UNIVERSIDADE CATÓLICA PORTUGUESA

H2020 Twinning Projects:

Impact on R&I in Portuguese Higher Education Institutions and Research Centres

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By

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Abstract

This thesis examines the impacts and results of Portuguese Twinning Projects funded by European Union H2020 Framework Programme for R&I. The thesis includes a descriptive analysis of the evolution of average R&I performance between 2014 and 2021, as well as of its between-country and within-country dispersion. Thus, the thesis analyses the relations between the participation in Twinning projects and the performance of Portuguese research institutions. To be more precise, two research questions are analysed.

The first research question is to find out whether the participation in these projects have contributed or not to improve the average performance of Portuguese research institutions.

The second one is to understand if that participation had or not the effect of increasing the disparities of performance among research institutions in Portugal.

The results of this study aim to provide a positive answer both to the first question (improvement in the average performance) and the second one (increase in the performance disparities).

These results point to the need of European and national policies that may diminish disparities, without compromising the promotion of research excellence.

Keywords: Horizon 2020; Twinning; R&I performance; disparity in R&I performance

Number of words: 6902

Resumo

Esta tese analisa os impactos e resultados de projetos Twinning portugueses financiados pelo H2020 Programa Quadro da União Europeia para a investigação. A tese inclui uma análise descritiva da evolução da média de desempenho da investigação e desenvolvimento entre 2014 e 2021, e da sua dispersão entre países e no interior de países da União Europeia. Por conseguinte, a tese analisa as relações entre a participação em projetos Twinning e o desempenho de instituições de investigação portuguesas. Mais precisamente, são analisadas duas questões de investigação.

Uma questão é saber se a participação nestes projetos contribuiu ou não para melhorar o desempenho médio das instituições de investigação portuguesas.

A outra questão é saber se essa participação teve ou não por efeito aumentar as disparidades de desempenho entre instituições de investigação em Portugal.

Os resultados deste estudo são no sentido de uma resposta positiva tanto à primeira questão (melhoria do desempenho médio) como à segunda (aumento das disparidades de desempenho).

Estes resultados apontam, pois, para a necessidade de políticas europeias e nacionais que combatam disparidades, sem prejuízo da promoção da excelência na investigação.

Palavras-chave: Horizon 2020; Projetos Twinning; Disparidades no desempenho das instituições I&D.

Número de palavras: 6902

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List of Abbreviations

EU	European Union
R&D	Research & Development
R&I	Research & Innovation
FPs	Framework Programmes
H2020	Horizon 2020
HE	Horizon Europe
SEWP	Spreading Excellence and Widening Participation
HEI	Higher Education Institute
RIA	Research and Innovation Action
IA	Innovation Action
CSA	Collaboration and Support Action
EC	European Commission
EIS	European Innovation Scoreboard

1. Object of study and research questions

There is a perception that the European Union (EU) has been lagging in Research & Innovation performance when compared to other advanced or emerging economies like the United States and China (European Commission, 2020a) The underperformance of the EU relative to the United States is felt more in terms of quality and impact of research than in terms of quantity. There is also the perception that Research & Development (R&D) and R&I-related human capital is very concentrated in a few regions in Europe (10% of EU regions account for half of EU's R&D spending and patent applications). These perceptions and the facts behind them are an important concern for EU and EU Member States policy makers.

To address these concerns the EU created the Framework Programmes (FPs). The FPs grant funding to Member States, and Associated Countries in R&I.[1] Of the 9 FPs to date, Horizon 2020 (H2020) was the eighth to support R&I and European competitiveness and was in place from 2014 to 2020. H2020 was followed by Horizon Europe (HE) which is still ongoing. H2020 and HE not only increased funding for R&D across the EU and Associated Countries, but also brought important innovations such as the Spreading Excellence and Widening Participation (SEWP). The SEWP's main goal was to reduce the apparent innovation gap between EU member states, namely between the countries served

[1] The EU member states are Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden. At the time of H2020, the United Kingdom was also a EU member state.
The Associated Countries are Albania, Armenia, Bosnia & Herzegovina, Faroe Islands, Georgia, Island, Israel, Macedonia, Republic of Moldova, Montenegro, Norway, Switzerland, Serbia, Tunisia, Turkey, and Ukraine.

by SEWP (EU-13) and the rest (EU-15).[2] However, despite the efforts on reducing disparities across Europe, results of H2020 have shown a still substantial innovation gap between EU member states as depictured in Figure 1. and 2.

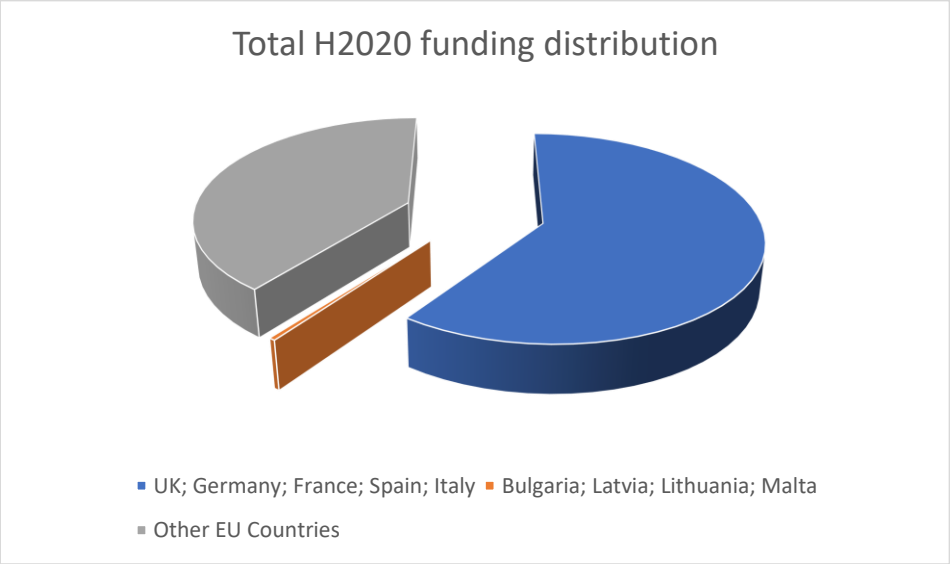

Figure 1. Top 5 funded countries (60%) VS bottom 4 funded countries (0.4%) by H2020
Source: (Puukka, 2020)

This thesis examines the impacts and results of completed and ongoing Twinning Projects funded and monitored by the European Union.

I first describe the trends in R&I performance at the country and regional level between 2014 and 2021, approximately the period during which H2020 was in place. I try to compare the average performance and the dispersion in performance across and within countries, by participation in Twinning. I build descriptive statistics to document these trends. I then investigate the differences in R&I performance between Portuguese Higher Education Institutes (HEIs) and research centres that applied and received a Twinning grant and those that did not.

[2] When H2020 was launched, the EU's 28 countries were divided into two groups, the EU-15 and the EU-13, or in this matter, 'non-widening' and 'widening' countries. Later in this thesis I provide more detail on these two groups of EU member states.

This dissertation examines two research questions. The first one is the following:

H1: Is the impact of H2020 on the performance of Portuguese HEIs and research centres positive?

There are many reasons for Twinning to have a positive impact in the coordinating institution. First, it forms a bridge of knowledge with at least two other institutions, which fosters the possibility of making staff exchanges and collaborative activities. Second, it makes available human and financial resources available to all partners, in particular the coordinator. Third, it gives the possibility to really strengthen the coordinator in the selected research field, which can be observed by the recruitment of researchers (usually early-stage researchers) (Dobranskyte-Niskota et al., 2021), increases in the publication of scientific papers, and in some cases when the coordinator is a HEI, the expansion of academic curricula. Fourth, for most EU projects, their coordination is often administratively demanding but provides discipline as the process involves preparation, research, submission, execution, communication, and monitorization. Furthermore, the projects will be supervised by the EC and are asked for deliverables defined in the proposal and standard reports.

There are, however, motives for the Twinning effect not to be positive. First, the project is focused on bridging research attainment gaps across countries when it perhaps should try to close gaps across institutions.

Second, within Widening countries, the strongest institutions end up receiving the resources due to their proposals having more excellence, which may further deepen the gap across institutions with the country. Thus, the first reasons create more asymmetry within each country and do not encourage equity and access to R&I funding.

Twinning incentivizes networking and the recruitment of researchers from non-widening countries' institutes to widening countries' institutes. Yet, there

are many reasons for such not to happen—unattractive salaries, restrictions of national employment law, lack of explicitness in the Twinning for recruitment as a goal, among other reasons. A survey made for the 2017 and 2018 calls concluded that there exists recruitment being made reversely, from the widening institute to the non-widening one—17% of projects of the 2017 call and 8% of projects of the 2018 call reported of that happening (Dobranskyte-Niskota et al., 2021).

Why could this matter? If R&I spending has decreasing returns, spending funds in the strongest institutions in a country will have overall smaller effects in lifting Widening countries' R&I profile. In fact, there is evidence that spending in R&D and innovation has decreasing returns to scale (Barbero et al., 2021; *Graves & Langowitz*, 1996). This means that if we double R&I spending in a given institution, we will less than double the R&I performance of said institution. Therefore, investing in R&I and innovation in smaller institutions or institutions with lower R&I performance should bring 'more bang for the buck'.

The second research question is the following:

H2: Did H2020 Twinning funding increase disparities in R&I performance across institutions withing Portugal?

If this hypothesis cannot be rejected the gap should increase if the institutions that receive funding are the ones that have the strongest R&I performance to start with.

However, one possibility is that support provided by the SEWP actions is completely ineffective in raising recipient institutions' R&I profile. If this was the case, there would be no difference in performance change between the group of recipient institutions and the group institutions that did not receive. Another possibility is that the spill over effects from the recipient institutions to non-recipient institutions (through collaboration efforts, staff exchanges, networking) are so strong that they cancel out any differential effects coming from access to

funding through Widening. The latter hypothesis, however, is highly unlikely since indirect effects tend to be smaller than direct ones, and impossible to measure directly given the data that is available.

This thesis is organized as follows. In Chapter 2, I review some descriptive literature on H2020 and Spreading Excellence and Widening Participation initiatives, with a focus on Twinning, its objectives, and its performance. In Chapter 3 I present the methods and the data used for examining the research questions. In Chapter 4 I present and discuss the findings and in Chapter 5 I conclude this analysis and propose some recommendations for future work.

2. Descriptive presentation of H2020 and the Twinning projects

2.1 Horizon 2020: Objectives and performances

H2020 is the biggest European funding programme with a budget of €77 billion. It is the eighth instalment of the European Framework Programme (FP) for Research and Innovation, which occurred from 2014 to 2020 and had its budget allocated to successful proposals submitted during that period (European Commission, 2017a). The FPs began in 1984, H2020 succeeds Framework Programme 7 (FP7), and was now replaced by Horizon Europe (HE).

The FPs have already constructed various networks of scientists, academia, and industry (European Commission, 2014). Throughout the FPs editions, the funding budgets have been increasingly higher as well as the programme's

structure and goals. H2020 is the first to establish that investment in R&I is crucial for Europe's growth strategy.

The structure of H2020 lies in three major pillars—Excellent Science; Industrial Leadership; and Societal Challenges— and two priorities—'Spreading Excellence and Widening Participation' (SEWP) and 'science with and for society'— each sub-dividing into many thematic priorities (e.g., Marie Sklodwska-Curie Actions, European Research Council, and Biotechnology) that branch-out to diverse topics. Each of the latter have a detailed description to the challenge it seeks to answer, allowing any eligible research institution to submit a proposal fit for the subject.[3] The submission of a proposal to a certain topic or call may give the opportunity to the submitter to receive EU funding.

The first goal of H2020 was to foster growth and to create new jobs. The second goal was to improve people's livelihoods, safety, and environment. Finally and probably the one which was the most important goal, to strengthen the EU's position in the world regarding research, innovation, and technology (European Commission, 2013). Underlying these three ultimate goals, there was an intermediate goal of raising R&D spending in EU member states to 3% of GDP.

Although these goals have unquestionable merit, the fact is that by end-2020 very few countries in the EU met the 3% spending goal (Figure 2). In fact, only five out of 27 met the proposed goal in 2020. In Section 5, I will discuss this at length.

There are many good cases of successful projects under H2020 in many EU countries, including Portugal. The projects typically fall under different types of actions defined for H2020, including 'Research and Innovation Action' (RIA), 'Innovation Action' (IA), and 'Coordination and Support Action' (CSA) (European Commission, 2014). Here are some examples that can make H2020 easier to understand.

[3] DEFINE PROPOSAL

A first good example of a H2020 project is VisorSurf. This is an RIA type project funded under the pillar of 'Excellent Science' on the thematic of 'Future and Emerging Technologies' to the call of FET-Open – Novel ideas for radically new technologies (H2020-FETOPEN-2016-2017) coordinated by a Greek institution with a consortium of five European partners. This is an interesting example because the project developed planar materials with software-programmable electromagnetic behaviour that will revolutionize wireless technology with an app.

Another good example is MOODSTRATIFICATION, a RIA type project funded under the pillar of 'Societal Challenges' on the thematic of 'Health, demographic change and well-being' to the topic of 'New concepts in patient stratification' coordinated by a Dutch HEI with a consortium of 11 European partners. It is a good example of a project in the life and health sciences, and it proposes to stratify patients with a major depressive episode on the basis of leukocyte immune profiles.

A good example of a project coordinated by a Portuguese institution is the SHIKIFACTORY100. This is a RIA type project funded under the pillar of 'Industrial Leadership' on the thematic of 'Leadership in enabling and industrial technologies – Biotechnology' to the topic of 'Synthetic biology to expand diversity of nature's chemical production' with a consortium of 12 European partners. The project aims to produce over 100 high added value compounds from the shikimate pathway, a hub in cell metabolism, by developing an optimised shikimate chassis.

Finally, SCICLI is a CSA type project funded under the pillar of 'Excellent Science' on the thematic of 'Marie Sklodowska-Curie Actions' to the topic of 'European Researchers' Night' coordinated by the University of Lisbon with another 8 Portuguese partners. The project seeks to promote science among

Portugal's youth by carrying out engagement activities in HEIs, municipalities and research institutions from different scientific fields.

The past examples try to depicture the branch-type structure (pillar to thematic to topic to sub-topic) of H2020, which allows the definition of focus areas to facilitate and foster interdisciplinary solutions to existing and upcoming global challenges. Indeed, H2020 has shown visible benefits when compared to national and regional support to R&I, mostly due to its transnational and multidisciplinary networks (European Commission, 2017b). In fact, stakeholders consider H2020 increasingly more attractive to compete for funded projects in order to enhance and perform their research. Nevertheless, H2020 is not a replacement for other types of funding programmes (national or regional), but is considered to be of added value as 83% of funded projects would not have been carried out if not for the EU support (European Commission, 2017a).

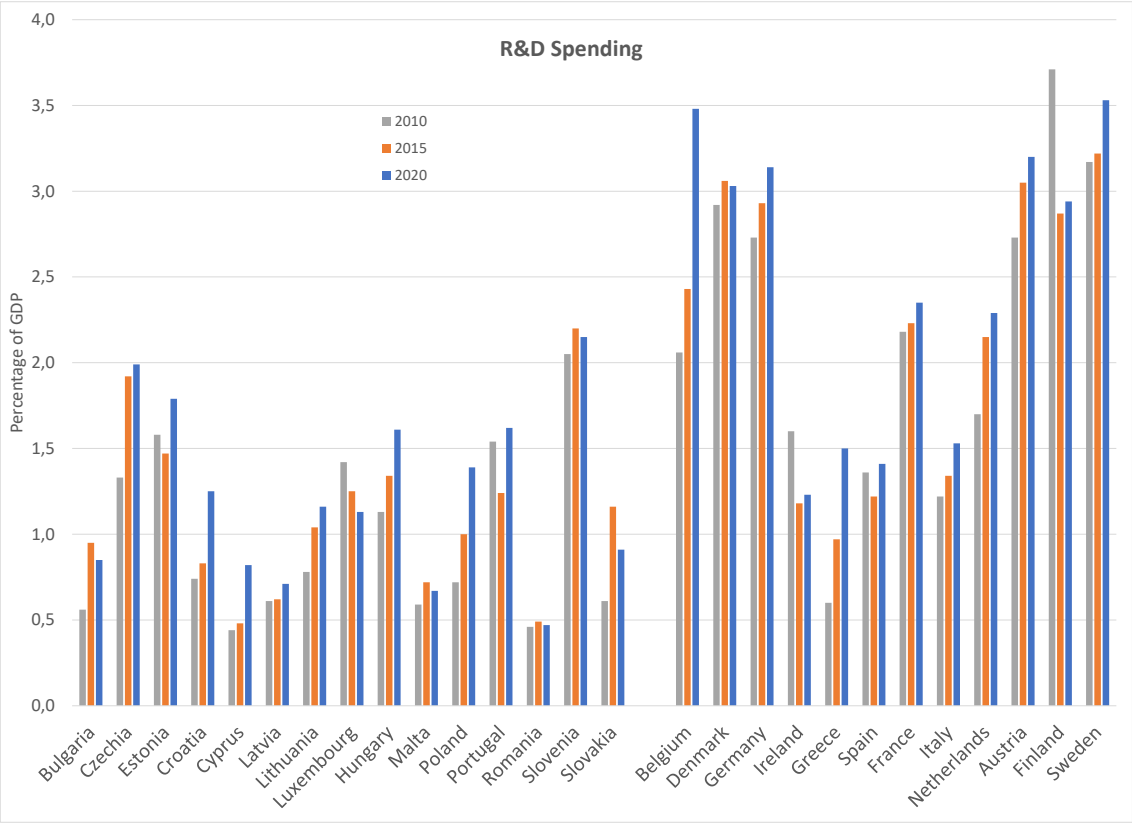

Figure 2. Percentage of GDP spending on R&D by EU country and year
Source: Eurostat

Note: The set of countries on the left of the chart are the EU-13 countries. The set of countries to the right are the EU-15 countries.

2.2 Horizon 2020: Spreading Excellence and Widening Participation

The SEWP is considered an 'additional priority' in H2020, but later in HE it is included as a 'transversal pillar' making it the fourth pillar of the FP structure (European Commission, 2021a). This means that SEWP's projects and goals were deemed important enough to have a bigger relevance in the succeeding FP and thus a wider impact in Europe.

SEWP, as its designation suggests, intends to widen participation, and spread excellence across Europe by boosting R&I performance throughout the EU. Frequently SEWP is referred as Widening actions. H2020's SEWP's actions will give aid to the EU countries that remain behind in terms of their R&I levels by improving the research capacity of institutions, establishing collaborative networks, attracting talents, and enhancing the skills of new and existing researchers (European Commission, 2015).

The eligibility criteria for Widening is that the member state where the project coordinator is domicile has a Composite Indicator of Research Excellence below 70% of the EU average (Kroll, 2019). The EU countries considered as low performers in R&I are often referred to as Widening countries or as EU-13, although this may be a simplification (European Commission, 2017a). At the time H2020 was launched, in 2014, the EU consisted of 28 countries, divided into two groups, the EU-15 and the EU-13, or in this matter, 'non-widening' and 'widening' countries. However, currently there are 15 Widening countries which are member states of the EU (Bulgaria, Croatia, Cyprus, Czechia, Estonia, Greece Latvia, Lithuania, Luxembourg, Malta, Poland, Portugal, Romania, Slovakia, and Slovenia) and 12 other Widening countries which are associated countries of the

EU (Albania, Armenia, Bosnia and Herzegovina, Faroe Islands, Georgia, Moldova, Montenegro, Republic of North Macedonia, Serbia, Tunisia, Turkey, and Ukraine).

SEWP has three types of actions: 'Teaming', 'Twinning', 'ERA Chairs'. The first action, Teaming, intends to create and/or upgrade Centres of Excellence by establishing partnerships with lead players in the field. The second action, Twinning—which I will go in further in the following section—aims to link a research institution from a widening country with at least two others from other leading counterparts (non-widening countries), to encourage knowledge sharing and the exchange of good practices. The third and last action, ERA Chairs, seeks to bring top researchers to HEIs and research centres in order to improve their excellence.

The results of H2020 show that there is a clear disparity in the number of submitted and approved proposals to the SEWP between all the Widening countries (Dobranskyte-Niskota et al., 2021). Portugal stands with the highest number, 80 projects, followed by Estonia (37 projects), Cyprus (35 projects), and Poland (34 projects). Of the three Widening actions, the number of Twinning actions is considerably higher than the other two.

In what follows, I present two projects that are interesting and timely, and give shape to two of the three Widening Actions, ERA Chairs and Teaming.

The first project is TROPIBIO—Expanding potential in TROPIcal BIOdiversity and ecosystem research towards sustainable life on land— an ongoing 'ERA Chairs' project that seeks to expand the R&I potential of a Portuguese research institution, CIBIO with a budget of €2.5 million. This project brings an ERA Chair holder—a high quality researcher and his team—to create an ERA (European Research Area) Chair in Tropical Biodiversity and Ecosystems Research. CIBIO avails the network of TwinLabs established in institutions from Portuguese-speaking African countries. The main objective is to contribute on achieving the

Live of Land goal of the United Nation 2030 Agenda for Sustainable Development, by boosting the research capacity of CIBIO in the field of research and its capability to succeed in competitive research funding.

The second project is Sano (Centre for New Methods in Computational Diagnostics and Personalised Therapy), an ongoing 'Teaming' project coordinated in Kraków, Poland by Sano, with a budget of almost €15 million and a consortium of 10 participants. The main objective is for Sano to become a prestigious Centre of Excellence in computational medicine. This project will establish partnerships in industry players and act as a knowledge-provider in the development, from concept to commercialization, of advanced solutions to complex medical challenges.

Compared to Twinning projects, the projects above involve very large investments and have ambitious transformational goals. As we will see next, Twinning projects are smaller in size and emphasize more the networking aspects than the transformational ones.

2.2.1. Twinning Projects/Actions

Twinning projects are CSA that have a duration of up to three years with a maximum budget of 1.000.000€.[4] Twinning actions are part of the SEWP "pillar" and have two main objectives: to improve the science and technology capacity of the involved institutions, and to enhance the staff's research profile of the coordinating organization. There were four calls for Twinning from 2015 to 2019 (the first four entries in Table 1).[5]

[4] The call WIDESPREAD (H2020-WIDESPREAD-2018-2020), opened from July to November of 2019 had a maximum budget of 900.000€.
[5] The final entry in Table 1 is the first call of Twinning on the new FP Horizon Europe.

Call ID	Project End Year	Nº of Projects Funded	Nº of Proposals Submitted	Success Rate
H2020-TWINN-2015	2018	67	553	12%
H2020-WIDESPREAD-05-2017	2020	30	483	6%
H2020-WIDESPREAD-03-2018	2021	37	459	8%
H2020-WIDEPREAD-05-2020	2022	77	439	18%
Twinning (HORIZON-WIDERA-2021-03)	2024	104	391	27%

Table 1. Success rate of twinning proposals
Source: CORDIS | European Commission; Author's calculation.

The first four Call IDs were made in the scope of H2020, whereas the fifth is the first Twinning Call of the Horizon Europe FP.

Although I could not find data on participation rates in H2020, there is a perception that a significant number of eligible institutions did not bother to apply to the programme. In addition, I could not find data specifically on Twinning calls. The available data show that the first reason for not applying to H2020 funds is the perception that success rates are too low to be worth applying (European Commission, 2017c). The second reason mentioned in surveys is that the eligible institutions do not have sufficient financial and human resources to prepare proposals (European Commission, 2017a; Puukka, 2020). Other reasons mentioned are the lack of relevant topics and difficulties to find project partners.

Table 1 shows that the success rates on Twinning are low, which may mislead individuals into thinking it is not worth submitting a proposal to H2020 or even discourage them. The EC evaluates proposals, first by determining if it is an 'eligible proposal'—by having all fields correctly filled in the EU Portal, which means that even a poor-quality proposal can be submitted— and then by sending it to an evaluator that will assign a score, based on the criteria of the topic. The maximum score in most H2020 calls is 15 and a threshold is set at 10, which automatically excludes any proposal that scores below. The EC (European Commission), like Table 1, presents the success rates by dividing the number of approved proposals by the number of 'eligible proposals', reporting an average success rate of the first four entries of 10,9%. Mccarthy (2020) shows that from

2014 to 2016 the success rate of all H2020 submitted proposals was of 10,88%. However, he defends that the success rates should be calculated differently, by dividing the approved proposals only by the ones that scored above the threshold (high quality proposals) instead of all the submitted. If the success rates were displayed through this calculation, we would find that the percentages double their value in most cases. This would mean that in fact, the 'real' success rate of Twinning would be above 20%, which is far more reassuring for researchers to think on developing a winning proposal. Regarding Table 1, due to lack of data I was not able to calculate the 'real' success rate, but the 'real' rate is undoubtedly higher than the one displayed. The last entry on Table 1 relates to HE's first Twinning call and, even though there are no results on the number of projects funded to analyse, the budget was substantially increased and the number of submitted proposals was lower which allows me to speculate on a success rate of 27%. Hopefully, this percentage will encourage more institutions on seizing the opportunity to construct and submit a proposal to the next Twinning call of HE.

Preparing a proposal for submission is time consuming and, therefore, costly. According to surveys made by the EC, more than 50% of coordinators of multi-partner projects state that they spend around 30 days in preparing a proposal (European Commission, 2017a). Cost estimates for the preparation of Twinning project proposals are around €20000. This is still a relatively low number given that Twinning are CSA type. More expensive project like RIA and IA are estimated to cost upwards of €50000.

Difficulties in finding relevant areas in project applications are probably not as relevant for Twinning as they are for other H2020 priorities. This is because, applications for Twinning are welcomed from most research areas (Dobranskyte-Niskota et al., 2021).

Finally, difficulties in finding partners may be an important impediment for first time applicants to H2020 and Twinning. However, it is less likely to be a relevant concern for second time applicants because one of the main benefits of twinning is to provide opportunities of networking and collaboration with European and international partners. In fact, at the basis of Twinning is a specific field of research to be studied or strengthened in a certain institution (e.g., a university, a research organization) of a Widening country by pairing the institution with at least two internationally leading research institutions of non-widening member states.

For example, STRONGMAR is a completed twinning project coordinated by INEST TEC centred in the study of maritime technology. Almost reaching the maximum budget of €1M, the project occurred from January 2016 until December 2018, with a consortium of 6 institutes counting with the coordinator—University of Girona (Spain), Heriot-Watt University (United Kingdom), CINTAL (a research centre in Algarve, Portugal), the University of Aberdeen (United Kingdom), and NATO Science & Technology Organization (Belgium). STRONGMAR seeks to create a linkage in the specific topic of deep-sea technologies between INEST TEC and the 5 European partners which are leaders in the area. The project proposes to uphold the two main objectives of Twinning by conducting summer and winter schools, scientific meetings, staff visits, workshops, dissemination activities, among others. Moreover, INESC TEC is committed to becoming a centre of excellence in maritime technology and this Twinning shortens the attainment of this goal by reaching results which enhance the organisation's visibility and science and technology capacity—28 peer reviewed articles, 25 thesis dissertations, 61 conference proceedings, more than 30 international scientific events attendance and more than 10 international trade fairs. To conclude, INESC TEC is now a recognised European maritime research asset.

3. Methods and data for testing the research hypotheses

3.1. Methods

I used two types of approaches to examine the research questions. The first approach relies on data visualization and tabulation to show the differences in R&D performances and participation in H2020 and Widening across countries. I used the same approach to summarize the same differences at the individual institution level in Portugal, as well as to measure trends in terms of average R&D performance and dispersion across EU countries and within EU countries (i.e., at the subnational or regional level).

This first method should be understood as a preliminary analysis. The conclusions drawn from this type of analysis are very likely to be biased, because they do not control for other determinants of the explained variable.

The second approach consists in the estimation of linear regression models using pooled data at the individual institution level, also for Portugal.

The first model that was estimated is the following:

$$Score_{it} = \alpha_0 + \alpha_1 D(Year = 2015) + \alpha_1 D(Year = 2015) + \alpha_2 D(Year = 2016) + \alpha_3 D(Year = 2017) + \alpha_4 D(Year = 2018) + \alpha_5 D(Year = 2019) + \alpha_6 D(Year = 2020) + \alpha_7 Project_{it} + u_{it,}$$

where *Score* is institution i's research score on year t. The variables D(Year=2015) to D(Year=20) are dummy variables that are equal to one for year 2015, …, or 2020 and zero otherwise. The variable *Project* is also a dummy variable that takes value one once the institution is awarded a grant from the Twinning Program and all subsequent years.

Since this first specification does not control for characteristics that are idiosyncratic to each institution, a second specification was estimated by dummies for each institution (or institution fixed effects).

$$Score_{it} = \alpha_{0i} + \alpha_1 D(Year = 2015) + \alpha_2 D(Year = 2016) + \alpha_3 D(Year = 2017) + \alpha_4 D(Year = 2018) + \alpha_5 D(Year = 2019) + \alpha_6 D(Year = 2020) + \alpha_7 Project_{it} + u_{it,}$$

With this specification the estimate of the coefficient of the variable "project" gives the estimating differences in differences, which is typically one of the methods used to assess the impact of projects. This coefficient gives an answer to hypothesis H1.

To make this kind of model more appropriate to test hypothesis H2 another specification was estimated by augmenting the previous one with an interaction term of the *Project* dummy and the institution score in 2014 to understand who benefits most: those who were the best before the projects, or the others. The coefficient of this new variable gives an answer to hypothesis H2.

$$Score_{it} = \alpha_{0i} + \alpha_1 D(Year = 2015) + \alpha_2 D(Year = 2016) + \alpha_3 D(Year = 2017) + \alpha_4 D(Year = 2018) + \alpha_5 D(Year = 2019) + \alpha_6 D(Year = 2020) + \alpha_7 Project_{it} + \alpha_8 Project_{it} \times Score_{i2014} + u_{it,}$$

3.2. Data

The data on the research score of each research institution come from the European Research Ranking (www.researchranking.org). These data are only for higher education institutes and research centres and exclude companies from 2014 through 2020. The data on grants and projects submitted to H2020' Twinning programme come from the European Commission´s Community Research and Development Information Service (CORDIS) dataset (https://cordis.europa.eu/en).

The data on R&D intensity are the country-level R&D expenditure as a percentage of GDP comes from Eurostat. Finally, the data on innovation

performance at the country and regional level come from the European Commission´s European Innovation Scoreboard (https://ec.europa.eu/info/research-and-innovation/statistics/performance-indicators/european-innovation-scoreboard). They include the overall *Summary Innovation Index* and the subcategories *Attractive Research Systems* (including *International scientific co-publications*) and *Intellectual Property Assets* (including *PCT patent applications*). I chose the summary innovation index as the main indicator of R&D performance because it captures its many dimensions including human resources, finance and support, innovation, and economic and social impact. However, because the index is so broad, it makes sense to look at more specialized measures of performance like the attractiveness of research systems, the number of publications, and the number of patent applications.

Many of these indicators are widely used in the literature (e.g., Cozza & Plechero, 2017; Goddard et al., 2014) and are often enunciated by the EC as objectives and expected impact of European research support programmes, in specific the Twinning action of H2020 (European Commission, 2015).

4. Results

4.1. Funding and Spending in R&D

EU-13 countries receive a smaller share of H2020 funding (4.4%) than what is warranted by their share of EU GDP (7%), which suggests that those countries are underrepresented in the programme (Puukka, 2020). However, the funding awarded to EU-13 countries seems to be in line with their R&D spending, which is about one third of what is done by EU-15 countries (Figure 2). One interpretation of this fact is that H2020 has a strong bias towards high R&D

intensity countries, therefore not contributing to closing R&D performance gaps across the EU. Hence, the SEWP pillar in H2020 and Horizon Europe is of paramount importance. In this context, it is difficult to understand the very small weight that SEWP has in the total financial resources made available by both programmes.

Although H2020 had a budget of almost €77 billion, 4% to 5% were spent in administrative costs making the expenditure of less than €70 billion (Reillon, 2020). Hence, H2020 had a Net EU Contribution of more than €68 billion. Of this amount, around €1.02 billion (1.49%) was attributed to the SEWP Pillar. Horizon Europe framework (2021-2027) has a total budget of almost €97 billion and considers SEWP as a transversal pillar rather than a specific objective and intends to allocate close to €3.4 billion (3.5% of total budget) to it (European Commission, 2021). This points out the success and importance that SEWP had in H2020.

In Portugal, the distribution of funds from H2020 Twinning projects is highly concentrated at the regional level. The Lisbon Metropolitan Area got 58% of the funds (Figure 3) and 59% of all accepted projects—23 in the total of 39 project with a Portuguese institution as the coordinator. The second region with most Twinning projects is the North region with 12 Twinning projects and around 30% of the net EU contribution.

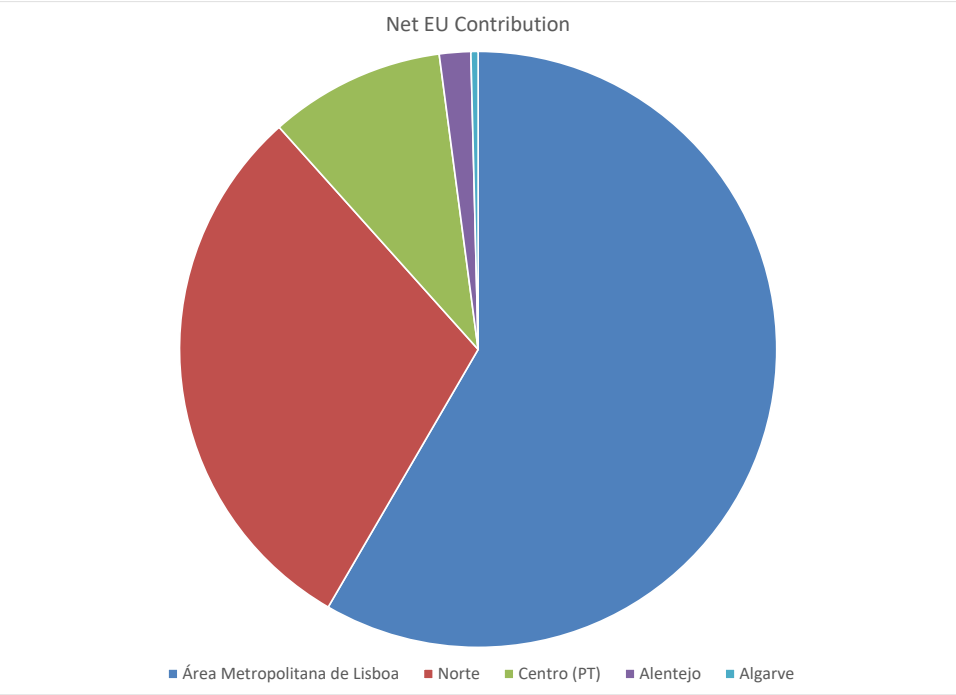

Figure 3. Geographical Distribution of Twinning Grants in Portugal
Source: Horizon Dashboard

4.2. Performance

4.2.1 The non-econometric approach

The impact of H2020 in general and of Twinning projects in particular can be measured by comparing the number of peer-reviewed publications before and after the project. Other indicators, used in the reports of some projects, are the number of early-stage researchers involved, and number of requests for patents. A summary indicator also used to measure R&I performance is the EIS summary index. The EIS summary index quantifies R&I quality across 12 innovation dimensions and uses 32 indicators (European Commission, 2021). The index covers framework conditions, innovation activities, investments, and impacts. It is also widely used in research papers (e.g., Barbero et al., 2021).

Between 2014 and 2021, the years immediately before and after H2020 respectively, the average R&I performance measured by the EIS summary index

increased for both non-widening and widening countries (Table 2). In fact, the summary index grew relatively more for widening countries (20%) than for the EU as a whole (16%). This suggest that there was convergence between widening countries and non-widening countries during the programme's duration.

The catching up in performance was even stronger for the sub-indexes measuring the attractiveness of research systems and the number of international scientific publications: the growth in both indicators in widening countries was 47% and 52%, respectively, while in non-widening countries was only 10% and 27%. Although the indicators measuring intellectual assets and patent applications declines overall for EU countries, the average decline was smaller for widening countries (4%) than for non-widening countries (9%), thus showing that even in this dimension there was some convergence across countries.

	Not Widening Countries		Widening Countries		Total EU Countries	
	2014	2021	2014	2021	2014	2021
Summary Index	114,5	128,8	71,3	85,5	90,5	104,7
Attractiveness of research systems	130,4	143,8	59,1	86,8	90,8	112,1
International scientific co-publications	131,6	166,7	81,6	124,3	103,8	143,1
Intellectual assets	109,0	103,7	67,7	66,6	86,1	83,1
PCT patent applications	131,2	119,2	27,3	26,2	73,5	67,6

Table 2. Average Score of R&I Performance in Widening Countries and Non-Widening Countries

Source: European Innovation Scoreboard (EIS).

Note: The table shows the average within-country of each R&I performance index, for all EU countries and for Widening and Non-widening countries.

The dispersion of the summary index fell across non-widening countries but rose for widening countries, suggesting that the effect of the programme was somewhat uneven for the latter group (Table 3). However, for intellectual assets and patent applications the dispersion fell across the board, especially for widening countries. Therefore, when it comes to cross country in equality the trends are somewhat ambiguous. So, it is not clear, according to these figures,

that the unevenness in R&I performance at the country level fell during H2020. This is somewhat surprising given that one of the objectives of Widening was the convergence between leader and emerging innovator countries.

	Not Widening Countries		Widening Countries		Total EU Countries	
	2014	2021	2014	2021	2014	2021
Summary Index	25,1	21,9	25,1	27,9	33,0	33,2
Attractiveness of research systems	36,8	39,0	45,8	46,1	54,8	51,2
International scientific co-publications	38,0	48,3	45,4	57,4	48,6	56,8
Intellectual assets	41,6	39,1	40,9	29,8	45,5	38,4
PCT patent applications	74,4	71,2	24,7	17,4	73,8	67,3

Table 3. Dispersion of R&I Performance Across EU Countries
Source: European Innovation Scoreboard (EIS).
Note: The table shows the across country standard deviation of each R&I performance index, for all EU countries and for Widening and Non-widening countries.

For the hypothesis H2 of this study extended to the EU countries —H2020 did not contribute to reduce within country gaps in research performance—the results in Table 4 show that the within country dispersion of the overall summary index and the number of scientific publications increased for all countries, including for widening countries. The exception is the measure of patent applications where there seems to have occurred some within country convergence, for all country groups.

	Not Widening Countries		Widening Countries		Total EU Countries	
	2014	2021	2014	2021	2014	2021
Summary Index	20,0	21,7	18,0	22,3	19,1	22,0
International scientific co-publications	42,0	45,0	42,1	46,3	42,1	45,6
PCT patent applications	21,2	20,0	14,1	10,0	18,0	15,4

Table 4. Regional Dispersion of R&I Performance Within EU Countries
Source: European Innovation Scoreboard (EIS).
Note: The table shows average within-country standard deviation of each R&I performance index from regional-level data, for all EU countries and for Widening and Non-widening countries.

In the case of Portugal, we see the same regional trends as in the rest of Europe (Table 5). From the start of H2020 (2014) to the last year of the programme (2021), the average R&I performance of the Portuguese regions increased for all indicators and especially so for the number of publications. However, the dispersion of R&I performance (measured by the standard deviation of the EIS indicators across regions in Portugal) also increased except for the number of patents for which there was a small decline. So, the data in Table 5 confirm the two hypotheses of this study.

	Average		Standard Deviation	
	2014	2021	2014	2021
Summary Index	62,00	70,64	21,99	24,05
Publications	95,27	125,87	26,41	30,97
Patents	30,04	35,67	18,15	17,85

Table 5. Regional Dispersion of R&I Performance Within Portugal
Source: European Innovation Scoreboard (EIS).

Note: The table shows averages and standard deviations across Portuguese regions of each R&I performance index from regional-level data.

To dig deeper into this issue, I looked at an institution-level measure of research performance (European Research Ranking) for a sample of Portuguese HEI and research institutes.

The sample consists of 76 Portuguese institutions that had at least one research ranking score in one of the years from 2014 to 2020. This is because there are no score

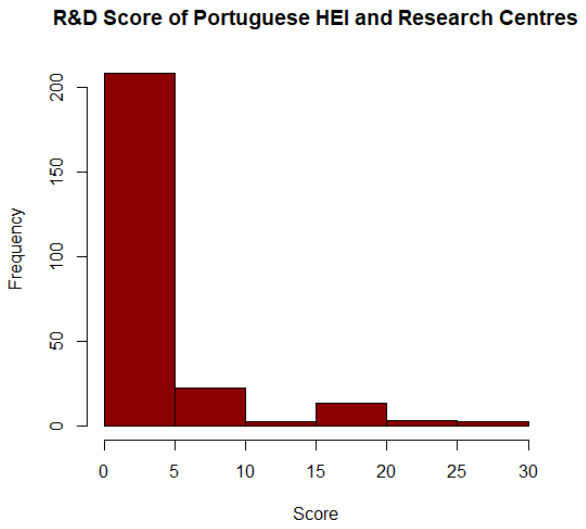

Figure 4. Histogram of R&I Scores of Portuguese HEI and Research Centres

data in some years for some institutions. The sample has 250 institution-year observations, which means that on average there are 3.3 years of data per institution. The average R&I score of all institutions is 3.07 and the median is of 0.92. Figure 4 shows that most institutions have scores between 0 and 5 between 2014 and 2020, but some institutions have very high scores which means that there is a lot of dispersion of R&I scores among Portuguese HEI and research centres.

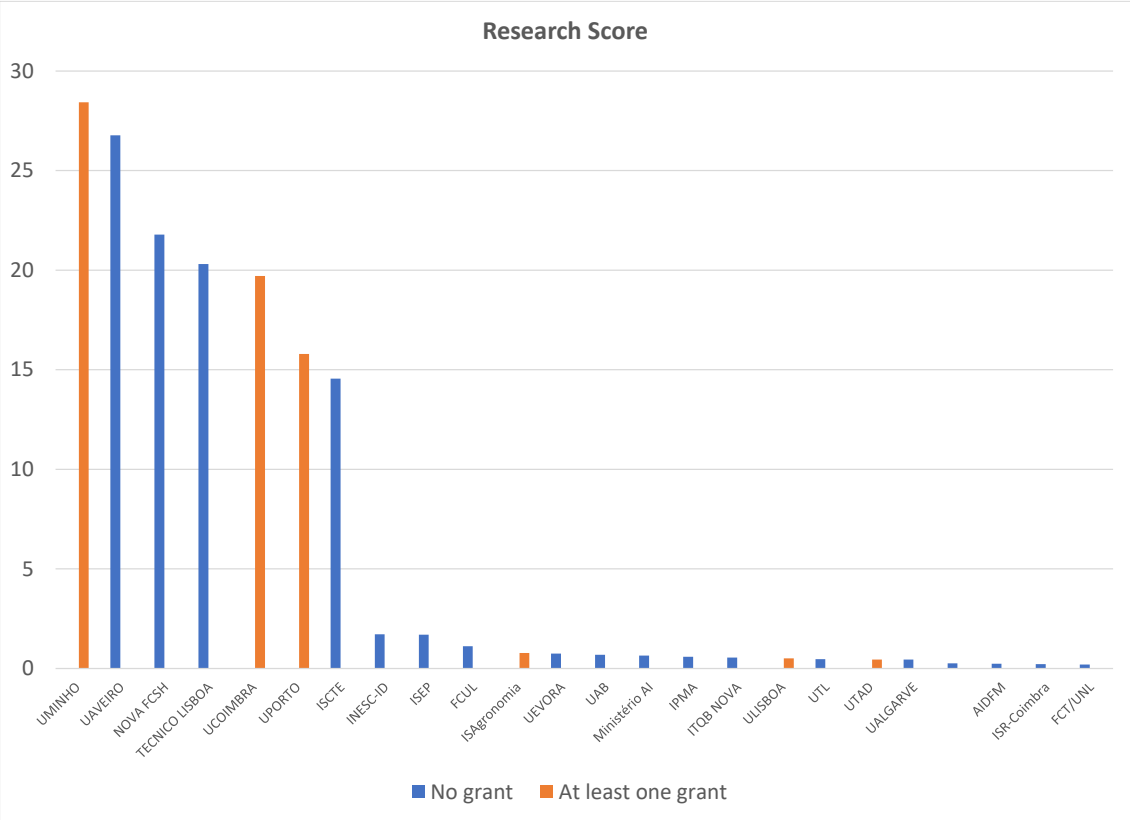

Figure 5. Research Score in 2014 by Portuguese Research Institution

The institutional level measure of research performance shows a high disparity in R&I performance across Portuguese institutions at the start of H2020 (Figure 5). This confirms the notion that initial conditions for the potential Portuguese applicants for H2020 were very uneven.

In addition, when looking at the R&I performance at the start of H2020, we can see that the institutions which never received a grant had a significantly lower performance than those that received at least one grant during H2020 (Figure 6). This was perhaps by design given the criteria imposed by the EC for access to H2020 funds (i.e., the EC recognizes that widening participation is important but that it should not come at the expense of promoting excellence (European Commission 2017a) and the highly competitive nature of the application process.

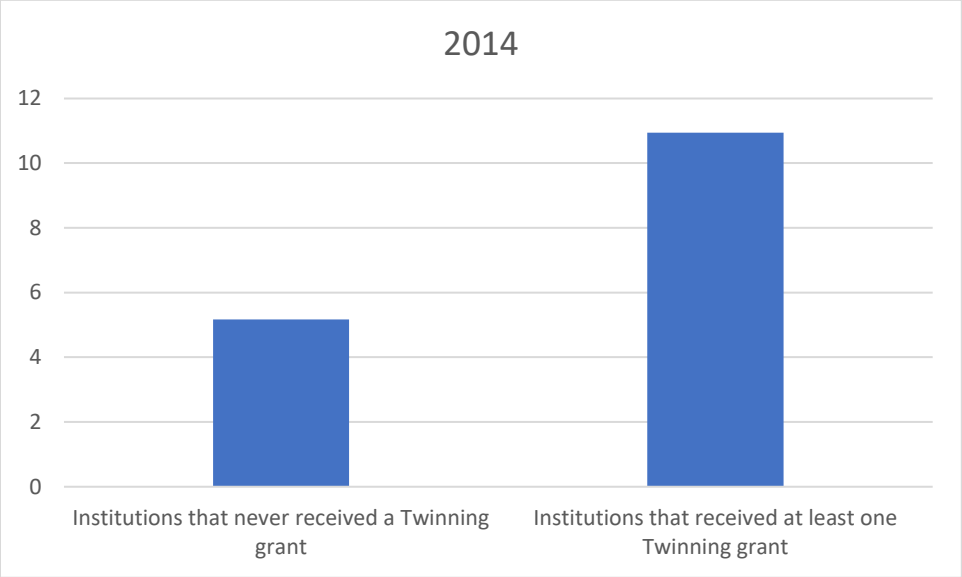

Figure 6. Average Research Score in 2014 of Portuguese Research Institutions According to Twinning Grant Received or Not (2015-2020)

4.2.2 The econometric approach

As was said before, the non-econometric approach should be understood as a preliminary analysis because its findings presented in the previous section are very likely to be biased due to the fact that they do not control for all possibly relevant determinants of the explained variable.

This is why an econometric approach was used to overcome these shortcomings. The first step was the estimation of the following OLS linear regression model using pooled data at the individual institution level:

$$Score_{it} = \alpha_0 + \alpha_1 D(Year = 2015) + \alpha_2 D(Year = 2016) + \alpha_3 D(Year = 2017) + \alpha_4 D(Year = 2018) + \alpha_5 D(Year = 2019) + \alpha_6 D(Year = 2020) + \alpha_7 Project_{it} + u_{it,}$$

The results are in column (1) in Table 6. By comparing Portuguese institutions that had received one funding grant and institutions that had not, the findings are that, from 2014 to 2020, the overall research score decreased. However, the research ranking of the institutions which received at least one Twinning grant either did not fall for most years or fell comparatively less than for the first group (Table 6). This is because the estimated coefficients of most year dummies are negative and statistically significant while the coefficient of the programme dummy is positive, statistically significant, and either greater or close to the estimate of the year dummies' coefficients. For any given year, institutions which received a Twinning grant had on average a research ranking higher above that of the others by at least 3 points. This seems to be in line with hypothesis H1 (see Chapter 1).

To capture characteristics that are idiosyncratic to each institution, the previous model was expanded by adding dummies for each institution (or institution fixed effects).

$$Score_{it} = \alpha_{0i} + \alpha_1 D(Year = 2015) + \alpha_2 D(Year = 2016) + \alpha_3 D(Year = 2017) + \alpha_4 D(Year = 2018) + \alpha_5 D(Year = 2019) + \alpha_6 D(Year = 2020) + \alpha_7 Project_{it} + u_{it,}\ and$$

The results of this second specification are in column (2) of Table 6. They show that the effect of having a project is no longer significant (in fact, the estimate comes out negative at -1.931). This means that once we account for different initial conditions among institutions, hypothesis H1 is rejected (i.e., on average, receiving a Twinning project made no difference for an institution's R&I score).

A third specification of the model was estimated to take into account the possibility that the effect of having a Twinning project is different depending on the initial R&I score of the institution. This was done by augmenting the previous specification with an interaction term of the *Project* dummy and the institution score in 2014.

$$Score_{it} = \alpha_{0i} + \alpha_1 D(Year = 2015) + \alpha_2 D(Year = 2016) + \alpha_3 D(Year = 2017) + \alpha_4 D(Year = 2018) + \alpha_5 D(Year = 2019) + \alpha_6 D(Year = 2020) + \alpha_7 Project_{it} + \alpha_8 Project_{it} \times Score_{i2014} + u_{it,}$$

The results of the estimation of this third specification are in column (3) of Table 6. They show that the estimate of the coefficient of this interaction variable is negative and significant (the estimate is -0.637), which means that the effect of Twinning projects is smaller for institutions that started with a higher score.[6]

This result, together with my earlier finding that institutions with an initial higher rank received more projects (Figure 6), mean that in Portugal the Twinning grants did not contribute to reducing the disparities in R&I score across institutions. So, a negative answer to research question H2 is rejected.

[6] The number of available observations for this regression is smaller than the one available for the previous two because there are no R&I scores for several institutions in 2014.

	Dependent variable: Score		
	Pooled OLS	Fixed effects	
	(1)	(2)	(3)
Year 2015	-1.890	-1.371	
	(1.161)	(1.102)	
Year 2016	-4.365***	-4.168***	-3.451***
	(1.219)	(1.137)	(1.162)
Year 2017	-2.448	-5.657***	-5.729***
	(1.647)	(1.510)	(1.592)
Year 2018	-5.938***	-4.797***	-5.172***
	(1.176)	(1.122)	(1.154)
Year 2019	-5.506***	-4.981***	-5.748***
	(1.199)	(1.184)	(1.270)
Year 2020	-5.676***	-4.977***	-5.865***
	(1.218)	(1.201)	(1.291)
Project	3.039***	-1.931	5.710**
	(0.796)	(1.188)	(2.421)
Project x Score in 2014			-0.637***
			(0.182)
Observations	250	250	87
R2	0.167	0.245	0.474
Adjusted R2	0.143	-0.126	0.207
F Statistic	6.942*** (df = 7; 242)	7.733*** (df = 7; 167)	7.342*** (df = 7; 57)

Table 6. Effect of Twinning Projects on Portuguese Research Institutions´ Research Scores

Note: The table shows ordinary least squares estimates of the following models:

$$Score_{it} = \alpha_0 + \alpha_1 D(Year = 2015) + \alpha_2 D(Year = 2016) + \alpha_3 D(Year = 2017) + \alpha_4 D(Year = 2018) + \alpha_5 D(Year = 2019) + \alpha_6 D(Year = 2020) + \alpha_7 Project_{it} + u_{it,}$$

$$Score_{it} = \alpha_{0i} + \alpha_1 D(Year = 2015) + \alpha_2 D(Year = 2016) + \alpha_3 D(Year = 2017) + \alpha_4 D(Year = 2018) + \alpha_5 D(Year = 2019) + \alpha_6 D(Year = 2020) + \alpha_7 Project_{it} + u_{it,} \; and$$

$$Score_{it} = \alpha_{0i} + \alpha_1 D(Year = 2015) + \alpha_2 D(Year = 2016) + \alpha_3 D(Year = 2017) + \alpha_4 D(Year = 2018) + \alpha_5 D(Year = 2019) + \alpha_6 D(Year = 2020) + \alpha_7 Project_{it} + \alpha_8 Project_{it} \times Score_{i2014} + u_{it,}$$

for columns (1), (2), and (3), respectively, where *Score* is institution *i*´s research score on year *t*, according to the European Research Ranking (www.researchranking.org). D(Year=2015), … are dummies that are equal to one for year 2015, …, and 0 otherwise. *Project* is a dummy variable that takes value one once the institution is awarded a grant from the Twinning Program and all subsequent years, and $Score_{2014}$ is the score of institution *i* in 2014. ***, **, and * mean the estimates are significant at the 1, 5, and 10 percent significance levels, respectively.

5.Conclusions, recommendations for public policy, shortcomings, and proposals for future work

The main goal of this thesis is to examine the effect of H2020's Twinning projects in the R&I performance of Portuguese institutions and research centres. Twinning is part of the SEWP pillar of H2020 that seeks to narrow the gap in R&I between EU countries. Since the H2020 programme upholds excellence and the institutions that get the fundings are the ones who are stronger in R&I, this thesis studies the dispersion of R&D performance within country regions instead of across EU countries.

The results of this study show that for most measures of the EIS, including the number of scientific publications, between 2014 and 2021, there was an improvement in performance for all EU countries, but it was much more pronounced for the EU-13 (i.e., the Widening countries). It was also found that the disparity in performance across countries increases in terms of overall R&I performance and in terms of indicator that measure the attractiveness of research centres, in particular the number of scientific publications, increased slightly for Widening countries, whereas it decreased for non-Widening countries. Importantly, the dispersion of these indicators within countries increased during the same period, with a slightly higher increase for Widening countries. This suggests that the programme did not contribute to a reduction in disparities across and within EU countries.

The analysis for Portugal was carried out using data for the research ranking scores of all Portuguese institutions present in the European Research Ranking, from 2014 to 2020, which is the duration of H2020.

The results for the non-econometric and the econometric approaches used to analyse that data were the following:

1) The answer to the first research question is positive, on average, that is, the impact of H2020 on the average performance of Portuguese Higher Education Institutes (HEIs) and research centres was positive;
2) The answer to the second research question is also positive, that is, H2020 Twinning funding increased disparities in R&I performance across institutions withing Portugal.

The major recommendation for public policy that can be drawn from these research fundings is that there is a need for including goals and policy instruments in the EU and in the national research funding programmes to help small research institutions to face the challenges involved in applying to EU grants (Cozza & Plechero, 2017).

This being said, these equity issues should not be addressed through changes in the design of the programmes which could be detrimental to excellence in research (European Commission, 2017a).

This study has several shortcomings. One is that there was no interviews or survey of Twinning projects coordinators in Portugal which could have enriched the analysis of this case. That kind of work could have complemented surveys already available for other countries (European Commission, 2017a; Puukka, 2020).

Another situation that was not taken into account has to do with the effects of COVID-19. This pandemic might have had some influence in the implementation of the Twinning Programme as it is focuses mostly on institutional networking (Dobranskyte-Niskota et al., 2021).

Another shortcoming to take into account is the fact that, of the three SEWP actions, Twinning is the one with less impact on R&I (Goddard et al., 2014). This makes the results presented in this thesis somewhat less generalizable. So, the extension of this kind of study to other areas of H2020 and HE could be an interesting topic for future research.

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