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**Working Paper**

## Regional participation to Research and Innovation programmes under Next Generation EU: The Portuguese case

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JRC WORKING PAPER

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Territorial Modelling and Analysis

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# Regional participation to Research and Innovation programmes under Next Generation EU: The Portuguese case

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## JRC Working Paper

JRC Working Papers on Territorial Modelling and Analysis No 07/2023

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## Executive Summary

The Next Generation EU (NGEU) is a temporary recovery instrument, designed to contribute to the sustainable recovery of the EU economy from the damage caused by the COVID-19 pandemic. The largest component of the NGEU (90%) is the Recovery and Resilience Facility (RRF). To apply for RRF funds, Member States had to submit a Recovery and Resilience Plan (RRP), describing how the funds will be used, and what milestones and targets the Plan is expected to achieve. The Plans include reforms and investment projects to be implemented by 2026.

Portugal requested an amount of €16,644 million, of which €1,344 million<sup>1</sup> (around 8% of the total) is for Research and Innovation (R&I) related measures. This amount is higher than what Portugal received from the EU Horizon 2020 (H2020) for 2014-2020 (€1,152 million<sup>2</sup>), and about half of the EU R&I budget (€2,403 million) under the European Structural and Investments (ESI) funds allocated for the period 2014-2020. Portugal ranks 13th in the EU27 in terms of its ability to attract competitive H2020 funds in 2014-2020 (Marques Santos et al., 2023). On average, in 2014-2020 the contribution of ESI funds to the financing of R&D expenditure was around 4 times higher than that of H2020 funds (Marques Santos et al., 2023), making the country more dependent on Cohesion Policy funds than on competitive H2020 funds to finance R&D (and innovation) activities. The RRF-R&I measures, under the form of funding programmes, are expected to complement other sources of funding Portugal has access in the programming period 2021-2027.

The present paper aims to examine regional participation in a new Portuguese Research and Innovation (R&I) programme (so-called 'Agendas for Industrialization') funded by the NGEU. The funds are accessible through competitive calls with no pre-regional allocation, similar to the calls in the previous programming (2014-2020) managed by National Operational Programmes. To perform our analysis, we created a novel dataset at the municipal-level using information from different sources. Our dataset covers the 308 municipalities in Portugal. 67% of them have at least one entity that has applied for a NGEU R&I-RRP programme in 2021-22 and 55% have at least one entity that is a final beneficiary of these programmes by 2025.

We found that the distribution of territorial participation of the NGEU-related programme is more similar to that observed for the European Commission's R&I Horizon 2020 programme than for the R&I funds under the Cohesion Policy (2014-2020).

The study also shows that those Portuguese territories which are more innovative and more active in international markets are also more likely to participate in the programme analysed.

Finally, the results show a rural-urban divide in participation in R&I funding and a lack of demand for R&I funding in less developed regions compared to more developed regions. This lack of demand may also be related to the sectoral patterns and business dynamics of the territories, as some economic activities are more likely than others to undertake R&D activities, and to be beneficiaries of R&I funding.

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<sup>1</sup> The amount refers only to measures related to R&I subsidies or similar, aimed at improving access to finance, and following the Marques Santos (2021) classification.

<sup>2</sup> This value corresponds to the total Net EU contribution extracted from the Horizon Dashboard on 21/12/2022.

# Regional participation to Research and Innovation programmes under Next Generation EU: The Portuguese case

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## Abstract

The paper aims to investigate regional participation in a new Portuguese Research and Innovation (R&I) programme (so-called 'Agendas for Industrialization') funded by the European Next Generation EU (NGEU). Using a probit model with sample selection and a novel dataset, we find that the distribution of territorial participation to the NGEU-related programme is more similar to that observed for the European Commission's R&I Horizon 2020 programme than for the R&I funds under the Cohesion Policy (2014-2020). Results also show a rural-urban divide in regional participation, which is eventually due to a lack of demand for this type of funding due to the sectoral composition of the economy in less developed regions.

Keywords: R&I funding; Recovery and Resilience Facility; Innovation; Portugal.

JEL code: O38, O31, R10.

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# 1. Introduction

In 2020, the COVID-19 pandemic was responsible for an unprecedented contraction of the EU economy, with the southern countries (Spain, Greece, Italy, Croatia, Malta and Portugal) most affected (Eurostat, [NAMA 10 GDP](#)). The magnitude of the crisis and its origin (health crisis) led the EU to agree on a strong support package – Next Generation EU (NGEU) – to help the sustainable recovery of the EU economy from the damage caused by the COVID-19 pandemic. The Recovery and Resilience Facility (RRF), with a budget of €723.8 billion, represents 90% of the NGEU. Funds under the RRF take the form of grants (€338 billion) and/or loans (€385.8 billion). The maximum grant allocations to each Member State were based on their positioning in terms of i) unemployment rate; ii) inverse GDP per capita; and iii) population (for more details see COM(2020) 408final/3). These criteria are similar to the ones used by the Commission to allocate Cohesion Policy funds to EU countries and regions.

To apply for RRF funds, Member States have to submit a Recovery and Resilience Plan (RRP), describing how the funds will be used, and what milestones and targets the plan is expected to achieve. The Plans include reforms and investment projects to be implemented by 2026.

Portugal requested an amount of €16,644 million, of which Research and Innovation (R&I)-related measures account for €1,344 million<sup>3</sup> (around 8% of the total) (Marques Santos, 2021). These measures, under the form of R&I funding programmes, are expected to complement other source of funding Portugal has access in the programming period 2021-2027, such as Horizon Europe (successor to Horizon 2020) and Cohesion Policy funds.<sup>4</sup>

The three EU programmes mentioned above have different funding mechanisms and governance models, although they have a similar primary objective: to support R&I activities. For example, Horizon Europe (or Horizon 2020) is a competitive R&I funding programme managed centrally by the European Commission, R&I funding programmes under Cohesion Policy aimed at regional development are managed nationally or regionally, and the RRF, which is mainly aimed at economic recovery, allocates R&I activities within broader national plans. Therefore, any comparative analysis of their territorial distribution can be very interesting for policy makers and novel from an academic point of view.

Using an original dataset on applicants and final beneficiaries of the R&I-related funding ('Agendas for Industrialization') under the Portuguese RRP<sup>5</sup>, this paper aims to understand the territorial participation in R&I-RRF funding programmes and to compare similarities with the geographical distribution of other EU R&I funding programmes. We decided to focus on innovation measures due to the importance of innovation to overcome the negative effects of the Covid-19 crisis (Marques Santos et al. 2021), as well as, other economic downturns (Hausman and Wesley 2014), as empirically tested in scientific literature.

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<sup>3</sup> The amount refers only to measures related to R&I subsidies or similar, aimed at improving access to finance, and following the Marques Santos (2021) classification.

<sup>4</sup> For more details see pp. 212-215 of the [Portuguese RRP](#).

<sup>5</sup> The Portuguese case study was selected due to the availability of data on both applicants and beneficiaries of the RRP.

This paper aims to answer to the following research questions: (1) In which Portuguese regions are hosted entities that apply and are then successfully selected to receive a RRF funding for R&I?; (2) Is there a territorial participation of R&I RRF funds similar to other EU programmes managed at regional, national or EU level?; (3) What are the socio-economic characteristics of the regions with applicants and beneficiaries of the R&I RRF funding programmes?

To answer to these questions, we combine detailed R&I-RRF data on the location of applicants and beneficiaries at the municipal-level with other different data sources on the territorial distribution of Cohesion Policy 2014-2020 and Horizon 2020 funds, as well as socio-economic indicators characterizing the municipality before the implementation of the RRF from Statistics Portugal. We use a probit model with sample selection, and a maximum likelihood method, to estimate and explain the probability of participating in R&I-RRF projects.

This paper presents three novelties. First, it is the first to assess the territorial participation in NGEU-related R&I funding programmes in Portugal. Second, it analyses the link between territorial participation to NGEU and past experience with different EU programmes managed regionally, nationally (Cohesion Policy 2014-2020) or centrally at Commission's level (Horizon 2020). Indeed, most of the existing studies assessing the regional concentration of R&I funding (e.g. Dotti and Spithoven 2018; Archibugi et al. 2021 and Mieszkowski and Barbero 2021) do not perform such type of analysis, focusing only on regional characteristics or past performance under the same funding programme.<sup>6</sup> We also acknowledge that this type of analysis is difficult to conduct due to data unavailability and could be challenging from a methodological point of view due to the difference between the funding mechanisms. Third, it contributes to the literature on the geography of R&D and innovation funding, which is still in an early stage and the topic not well explored (Aagaard et al. 2020), as well as to the debate on the governance model of the NGEU (see e.g. Crescenzi et al. 2021).

The paper is divided into seven sections. After the introduction, section 2 summarizes the main findings in the literature on the territorial concentration of R&I funds. Section 3 describes the characteristics of the R&I programmes funded by Next Generation EU in Portugal. Sections 4 and 5 present the econometric model and the data used, respectively. Section 6 discusses the results and section 7 concludes.

## 2. Territorial concentration of Research and Innovation funds: a literature review

The main EU funding instruments to support Research and Innovation (R&I) are:

- i) EU Framework Programmes (FP) until 2013, replaced by Horizon 2020 (H2020) for the period 2014-2020 and Horizon Europe (HE) for 2021-2027;
- ii) ESI funds (supporting Cohesion Policy) under the Thematic Objective 1 (TO1) for 2014-2020 period and Policy Objective 1 (PO1) for 2021-2027.

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<sup>6</sup> Hoekman, et al. (2013) assessed the relationship between participation in the R&I programme (FP6 – Sixth Framework Programme) and by the participation in the same programme in the previous period (FP5). However, these authors do not provide an assessment of the relationship between participation in FP6 and other R&I programmes.



Even if these funds have overlapping objectives (to support research, development, and innovation activities), they have different focus, scope and funding mechanism. On the one side, FP (which includes H2020 and HE)<sup>7</sup> is a financial instrument aiming at supporting European R&I capacity by building the European Research Area and driving scientific excellence and technological leadership (Dotti and Spithoven 2018). The funding mechanism of the FPs covers a wide range of scientific disciplines and sectors to improve Europe's competitiveness. On the other side, ESI funds aimed to support research and innovation within specific EU regions to foster economic development and reduce territorial disparities. ESI funding for research and innovation is also targeted at specific areas selected on the basis of regional priorities and strategies, such as the smart specialisation strategy, which identifies priority areas for investment.

Whereas FP funds are managed directly by the European Commission (EC), and access to funds is available through spatially-blind competitive calls at EU-level, ESI funds are pre-allocated to EU regions (or countries) at the beginning of each programming period (Multi-Annual Financial Framework) based on socio-economic criteria (GDP and unemployment levels) and size (measured by population), and are then managed by regional or national authorities. These authorities are responsible for disbursing and managing the funds by setting eligibility criteria and application procedures.

In summary, FP is a broader EU programme to support R&I on a European scale, whereas ESI funds are targeted at specific regions or areas to promote cohesion through R&I activities. Their different design has led to a different geographical concentration across EU regions, with more developed regions attracting not surprisingly more FP/H2020 funding (Dotti and Spithoven 2018; Archibugi et al. 2021), while less developed regions are more dependent on ESI funds (Varga and Sebestyén 2017).

Scientific literature has provided evidence on the determinants of territorial concentration of both FP/H2020 funds (see e.g. Dotti and Spithoven 2018; Archibugi et al. 2021) as well as R&I ESI funds (see e.g. Mieszkowski and Barbero 2021). For instance, Archibugi et al. (2021) show that competitive-based H2020 funds are concentrated in more innovative, densely populated and capital regions. These findings are in line with Dotti and Spithoven (2018), who underline that the territorial concentration of FP funding is caused by the cumulative nature of knowledge, with more developed regions attracting more funds because they are regions where R&D activities are also more concentrated.

By looking at the territorial distribution of R&I-related ESI funds in Poland (a country where more than 85% of the population lives in less developed regions<sup>8</sup>), Mieszkowski and Barbero (2021) found evidence of an urban-rural divide across Nuts-3 level regions. Although less developed regions (classified at Nuts 2-level) are the ones receiving more in *per capita* terms under the ESI funds allocation criteria, within these territories smaller and less innovative regions have more difficulties in attracting R&I projects. All the above-mentioned studies related to EU funds seem to coherently confirm the findings highlighted in the literature on the geography of innovation (see e.g. Feldman 1994; Gordon and McCann 2005). In particular, innovation is spatially concentrated where knowledge inputs (ie. technological infrastructure) are also concentrated as

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<sup>7</sup> For more details see the [official webpage of the European Commission](#).

<sup>8</sup> Based on the cohesion criteria for regions classification (more developed, less developed or transition regions) in the period 2014-2020 and Eurostat data on population for 2014-2020.

they facilitate innovation diffusion by reducing its risks and lowering its costs (Feldman, 1994). Therefore, the main arguments explaining the concentration of R&D funding may also be related to economies of scale (Krugman 1991) and agglomeration effects (Henderson 1988; Thisse 2000; Bonaccorsi and Daraio 2005; Liargovas and Daskalopoulou 2011; Hellström et al. 2018). This in turn can also be linked to the so-called Myrdal (1957) effect. As knowledge is cumulative, it tends to polarize across territories and/or clusters (Dotti and Spithoven 2018). In relation to the concept of concentration, Hoekman et al. (2013) show that previous FP experience positively influences participation in the next rounds of FP funding. Furthermore, these authors stress how this effect could be even more important than the degree of innovativeness of the regions (proxied by number of publications). As a result, this tendency would lead to a cumulative concentration of R&I funding across the same territories.

This framework leads us to define the first three hypotheses to be tested in this analysis:

*Hypothesis 1: Participation in R&I funding programme is concentrated in more innovative regions*

*Hypothesis 2: Participation in R&I funding programme is concentrated in more developed regions*

*Hypothesis 3: Participation in an R&I funding programme depends on previous participation in similar programmes*

To complement the previous literature on economic geography, we also look at firm-level studies that assess the determinants of participation in R&D and/or innovation programmes. There are essentially four main factors that explain the decision to apply for a R&D programmes:

- Knowledge capacity, proxied by human capital qualification or R&D expenditures (Blanes and Busom 2004; Aschhoff 2010);
- Path-dependency on public funding (Aschhoff 2010; Enger and Castellacci 2016; Busom et al 2017);
- Entities' size measured by employment level (Blanes and Busom 2004; Aschhoff 2010; Enger and Castellacci 2016), which is in turn correlated with overall R&D activity (Altomonte et al. 2016) and/or innovation capacity (Du et al. 2007);
- Financial health (Blanes and Busom 2004) or accessibility to external sources of funding (Hud and Hussinger 2015; Enger and Castellacci 2016).

The above factors influence the decision to participate in public R&D funding schemes, together with the past competitiveness performance of the applicants measured either via productivity or via export intensity (Santos et al. 2019). This survey on firm-level literature tends to show some similarities with the findings coming from the economic geography literature. On average, more innovative firms, with experience in previous R&I programmes and a higher economic performance are more likely to participate in R&D programmes. However, firm-level analyses also point to the importance of a firm's internal and/or external financing capacity on the decision to apply. For instance, Hud and Hussinger (2015) find that firms that have more difficulties in attracting external financing are more likely to apply for subsidies in a period of economic crisis. In the present context, the economic context is also assumed to be also extremely important as a potential explanatory factor, in line with our fourth hypothesis to be tested:

*Hypothesis 4: Regions with more financial constraints are more likely to host entities applying for public R&I funding schemes*

### 3. The characteristics of R&I programs funded by NGEU: the Portuguese case

The Portuguese RRP is made of 20 components divided by 83 investment and 37 reform categories. In total, it sums up to €16.6 billion (84% grants and 16% loans). According to Marques Santos (2021), innovation-related measures linked to R&I funding are included in Components 5 (Investment and Innovation) and 12 (Sustainable Bioeconomy) of the Plan, as described in Table 1, and they account for €1,344 Million of the total grants.<sup>9</sup> This amount is higher than what Portugal received from the EU Horizon 2020 (H2020) for 2014-2020 (€1,152 million<sup>10</sup>), and about half of the EU R&I budget (€2,403 Million) under the European Structural and Investments (ESI) funds allocated for the period 2014-2020.<sup>11</sup> Portugal ranks 13th in the EU27 in terms of its ability to attract competitive H2020 funds in 2014-2020 (Marques Santos et al., 2023). On average, in 2014-2020 the contribution of ESI funds to the financing of R&D expenditure was around 4 times higher than that of H2020 funds (Marques Santos et al., 2023), making the country more dependent on Cohesion Policy funds than on competitive H2020 funds to finance R&D (and innovation) activities.

Table 1. Subsidies to R&I investments included in the Portuguese RRP

Measures	Amount (€ Million)	Main beneficiaries	Main public body managing the measure
RE-C05-i01.01 - Mobilising Agendas/Alliances for Reindustrialisation	558	Companies (as project leaders and consortia members, as well) and entities from other legal form (e.g. associations, public bodies) as members of consortia but not as leaders	IAPMEI, I.P. - Agency for Competitiveness and Innovation (under the scope of Ministry of Economy and Maritime Affairs)
RE-C05-i01.02 - Agendas/Green Alliances for Reindustrialisation	372		
RE-C05-i02 - Interface mission - Renewal of the scientific and technological	186	Technology and innovation centres (in the legal form of associations and bodies of public administration) and laboratories	ANI - National Innovation Agency (owned by the Ministry of Science, Technology and Higher Education and Ministry of Economy and Maritime Affairs)
RE-C05-i03 - Research and innovation agenda for sustainable agriculture, food and agro-industry	93	Technology and innovation centres, laboratories, public administration, higher education institutions	IFAP, I.P. - Institute for Financing Agriculture and Fisheries (Ministry of Agriculture and Food)

Continued on next page ...

<sup>9</sup> The loans (€1,675 Million) of Component 5 are not included in the present analysis because the “final beneficiaries are not only actors of the regional innovation ecosystem (...) [and] only part of it (unknown value when the study was performed) can be used to support innovation-related activities; in fact, R&D and innovation activities are just one of the typologies that this instrument can support financially” (Marques Santos, 2021:25-34).

<sup>10</sup> This value corresponds to the total net EU contribution extracted from the Horizon Dashboard on 21/12/2022.

<sup>11</sup> Based on DG REGIO Cohesion Data Platform (data extracted on 8/12/2022).

Table 1. Subsidies to R&I investments included in the Portuguese RRP (continuation)

Measures	Amount (€ Million)	Main beneficiaries	Main public body managing the measure
TC-C12-i01 - Bioeconomy: (1) research, development and innovation lines	135	Companies, higher education institutions, non-governmental organizations, scientific and technological centres (only for textile, clothing, footwear and natural resin activities)	Environmental fund (under the Ministry of Environment)
<b>Total</b>	<b>1,344</b>		

Source: Own elaboration based on Marques Santos (2021) and complemented by information extracted from '[Recuperar Portugal](#)', [IAPMEI](#), [ANI](#), [IFAP](#) and '[Fundo ambiental](#)' webpages.

Note: The classification of the legal form of the technology and innovation centres is based on Orbis data. Part of the component 10 (Sea) identified as an innovation-related measure in Marques Santos (2021) is not included in the table because the investments under this component are aimed at improving the infrastructure of research centres, HUBs and clusters and not at financing R&D expenditure related to the development of a new product and/or process.

The governance of the Portuguese RRP is centralized at national-level with different ministries managing the funds associated with their own thematic responsibility. For example, as described in Table 1, the management of the innovation-measures of the Portuguese RRP is divided among several public bodies belonging to different ministries (e.g. Ministry of Economy and Maritime Affairs, Ministry of Science, Technology and Higher Education, Ministry of Agriculture and Food, Ministry of Environment). The governance of the RRP differs from that of the Cohesion Policy where, in addition to the national Operational Programmes (OPs), there are seven regional OPs (for each Nuts-2 level region). Therefore, the governance model of the innovation-measures of the Portuguese RRP is similar to the National OPs funded by the Cohesion Policy.

The present study focuses on the analysis of the so-called 'Agendas for Reindustrialisation' and 'Green Agendas for Reindustrialisation', which cover almost 70% of the innovation-related investments in the RRP (€930 million of grants), because only for these measures is information on the applicants publically available. For the other R&I measures in Table 1 the only information available is the list of final beneficiaries (approved projects), and therefore we are unable to control for the effect of selection bias in the decision to apply (as we can do for the 'Agendas'). In addition, measures RE-C05-i03 and TC-C12-i01 in Table 1 are limited to some sectors only, namely agriculture, agro-industry (RE-C05-i03), textiles, clothing, footwear and natural resin activities (TC-C12-i01), whereas the so-called 'Agendas' do not have a pre-defined sectoral focus. Similarly, measure RE-C05-i02 (interface mission) is targeted only at some entities, namely certified or officially recognized 'Collaborative laboratories' (35 entities) and 'Technology and innovation centres'. Therefore, due to these different selection criteria, it does not seem appropriate to include these measures in the analysis.

The main objective of the R&I programme, so-called 'Agendas', is to financially support R&D and innovation investments, carried out in a partnership where the project leader is a private company. The investment projects should focus on enhancing the competitiveness and resilience of the Portuguese economy and, in particular, contribute to the following strategic objectives by 2030:

- (i) Supporting changes in the specialization patterns of the Portuguese economy towards higher value-added and knowledge-intensive activities, with a focus on the international market and the creation of skilled jobs;
- (ii) Improving the exports of goods and services, with the aim of achieving an export volume equivalent to 50% of the GDP by 2027;
- (iii) Increasing R&D investments to reach the target of 3% of GDP by 2030;
- (iv) Reducing CO2 emissions by 55% by 2030.

The funds are accessible through competitive calls without regional allocation, similar to the calls in the previous programming period 2024-2020 managed by the National OP. In chronological order, a first 'call for ideas' ([Notice n.º 01/C05-i01/2021](#)) was organised followed by a 'call for applications' ([Notice n.º 02/C05-i01/2022](#)). The first step – 'call for ideas' - selected the consortia that would implement the investment projects under these 'Agendas'. This 'call for ideas' was open for the submission of proposals between 01/07/2021 and 30/09/2021. Once the consortia had been selected, a second phase of calls was launched (31/01/2022 – 31/03/2022) to identify the final projects (and beneficiaries) to be funded from among the projects selected in phase 1. The objective of this call is to allocate all the available funds (€930 million in grants) to the so-called 'Agendas for Reindustrialisation' and 'Green Agendas for Reindustrialisation'. Following phase 1, 143 proposals for ideas were analysed and 70 agendas were selected for phase 2. At the end of the process, 64 applications were retained as final proposals for funding. More details on the selection criteria used can be found in Appendix A. The total estimated investment to be achieved by RRP beneficiaries by 31/12/2025 is around €8.4 billion, which is higher than the total eligible cost of R&I projects financed by ESIF in 2014-2020 (Table 2).

Table 2. Number of projects and amount of investment by R&I fund: RRF-R&I (2022-2025) versus ESIF-R&I and H2020 (2014-2020)

Type of R&I funds	Nr. Project	Investment	Investment by project
RRF-R&I, 2022-2026 (estimated)	64	8,385,428,255 €	131,022,316 €
ESIF-R&I, 2014-2020	5,638	6,997,286,777 €	1,241,094 €
ESIF-R&I, 2014-2020: Regional OP	2,787	1,808,590,773 €	648,938 €
Maximum	1	48,314,069 €	48,314,069 €
P(99)	28	333,404,390 €	11,907,300 €
ESIF-R&I, 2014-2020: National OP	2,851	5,188,696,005 €	1,819,957 €
Maximum	1	120,476,104 €	120,476,104 €
P(99)	29	1,226,495,368 €	42,292,944 €
Horizon 2020, 2014-2020	3,947	1,306,419,121 €	330,990 €

Source: Own elaboration based on data from [IAPMEI webpage](#) (R&I-RPP), [Portugal 2020](#) (ESIF-R&I) and [Cordis](#) (H2020) webpages.

Note: RRF-R&I amount refers to the estimated total investment of the projects in the 'Agendas for Reindustrialization' and to the total of cost of all the members of the consortia. The H2020 investment value refers to the total cost of the project-participants located in Portugal and not to the total project cost.

The average size of RRF-R&I projects is around €131 million per project, which is very close to the ESIF-R&I project with the highest eligible cost under the National OP (€120 million). Table 2 also shows that the Regional OP ESIF-R&I projects under Regional OPs are, on average, smaller than those financed under the National OP. In fact, the National OP tends to finance larger projects and projects in partnerships (Santos et al. 2022), similar characteristics to the projects financed by the RRP.

#### 4. Econometric strategy

To estimate and explain the regional probability of participation in the so-called ‘Agendas for Reindustrialisation’ and ‘Green Agendas for Reindustrialisation’ (hereafter referred to as RRF-R&I investments or programmes), we use a bivariate probit model with sample selection (Van de Ven and Van Pragg 1981). This estimation method, similar to a Heckman’s (1979) two-step method, allows to correct for sample selectivity when the outcome is not random, and therefore, a simple probit for a selected sub-sample would lead to biased results.

In the present study, the outcome variable corresponds to the successful participation in a R&I-RRF programme ( $y_i^*$ ) which depends on the decision to apply ( $d_i^*$ ). Indeed, as expressed in equation (1.2), the successful participation is only observed if the decision to apply is  $> 0$ . Furthermore, a standard probit estimation (i.e. without sample selection) applied to the outcome equation (1.2) will produce biased results if the correlation coefficient ( $\rho$ ) between the error terms of the two equations ( $\varepsilon_{1i}$  and  $\varepsilon_{2i}$ ) is  $\neq 0$ . However, if  $\rho = 0$  this means that there is no selection bias and the participation equation can be estimated independently. Using a probit model with sample selection provides consistent and asymptotically efficient estimates for all the parameters in the presence of the above-mentioned circumstances (Van de Ven and Van Pragg 1981). This model also assumes that the error terms ( $\varepsilon$ ) follow a standard bivariate normalization distribution (2.1 and 2.2).

$$d_i^* = W_i\gamma + X_i\beta + \varepsilon_{2i}; \quad d_i = \begin{cases} 1, & \text{if } d_i^* > 0, \\ 0, & \text{else,} \end{cases} \quad (1.1)$$

$$y_i^* = X_i\beta + \varepsilon_{1i}; \quad y_i = \begin{cases} 1, & \text{if } y_i^* > 0, d_i = 1, \\ 0, & \text{if } y_i^* \leq 0, d_i = 1, \\ \text{missing,} & \text{else} \end{cases} \quad (1.2)$$

where

$$\varepsilon_{1i} \sim N(0,1) \quad (2.1)$$

$$\varepsilon_{2i} \sim N(0,1) \quad (2.2)$$

$$\text{corr}(\varepsilon_{1i}, \varepsilon_{2i}) = \rho$$

Our equations (1.1. and 1.2.) are indexed to municipality  $i$  and adopt a cross-sectional structure, where the dependent variables measured at time  $t$  are explained by variables referring to the period  $t - 1$  (i.e. before the decision to apply and to be selected). Both equations (1.1. and 1.2.) are estimated using the same vector of explanatory variables ( $X$ ), but the selection equation (1.1.) also includes a vector of explanatory variables ( $W$ ) that are not included in the outcome equation (1.2.), called as exclusion restrictions (Dubin and Rivers

1990). The presence of at least one variable not included in the outcome equation allows the model to be well identified and helps it to converge (Bushway et al. 2007).

For the present study, we have chosen to use as the dependent variable in the outcome equation the binary variable equal to one if the municipality has at least one entity located in the territory that is a beneficiary of the programme (and 0 otherwise), instead of the amount of the investment. This choice can be justified as the investment volume refers to the amount planned until 2025, and may change during the implementation phase; as may the number of entities involved in the consortia. However, as a robustness test, we have also analysed (and reported in Appendix E) the results of a Poisson model with sample selection, where the dependent variable refers to the number of times that an entity located in municipality  $i$  is a beneficiary from the RRF-R&I measures.

To identify the variables to be included in the outcome and selection equations we rely on the findings summarized in section 2 and adapted to the characteristics of the RRF-R&I programme described in section 3. Then, based on the existing literature and the objective of the RRF, we use the following explanatory variables in our regressions to explain the probability of applying for and, to receiving the funds (the data are at the municipal level):

- Past experience in 2014-2020 EU funding schemes (Cohesion policy funds managed at national or regional level, and H2020);
- Share of employment with tertiary education (average 2017-2019), as a proxy for knowledge capacity;
- Past innovation performance measured by the total R&D expenditure as a share of total employment (average 2017-2019);
- Past competitiveness performance measured by the share of goods exports in total turnover (average 2017-2019);
- Region dummy at NUTS-2 level.

As an exclusion restriction in the selection model, we use variables related to the Covid-19 socio-economic effects to proxy financial health. Therefore, we include the following variables in the first step of the model:

- Negative Covid-19 turnover effect: dummy variable equal to 1 if the average turnover of the firms decreased between 2019 and 2020;
- Negative Covid-19 employment effect: dummy variable equal 1 if there was a decrease in the average employment level of the firms between 2019 and 2020 dropped;
- Interaction term between these two variables.

These three variables are not correlated with the probability of being a recipient municipality of the R&I-RRP funds in our sample, as shown in Table B1 and Table B2 in Appendix B. Our rationale for including them in the application decision, which is also related to the investment decision, is that they are likely to be influenced by the socio-economic context of the municipality in two different ways:

- Covid-19 significantly affected firms in terms of turnover/employment, therefore, with harmful effects on cash-flow/equity needed to invest in R&I; also, increasing uncertainty about the future may discourage R&I investment (see e.g. Archibugi et al. 2013) - *Hypothesis of a negative effect of Covid-19 on the decision to apply*;
- Covid-19 significantly affected firms in terms of turnover/employment, but new market trends and the need to overcome the current crisis may have led to the decision to invest in R&I. This reasoning is line with previous studies showing that firms that invest in R&I are less affected by the crisis (see e.g. Marques Santos et al. 2021) or apply for more public funding due to financing constraints caused by the crisis (see e.g. Hud and Hussinger 2015) - *Hypothesis of a positive effect of Covid-19 on the application decision*.

## 5. Data

### 5.1. Data source

To carry out our analysis, we created a novel dataset at municipal-level using information from different sources. The list of RPP-R&I applicants and beneficiaries, their location, as well as, the planned investment amount were extracted from the [IAPMEI webpage](#) and the additional information provided by the Portuguese Agency for Competitiveness and Innovation (IAPMEI). The list of ESIF-R&I (under national and regional OPs) and H2020 beneficiaries in 2014-2020, together with their location and total project expenditure, comes from the [Portugal 2020](#) and [Cordis](#) websites, respectively. If the location at municipal-level was missing in the previous databases, we used the information available in [BvD Orbis](#) (city and the postal code of the entity) to identify the municipality.

To link postal codes and municipalities, we use the correspondence table produced by '[Data Science for Social Good](#)'. Statistical information on the socio-economic characteristics of the municipalities comes from [Statistics Portugal \(INE\)](#). Table 3 describes the variables included in the database. Data on R&I-RRP applicants and beneficiaries were collected between December 2021 and June 2022. Information about Cohesion Policy 2014-2020 beneficiaries refers to the reporting data of 30/09/2022.

Table 3. Variable description

Variable name	Variable description	Source
Applicant R&I (RRF) (Y/N)	= 1 if there is at least one applicant (2021-2022) to RRF-R&I measures in the municipality; 0 otherwise	Own estimation based on IAPMEI data
Beneficiary R&I (RRF) (Y/N)	= 1 if there is at least one beneficiary of the RRF-R&I measures (2022-2025) in the municipality; 0 otherwise	Own estimation based on IAPMEI data
Beneficiary R&I (ESIF) regional OP (Y/N)	= 1 if there is at least one beneficiary of the R&I (ESIF) measures managed under the regional OP (2014-2020) in the municipality; 0 otherwise	Own estimation based on Portugal 2020

Continued on next page ...



Table 3. Variable description (continuation)

Variable name	Variable description	Source
Beneficiary R&I (ESIF) national OP (Y/N)	= 1 if there is at least one beneficiary of the R&I (ESIF) measures managed under the national OP (2014-2020) in the municipality; 0 otherwise	Own estimation based on Portugal 2020
Beneficiary H2020 (Y/N)	= 1 if there is at least one beneficiary of H2020 (2014-2020) in the municipality; 0 otherwise	Own estimation based on Cordis data
Covid-19 turnover's effect (Y/N)	= 1 if a municipality observed a drop in firms' turnover between 2019 and 2020; 0 otherwise	Own estimation based on Statistics Portugal
Covid-19 employment's effect (Y/N)	= 1 if a municipality observed a drop in firms' employment level between 2019 and 2020; 0 otherwise	Own estimation based on Statistics Portugal
Covid-19 effect (Y/N)	= 1 if a municipality observed a simultaneous drop in firms' turnover and employment level between 2019 and 2020; 0 otherwise	Own estimation based on Statistics Portugal
Share employment tertiary education	Share of employment with tertiary education (average 2017-2019) in the municipality	Own estimation based on Statistics Portugal
R&D expenditure per job	Gross R&D expenditure per capita (average 2017-2019) in the municipality in the municipality	Own estimation based on Statistics Portugal
Exports over turnover	Share of exports of goods over total turnover (average 2017-2019) in the municipality	Own estimation based on Statistics Portugal

Source: Own elaboration.

## 5.2. Data description

Our dataset covers the 308 municipalities in Portugal. 67% of them have at least one entity that has applied for a R&I-RRP programme in 2021-22, and 55% have at least one entity that is a final beneficiary of these programmes by 2025 (Table 4). Past experience with R&I subsidies from ESIF or H2020 in 2014-2020 is observed in 75% of the Portuguese municipalities. However, there is a higher territorial concentration when the funds are managed at EU-level (43% for H2020) compared to country-level (52% for ESIF-R&I national OP) or regional-level management (64% for ESIF-R&I regional OPs).

Table 4 also shows a higher frequency of municipalities affected by a decrease of firms' turnover (85%) in the period 2019-2020 (proxy for the Covid-19 effect) than by employment (70%). Municipalities affected by both (decrease of firms' turnover and employment) represent 62% of the total. The share of employment with tertiary education (2017-2019) is equivalent to 14.7%. The average R&D expenditure per worker registered in 2017-2019 is equal to €244. Exports represent on average (2017-2019) around 12% of firm's turnover. Table D1 in Appendix reports the results of the t-test for equality of means. It shows that municipalities with applicants and beneficiaries are on average outperforming those municipalities with non-applicants or non-beneficiaries of the RRF-R&I programme.

Table 4. Descriptive Statistics: Mean, Standard Error, Min and Max

Variable	Mean	Std. dev.	Min	Max
Applicant R&I (RRF   2021-2022) (Y/N)	0.672	0.470	0	1
Beneficiary R&I (RRF   2022-2025) (Y/N)	0.552	0.498	0	1
Beneficiary R&I (ESIF or H2020   2014-2020) (Y/N)	0.753	0.432	0	1
Beneficiary R&I (ESIF   2014-2020) (Y/N)	0.727	0.446	0	1
Beneficiary R&I (ESIF  2014-2020) regional OP (Y/N)	0.636	0.482	0	1
Beneficiary R&I (ESIF  2014-2020) national OP (Y/N)	0.516	0.501	0	1
Beneficiary Horizon 2020 (2014-2020) (Y/N)	0.429	0.496	0	1
Negative Covid-19 effect on employment (2019-20) (Y/N)	0.701	0.458	0	1
Negative Covid-19 effect on turnover (2019-20) (Y/N)	0.847	0.360	0	1
Negative Covid-19 effect on employment and turnover (2019-20) (Y/N)	0.620	0.486	0	1
Share employment tertiary education (2017-2019)	0.147	0.053	0.032	0.435
R&D expenditure per job (€ thousands, 2017-2019)	0.244	0.497	0	3.59
Exports over turnover (2017-2019)	0.119	0.152	0	1

Source: Own elaboration.

Note: Number of observations = 308.

Figure 1 and Figure 2 show the regional distribution of municipalities where applicants and beneficiaries of RRF-R&I measures are located. The dark areas are municipalities with at least one applicant (or beneficiary) to (of) the RRF-R&I measures located in the territory, in white we have the municipalities without applicants or beneficiaries.

Figure 1. Portuguese municipalities with applicants to RRF-R&I programme

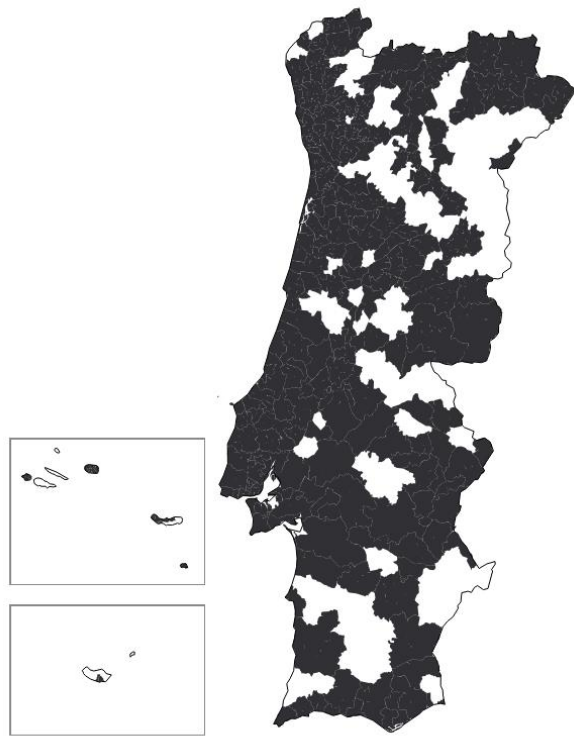
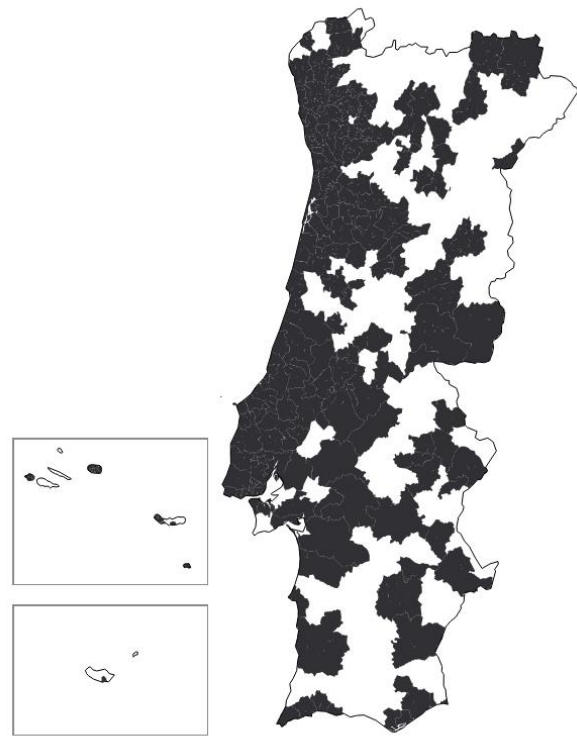


Figure 2. Portuguese municipalities with beneficiaries of RRF-R&I programme



Source: Own elaboration based on data from IAPMEI.

Legend: Dark areas mean that the municipality has at least one applicant (or beneficiary) to (of) the RRF-R&I measures located in the territory, white areas indicate municipalities without applicants or beneficiaries.

## 6. Results and discussion

Table 5 reports the results of a standard probit regression model without sample selection in column (1) and a bivariate probit model with sample selection in columns (2) and (3). The Rho ( $\rho$ ) is statistically significant and different from zero, implying that the results are biased if we do not correct for sample selection; as observed when comparing the estimated coefficients in column (1) and column (2). The exclusion restrictions (Covid-19 effect) included in the selection model (column 3) are also jointly significant, and are not correlated with the outcome equation (Table A1 in Appendix A). The model is correctly specified, based on the results of the Wald test for the joint-significance and the results of the Hosmer-Lemeshow goodness-of-fit test. We also control for the existence of multi-collinearity issues between the different explanatory variables, using the values of the correlation matrix and the results of the Variance Inflation Factor (VIF) - Table B1 in Appendix B. Since the mean of VIFs is close to one and the largest VIF is lower than 10 (Baum, 2006), the coefficients of our regressions are not biased. Furthermore, Table D1 in Appendix D shows that the results are stable when some explanatory variables are removed from the model specification.

Table 5. Results standard Probit regression model versus Bivariate Probit model with sample selection, dependent variable: being a municipality beneficiary of RRF-R&I measures

Variables	Standard Probit	Probit model with sample selection	
	Y = Being beneficiary of RRF-R&I sub-sample (d=1) (1)	Y = Being beneficiary of RRF-R&I equation 1.2 (2)	Y = Applying to RRF-R&I actions equation 1.1 (3)
Beneficiary R&I (ESIF) regional OP (Y/N)	-0.0893 (0.293)	0.153 (0.221)	0.469** (0.192)
Beneficiary R&I (ESIF) national OP (Y/N)	0.857*** (0.299)	0.881*** (0.220)	0.522** (0.221)
Beneficiary H2020 (Y/N)	1.457*** (0.317)	1.364*** (0.243)	0.867*** (0.230)
Share empl. tertiary education (log)	-0.105 (0.536)	0.246 (0.391)	0.706* (0.362)
R&D expenditure per job (log)	2.178 (1.415)	1.596* (0.824)	0.118 (0.664)
Exports over turnover (log)	0.164 (0.187)	0.219* (0.125)	0.258*** (0.0969)
Negative Covid effect on employment (Y/N)	- -	- -	0.617** (0.312)
Negative Covid effect on turnover (Y/N)	- -	- -	0.722*** (0.241)
Neg. Covid effect on employment # turnover (Y/N)	- -	- -	-1.007** (0.414)
Nuts 2 level fixed effect	Yes	Yes	Yes
Constant	-1.559 (1.459)	-3.420*** (1.022)	-4.049*** (1.039)
Observations	207	308	308
Log pseudolikelihood	-64.12	-187.87	
Wald test joint-significance (p-value)	0.000	0.000	
Rho	- -	15.69*** (0.180)	
Wald test of indep. eqns. (rho = 0)	-	0.0000	
Test model specification (individual Probit)			
Pseudo R2	0.3938	0.4185	0.3528
Correctly classified	85.99%	82.47%	80.19%
Hosmer-Lemeshow goodness-of-fit test (p-value)	0.9423	0.5464	0.7247

Source: Own elaboration.

Note: Robust standard errors in parentheses. Significance level: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Columns (2) and (3) include 308 observations, with selected = 207 and non-selected = 101.

The results of the selection equation reported in column (3) of Table 5 confirm the hypothesis that Covid-19 had a positive effect on the decision to apply, but only when municipalities were negatively affected in terms of turnover or employment. On the contrary, when territories were more heavily affected (simultaneously by a decrease in employment and turnover), we observe a negative effect of Covid-19 on the decision to apply. This suggests that when the effect of Covid-19 was stronger, uncertainty prevailed on the incentive to engage in public R&I investment schemes.

Territories with firms that are more active in international markets are more likely to have entities applying and being beneficiaries of RRF-R&I measures, in line with firm-level analysis (Czarnitzki and Lopes Bento 2014; Hud and Hussinger 2015). As exposure to international trade generates a higher competitive pressure, there is a greater incentive to innovate, as a means of differentiating from competitors (Santos et al. 2019). Furthermore, as access to public support reduces the cost of innovation activities, more active innovators may see this as an opportunity (even a competitive advantage), which may justify the positive relationship between export intensity and participation in R&I programmes.

Territorial R&D expenditure *per capita* only influences the probability of becoming a beneficiary, but not the decision to apply. Such findings are consistent with studies showing that more innovative regions attract more R&D funding (Archibugi et al. 2021) or have a higher number of successful participations (Mieszkowski and Barbero 2021). As innovation is spatially concentrated in regions where knowledge inputs are also concentrated for reasons of efficiency (Feldman 1994), these regions may have more viable projects due to economies of scale, and thus be more likely to participate in RRF-R&I programmes.

Knowledge capacity, measured by labour market skills, explains the decision to apply but not the likelihood of being a municipality beneficiary of RRF-R&I measures. Our evidence is in line with the results of firm-level analysis of Blanes and Busom (2004) and Aschhoff (2010), who argue that the higher the qualification of the human capital, the greater the capacity to generate new R&I projects, and therefore, the higher the probability of applying for R&I funding. Even though human capital is also associated with the capacity to implement R&I projects (Blanes and Busom 2004), we didn't find a significant effect of the territorial share of employees with tertiary education in the probability of being a municipality beneficiary of RRF-R&I measures.

Past experience with R&I funding (2014-2020) influences both the decision to apply and the probability of being successfully selected, in line with findings conducted at firm-level (Aschhoff 2010; Enger and Castellacci 2016; Busom et al. 2017). At territorial level, this translates into a certain concentration and persistence of R&I funding in the same municipalities. Moreover, interesting conclusions emerge when we look at the differences by type of fund and governance model. For instance, regional participation in H2020 projects (programme managed at EU-level) has the largest effect on both, the decision to apply and the probability of being successfully selected. Regional participation in H2020 projects increases by 19.8% the probability of applying and the regional probability of being successfully selected in RRF-R&I measures by 28% (Table 6). The effect of past participation in the ESIF-R&I programme in 2014-2020 on the probability of being successfully selected is only significant if a territory is a beneficiary of funds managed at national-level.

In addition to the previous analysis, we estimate the probabilities of applying for and successfully participating in RRF-R&I programmes by regional taxonomies. The estimated probabilities in Table 7 show that more developed regions have a 95% probability of having entities applying to RRF-R&I programmes, whereas this probability is only 64% in less developed regions. The probability of success is also higher in more developed regions (77%) than in other types of region (52% for less developed and 49% for transitions regions). Urban areas are also more likely to have located entities that apply (76%) and are then selected to

receive RRP funding for R&I (66%) than rural areas (66% and 51%), showing the same patterns of a rural - urban divide in R&I funding highlighted by Mieszkowski and Barbero (2021).

Table 6. Marginal effects of Bivariate Probit model with sample selection reported in Table 5

Variables	dy/dx	Std. err.	P>z
Y = Being beneficiary of RRF-R&I			
Beneficiary R&I (ESIF) regional OP (Y/N)	0.032	0.045	0.483
Beneficiary R&I (ESIF) national OP (Y/N)	0.182	0.044	0.000
Beneficiary H2020 (Y/N)	0.282	0.044	0.000
Share empl. tertiary education (log)	0.051	0.081	0.529
R&D expenditure per job (log)	0.330	0.172	0.056
Exports over turnover (log)	0.045	0.025	0.070
Y = Applying to RRF-R&I actions			
Beneficiary R&I (ESIF) regional OP (Y/N)	0.107	0.042	0.011
Beneficiary R&I (ESIF) national OP (Y/N)	0.119	0.050	0.017
Beneficiary H2020 (Y/N)	0.198	0.050	0.000
Share empl. tertiary education (log)	0.161	0.082	0.049
R&D expenditure per job (log)	0.027	0.152	0.859
Exports over turnover (log)	0.059	0.021	0.006
Negative Covid effect on employment (Y/N)	0.141	0.070	0.044
Negative Covid effect on turnover (Y/N)	0.165	0.053	0.002
Neg. Covid effect employment # turnover (Y/N)	-0.230	0.091	0.012

Source: Own elaboration.

Table 7. Estimated probabilities, by regions taxonomy

Taxonomy	Probability to apply (1)	Probability of successful application (2)	Probability of unsuccessful application (3)
Average	67%	54%	13%
Cohesion criteria 2021-2027 taxonomy			
More developed region	95%	77%	18%
Less developed region	64%	52%	12%
Transition region	82%	49%	32%
Rural-urban classification			
Predominantly urban region	76%	66%	10%
Predominantly rural region	66%	51%	15%
Intermediate region	63%	51%	11%

Source: Own elaboration based on the results of Table 5.

Note: Probability of successful application corresponds to have a probability to apply = 1 and a probability to participate in the programme = 1. Unsuccessful application corresponds to have a probability to apply = 1 and a probability to participate in the programme = 0. Cohesion criteria taxonomy based on Nuts-2 level and rural-urban classification on Nuts-3 level Eurostat classification.

As a robustness test, we replace the binary outcome variable by a count variable referring to the number of beneficiaries of the RRF-R&I programme in the municipalities. The results reported in Table E2 and Table E3 in Appendix E show similar findings than the previous one on the influence of past-experience in R&I programme. H2020 participation affects the most the number of participations in R&I-RRP programme (by 16.8%) followed closely by ESIF-R&I National OP (by 14.6%) while participation in ESIF-R&I Regional OPs has a smaller effect (by 6.9%) on our dependent variable (Table E3 in appendix E).

## 7. Conclusion

Existing literature on the geography of R&D (and innovation) funding is at an early stage (Aagaard et al. 2020), with few studies empirically exploring the determinants of participation in R&I programmes and their spatial location. Identifying the determinants of such R&I funding dispersion or concentration across regions is extremely important for policymakers. For instance, it helps to assess the territorial implication of the policy design by looking at whether funding is going to the neediest regions (for those policies that aim at reducing territorial inequalities and boost R&I in less developed regions such as Cohesion policy). In the opposite way, if the aim of the programme is to boost excellence in science and to improve competitiveness, without a specific territorial dimension (like FP/H2020), the allocation is expected to go to the best performing and most innovative regions. The NGEU is a temporary financial instrument where innovation investments are integrated in three pillars: i) smart, sustainable and inclusive growth (including economic cohesion); ii) green transition; iii) digital transition.

This paper contributes to the literature on the geography of R&I funding by providing novel empirical evidence on the factors influencing geographical participation in R&I funding schemes while also contributing to the debate on the potential distribution of the NGEU funds by 2026. Using a bivariate Probit model with sample selection, the results show that more developed regions and urban areas are more likely to host entities that apply and are then successfully selected as beneficiaries of R&I funding under the NGEU.

Moreover, the results confirm the hypothesis that participation in R&I funding programmes is path dependent (i.e. it depends on previous participation to similar programmes). Regarding the impact of the governance of different R&I funding programmes, we provide evidence of the similarities between the territorial concentration of NGEU and Horizon 2020 participation and the territorial differences with Cohesion Policy. This is also reinforced by the ability of some beneficiaries, located in certain regions, to implement more successfully larger projects (a specific feature of both RRP and H2020 R&I projects) due to some place-specific characteristics and economies of scale, in line with the Myrdal (1957) effect.

The present study also shows that Portuguese territories which are more innovative and more active in international markets are more likely to participate in the programme analysed. We can only partially confirm the hypothesis that regions with more financial constraints are more likely to have entities applying for R&I funding. Indeed, we found a mixed effect of Covid-19 on the probability of applying.

Finally, the results display a rural-urban divide in participation in R&I funding and a lack of demand for R&I funding in less developed regions compared to more developed regions. This lack of demand may also be

related to the sectoral patterns and business dynamics of the territories, as some economic activities are more likely to undertake R&D activities than others (Potters 2009), and to be beneficiaries of R&I funding (Santos et al. 2021).

Future research should focus on understanding the potential effects of the selected projects under the RRF-R&I measures compared to the non-selected projects. Indeed, this paper opens the door to a better knowledge of the likely distribution of R&I funding when the governance model is centralized and under some specific characteristics of the calls for applications.

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## Appendix

### *Appendix A. Selection criteria of the 'Agendas for reindustrialization' - Portuguese RRP*

The selection criteria used to analyse and classify the applications received in phase 1 and phase 2 of the 'Agendas for reindustrialization' are described as follows:

- A. Degree of innovativeness of the proposal;
- B. Impact of the project on business competitiveness and its capacity to induce structural change at sector or cluster-level, or in the country's productive specialisation profile;
- C. Potential impact of the project in regions where the project will be implemented, especially in less developed and low-density regions, in terms of contribution to territorial cohesion and economic benefits for these regions;
- D. Leverage and synergy effects of the investments on other sources of co-financing, public and private, national and European;
- E. Potential of innovation economic valorisation, namely in terms of technology transfer at a national level and on the whole value chain, as well as its quick dissemination among the various actors of the consortium;
- F. Contribution of the project to carbon neutrality and energy efficiency;
- G. Quality of the consortium in terms of the competencies of the promoters concerning the objectives of the project and the governance model of the consortium;
- H. Economic and financial viability of projects and applicants.

All the applications received a score between 1 (weak) and 5 (excellent) in all the eight dimensions. The final score corresponds to the weighted sum of the different dimensions, allowing to ranking all the projects.

The projects selected in phase 1 (and then to go to phase 2) should also be aligned with the innovation priorities of the national Smart Specialisation Strategy (S3) of the country. Then they should fall within one or more of the following areas and their sub-areas:

- Cross-cutting technologies and their applications (Energy; Information and Communication Technologies; Raw materials and materials);
- Industries and production technologies (Production Technologies and Product Industries; Production Technologies and Process Industries);
- Mobility, space and logistics (Car, Aeronautics and Space; Transport, Mobility and Logistics);
- Natural resources and environment (Agri-food; Forest; Blue Economy; Water and Environment);
- Health, well-being and territory (Health; Tourism; Cultural and Creative Industries, including Audiovisual; Habitat).

Such areas are also aligned with the innovation priorities of the S3 of the seven Portuguese regions (for more details see Marques Santos, 2021). Furthermore, according to the information in the Portuguese RRP<sup>12</sup>, the so-called 'Agendas for Industrialisation' aims to be complementary with the R&I funding under the PO1 of Cohesion Policy, which is going to finance the S3 innovation priorities at national and regional-level.

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<sup>12</sup> For more details, see pp. 212-220 of the [Portuguese RRP](#).

## Appendix B. Validation of exclusion restriction

Table B1. Results Probit regression model, dependent variable: being a municipality beneficiary of R&I-RRP measures

Variables	Y = Being beneficiary of R&I-RRP	
	Coeff	St. Error
Negative Covid-19 effect on employment (Y/N)	-0.164	(0.368)
Negative Covid-19 effect on turnover (Y/N)	0.0658	(0.308)
Neg. Covid-19 effect employment # turnover (Y/N)	0.123	(0.408)
Constant	0.114	(0.268)
Observations	308	

Source: Own elaboration.

Note: Robust standard errors in parentheses. Significance level: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table B2. Pairwise correlation coefficients

Variables		Being a municipality beneficiary of R&I-RRP measures
Negative Covid-19 effect on employment (Y/N)	Coeff.	-0.0174
	P-value	0.7608
Negative Covid-19 effect on turnover (Y/N)	Coeff.	0.0353
	P-value	0.5377

Source: Own elaboration.

## Appendix C. Multi-collinearity diagnostic

Table C1. Results of Correlations matrix and Variance Inflation Factor (VIF)

#	Variables	VIF	Correlation matrix							
			1	2	3	4	5	6	7	8
1	Negative Covid effect on employment (Y/N)	1.05	1							
2	Negative Covid effect on turnover (Y/N)	1.06	0.16	1						
3	Beneficiary R&I (ESIF) regional OP (Y/N)	1.39	-0.01	0.11	1					
4	Beneficiary R&I (ESIF) national OP (Y/N)	1.62	-0.06	0.04	0.40	1				
5	Beneficiary H2020 (Y/N)	1.50	0.05	0.15	0.44	0.38	1			
6	Share empl. tertiary education (log)	1.57	0.03	0.04	0.33	0.35	0.42	1		
7	R&D expenditure per job (log)	1.81	-0.08	0.04	0.37	0.44	0.43	0.56	1	
8	Exports over turnover (log)	1.47	-0.01	-0.04	0.29	0.51	0.24	0.26	0.43	1
	Mean VIF	1.43								

Source: Own elaboration.

*Appendix D. Characterization of municipalities with applicants and beneficiaries of R&I-RRF*

Table D1. Results of t-test equality of means, by groups

Municipalities with applicant(s) to R&I-RRF, 2021-2022 (Y/N)								
Variables	Yes	No	Mean (Y)	Mean (N)	Diff.	St. Err.	P-value	
Beneficiary R&I (ESIF   2014-2020) (Y/N)	207	101	0.865	0.446	0.42	0.049	0.000	
Beneficiary R&I (ESIF   2014-2020) regional OP (Y/N)	207	101	0.773	0.356	0.42	0.053	0.000	
Beneficiary R&I (ESIF   2014-2020) national OP (Y/N)	207	101	0.666	0.208	0.46	0.055	0.000	
Beneficiary Horizon 2020 (2014-2020) (Y/N)	207	101	0.585	0.109	0.48	0.054	0.000	
Share employment tertiary education (2017-2019)	207	101	15.50	12.04	3.46	0.585	0.000	
R&D expenditure per job (€ thousands, 2017-2019)	207	101	0.336	0.056	0.28	0.058	0.000	
Exports over turnover (2017-2019)	207	101	0.144	0.068	0.08	0.018	0.000	
Municipalities with beneficiary(ies) of R&I-RRF, 2022-2025 (Y/N)								
Variables	Yes	No	Mean (Y)	Mean (N)	Diff.	St. Err.	P-value	
Beneficiary R&I (ESIF   2014-2020) (Y/N)	164	43	0.920	0.651	0.27	0.056	0.000	
Beneficiary R&I (ESIF   2014-2020) regional OP (Y/N)	164	43	0.823	0.582	0.24	0.070	0.001	
Beneficiary R&I (ESIF   2014-2020) national OP (Y/N)	164	43	0.780	0.233	0.55	0.072	0.000	
Beneficiary Horizon 2020 (2014-2020) (Y/N)	164	43	0.695	0.163	0.53	0.076	0.000	
Share employment tertiary education (2017-2019)	164	43	16.13	13.11	3.02	0.894	0.001	
R&D expenditure per job (€ thousands, 2017-2019)	164	43	0.407	0.063	0.34	0.094	0.001	
Exports over turnover (2017-2019)	164	43	0.163	0.071	0.09	0.026	0.001	

Source: Own elaboration.

Appendix E. Robustness test

Table E1. Robustness test: results Bivariate Probit model with sample selection, dependent variable: being a municipality beneficiary of R&I-RRP measures

Variables	Y = Being beneficiary of R&I-RRP	Y = Applying to R&I-RRP actions	Y = Being beneficiary of R&I-RRP	Y = Applying to R&I-RRP actions	Y = Being beneficiary of R&I-RRP	Y = Applying to R&I-RRP actions
	<i>equation 1.2</i>	<i>equation 1.1</i>	<i>equation 1.2</i>	<i>equation 1.1</i>	<i>equation 1.2</i>	<i>equation 1.1</i>
	(1)	(2)	(3)	(4)	(5)	(6)
Beneficiary R&I (ESIF)	0.209	0.540***	0.182	0.513***	0.167	0.527***
regional OP (Y/N)	(0.193)	(0.181)	(0.212)	(0.191)	(0.191)	(0.186)
Beneficiary R&I (ESIF)	1.168***	0.716***	0.966***	0.630***	1.002***	0.546**
national OP (Y/N)	(0.192)	(0.182)	(0.226)	(0.229)	(0.210)	(0.224)
Beneficiary H2020 (Y/N)	1.328***	0.868***	1.393***	0.837***	1.442***	0.956***
	(0.217)	(0.208)	(0.259)	(0.234)	(0.222)	(0.225)
Share empl. tertiary education (log)	0.571	0.676*	-	-	-	-
	(0.388)	(0.353)	-	-	-	-
R&D expenditure per job (log)	-	-	2.131***	1.076	-	-
	-	-	(0.761)	(0.720)	-	-
Exports over turnover (log)	-	-	-	-	0.292**	0.276***
	-	-	-	-	(0.119)	(0.107)
Negative Covid effect	-	0.695*	-	0.603*	-	0.666
on employment (Y/N)	-	(0.408)	-	(0.331)	-	(0.422)
Negative Covid effect	-	0.661*	-	0.613***	-	0.663*
on turnover (Y/N)	-	(0.343)	-	(0.223)	-	(0.356)
Neg. Covid effect on employment	-	-0.990**	-	-0.905**	-	-0.933**
# turnover (Y/N)	-	(0.456)	-	(0.409)	-	(0.468)
Log pseudolikelihood	-195.77		-192.24		-192.51	
Wald test joint-significance (p-value)	0.000		0.000		0.000	
Rho	12.03***		12.36***		13.58***	
	(0.860)		(0.201)		(0.169)	
Wald test of indep. eqns. (rho = 0)	0.000		0.000		0.000	

Source: Own elaboration. Note: Robust standard errors in parentheses. Significance level: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Number of observations = 308 observations, with selected = 207 and non-selected = 101. Estimations include Nuts 2 level fixed effects and constant.

Table E2. Results Heckman selection model, two-step estimates

Variables	Y = Nr of beneficiaries of R&I-RRP (log) OLS (1)	Y = Applying to R&I-RRP actions Probit (2)	Y = Nr of beneficiaries of R&I-RRP Poisson (3)	Y = Applying to R&I-RRP actions Probit (4)
Beneficiary R&I (ESIF) regional OP (Y/N)	0.317 (0.240)	0.479** (0.203)	0.667** (0.273)	0.479** (0.199)
Beneficiary R&I (ESIF) national OP (Y/N)	0.804*** (0.291)	0.532** (0.217)	1.404*** (0.390)	0.532** (0.242)
Beneficiary H2020 (Y/N)	1.164*** (0.280)	0.888*** (0.232)	1.617*** (0.333)	0.888*** (0.232)
Share empl. tertiary education (log)	0.839** (0.377)	0.669 (0.408)	2.312*** (0.526)	0.669* (0.381)
R&D expenditure per job (log)	1.187*** (0.389)	0.108 (0.633)	0.756*** (0.261)	0.108 (0.686)
Exports over turnover (log)	0.255** (0.118)	0.251** (0.109)	0.333* (0.183)	0.251** (0.103)
Negative Covid effect on employment (Y/N)	- -	0.527 (0.437)	- -	0.527 (0.458)
Negative Covid effect on turnover (Y/N)	- -	0.526 (0.385)	- -	0.526 (0.372)
Neg. Covid effect on employment # turnover (Y/N)	- -	-0.967* (0.506)	- -	-0.967* (0.522)
Nuts 2 level fixed effect	Yes	Yes	Yes	Yes
Mills Ratio	1.246* (0.650)		1.996* (1.049)	
Constant	-3.955** (1.816)	-3.731*** (1.136)	-9.115*** (2.588)	-3.731*** (1.066)
Observations				
Selected	207		207	
Non-selected	101		101	

Source: Own elaboration.

Note: In parentheses, standard errors in column (1) and (2) and robust standard errors in column (3) and (4). Significance level: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

Table E3. Marginal effects of Poisson regression model reported in column (3) of Table E2

Variables	dy/dx	std. err.	P>z
Beneficiary R&I (ESIF  2014-2020) regional OP (Y/N)	6.91	3.20	0.031
Beneficiary R&I (ESIF  2014-2020) national OP (Y/N)	14.55	5.06	0.004
Beneficiary Horizon 2020 (2014-2020) (Y/N)	16.76	4.79	0.000
Share employment tertiary education	23.96	7.41	0.001
R&D expenditure per job	7.83	2.58	0.002
Exports over turnover	3.45	2.13	0.105

Source: Own elaboration.



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