	Kentriki Makedonia	MT	Malta
	EL13	Dytiki Makedonia	PL11	Lodzkie
	EL21	Ipeiros	PL22	Slaskie
	EL22	Ionia Nisia	PL31	Lubelskie
	EL23	Dytiki Ellada	PL33	Swietokrzyskie
	EL24	Sterea Ellada	PL34	Podlaskie
	EL25	Peloponnisos	PL41	Wielkopolskie
	EL41	Voreio Aigaio	PL42	Zachodniopomorskie
	EL42	Notio Aigaio	PL43	Lubuskie
	ES11	Galicia	PL51	Dolnoslaskie
	ES12	Principado de Asturias	PL52	Opolskie
	ES13	Cantabria	PL61	Kujawsko-Pomorskie
	ES23	La Rioja	PL62	Warminsko-Mazurskie
	ES42	Castilla-La Mancha	PL63	Pomorskie
	ES43	Extremadura	PT15	Algarve
	ES53	Islas Baleares	PT18	Alentejo
	ES62	Region De Murcia	PT20	Acores
	ES70	Canarias	PT30	Madeira
	FR21	Champagne-Ardenne	RO11	Nord-Vest
	FR26	Bourgogne	RO12	Centru
	FR30	Nord - Pas-De-Calais	RO21	Nord-Est
	FR53	Poitou-Charentes	RO22	Sud-Est
	FR83	Corse	RO31	Sud - Muntenia
	HR	Hrvatska	RO32	Bucuresti – Ilfov
	HU22	Nyugat-Dunantul	RO41	Sud-Vest Oltenia
	HU23	Del-Dunantul	RO42	Vest
	HU31	Eszak-Magyarorszag	SE32	Mellersta Norrland
	ITC2	Valle dAosta	SK02	Zapadne Slovensko
	ITF1	Abruzzo	SK03	Stredne Slovensko
	ITF2	Molise	SK04	Vychodne Slovensko
	ITF4	Puglia		

Group 2: 'Intermediary' R&I regions: Higher ESIF allocation than H2020 funding and higher R&I intensity

This intermediate group can be considered as a 'transition' stage between groups 1 and 3. Assuming that regional innovation systems in this group can continue on a sustainable development trajectory, progressively more R&D–intensive, more interactive and more ambitious innovation activity would reduce the dependence on ESIF funding and reinforce capacity of research organisations (public and private) to secure Horizon 2020 funding.

As these regions are positioned away from the central tendency of EU regions (denoted by the continuous regression line in Figures 1 and 2), it can be argued that their H2020 performance is below what would be expected in view of their R&D intensity. The challenge for these regions is to

identify the necessary bottlenecks, both in the orientation/governance of their public research and in terms of capability accumulation in the business sector so that they reap the benefits of the already notable local R&D activity. As this group of regions is also numerous, creating further subgroups could be useful. For instance, South Moravia (CZ06) is among the EU regions with the highest R&D intensity but with only a low ratio of H2020/ESIF, and is likely to require different policy interventions than other members of this group.

Table 4: Intermediary R&DI regions: Higher ESIF allocation than H2020 funding and higher R&I intensity

Group 2 ESIF allocation > H2020 funding R&I intensity>1 44 Regions (22%) 19.8% of the EU population 14.4% the EU GDP 10.8% of EU R&D expenditure	BG41	Yugozapaden	FR25	Basse-Normandie
	CZ02	Stredni Cechy	FR41	Lorraine
	CZ03	Jihozapad	FR43	Franche-Comte
	CZ05	Severovychod	FR51	Pays De La Loire
	CZ06	Jihovychod	FR61	Aquitaine
	CZ07	Stredni Morava	FR63	Limousin
	CZ08	Moravskoslezsko	FR72	Auvergne
	DE4	Brandenburg	HU21	Kozep-Dunantul
	DE8	Mecklenburg-Vorpomn	HU32	Eszak-Alfold
	DED	Sachsen	HU33	Del-Alfold
	DEE	Sachsen-Anhalt	ITF3	Campania
	DEF	Schleswig-Holstein	PL12	Mazowieckie
	DEG	Thuringen	PL21	Malopolskie
	DK02	Sjaelland	PL32	Podkarpackie
	EE	Eesti	PT11	Norte
	EL14	Thessalia	PT16	Centro
	ES41	Castilla Y Leon	SE21	Smaland och oarna
	ES52	Comunidad Valenciana	SE31	Norra Mellansverige
	ES61	Andalucia	SI	Slovenija
	FR22	Picardie	SK01	Bratislavsky Kraj
	FR23	Haute-Normandie	UKL	Wales
	FR24	Centre	UKN	Northern Ireland

Group 3: Better-performing R&I regions: Higher H2020 funding than ESIF allocation and higher R&I intensity

Group 3 could be considered as the target to reach for all other EU28 regions. This group gathers the regions with the highest R&D intensity and is mostly composed of regions from western EU (EU 15) and capital regions from new Member States.

Agglomeration in a region and the presence of large companies in particular, may influence considerably the level of R&D expenditure. Among the regions with the highest EU R&D intensity figure regions with important corporate presences, for instance by Airbus for the Midi-Pyrenees NUTS2 (FR62) region (now part of the new Occitanie region) in France. The Styria region (AT22) in Austria and Baden-Württemberg region (DE1) in Germany are also among the biggest R&D investors in the EU. Subgroups may better discriminate regions in this group too: as our chosen R&D intensity threshold is low (1%) there is ample room to discriminate regions between 1% and regions with the highest R&D intensity (near 5%).

Table 5: Better-performing R&I regions: Higher H2020 funding than ESIF allocation and higher R&I intensity

Group 3

H2020 funding capture > ESIF allocation
R&I intensity >1

74 Regions (37%)
53.8 % of the EU population
69.3% the EU GDP
83% of EU R&D expenditure

AT12	Niederosterreich	FR52	Bretagne
AT13	Wien	FR62	Midi-Pyrenees
AT21	Karnten	FR71	Rhone-Alpes
AT22	Steiermark	FR81	Languedoc-Roussillon
AT31	Oberosterreich	FR82	Prov-Alpes-Côte Dazur
AT32	Salzburg	HU10	Kozep-Magyarorszag
AT33	Tirol	IE01	Border Midland And W
AT34	Vorarlberg	IE02	Southern and Eastern
BE1	Region De Bruxelles-	ITC1	Piemonte
BE2	Vlaams Gewest	ITC3	Liguria
BE3	Region Wallonne	ITC4	Lombardia
CZ01	Praha	ITH2	Trento
DE1	Baden-Wurttemberg	ITH3	Veneto
DE2	Bayern	ITH4	Friuli-Venezia Giulia
DE3	Berlin	ITH5	Emilia-Romagna
DE5	Bremen	ITI1	Toscana
DE6	Hamburg	ITI4	Lazio
DE7	Hessen	LU	Luxembourg
DE9	Niedersachsen	NL1	Noord-Nederland
DEA	Nordrhein-	NL2	Oost-Nederland
Westfalen		NL3	West-Nederland
DEB	Rheinland-Pfalz	NL4	Zuid-Nederland
DEC	Saarland	PT17	Lisboa
DK01	Hovedstaden	SE11	Stockholm
DK03	Syddanmark	SE12	Östra Mellansverige
DK04	Midtjylland	SE22	Sydsverige
DK05	Nordjylland	SE23	Vastsverige
EL43	Kriti	SE33	Övre Norrland
ES21	Pais Vasco	UKC	North East (England)
ES22	Navarra	UKD	North West (England)
ES30	Comunidad De	UKE	Yorksh and The Humber
Madrid		UKF	East Midlands (England)
ES51	Cataluna	UKG	West Midlands (England)
FI19	Lansi-Suomi	UKH	East Of England
FI1B	Helsinki-Uusimaa	UKJ	South East (England)
FI1C	Etela-Suomi	UKK	South West (England)
FI1D	Pohjois- Ja Ita-Suomi	UKM	Scotland
FR10	Ile De France		
FR42	Alsace		

6 Concluding remarks: creating virtuous cycles of European funding, research excellence and economically useful innovation

Targeting ESIF support towards strengthening scientific excellence, by investing in, upgrading and reorienting regional and national research systems so that they are increasingly internationalised, appears a meaningful policy direction. ESIF support for capability development of this kind and associated governance reforms – e.g. in terms of recruitment, mobility, collaboration and evaluation practices - can progressively anchor research teams, institutions, and entire innovation systems into science and technology networks dealing with research questions of global significance. Insofar as international scientific collaboration is a precursor to H2020 participation, it should also help raise the participation of these regions in H2020, instigating a virtuous cycle of capability accumulation and scientific excellence.

The evidence presented in this report highlights that there are large gaps of both capabilities and outcomes between and across EU member states and their constituent regions. Mobilising EU funding for research and innovation in the countries and regions that stand to gain the most from them is a formidable challenge, requiring a context-specific understanding of the bottlenecks and tailored solutions. However, the stylised development path discussed in this report foresees both a division of labour and synergies between ESIF and H2020, and holds the following policy lessons for all developing regions:

- Whereas ESIF is geared towards strengthening innovation capabilities of all kinds, H2020 is very much focused on research problems of global economic significance. For new member states in particular, improving participation in H2020 is more than just about access to funding – it is about setting the basis for a public research system that operates at the global level.
- Lack of sufficient international orientation and connectedness is likely both a cause and an effect of the difficulties new member states face in participating in H2020. In this context, the opening up and internationalisation of research and innovation systems can be a profitable instrumental objective for innovation policy in general and RIS3 in particular.
- Disparity in business innovation capabilities, particularly between new and old member states, also appears to be a delineator of H2020 mobilisation. Strengthening the innovation capabilities of businesses can be a complementary instrumental objective for ESIF that would have many other obvious benefits besides H2020 mobilisation.
- National funding is also important. Success in the mobilisation of EU instruments also depends on complementary policy interventions at the national level. Regional innovation ecosystems are themselves part of national, and technological/sectoral innovation systems that cannot always be supported by EU funds.
- The synergies at the level of policies we highlight here – such as the conditionality of H2020 success on ESIF support for scientific excellence and of support for business innovation capabilities - are especially important for RIS3, as they imply that finely tailored territorial strategies employing a sophisticated and appropriate sequenced policy mix can be profitable.

Further analytical work can provide more specific directions for policy development. For instance, matching the regional data already examined with the specialisation areas available on the JRC's Eye@RIS3 database[24] or other economic indicators (unemployment rate, research capacity such as number of researchers etc.), similarities between regions within a group can be further investigated. A thematic approach can be envisaged by selecting areas in H2020 and considering only regions that have chosen the same area of specialisation in their RIS3. Boundaries can be refined or adapted in order to investigate more precisely regional characteristics. For example, Group 3 and 4 can each potentially be divided further into two sub-groups according to H2020 performance. The incidence and conditions under which (the anecdotally reported but not yet confirmed) discretionary substitution between ESIF and H2020 can occur should be investigated further.

[24] Innovation Priorities in Europe - http://s3platform.jrc.ec.europa.eu/map.

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Annex

Annex List of categories of intervention taken into account to define R&I in ESIF

002 Research and innovation processes in large enterprises-
056 Investment in infrastructure in SMEs-
057 Investment in infrastructure capacities and equipment in large enterprises-
058 Research and innovation infrastructures (public)-
059 Research and innovation infrastructures (private incl. science parks)-
060 Research and innovation activities in public research centre)-
061 Research and innovation activities in private research centre-
062 Technology transfer and university-enterprise cooperation-
063 Cluster support and business networks-
064 Research and innovation processes in SMEs (including voucher)-
065 Research & innovation processes, Techno transfer in low carbon economy-
066 Advanced support services for SMEs and groups of SMEs-
067 SME business development support to entrepreneurship and incubation-
073 Support to social enterprises (SMEs)-
101 Cross financing under the ERDF: support to ESF type actions

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