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portuguese association of researchers and students in the uk

‘PUMP’

Mapping Scientific Collaborations between Portugal and the United Kingdom

2023

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Diogo Martins,
Presidente PARSUK

foreword

It is my great pleasure to introduce this report, which presents the most comprehensive analysis of scientific collaborations between Portugal and the UK to date. As the president of PARSUK, the association of the Portuguese scientific diaspora in the UK, I am deeply committed to promoting and strengthening scientific partnerships between our two nations. This report is the result of a collaborative effort between PARSUK and a team of researchers from leading academic institutions in Portugal and the UK. The goal of this report is to provide policymakers, academics, and other stakeholders with a detailed overview of the existing scientific collaborations between our two countries, as well as to identify areas where further collaboration and investment are needed.

As the world continues to face complex challenges, from climate change to global pandemics, it is imperative that we work together to advance scientific knowledge and develop innovative solutions. Portugal and the UK have a long history of scientific collaboration, and this report highlights the many successes that have been achieved through joint research projects, exchange programs, and other initiatives.

At the same time, the report also identifies challenges and barriers to collaboration, such as differences in funding models, regulatory frameworks, and cultural norms. By addressing these challenges, we can create a more conducive environment for collaboration and ensure that the scientific partnerships between Portugal and the UK continue to flourish in the years to come.

I would like to express my sincere thanks to all those who contributed to this report, including the researchers who conducted the analysis, the funding agencies that supported the research, and the many stakeholders who provided feedback and insights. I hope that this report will serve as a valuable resource for all those who are committed to advancing scientific collaboration between Portugal and the UK.

DIOGO MARTINS
President PARSUK
2023

Madalena Alves,
President
of the Foundation
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preface

Science diplomacy is essential for promoting the image and national interests in the area of science and technology, opportunities for knowledge, communication and reciprocal collaboration between Portugal and other States. In 2019, the Portuguese Foundation for Science and Technology (FCT) signed cooperation protocols with several associations of Portuguese researchers abroad, thus recognizing the importance of these associations for strengthening bilateral scientific relations between Portugal and the host countries of those Portuguese researchers. The purpose of these collaborations is precisely the creation of conditions that contribute to the strengthening of these bilateral relations.

Four protocols were signed between FCT and associations of Portuguese researchers abroad: with PARSUK - Association of Portuguese Researchers and Students in the United Kingdom, with ASPPA - Association of Portuguese Graduates in Germany, with PAPS - Community of Portuguese Graduates in North America, with and AGRAFr - Association of Portuguese Graduates in France. In parallel, FCT has been dialoguing with other associations to celebrate new protocols.

Within the scope of these protocols, each association proposes a plan to FCT, of activities that contribute to the strengthening of bilateral scientific relations. The proposed activities have been very relevant. One of the lines of collaboration aims at better understanding the Portuguese scientific diaspora, through the creation of databases of Portuguese researchers abroad, as well as the mapping of scientific collaborations between Portugal and other countries. This is the scope of the mapping of scientific collaborations presented in this report. The inter-institutional collaboration carried out in this work, which brought together PARSUK, the United Kingdom Embassy in Lisbon and FCT, should also be highlighted.

The United Kingdom has long attracted many Portuguese researchers. However, the development of science in Portugal, which had particular impetus in recent decades, has allowed for the strengthening of bilateral collaborations between institutions and researchers from both countries. Mapping these collaborations makes it possible to recognize their importance and find ways to strengthen them, with benefits for both scientific systems.

FCT also contributes, and will continue to contribute, to the reinforcement of these bilateral collaborations. On the one hand, within the framework of its regular calls, FCT may provide return opportunities for Portuguese researchers abroad. On the other hand, by promoting the Portuguese participation in European R&I Programs such as Horizon Europe, within the framework of which, institutions from both countries can form consortia. Knowledge is the first step towards recognition and the creation of new opportunities. And in that sense, this report is a very relevant contribution.

MADALENA ALVES
President of the Foundation for Science and Technology

On behalf of the British Embassy in Lisbon I am delighted to introduce this important study: *PUMP - Mapping Scientific Collaborations Between Portugal and the United Kingdom*. My warm thanks are due to PARSUK for coordinating this research and to FCT for co-funding the project in partnership with the British Embassy.

This study provides us with valuable data and insight regarding the bilateral scientific relationship between the UK and Portugal; and a better understanding of the scale and breadth of that relationship. It tells us that:

- Collaborations between Portuguese and British researchers are significant, both in quantity and quality.
- The main thematic areas in which these collaborations occur are closely aligned with the policy agendas of our two countries, with emphasis, for example, on global challenges such as climate and sustainability.
- These collaborations generate economic value for our societies through knowledge creation, patenting and developing new products, services and solutions to the societal challenges we face.
- In addition to formal collaborations, which result in scientific articles or the development of research projects, there are many so-called "invisible" collaborations, informal partnerships between two or more researchers who share information and knowledge.
- Finally, the study reinforces the importance of personal relationships between British and Portuguese researchers.

The study is in part a celebration of past and present scientific links between our two countries. But more importantly, it looks forward and discusses ways to deepen those links in the future. It positions science and innovation at the heart of the UK-Portugal relationship, building on the Joint Declaration on Bilateral Cooperation signed by our two Prime Ministers in June 2022.

The UK is blessed with a very strong science sector and a world-leading research base. With less than one per cent of the world's population, the UK produces over 6% of the world's academic publications, and over 13% of the world's most highly cited academic publications [SciVal / Scopus]. This is a consequence of decades of public investment and the British Government has recently committed to spending £20 billion a year by 2024/25 on research and development, to ensure the UK continues to be a global leader in science and technology.

But we are acutely aware that international collaboration is vital in addressing the great global and societal issues of our times, from tackling climate change to responding to the challenge of our ageing populations. And in that context we greatly value our science and research collaboration with Portugal. Our ambition is for this relationship to prosper and flourish in the years ahead.

CHRIS SAINTY
His Majesty's Ambassador to Portugal

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EMBARGO

glossary

AICEP
Portuguese Agency for Investment in Foreign Trade, Agência para o Investimento e Comércio Externo de Portugal

BRF
Bilateral Research Fund

CORDIS
Community Research and Development Information Service

ERC
European Research Council

EU
European Union

FCT
Portuguese Foundation for Science and Technology, Fundação para a Ciência e a Tecnologia

FWCI
Field-Weighted Citation Impact

GDPR
General Data Protection Regulation

HE
Horizon Europe

IRR
Inter-Rater Reliability

LUSO
PARSUK's annual event

PARSUK
Portuguese Association of Researchers and Students in the United Kingdom

PCR
Policy Cures Research

PUMP
Portugal – United Kingdom Mapping Project

R&D
Research & Development

SAB
Scientific Advisory Board

UK
United Kingdom

UKRI
United Kingdom Research and Innovation

UKRI
United Kingdom Science and Innovation Network (SIN)

WOS
Web of Science

executive summary

executive summary

PUMP (Portugal – United Kingdom Mapping Project) is a project led by PARSUK, funded by FCT and the British Embassy in Lisbon / UK Science and Innovation Network, with the goal of mapping the recent evolution of scientific collaborations between Portugal and the United Kingdom.

The results of this research project are anticipated to be used by a variety of stakeholders, including senior leadership and decision makers in government agencies, academic and research institutions, and provide insights into potential future investment opportunities for both countries. In addition, this report serves as a useful tool for PARSUK to determine the sort of projects that have had success and those that haven't which help hone the focus of the PUMP project in the future.

The ten key findings of this report are:

ten key findings

1. **The scale of scientific collaborations between Portugal and the UK is robust.** Almost 1,500 international scientific projects were identified, a combination worth billions.

2. **The most prominent areas of collaboration represent important research priorities for the present and future of both countries and beyond.** These include research on climate change, oceans and biotechnology.

3. **Both countries share a vibrant ecosystem of dynamic and collaborative institutions.** The three most collaborative institutions in Portugal were the Instituto Superior Técnico, Universidade do Porto and CIIMAR. The three most collaborative institutions in the UK were University of Exeter, Imperial College London, and the Scottish Association for Marine Science.

4. **Scientific collaborations between Portugal and the UK are highly productive, impactful and of recognised quality.** Almost 15,000 publications, 80% of which published in the top 25% most prestigious journals of their respective fields, and 40 patent applications were identified.

5. **Portugal and the UK invest in international training opportunities that accompany their research priorities.** Over 350 international doctoral projects were identified, a combination worth millions.

6. **Early and mid-senior career researchers are often initiators of international scientific collaborations.** This was often associated with bandwidth and link with career progression.

7. **Both remote and face-to-face engagement opportunities are important formats to initiate and maintain these collaborations.** Brexit and COVID-19 have demonstrated that the international research community has a remarkable ability to adapt to change.

8. **Researchers often seek specific field expertise but also partnerships with prestigious international institutions.** Expertise and prestige were sought in both countries, but more can be done to achieve a more equal recognition of the strengths in both research ecosystems.

9. **Critical enablers include the existence of mobility/exchange programmes and formal inter-institutional agreements, whereas critical blockers include lack of funding and institutional bureaucracy.** International PhD scholarships and institutional cultures that value international scientific collaborations were deemed critical.

10. **International scientific collaborations have an undeniable positive impact on building research networks, progressing research careers and scientific progress.** Over 90% of researchers agreed that international scientific collaborations had a positive impact on their careers.

Five recommendations for future investments between Portugal and the UK emerged:

five recommendations

1. **Engage in joint research and development in areas of strategic and mutual interest.** These include research on climate change, oceans and biotechnology.

2. **Support the creation of official collaboration agreements between research institutions that cooperate the most internationally.** Formal collaboration agreements between the most active institutions in both countries has the potential to mitigate the lack of institutional endorsement for international cooperation and bureaucratic procedures.

3. **Enable the transfer of innovation and technology between both countries.** To accelerate innovation, joint ventures, technology transfer offices, innovation hubs, incubators, and tax incentives for companies that invest in science and technology should be considered.

4. **Promote international cooperation across all career stages in research, with a focus on early-career researchers.** These may include PARSUK's Bilateral Research Fund scheme, as well as informal networking events to foster inter-personal skills.

5. **Monitor and evaluate the evolution of scientific collaborations between Portugal and the UK over time.** Surveys and questionnaires from this study can be repurposed and disseminated during relevant meetings organised by both countries.

This initiative is a first step towards what hopefully will become ongoing research in international scientific collaborations, particularly in the context of the bilateral relationship between Portugal and the UK. This study suggests both countries have a long-standing history of collaboration and are still interested in engaging in collaborative research going forward.

The results of this project may serve as a starting point for understanding the interests and shared needs of the two countries, which will help determine which areas of collaborative research and themes should be prioritised.

introduction

Under the aegis of the Treaty of Windsor, Portugal and the United Kingdom (UK) have enjoyed the oldest bilateral alliance in known history, which is still bearing fruit to this day. While mostly mediated through other international unions during the last century, this bond has paid many dividends in several areas. This includes a rich history of cooperation and mobilisation of students, academics, and researchers between the two nations. In June 2022, Portugal and the UK reaffirmed their commitment to this alliance by signing a Declaration on Bilateral Cooperation in London. Of even greater relevance to this report, a whole section of this proclamation is devoted to science, innovation, and technology (GOV.UK, 2022).

Over the years, Portugal and the UK have matured robust ties in science and innovation. Between 2018 and 2020, the UK saw a 17.7% increase in incoming students from Portugal, which makes Portugal the 3rd (third) fastest-growing global provider to UK Higher Education institutions after India and Nigeria, and the fastest in Europe (UUK, 2021). By 2020, both countries had also co-authored 24,003 publications according to SciVal. This makes the UK Portugal's 3rd (third) most collaborative research partner, whereas Portugal is UK's 20th (twentieth) most collaborative research partner. In the context of the European Union (EU) Horizon 2020 Framework Programme, Portugal was the UK's 13th (thirteenth) most collaborative research partner (UUK, 2021), ahead of Norway, Ireland, and Poland, which resulted in 1,990 collaborations worth €10.7 billion (Lyra, 2021). The value of these ties is undisputable.

However, a comprehensive record of the research landscape between these two nations is not yet available. From existing literature, a mapping exercise attempted to capture the research landscape on biodiversity between Europe and Latin America and the Caribbean region (see Dangles et al., 2016), others involved the two and more comparable countries (see Gazni et al., 2012 or Csomós & Lengyel, 2020), and statistics on the level of each nation's international scientific cooperation have been collected (see Patricio, 2010, FCT, n.d. or Elsevier, 2020). To our knowledge, no previous study has been published to specifically describe the scale and nature of the bilateral alliance in science and innovation between Portugal and the UK, including how these bonds were established. Considering our historical links, mapping such scientific collaborations is fundamental to forge future areas of cooperation.

With the goal of strengthening science diplomacy between Portugal and the UK, a protocol between the Portuguese Association of Researchers and Students in the UK (PARSUK) and the Portuguese Foundation for Science and Technology (FCT) was established in 2019. It anticipated the creation of a Scientific Advisory Board (SAB) to aid science advice to Portuguese agencies and the emergence of new opportunities for scientific exchange for the Portuguese scientific community in the UK, such as Bilateral Research Fund (BRF) grants (PARSUK, 2019). Not least important, this agreement was the driving force behind the intention to map the scientific collaborations between the two countries, which led to the genesis of this project: PUMP (Portugal – United Kingdom Mapping Project).

In September 2021, a new partnership boosted the level of ambition of the bilateral relationships in science and innovation between Portugal and the UK. A new memorandum of understanding was celebrated between PARSUK and the British Embassy in Lisbon - UK Science and Innovation Network (SIN), with the aim of supporting bilateral science cooperation through joint initiatives. These included doubling the offer of grants in the BRF scheme and bolstering the PUMP project to a scale that demonstrates the truly bi-directional nature of scientific collaborations between the two countries. In particular, the UK partners demonstrated interest in gaining a deeper understanding of the dynamics behind the set up of these collaborations and what factors contributed to their success.

Consequently, the PUMP project emerges as a key product of this new reinvigorated triangular cooperation. PARSUK was hence formally recognised as the representative of the Portuguese scientific diaspora in the UK, and a key strategic partner in international scientific affairs to both Portugal and the UK.

The aim of this project is to map the recent evolution of scientific collaborations between Portugal and the UK and better understand how these collaborations were formed.

Our approach is based on the systematisation of existing collaborations between Portugal and the UK, whilst allowing for intriguing case-studies to be investigated in further detail. The specific outputs of this initiative include a comprehensive database of scientific collaborations between Portugal and the UK (Excel-based), and a final report that may serve as a state-of-the-art reference to subsequent discussions between both countries when negotiating which research areas to prioritise going forward.

The results of this project are anticipated to provide insights to high-level stakeholders, including policy and decision-makers, and senior leadership in academic and research institutions in Portugal and in the UK, about future investment opportunities for both countries in the field of science and innovation. In specific, this is a timely window of opportunity for Portugal and the UK to align priorities in their respective research agendas and to identify strategies and plans that predict more effective and successful collaborations for international research.

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methodology

aim and objectives

The central aim of this project is to map the recent evolution of scientific collaborations between Portugal and the UK and better understand how these collaborations were formed. To achieve this goal, taking into account the interests of each partner organisation was vital. A workshop was held in November 2021, with FCT and the British Embassy in Lisbon, to clarify expectations and to refine the remit for this project.

From this workshop, two streams of work emerged with distinct yet complementary objectives:

A. **Mapping approach**, to identify scientific projects between Portugal and the UK based on public funding data from both countries and the EU, combined with data on the scientific outputs (quantitative and qualitative);

B. **Case-study approach**, to identify additional scientific projects between Portugal and the UK and better understand how these were established (qualitative).

In addition, this workshop provided insights on the intended use of this report: a report that considers its target audience, including policy and decision-makers, senior leadership in academic and research institutions; one that values the dynamic evolution of scientific collaborations through a specific timeframe; one that has a clear focus based on the EU Horizon Europe (HE) Framework Programme missions; and one that also reflects on the experiences of building collaborations that are often invisible.

design and approach

A mixed and convergent methodological design (Wisdom & Creswell, 2013) allowed an integrated collection and analysis of different data types to achieve a holistic understanding of the research landscape between Portugal and the UK (Ivankova, 2006). This combination of methodologies is what sets this study apart from comparable ones.

Thanks to the generous financial support of both the FCT and the British Embassy in Lisbon - UK SIN, PARSUK was able to recruit two research analysts to plan and implement this project. A scoping document outlining the remit and methodology of this exercise was prepared by the research team and subsequently validated by the funding partners over e-mail (see Appendix A). This document establishes fundamental working definitions for this exercise, including: scientific collaboration; research and development (R&D) activities and projects; research types and scientific disciplines, according to the Frascati manual; R&D performers – researchers and their career levels or research bodies and institution types; and funding sources and scientific outputs.

According to each workstream – mapping and case-study – tailored search strategies were devised for a more robust and replicable data collection and analysis.

A. MAPPING APPROACH

Conceptual framework

A conceptual framework was created with the goal of establishing a logical flow between the most traceable input and output domains involved in the research process: funding and scientific outputs, respectively (see Figure 1).

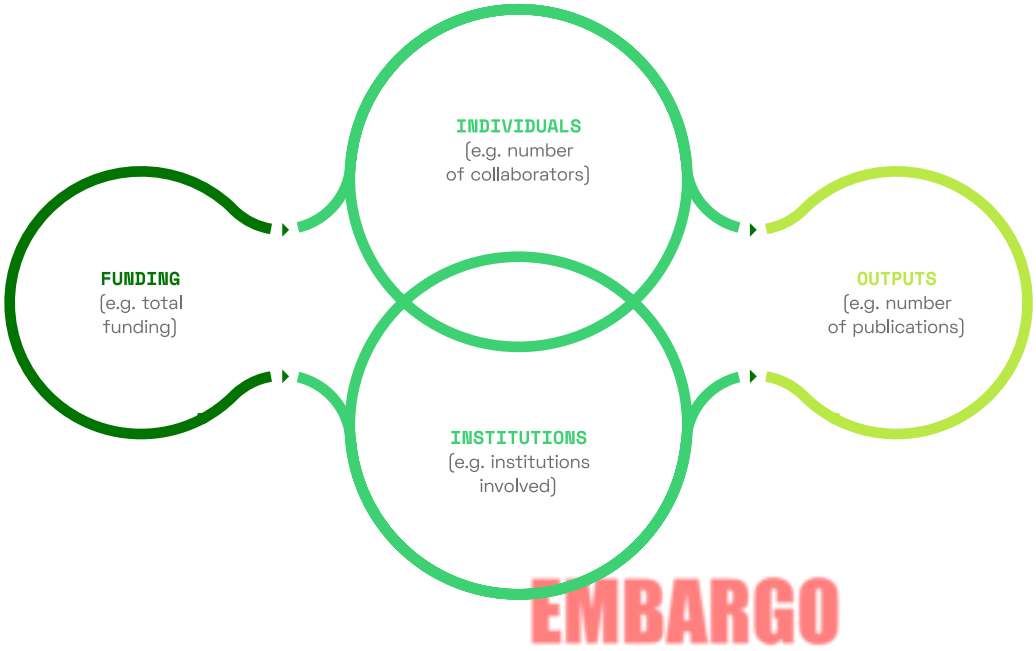

figure 1.
Conceptual Framework for the mapping stream of PUMP

Different indicators for each domain were agreed upon to guide a systematic data collection and analysis. By tracing these variables and associated keywords in the appropriate data sources, international scientific collaborations of interest were identified, including the respective projects and institutions.

Research questions

Based on this conceptual framework, general and specific research questions were defined as follows to better prioritise key insights and structure the results and discussion sections of this report:

GENERAL	SPECIFIC
For the duration of EU Horizon 2020 (2014-2020), which scientific collaborations have been established between Portugal and the United Kingdom, in the 5 mission areas of Horizon Europe?	1. How many projects were established and what are their key characteristics, including scale, mission area and scientific discipline? 2. Which were the most collaborative institutions in Portugal and the UK? 3. How many scientific outputs were produced and what are their key characteristics, including scientific disciplines and applicant country?

table 1.
General and specific research questions for the mapping workstream

Rationale

The timeframe agreed amongst partners was the duration of EU Horizon 2020 Framework Programme, covering a period ranging from 1 January 2014 to 31 December 2020. This timespan was deemed to provide an overview of the evolution of the scientific collaboration landscape, over a period that preserved coherence in terms of European research goal areas. Scientific projects created during that timeframe stand a greater chance of converging on their highlighted research areas in favour of greater European relevance (as a partner, which may also provide more fertile ground for international collaborations). Additionally, the EU Horizon 2020 Framework Programme identified the UK as one of its top-performing countries: the UK's ***'university researchers participated in and led more Horizon 2020 projects than any other participant country, and the UK had one of the programme's highest funding bids success rates (15.0%)'*** (UUK, 2021). Posterior timeframes, more relevant to other programmes, were left to be explored in future iterations of this mapping exercise.

The research areas were limited to the EU Horizon Europe Framework Programme's 5 (five) mission areas:

I. Adaptation to climate change, including societal transformation

II. Cancer

III. Healthy oceans, seas, coastal and island waters

IV. Climate-neutral and smart cities

V. Soil health and food

#HorizonEU

This selection provided a thematic focus that fits neatly into the broader scope of its predecessor, the EU Horizon 2020 Framework Programme. This ensured a sense of continuity congruent to the chosen timeframe, while limiting the breadth of explored areas. By analysing current EU priorities as they were featured during the current EU Framework Programme, this mapping exercise gathers insights about the past to inform present and future directions in research funding and policy.

The need to narrow down the thematic scope of this mapping exercise was agreed upon by the partners from the outset. Although desirable to capture a comprehensive selection of scientific collaborations in a broadest number of research areas possible, such an endeavour would require the time and a level of resource (financial and human) outside the scope of this project. The strategic decision to focus on the research areas in the EU Horizon Europe, a key programme for EU nations such as Portugal, provides a framework for a much-needed continued alignment between Portugal and the UK in the new Global Britain era. Additional thematic areas, more relevant to other programmes, were left to be explored in future iterations of this mapping exercise.

Data variables

Two types of evidence were prioritised:

» Scientific projects funded by Portuguese, UK and EU agencies (see Figure 1 in Appendix C);

» Scientific outputs from these or other projects (see Figure 2 in Appendix C).

Regarding the data variables, some were accessible (represented below by an * icon), while other data were not (represented below by an × icon). Additional data deemed relevant during data collection, is also presented (shown with a + icon).

* Data source
* Original ID
* Scientific Discipline
* Relevant HE Mission
* Acronym
* (Project)Title
* Year of creation
* Duration (Years)
* Primary institution
* Country of primary institution
* Number of institutions involved
* Institutions Involved
* Type of institution
* Number of Scientific publications
* Number of patents
* Funders
* Type of funding
* Funding Scheme
* (Publication) Title
* Author(s) (of publication)
* Nr authors (of publication)
* FWCI (of publication)
* Journal Quartile (of publication)
* Year
* Document Type (of publication)
+ Source-described Funding
+ DOI
+ Source Title (of publication)
+ Source Type (of publication)
+ UK/PT Cities involved
× Number of Grant Submissions
× Total Funding
× UK/PT Regions Involved
× Country of Primary Institution
× Number of Collaborators
× Career Level of Collaborator

Data sources

To identify the scientific projects, 2 (two) databases for scientific projects funded nationally: FCT (Portugal) and UKRI (United Kingdom); and 2 (two) databases for European-related funding were selected: ERC and CORDIS. The majority of data in both databases is publicly accessible.

For scientific outputs, 3 (three) of the most used data sources for peer-reviewed publications: SciVal, Scopus, and WOS. All these databases are often referred to for bibliometric studies that examine scientific activity.

The combination of these data sources was considered the most comprehensive and robust. A brief description of each data source is presented on table 2.

table 2.
Key characteristics of data sources for the mapping workstream by evidence type

EVIDENCE TYPE	DATA SOURCES	KEY CHARACTERISTICS
Scientific projects	FCT	The FCT data repository can be challenging to work with. Most publicly available information is already categorised by year and scientific discipline, yet without data regarding each application, funded grant or PhD. Complementary data may be accessible upon formal request.
	UKRI	The UKRI itself compiles a variety of outputs resulting from their funded projects, including information on international collaborations between research institutes. Data regarding projects funded by the UKRI, publications or patents associated with the projects are all accessible through the same UKRI portal. Similar to CORDIS, the UKRI database also encompassed most domains of the conceptual framework of this project.
	ERC	The ERC data archives do not allow for the extraction of detailed spreadsheets nor provide additional data that wasn't already covered by CORDIS data sets.
	CORDIS	Despite the original intention of using CORDIS for public funding data, this data source is very comprehensive and encompasses almost all domains of the conceptual framework of this project with the exception of the 'individuals' domain.
Scientific outputs	SciVal	SciVal enables the download of pre-filtered data with publications that involve scientific collaborations between Portugal and the UK. It also provides a unique collaboration metric that indicates the extent to which publications of a certain entity have international, national, and institutional co-authorship or single authorship. However, access to this data source is limited to academic institutions, or by paid subscriptions
	Scopus	Scopus allows for the filtering of relevant data but a keyword search is required for web-based data collection. In practice, a single dataset for each desired keyword must be downloaded and analysed individually.
	WOS	Data collection and mining on WOS is similar to Scopus.

Search terms

Each mission was analysed by reviewing official European Commission documents (European Commission, 2021a, 2021b, 2021c, 2021d and 2021e). This allowed for a better understanding of the scientific frameworks involved and resulted in the creation of working definitions for each mission area, example, and keyword developed to filter the desired data and produce relevant results for each mission (see Appendices A & B).

This list of keywords was updated since the original design in the scoping document. One of the keywords, 'sustainab' was particularly challenging to use, since it included several projects outside the scope of the HE mission areas. A manual review was necessary.

Inclusion and exclusion criteria

Considering the outlined scope, the team defined the inclusion and exclusion criteria based on the timeframe, themes, and types of research to be featured (see Table 3).

table 3.
Inclusion and exclusion criteria for the mapping workstream

CRITERIA	INCLUSION	EXCLUSION
Timeframe	01/01/2014 - 31/12/2020	Projects that were created before and after our established timeframe yet containing scientific output within that timeframe.
Themes	Horizon Europe Programme's 5 mission areas	Research collaboration whose primary outcomes are not directly related to one of the missions.
Types of research	Basic research and experimental developments	Applied research, such as general-purpose data collection (such as recording weather statistics): » scientific and technical information services (collecting, coding, recording, classifying disseminating, translating, analysing, and evaluating) except when integral to an R&D project. » testing and standardisation. » feasibility studies. » programmatic evaluations. » purely R&D financing activities. » indirect supporting activities. » routine testing and analysis of materials, components, products, processes, etc. » phase IV of clinical trials (unless they result in a further scientific or technological advance).

Data extraction

A PRISMA-like approach was developed and followed to assemble a database of scientific collaborations between Portugal and the United Kingdom, bilateral or multilateral, in the pre-defined timeframe and thematic scope. This not only ensures transparency and replicability, but also clarifies the logical framework behind the process (see flow diagrams in Appendix C).

In terms of thematic scope, given that each HE mission represents a broad and multi-faceted concept, a set of keywords was defined for each mission that needed to be present in the project title or abstract (see Appendices A and B). Each project or scientific output required at least an institution from each country, or a co-author affiliated to an institution of each country, within the specified timeframe.

Scientific collaborations are traditionally assessed through bibliometric studies, which only examine scientific outputs. Typically, bibliometric studies categorise and quantify scientific collaborations using co-authored publications (García-Villar & García-Santos, 2021). Nevertheless, a single collaboration, whether part of a project or not, can produce multiple publications (it is desirable to do so), while only representing a single connection between researchers or institutions. For that reason, the research analysts opted to classify each project as a collaboration, and the various scientific outputs as products generated by those collaborations.

A crossmatch of funding data and scientific output data was performed to identify the projects within scope and assess their scientific productivity. New collaborations were also identified through publications that were not linked to previously identified projects in funding data sources.

Synthesis of extracted evidence

Each entry contains as much data as was feasible to gather, and the researchers cross-matched all the data that could be used to characterise the collaborations with most of the desired indicators. However, as expected, a perfect convergence of data extracts for each project, in a way that fulfils all data points (i.e.: indicators), was not possible for all projects. This database includes publications without funding data, and grants without publications. There was some data obtained from other sources besides those previously stated, such as the Journal Quartile, which was extracted from Scimago journal rankings. Some indicators not provided by the data source were classified manually (e.g.: scientific discipline or cities of institutions) or classified according to the pre-established keywords (HE missions). Other indicators were calculated through Excel formulae or tools, based on the data provided.

The final database was constructed in Excel with the variables indicated above. This analysis in the report is descriptive, and summarises a selection of key data and trends, typically combining two or more indicators of particular interest to decision-makers. Except for the Sankey diagram generated by the online data visualisation tool SankeyMatic, all figures were generated in Excel.

To aid the development of case studies and future mapping research projects, a record of all steps involved in data collection, mining and analysis was kept. This will ensure quality assessment and replicability. These records are available upon request.

Photo by Dom Fou on Unsplash

Quality assessment

The research team was kindly trained by Juliette Borri from Policy Cures Research (PCR) to ensure best data mining practices. Quality assessment was performed internally by both research analysts, and externally by the project team and advisory group. Each research analyst double-checked their colleague's work, validating data collection and mining methods. This review was essential for assessing the quality and bias in all manual stages, which relied on the judgement call of the research team. The inter-rater reliability (IRR) between the two research analysts was measured and recorded (see Appendix D), including at which stage of the workflow tests were performed, which disagreements emerged, and how they were addressed (Belur et al., 2021). Due to the high volume of data, the research team selected a random sample of 10% for each dataset to determine the IRR. Agreement was determined with an IRR threshold exceeding 90%.

Sustainability

The scoping document also outlines the expected data sources, methodology, and how to conduct the data validation process and quality assessment, further elaborated in the methodology section of this report. This allows for the methodology to be replicated in future projects with the same or adapted remits.

The results of this workstream feed into the construction of a single database identifying collaborations that meet the inclusion criteria, with the goal of updatability over time (using a replicable methodology), enabling the monitoring of the dynamic evolution of those collaborations.

EMBARGO

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Polina Tankilevitch
on Pexels

B. CASE-STUDY APPROACH

This qualitative, case-study approach was designed with the added goal of detecting early-stage collaborations between international researchers who have not necessarily been awarded sizable funding nor produced peer-reviewed publications yet, independently from their alignment with EU Framework programmes.

This is ultimately our working definition for 'invisible collaborations', which may have escaped the quantitative mapping exercise given their lack of traditional traceable input and output signs, namely online registries for public funding or research output databases. This work stream sought to comprehend the mechanics underlying the creation of such collaborations, and potential for monitoring and evaluation over time.

Research questions

Research questions were defined as follows to better prioritise key insights and structure the results and discussion sections of this report:

1. **How were these scientific collaborations initiated and what motivated them?**
2. **Which factors have enabled or hindered the process of establishing these scientific collaborations?**
3. **What impact have these scientific collaborations had in the careers of the researchers?**

Rationale

Capturing the serendipitous encounters in science and innovation internationally is uniquely challenging using traditional quantitative data collection methods. One of the benefits of this project was the stewardship provided by PARSUK, an organisation with 15 years' experience with the international scientific diaspora in the UK and with a long-standing experience in emerging partnerships for research. A qualitative approach was adopted to best capture such initiatives and how they came to fruition.
Additionally, this exploratory approach also intends to characterise emerging partnerships, the factors that have contributed to their success, mechanisms by which they are formed, and derive lessons that might encourage future collaborations. The collection of interesting case-studies, senior accounts, and anecdotal reports obtained in the qualitative phase were instrumental in shaping a solid repertoire of common practices amongst established collaborations, with the goal of informing stakeholders of what has been successful or less so thus far.

Data sources

Researchers and academics with prior experience in international scientific collaborations between Portugal and the UK were pre-identified for in-depth interviews. Two groups were selected as indicated in table 4.

table 4.
Key characteristics of data sources for the case-study workstream

DATA SOURCES	KEY CHARACTERISTICS
PARSUK's Scientific Advisory Board (SAB)	The SAB is primarily composed of senior Portuguese academics and researchers based in Portugal and the UK. This Board is responsible for fostering scientific diplomacy in bilateral relations between Portugal and the UK, offering scientific advice to the Portuguese government, and national R&D institutions, contributing to the knowledge transfer of scientific and technological advancements between the two countries, and providing information about opportunities for new partnerships and funding (PARSUK, n.d.).
Bilateral Research Fund (BRF) awardees	The BRF is an annual programme that aims to support early career researchers with seed funding of €3,000 to accelerate existing and new scientific collaborations between Portugal and the UK (PARSUK, 2020). This programme is sponsored by the FCT and the British Embassy in Lisbon – UK SIN.

The two groups included both senior and junior academics and researchers, hence, a representative sample. A total 30 participants were included, and the target was to interview at least 50% of the group. Additional relevant contacts were identified using a snowballing approach.

Given the project timeline and the fact that the interviews were conducted in the summer of 2022, when most academics and researchers are less available, a survey was developed as a complement (see Appendix F).

This survey (Google Form) was also shared with the wider PARSUK community for additional perspectives not captured in the mapping stream of this project, including projects outside the EU HE mission areas and pre-selected timeframe. Contacts were facilitated by PARSUK, according to General Data Protection Regulation (GDPR) best practices, and by the research team itself based on previous connections with Portuguese institutions.

Themes

The interviews were exploratory, with well-defined topics of discussion, a method that allows a more comprehensive set of information about these partnerships and how they were established (see Appendix E).

Data extraction

The interviews were conducted online via the Zoom platform and were expected to last for 30 minutes. The data archives and all individual names were both anonymised for privacy. Explicit consent was sought to tape the interviews for transcription purposes only. Prior to the interview, participants were also provided with a participation information sheet (see Appendix G).

results

results

This section aims to describe a selection of key data and trends that emerged from the mapping and case-study workstreams. Each segment explains its purpose and significance in painting the picture of the scientific collaborations between Portugal and the UK, while reserving a more in-depth interpretation for the discussion section.

A. MAPPING APPROACH

The relevant research questions for this workstream were as follows:

1. How many projects were established and what are their key characteristics, including scale, mission area and scientific discipline?
2. Which were the most collaborative institutions in Portugal and the UK?
3. How many scientific outputs were produced and what are their key characteristics, including scientific disciplines and applicant country?

In total, 45,908 records of scientific projects and 29,799 recordings of scientific outputs were collected from the data sources and screened to ensure that only the records that met the inclusion criteria were included (see Appendix C). The database was also cleaned to avoid duplications and remove errors and inconsistencies. All the project and publication records were stored in two Excel databases, one for projects (see Appendix H1) and the other for publications (see Appendix H2).

Below, the findings of data on publicly funded scientific projects are reported first (FCT, UKRI and CORDIS), followed by data on from the scientific outputs (SciVal, Scopus, WOS and CORDIS), and finally by data on PhDs and post-doctoral scholarships (FCT).

Scientific projects

1. **How many projects were established and what are their key characteristics, including scale, mission area and scientific discipline?**

Between 2014 and 2020, the European Commission, the UKRI and the FCT funded a total of 444 research projects, involving Portuguese and UK institutions, centred around Horizon Europe-relevant themes. Table 5 illustrates the levels of porosity by timeframe, location and thematic scope, according to each data source

	NUMBER OF PROJECTS IN TIMEFRAME AND LOCATION	NUMBER PROJECTS IN THEMATIC SCOPE
UKRI	160	18
FCT	262	18
CORDIS	1,049	408
TOTAL	1,471	444

table 5.
Number of included projects from each data source (public funding). First level of inclusion: timeframe (2014- to 2020) and location (Portugal and UK involved). Second level of inclusion: thematic scope (five Horizon Europe missions)

This funding comprises the total sum of €2,516,719,492.08, with a median investment of €4,707,930.80 per project. 93.26% of these collaborations were multinational and multilateral.

The median number of institutions involved in the same collaboration is 18, with 71.69% of these projects (319) being coordinated by institutions outside of Portugal or the UK. However, there were more UK-led than Portugal-led collaborations, with 16.18% of projects coordinated by UK institutions (72) and 11.91% (53) coordinated by Portuguese institutions.

Figure 2 illustrates the total level of funding and number of projects for each HE mission thematic area. The volume of funding for each thematic area is represented through the right bars, while the number of projects developed around that area is represented by the left bars.

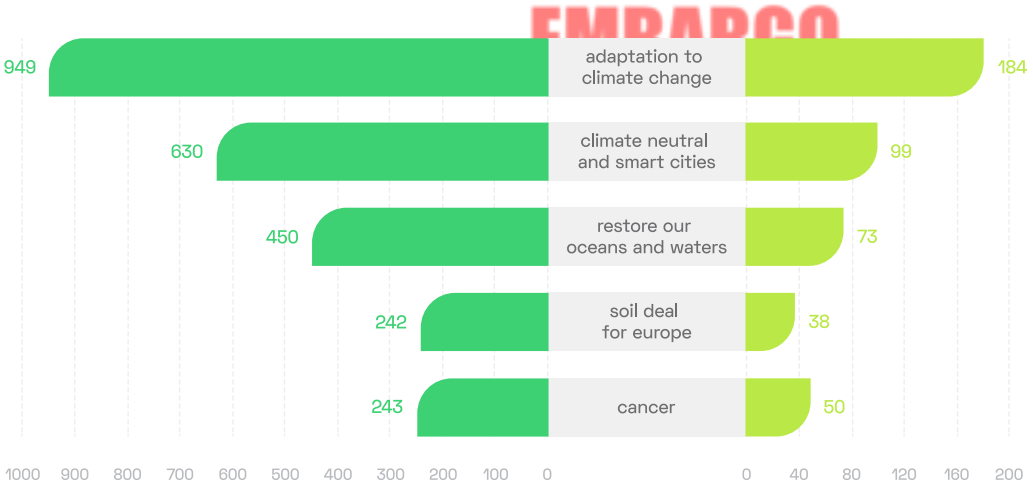

figure 2.
Composite chart: left bars with total funding (in millions of €) per Horizon Europe mission area (total funding = €2,516,719,492.08); the right bars the total number of projects per Horizon Europe mission area (n = 444)

'Adaptation to climate change' is the mission area with the highest total volume of funding and number of projects (with approximately €949 million for a total of 184 projects), while 'Soil deal for Europe' (with approximately €242 million for a total of 38 projects) and 'Cancer' represent the lowest (with approximately €243 million for a total of 50 projects).

Figure 3 portrays the proportion of disciplines represented in the included project, according to the classification used in the Frascati Manual.

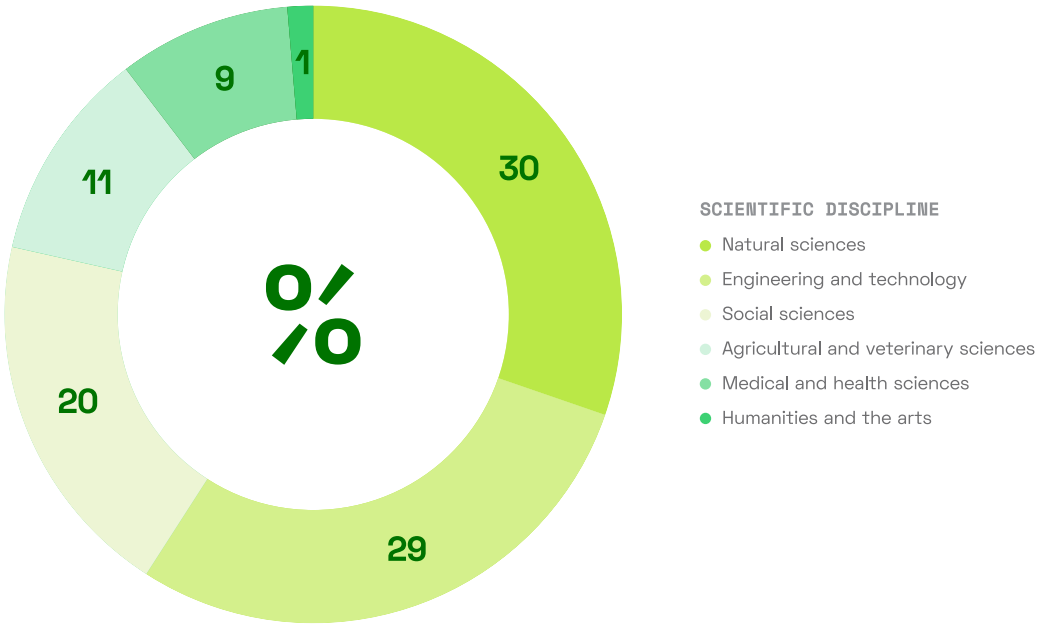

figure 3.
Proportion of included projects by scientific discipline (as classified by the Frascati Manual). Note: projects may contain multiple disciplines

59.46% of projects were multidisciplinary. The two most common disciplines were 'Natural Sciences' (30%), and 'Engineering and Technology' (29%).

2. Which were the most collaborative institutions in Portugal and the UK?

Two Sankey diagrams were created to illustrate the top 3 (three) most collaborative institutions in Portugal and in the UK, according to the number of connections with the other nation (see figures 4 and 5).

Photo by Annie Sprat on Unsplash

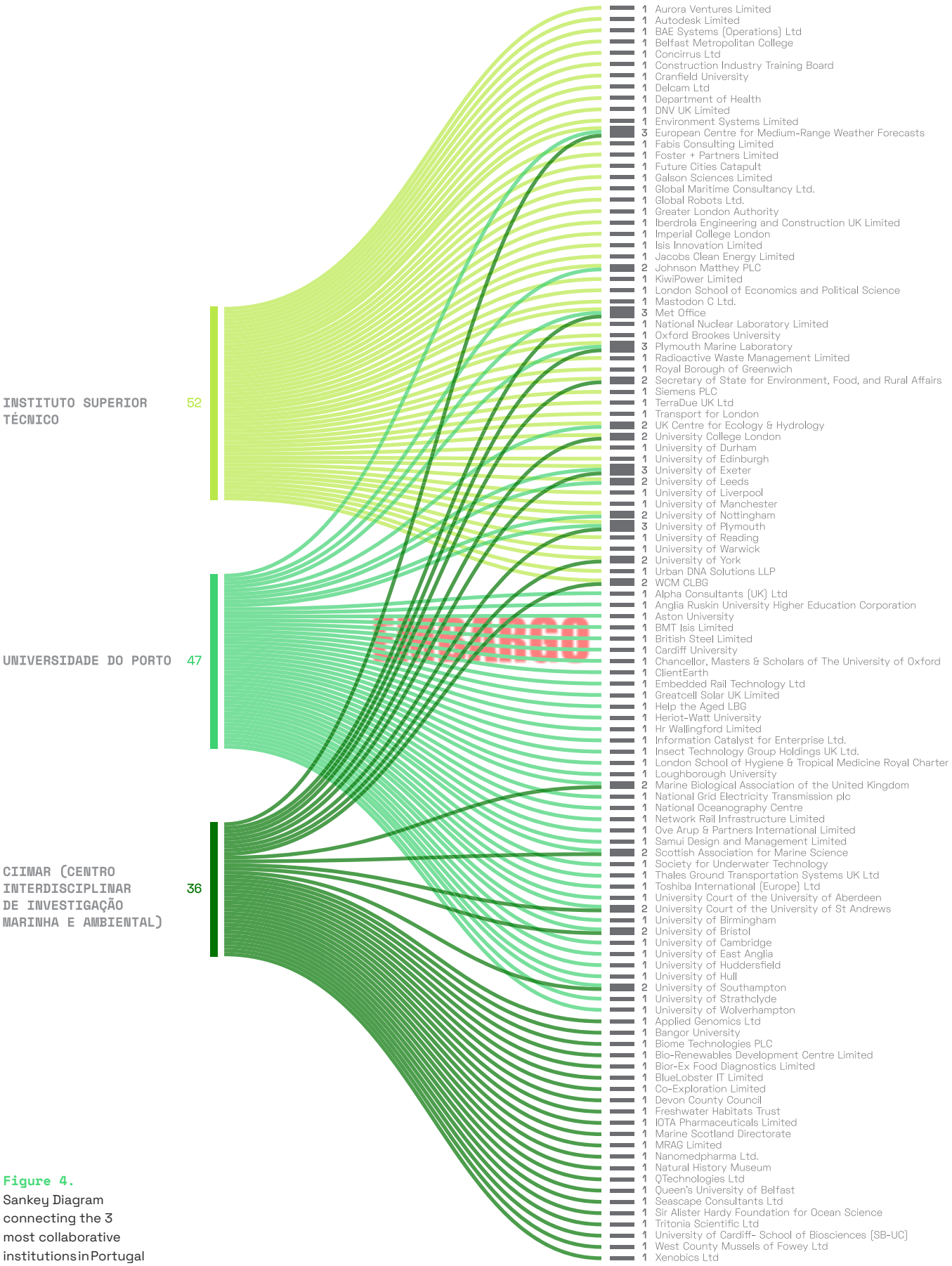

Figure 4.
Sankey Diagram connecting the 3 most collaborative institutions in Portugal

According to the inclusion criteria, the three most collaborative institutions in Portugal were the Instituto Superior Técnico (collaborating with 52 different UK institutions), Universidade do Porto (collaborating with 42 different UK institutions), and CIIMAR – Centro Interdisciplinar de Investigação Marinha e Ambiental (collaborating with 36 different UK institutions).

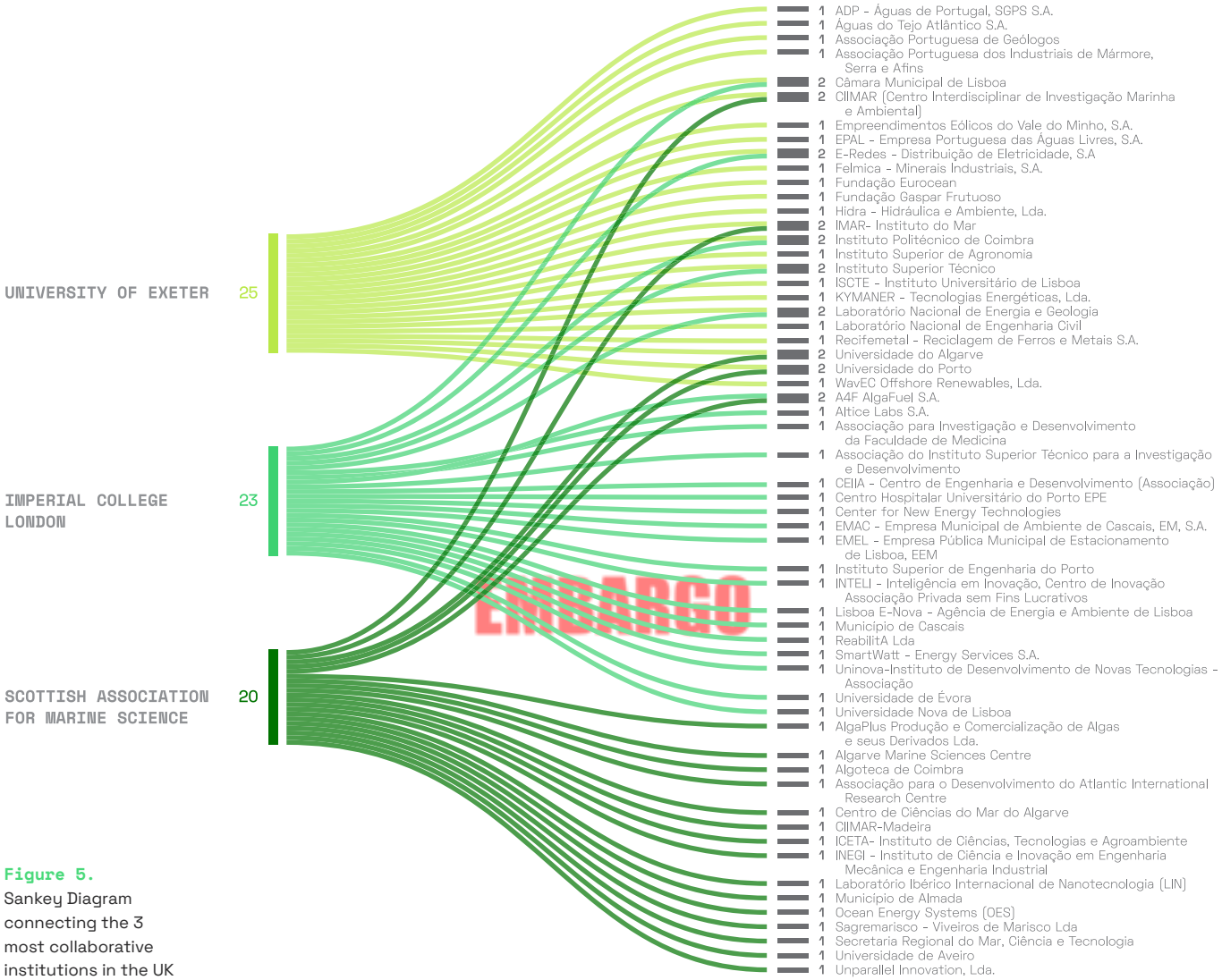

Figure 5.
Sankey Diagram connecting the 3 most collaborative institutions in the UK

The three most collaborative institutions in the UK, according to the selected criteria, were the University of Exeter (collaborating with 25 different institutions in Portugal), Imperial College London (collaborating with 23 different institutions in Portugal), and the Scottish Association for Marine Science (collaborating with 20 different institutions in Portugal). A comprehensive list of collaborations between Portugal and the UK is made available in the Appendix I.

Some of the examples in our database that illustrate the breadth and scale of ambition of funded projects involving Portugal and the UK include:

Title: 'BEESNESS'
Funding: 299,162.07 € (FCT)
Start: 2020
Duration: 3 years
Primary institution: Centro Interdisciplinar de Investigação Marinha e Ambiental (CIIMAR)
Partnering institution: University of Cardiff - School of Biosciences (SB-UC)
Short description: Bees play a key role in pollination. This process is key for animals (pollinators) to collect food resources, for plants to reproduce, and for maintaining life on the planet. Declines in bee diversity have been documented in various regions as a consequence of habitat destruction and fragmentation, insufficient floral resources, and pesticide use. This project aims at generating big data to understand and prevent bee decline in the São Francisco Valley in Brazil. More specifically, it will create an understanding of the extent to which pesticides used in the conventional agricultural crops may interfere with the dynamics of bee populations.

Title: 'Supergen ORE hub 2018'
Funding: 10,644,052.77 € (UKRI)
Start: 2018
Publications: 41
EMBARGO
Primary institution: University of Plymouth
Partnering institution: Universidade de Lisboa
Short description: The United Kingdom is at the forefront of Offshore Renewable Energy (ORE) technologies, including wind, wave and tidal energy. The role of Supergern ORE hub is to enable the transformation to future-scale ORE. It will also generate the pathway for translation of research and innovation into industry practice, for policy adaptation and public awareness in order to support the increased deployment of ORE technologies, reducing energy costs while increasing energy security, reducing CO2 emissions and supporting UK jobs.

Title: 'Joint Initiative for hydrogen Vehicles across Europe 2 (JIVE 2)'
Funding: 25,000,000.00 € (EU)
Start: 2018
Duration: 6 years
Primary institution: Element Energy Limited
Partnering institution: Petróleos de Portugal - Petrogal SA
Short description: JIVE initiatives aim at advancing the commercialisation of fuel cell buses through large-scale deployment of vehicles and infrastructure so that, by the end of the project, fuel cell buses are commercially viable for bus operators to include in their fleets without subsidy, and that local and national governments feel empowered to regulate for zero emission propulsion for their public transport systems. Combined, the JIVE projects will deploy nearly 300 fuel cell buses in 22 cities across Europe by the early 2020s – the largest deployment in Europe to date.

Projects with a higher average of funding produced in average more publications.

Scientific outputs

3. How many scientific outputs were produced and what are their key characteristics, including scientific disciplines and applicant country?

This section provides information about the scientific outputs, such as peer-reviewed articles, book chapters, and patents.

A total of 14,913 publications were included in the final database. From those, 66.1% were generated from the funded projects included in the database (9,857), and the remaining 33.9% had no apparent links to those projects (5,093). These 5,093 publications, spanning from 2014 to 2020, have at least one institution from each country, or a co-author affiliated to one, are centred around Horizon Europe-relevant themes, and can indicate new collaborations in addition to those already identified by the 444 included projects. In some cases, publications were evidence of relevant collaborations in the context of non-relevant projects (3.52%).

Figure 6 presents the proportion of each type of publication in the final database.

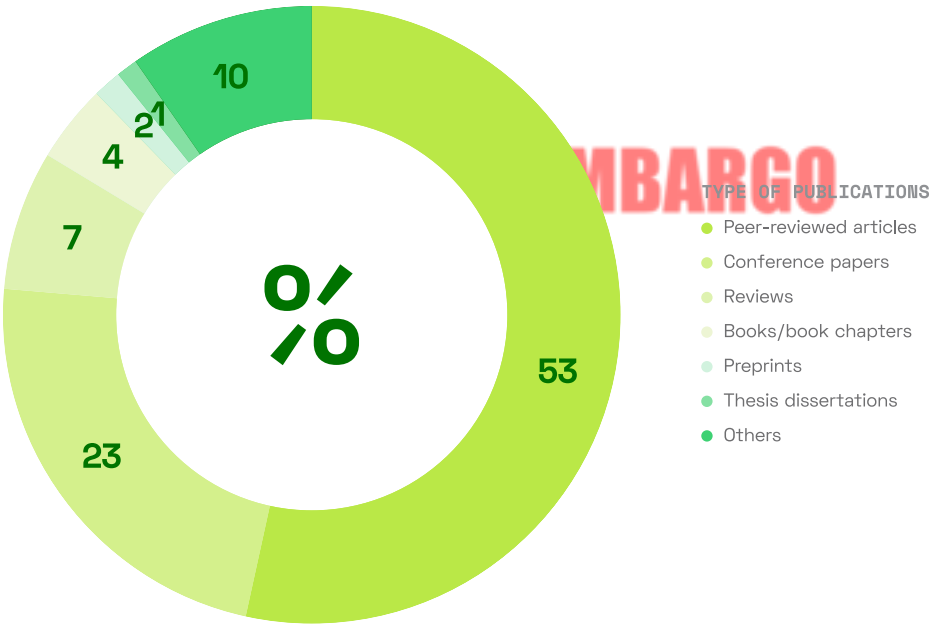

figure 6.
Proportion of each type of publications in the database

The most common type of publication was the peer-reviewed article (with 53%) followed by conference papers (with 23%).

Figure 7 reflects the proportion of publications that were published in each journal quartile.

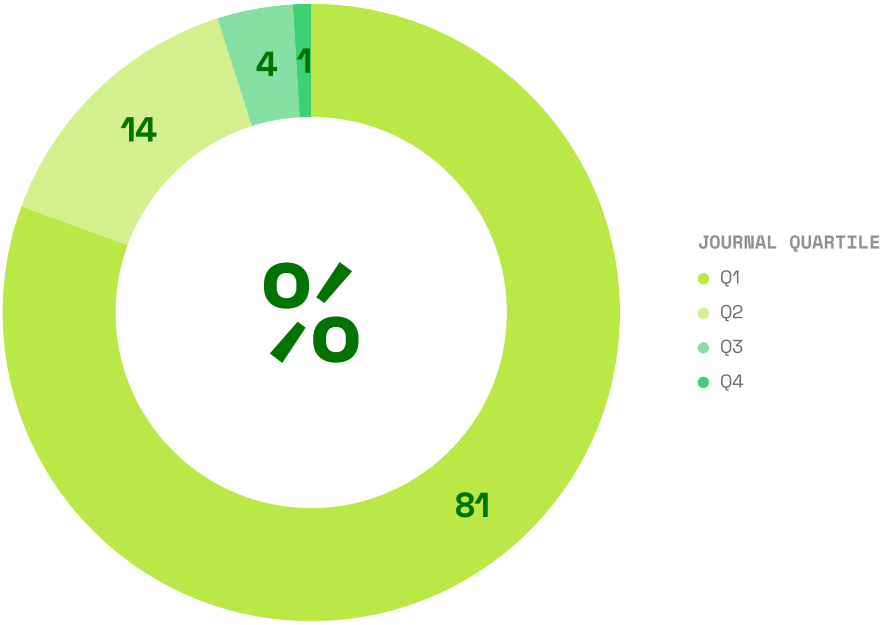

figure 7.
Proportion of publicationspublished in each journal quartile, according to the SciMago Ranking

Overall, the selected publications showed a median number of 8 authors per publication, with a median Field-Weighted Citation Impact (FWCI) score of 1.59, 80.60% publishing on 1st Rank Quartile Journals (Q1).

Figure 8 serves to compare the average number of scientific publications (right bars) a project centred around each of the HE mission areas can expect, with the average funding a project in each mission received (left bars).

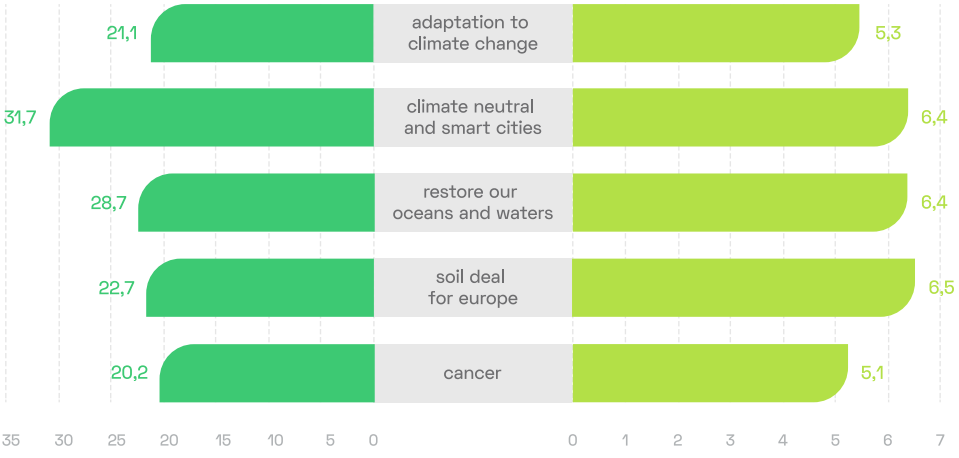

figure 8.
Composite chart: green bars represent the average amount of funding assigned to a project of a certain Horizon Europe mission area; the red line traces the average number of scientific publicationsproduced

Projects with a higher average of funding produced in average more publications, as it is the example of the 'Restoring our oceans and waters' thematic area, while projects with lower average funding produced in average fewer publications, such as the 'Cancer' thematic area.

Table 6 summarises the patents that emerged from the selected projects by scientific discipline and applicant country.

SCIENTIFIC DISCIPLINE (40)	
Engineering and Technology	15
Natural Sciences	7
Social Sciences	7
Other	11

APPLICANT COUNTRY (40)	
Portugal	11
UK	4
Other	25
TOTAL	40

table 6.
Summary of patents by scientific discipline and applicant country

The mapped projects generated a total of 40 patent applications, of which more were submitted by Portugal (27.50%) than the UK (10%), and the remaining were filed by other countries (62.50%). The 40 patent applications were generated from the total of 20 mapped projects (see appendixes H and J), with 'Engineering and Technology' as the most prevalent discipline. 'Natural Sciences' and 'Social Sciences' appeared secondly, both in an equal proportion. Each project may have involved more than one scientific discipline, as was previously noted. Regarding jurisdictions, of the 4 (four) patent applications by the UK, only half have global jurisdiction, while the others have a UK jurisdiction only. In contrast, only 2 (two) of the 11 (eleven) patent applications have national jurisdiction, 3 (three) have European jurisdiction, and 6 (six) have global jurisdiction. Only 12.50% of all patents were listed as granted, with the remaining 87.50% still in the application phase.

A comprehensive list of patents is made available in the Appendix J.

Photo by The Climate Reality Project on Unsplash

PhD and post-doctoral scholarships

This section presents the PhD and post-doctoral data between Portugal and the UK, which relates to scholarships for Portuguese students who pursued UK institutions for their PhD or post-doctoral research, and vice-versa. Table 7 illustrates the levels of porosity by time-frame, location and thematic scope, according to the dimensions of the PhD and post-doctoral data available.

	NUMBER OF PHDS IN TIMEFRAME AND LOCATION	NUMBER PHDS IN THEMATIC SCOPE
From the UK to Portugal	26	3
From Portugal to the UK	327	22
TOTAL	353	25

table 7.
Number of included PhDs as per student's trajectory. First level of inclusion: timeframe (2014-2020) and location (Portugal and UK involved). Second level of inclusion: thematic scope (five Horizon Europe missions)

The most common doctoral scholarship is the PhD scholarship. These programmes received a total of €1,621,615.58 funding, with a median funding of €59,252.23 per scholarship.

The UK was undoubtedly a more frequent host to Portuguese PhDs (88%) than vice versa. The top 4 (four) host institutions were the University of Cambridge, Imperial College London, the University College London, and Universidade de Lisboa, accounting for 40% of the sample. 'Cancer' research was the most pronounced HE mission amongst PhDs with 48%. 'Engineering and Technology' and 'Medical and Health Sciences' are the two most prominent scientific fields in PhD programmes with 28% each.

One example in our database of a funded doctoral degree involving Portugal and the UK:

Title: 'The role of hypoxia in T cell function and immunotherapy'
Funding: 119,236.53 € (FCT)
Start: 2017
Primary institution: University of Cambridge

B. CASE-STUDY APPROACH

The relevant research questions for this workstream were as follows:

1. How were these scientific collaborations initiated and what motivated them?

2. Which factors have enabled or hindered the process of establishing these scientific collaborations?

3. What impact have these scientific collaborations had in the careers of the researchers?

A total of 60 individual accounts by academics and researchers, formerly or currently engaged in scientific collaborations between Portugal and the UK, were collected. 20 participated in the in-depth interviews and 40 participated in the surveys (see Appendix K).

Table 8 summarises the key characteristics of the interviewees and survey respondents in relation to their scientific discipline and existence of funding.

table 8.
Summary of interviews and surveys by top 3 scientific discipline and funding

INTERVIEWS (20)

Scientific discipline	Engineering and Technology	6
	Medical and Health Sciences	6
	Natural Sciences	5
	Other	3
Funding	Yes	17
	No	3

SURVEYS (40)

Scientific discipline	Engineering and Technology	11
	Natural Sciences	11
	Medical and Health Sciences	7
	Other	11
Funding	Yes	23
	No	17

In addition to the institutions included in the mapping approach, this workstream identified a set of new institutions, including 11 (eleven) in the UK and 6 (six) in Portugal.

77.5% of respondents were based in Portuguese institutions and have scientific collaborations involving the UK. 22.5% of participants were based in the UK, with scientific collaborations with Portuguese institutions. With regards to scientific discipline, 'Engineering and Technology' (28.3%) and 'Natural Sciences' (26.7%) were the most prevalent. The remaining ones included 'Medical and Health Sciences' (21.7%), 'Social Sciences' (15%), and 'Humanities and the Arts' (8.3%).

The sections below describe the experiences of these researchers in establishing international scientific collaborations between Portugal and the UK, specifically looking at how these were initiated, what has facilitated or hindered the process, and the impact that these had in their respective careers.

1. How were these scientific collaborations initiated and what motivated them?

In terms of the career stage at which participants began scientific collaborations between Portugal and the UK, most were fully independent researchers (33%), followed by PhD students (32%). According to our respondents, early career researchers after their PhD who are

seeking full independence and senior field-leading/career-peak researchers are less likely to start new international scientific collaborations. When asked why early and mid-senior career researchers are critical in initiating and maintaining international scientific collaborations, a Portuguese professor and senior researcher #1 based in UK university commented:

"We academics have a lot of things on our plate. Typically, we do not work on a single problem. (...) Supervisors sharing PhD students or one of the supervisors has a PhD student who is involved in research. So there must be someone in the background who is working almost 100% of the time on the collaboration."

46.67% of collaborations were first established remotely, with 38.33% of these participants reporting the use of e-mail as the first point of contact. 38.33% of the collaborations were reported to have been formed in a shared physical space, such as scientific conferences or informal social events. Both Portugal and the UK presented similar rates of reported self-initiative as starters of new international scientific collaborations.

Figure 9 displays the different categories of motivators shared by the participants to pursue new international scientific collaboration.

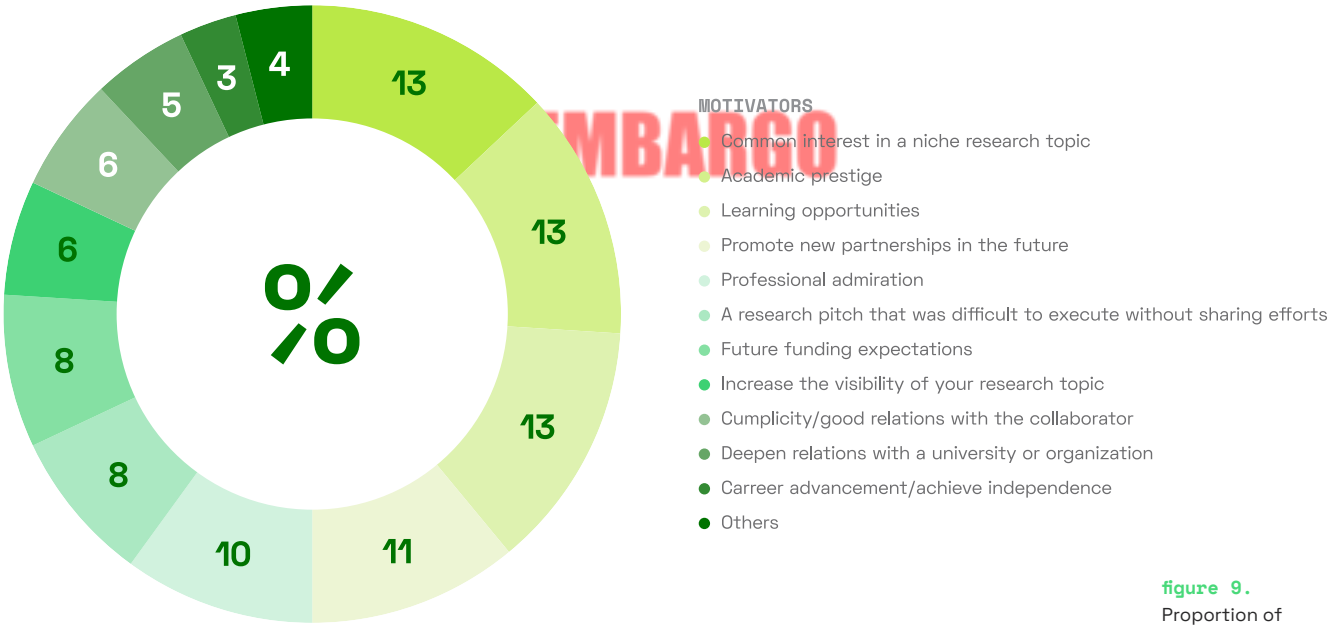

figure 9.
Proportion of motivators to pursue new international collaborations as identified by participants

Most participants are guided by professional interests, namely seeking a collaborator with specific expertise, gaining international experience, or building a reputation that can fuel their academic careers. Junior researcher #2 praised her collaboration for giving her the opportunity to 'Have wings to fly' as a main motivation. She also mentions that:

"It often happens that early career researchers, postdocs try to be independent, but (...) have their wings clipped, because they are often under the 'umbrella' of PIs, seniors (...) and being able to have my vision, my project, is something that motivates me a lot."

The international researcher #3 based in UK university mentions an institutional culture where:

"A lot of value is put on being able to demonstrate international prestige and international connections, and so having a collaboration like this, particularly one that led to publication, is really important."

2. **Which factors have enabled or hindered the process of establishing these scientific collaborations?**

The proportion of reported collaboration enablers is represented in Figure 10.

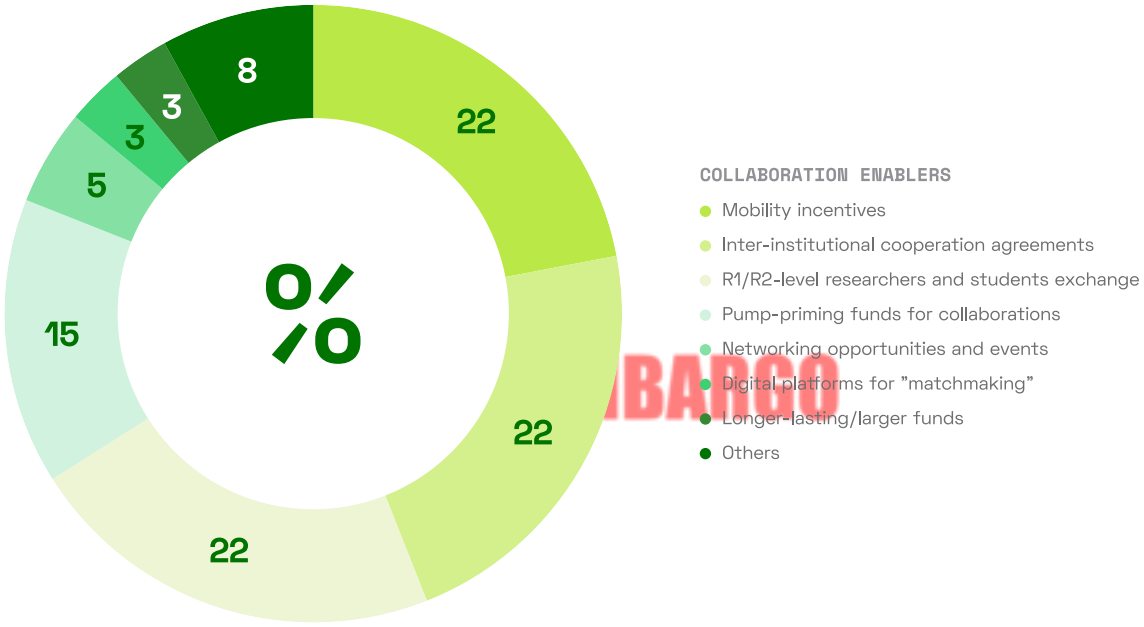

figure 10.
Proportion of collaboration enablers as identified by participants

When asked if their collaboration was facilitated by existing agreements and/or institutional support factors, 58.33% of respondents agreed that personal initiative remains a primary driver in forging these scientific collaborations over other external factors of a systemic nature. However, these systemic support factors are also referred to in the majority of testimonies. Mobility and exchange programmes, especially bilaterally coordinated PhDs and targeted at early career researchers, were frequently referred to as incentives of international collaboration. The Portuguese professor and senior researcher #4 based in the UK stated:

"Exchange programs, even if short, are very useful. Because they make it possible to implement these partnerships that, in many cases, remain on paper. (...) And we have very good ideas and we even go to visit each other and we have very 'beautiful' plans and then nobody manages to execute them, because there are no students or researchers at a junior level who can actually carry out the work."

The proportion of reported collaboration blockers is represented in Figure 11.

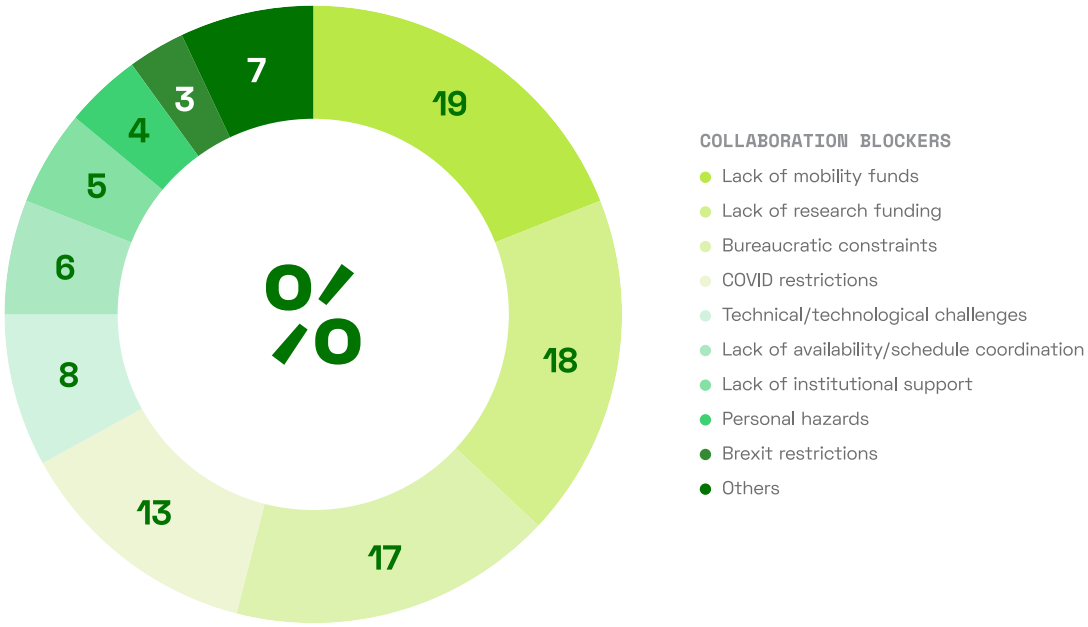

figure 11.
Proportion of collaboration blockers as identified by participants

Most researchers agreed that persistence is vital when pursuing these international collaborations to full fruition. Mirroring the previous figure, the lack of mobility funds was pointed as an important limitation. In addition, it has been reported that institutions and bureaucracy were more of a challenge to overcome than a helping hand. As expected, varying institutional cultures may be more appreciative of international outreach undertaken by their researchers and, therefore, provide supportive and rewarding environments for researchers to pursue open community values. Contrariwise, other institutions or areas may struggle to receive the required funding, support, or opportunities. Researcher #5 stresses the expectation of young investigators to **"Establish collaborations, win projects"**.

Nevertheless, most interviewees stated that their institutions lack a clear and well-defined pathway that is conducive of such collaborations. Protocols such as Erasmus+ or HPC-Europa3 were commonly suggested as being required to conduct the partnerships.

3. What impact have these scientific collaborations had in the careers of the researchers?

When asked about the impact that these scientific collaborations had on their careers, 90% of participants claimed that they did have an effect. The overall description provided to characterise this impact was positive (92%), with no negative impacts being reported.

The proportion of reported career impacts is represented in Figure 12.

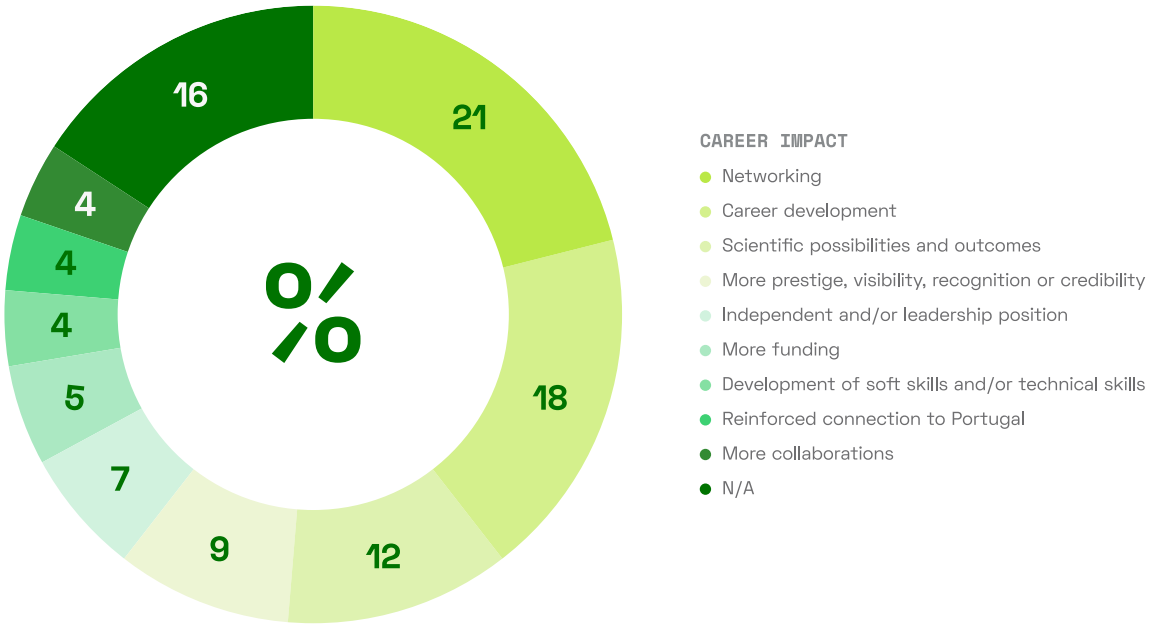

figure 12.
Proportion of career impacts as identified by participants

Opportunities for establishing new connections or networking was the most frequently described impact by participants. Participants shared the experiences of "growing research network" both nationally and internationally, and the possibility of strengthening collaborations ("enhanced relationships" and "developed a great relationship"). The second most frequent response was that of career development. This category includes participants that received job proposals as a result of the collaboration. Participants shared that these scientific collaborations "helped (them) get (their) postdoc job in the UK" or "now (they are) working almost full time on this project." Another common response was the importance of scientific outcomes, including publications which included terms such as "research arising", to "increase in scientific production", or "new horizons in terms of the development of (their) research".

One example of an 'invisible' collaboration:


Andreia Albuquerque

Researcher: Andreia Albuquerque-Wendt
Funding: 3,000 € (PARSUK's BRF scheme)
Start: 2022
Collaborating institutions:
University of Glasgow and Instituto de Higiene e Medicina Tropical (IHMT)

Experience:
"My first link with the IHMT, Universidade NOVA de Lisboa started in 2009, when I first joined the Vector Borne Diseases group from the GHTM centre, to do an undergraduate internship working with Prof. Lenea Campino and Dr. Sofia Cortes, who first introduced me to the on-going research on the Neglected Tropical Disease - Leishmaniasis.

Discovering PARSUK and accessing the BRF support, enabled the consolidation of this collaborative link, where I was able to lead an exciting project for the first time, generating important basic work which established the foundation for upcoming collaborative research projects."

discussion

discussion

This section provides an analysis of the new findings, their implications for policy and research, and the strengths and limitations of this project.

As the first of its kind, this project brought together high-level partners from both sides of the Anglo-Portuguese alliance into a truly complex exercise. The aim was to map the recent evolution of scientific collaborations between Portugal and the UK and better understand how these collaborations were formed.

Within the vast world of possible scientific collaborations, it was imperative to dive deeper into specific programmes of work with strategic interest to PARSUK and its international partners, whilst not losing sight of the opportunities that may arise from identifying unexpected areas of collaboration.

Two separate yet complementary workstreams were devised:

A. **A mapping approach**, whose high-level objective was to identify the scientific collaborations established between Portugal and the UK in the 5 mission areas of the EU Horizon Europe programme, between 2014-2020; and

B. **A case-study-approach**, whose high-level objective was to identify additional scientific collaborations between Portugal and the UK, not limited by the criteria of the mapping approach, but with a strong emphasis on understanding how these collaborations were established and what lessons we might learn for the future.

From the mapping approach, five key insights were generated:

Mapping: 5 insights

1. **The scale of scientific collaborations between Portugal and the UK is robust.**

Almost 1,500 international scientific projects were established between Portugal and the UK in the period of 2014 and 2020. These represent a multi-billion investment across a variety of thematic areas, scientific disciplines, with collaboration modalities including bilateral and multilateral research consortia.

When looking at a smaller sample of projects within themes of strategic interest, almost 450 projects were identified between both nations in the same period. This represents a total investment of over €2.5 billion, across five mission areas of the EU Horizon Europe programme - climate change, oceans and waters, smart cities, soil for Europe - in bilateral and multilateral collaboration efforts.

Considering that over 90% of these 444 projects derived from EU-supported programmes (408), this investment selection of €2.5 billion corresponds to an expressive proportion of international science between Portugal and the UK. In the context of the EU Horizon 2020 programme alone, Portugal and the UK received a combined total of €8 billion (approximately €1 billion to Portugal and €7 billion to the UK) (Schiermeier, 2020; Agência Nacional de Inovação, 2020). Equally, this is not a negligible amount when analysing how much Portugal and the UK invest in research and development. In 2020, it is estimated that the UK spent around £15.3 billion in R&D (Office for National Statistics, 2022) while Portugal spent approximately €3.2 billion (Nicholson, 2022).

Beyond the collective scale of these projects, the individual size of each project is also important to consider, with a median investment of almost €5 million per project. Projects of such scale are more likely to be high-profile in the public domain as well as sufficiently resourced to drive results and impact in their respective scientific fields. This is a massively important opportunity for Portugal and the UK to showcase their best contributors to the international scientific ecosystem, including research talent and the quality of their research institutions.

However, over 90% of these collaborations were multinational. While this suggests that Portugal and the UK are key partners in international research consortia with several countries, only a small proportion of these projects have Portugal or the UK as leading institutions (under 30%). Despite the prestige that comes with international research consortia, there is a clear opportunity for both countries to take a leading role in bilateral and multilateral research consortium and further strengthen their positions as global science and technology superpowers.

2. The most prominent areas of collaboration represent important research priorities for the present and future of both countries and beyond.

Despite the differences between both countries, Portugal and the UK are making significant efforts to increase their investments in R&D. In particular, Portugal has focused on renewable energy and biotechnology (República Portuguesa, 2020) and the UK has prioritised clean energy and life sciences (Department for Business, Energy & Industrial Strategy, 2017), amongst other areas.

Within the universe of the 450 projects identified in this project, the themes 'Adaptation to climate change', 'Climate neutral and smart cities' and 'Restore our oceans and waters' represent a combined €2 billion worth of investment and well over 350 projects. This clearly reflects why both countries have become important hubs for climate change research and ocean research in Europe, with a strong reputation for cutting-edge science.

On the one hand, Portugal has a strong renewable energy sector, with a focus on solar and wind power, which contributed to a vibrant research community, with expertise in developing new technologies and applications in this space (IEA, 2021). The country also has a long coastline, which makes it an ideal location to study marine habitats and species. Lastly, Portugal is home to a number of world leading research institutions, such as the Centro Interdisciplinar de Investigação Marinha e Ambiental (CIIMAR), the Instituto Português do Mar e da Atmosfera (IPMA) and the Instituto de Ciências da Terra (ICT).

On the other hand, the UK has a broad and deep pool of expertise, with a long history of world-class research in climate and marine science, and a number of leading research institutions, observatories and monitoring stations, such as the Met Office. The country is also

well-connected to the global research community and counts on the UK government as a significant investor in research, enabling the development of new technologies and approaches to address the complex challenges of climate change, as well as in oceanography and marine sciences (UKRI, 2022; UKRI, n.d.).

Together, Portugal and the UK can become global leaders in climate and ocean research, helping to generate scientific knowledge necessary to address the most pressing environmental challenges facing the world today. This ambition is also clearly reflected in the UK-Portugal Joint Declaration on Bilateral Cooperation (GOV.UK, 2022).

3. Both countries share a vibrant research ecosystem of dynamic and collaborative institutions.

Portugal and the UK have vibrant ecosystems that explore world-class research across a wide range of disciplines. In Portugal, several research institutions work closely with government agencies to advance our understanding of a variety of topics, including climate and oceans. Good examples emerging from this study include CIIMAR, the Universidade do Porto and the Instituto Superior Técnico. Altogether, these three institutions hold 130 collaborations with the UK. In the UK, several leading institutions have established themselves as international centres of excellence in climate and oceans research. Some of the collaborations mapped in this study illustrate precisely that, including international projects involving Imperial College London, the University of Exeter, and the Scottish Association for Marine Science. These three institutions combined have a total of 68 collaborations with Portugal.

All of these examples have a strong track record of international collaboration between Portugal and the UK, which demonstrates that the collaborative potential is well distributed across both counties, north and south, east and west. The respective governments have also committed to making significant investments in research and innovation, domestic and international, which opens a window of opportunity for further strategic investments in ongoing high-performing research partnerships.

4. Scientific collaborations between Portugal and the UK are highly productive, impactful and of recognised quality.

This study found a high volume of scientific outputs involving Portugal and the UK. Almost 15,000 publications were identified, 5,000 of which not associated with public funding from either FCT, UKRI or the EU. This demonstrates that international collaborations between both countries are highly productive yet often 'invisible', which means that they can be challenging to track using traditional funding metrics.

Over 80% of these articles were published in the top 25% most prestigious journals of their respective fields (Q1). According to the field-weighted citation impact (FWCI), which measures the average number of citations received by articles in a particular field, this study also found a median of 1.59 amongst publications involving Portugal and the UK. This means that, on average, these articles are highly cited (59% more than expected) which may indicate a higher level of quality and impact.

In addition to peer-reviewed publications, the number of patent applications is also an important indication of the potential for impact and innovation. In the context of the collaborations analysed, 40 applications were identified with the majority emerging from Portuguese institutions. Although this demonstrates the considerable technological gain, especially for

Portugal, and the factors involved in a patent application (such as field, technology, stage of development, and size and resources of applicant organisation) as a larger number of applications could be expected vis à vis the total research investment of €2.5 billion. It is also worth noting that not all research investment results in a successful patent application. The process of obtaining a patent can be complex and time-consuming, and there is always a risk that a patent application may not be granted.

5. **Portugal and the UK invest in international training opportunities that accompany their research priorities.**

Portugal and the UK have made several initiatives to boost the cadre of researchers in their respective countries, including promoting science education and encouraging international doctoral programmes. Equally, both countries are invested in attracting and retaining talent from abroad, namely by offering competitive salaries and benefits to highly skilled researchers. The ultimate goal is to promote Portugal and the UK as a leading destination for research and development.

This study was uniquely positioned to explore the extent to which both countries are preparing the future generation of research leaders in accordance with their respective research priorities. When analysing the doctoral scholarship programmes supported by the FCT alone, over 350 projects were identified involving Portugal and the UK. Within these, a sample of 25 doctoral scholarships were dedicated to the five themes of strategic interest. Despite the small number of projects, they represent a total of over €1.5 million with a median of almost €60,000 per project.

Interestingly, 'Cancer' was the most common research area, a trend not verified amongst the scientific projects mapped earlier. However, this is fairly aligned within the life sciences portfolio, a strong area of interest to both Portugal and the UK. Both countries have world-renowned institutions dedicated to the study of cancer and the development of new treatments, such as the Champalimaud Foundation in Portugal and the Cancer Research UK. Although only FCT-funded doctoral scholarships were analysed in greater detail, it was clear that the predominant flux of scholars was from Portugal to the UK. In fact, in almost 90% of the cases, the UK institutions were the hosts of Portuguese doctoral students. Understanding the factors behind the UK's success, along with exploring strategies to attract and retain researchers in the long term, will be crucial to secure a prosperous future for the research ecosystem in Portugal.

Case-studies: 5 learnings

From the case-study approach, five key learnings were generated:

1. **Early and mid-senior career researchers are often initiators of international scientific collaborations.**

Researchers in all career stages play an important role in international scientific collaborations. However, this study illustrates several occasions where early and mid-senior career researchers were decisive in initiating and maintaining these collaborations.

Different reasons were presented, including the limited bandwidth of mid-career (after PhD) and senior researchers (principal investigators), who are often focused on career progression and leading large-scale research projects. As a result, busier supervisors with doctoral students often rely on their ability and capacity to forge new and upkeep existing international collaborations, not seldom in the background.

2. **Both remote and face-to-face engagement opportunities are important formats to initiate and maintain these collaborations.**

Researchers are resourceful individuals. When seeking international collaborations, informants to this study indicated an equal frequency of remote and in-person interaction formats with their counterparts in Portugal and the UK. Amongst the latter, scientific conferences and informal networking events have been identified as prime platforms where international collaborations often begin, with both Portuguese and UK researchers affirming a similar propensity for self-initiation.

Brexit and COVID-19 have demonstrated the ability of the international research community to adapt with change. In the future, it becomes increasingly important that researchers collaborating internationally are capable of thriving in a hybrid environment, despite the geographical proximity of Portugal and the UK.

3. **Researchers often seek specific field expertise but also partnerships with prestigious international institutions.**

According to this study, Portugal and UK-based researchers are motivated by two main factors when pursuing international collaborations. The first, scientific expertise often lacking in their respective circles and institutions. The second, the prestige that comes with establishing formal links with an international research organisation. In fact, several Portuguese researchers mentioned that the opportunity to take part in an international scientific collaboration with the UK has enabled them to progress in their careers. This was particularly true when such collaborations resulted in concrete and tangible outputs, such as peer-reviewed publications.

Expertise and prestige exist in both sides of the partnership between Portugal and the UK. Although historical perceptions may have been asymmetrical in favour of the UK, future collaborations should strive to achieve a more equal recognition of the strengths in both research ecosystems.

4. **Critical enablers include the existence of mobility/exchange programmes and formal inter-institutional agreements, whereas critical blockers include lack of funding and institutional bureaucracy.**

Personal initiative and interpersonal relationships were often referred to as one of the most important factors in establishing bilateral collaborations. Nonetheless, the existence of mobility and exchange programmes as well as formal institutional agreements between Portuguese and UK institutions were deemed vital to their success. In particular, bilateral mobility and exchange programmes targeted at early career researchers, including PhD scholars, were a significantly valued incentive.

Conversely, a notable degree of individual persistence is required to overcome the hurdles in creating these international collaborations. Two of the most highly reported were the lack of funding and bureaucracy, both of which are associated with institutional cultures and value perceptions of international scientific collaborations.

Both the blockers and facilitators reported in this study may not be specific to Portugal and the UK. However, these recurrent themes shed some light on potential mitigation avenues that ought to be tailored to accelerate a collaborative ecosystem between both countries.

5. **International scientific collaborations have an undeniable positive impact on building research networks, progressing research careers and scientific progress.**

Over 90% of participants indicated that the international scientific collaborations between Portugal and the UK had a positive impact on their careers. In specific, researchers observed that their professional networks expanded and their careers have progressed faster and further, with new job opportunities. Not least important, scientific progress was at the heart of the perceived impact of these collaborations, much of which was made visible through scientific publications and other knowledge generation metrics.

Call to action: 5 opportunities for investment

The insights and learnings gained from this study provide a solid foundation for future investment opportunities for science and innovation between Portugal and the UK. Both countries should work together to build a strong, sustainable and mutually beneficial partnership through:

1. **Engaging in joint research and development in areas of strategic and mutual interest.**

Portugal and the UK should collaborate on joint research and development projects in areas of common interest, such as climate change, oceans and biotechnology. This would allow both countries to share expertise and resources, and develop new innovations that can benefit both nations and beyond.

2. **Support the creation of official collaboration agreements between research institutions that cooperate the most internationally.**

Portugal and the UK should prioritise the establishment of formal collaboration agreements, building on the strengths of the most active institutions between both countries. This would mitigate the lack of institutional endorsement for international cooperation and bureaucratic procedures, whilst widening the potential scope of scientific collaboration between those institutions.

3. **Enable the transfer of innovation and technology between both countries.**

Portugal and the UK should encourage the transfer of innovation and technology between the two countries, such as through the establishment of joint ventures, technology transfer offices, and innovation hubs. To accelerate innovation further, tax incentives for companies that invest in science and technology, and the creation of incubators and accelerators of start-ups could also be considered.

4. **Promote international cooperation across all career stages in research, with a focus on early-career researchers.**

Portugal and the UK should incentivise researchers in all career stages to collaborate internationally. Particular focus should be placed amongst early career researchers, whose careers can significantly benefit from small-scale funding schemes aimed at strengthening partnerships rather than scientific projects per se (<€5.000, with more flexible eligibility criteria). Good examples include PARSUK's Bilateral Research Fund (BRF) scheme, as well as in mobility and exchange programmes, and informal networking events to foster inter-personal skills.

5. **Monitor and evaluate the evolution of scientific collaborations between Portugal and the UK over time.**

Portugal and the UK should track international scientific collaborations systematically and continuously. This would allow a clearer understanding of the full scientific landscape, including when sudden or long-term priority shifts occur. Surveys and questionnaires from this study can be repurposed and disseminated during relevant meetings organised by both countries. Results should be made openly and widely available to both funders and the research community alike, integrated in existing databases and interactive online tools where appropriate, including those hosted by FCT, UKRI and the European Commission.

In summary, a dedicated science and innovation diplomacy initiative between Portugal and the UK is now more important than ever, to foster stronger ties between the two countries. This could include regular meetings between government officials, scientists and business leaders, as well as the exchange of scientists and researchers. Not least important, an ongoing strategic dialogue at all levels is vital to expand and facilitate the implementation of these recommendations.

This call to action could lead to the creation of new technologies, the promotion of economic growth, and the development of a more innovative and competitive workforce.

Strengths and weaknesses of this project

To our knowledge, this was the first comprehensive review of the scientific landscape between Portugal and the UK. As a result, this is a pivotal attempt to encapsulate the most significant scientific collaborations between the two countries, considering research areas of mutual interest. To achieve that, a mixed-methods approach was followed to combine both quantitative and qualitative data on funding, projects, individuals, institutions, and scientific outputs. The novelty of goals, methodology and results presented are, therefore, unique features of this project.

However, the robustness of this exercise is restricted by several factors. The scope for the mapping workstream, centred in the HE mission areas, the limited time for the interviews and surveys, data availability and heterogeneity, and the lack of additional data sources such as private funding leave room for improvement in this project. Future iterations of this exercise could benefit from a wider thematic scope into a wider selection of research areas of interest for Portugal and the UK.

Despite the prestige that comes with international research consortia, there is a clear opportunity for both countries to take a leading role in bilateral and multilateral research consortium and further strengthen their positions as global science and technology superpowers.

conclusion

This initiative is a first step towards what hopefully marks the beginning of ongoing research, much needed in international scientific collaboration, particularly for the bilateral alliance between Portugal and the United Kingdom.

The main objectives of this project were the creation of the database and the current report, characterising the scientific partnerships between Portugal and the United Kingdom, within the predefined criteria. The collaborations constitute a total of 444 projects, 14,913 publications, and 40 patents. Some publications were the direct output of the projects, and others might represent new or 'invisible' collaborations.

Regarding directionality, there is an apparent greater interest amongst Portuguese institutions and researchers in UK institutions. This is valuable insight as it may aid partners to strive for a more equitable and mutually beneficial partnership between students of both countries. This study suggests both countries are still interested in engaging in collaborative research and, if this level of new projects each year is maintained without additional disruptions, this trend should continue over the coming years.

The results of this project may serve as a starting point to understand the shared goals and needs, which can help determine which areas of collaborative research will likely become more prominent in the research agendas of both countries in the near future. This is especially relevant when forging a sustainable collaboration in the long-term.

In this study, Portugal and the UK have demonstrated robust and healthy relations in scientific cooperation, whether they manifest as multilateral and large-scale projects funded by UKRI or the EU, as doctoral scholarships funded by FCT, or as joint projects between two researchers who co-authored a paper on a niche topic. However, continued research on this ever-evolving scientific landscape is necessary to tailor specific funding schemes, mobility and exchange programmes, or formal and informal networking opportunities.

Historically, it is evident that the scientific bond between these two nations has been symbiotic and synergetic. In the future, regardless of any political upheavals, this bond should continue to grow and prosper.

references

1. Agência Nacional de Inovação. (2020, August 27). *Portugal exceeds one billion euro target of European funding in H2020.* ANI. https://www.ani.pt/en/news/ani-news/portugal-exceeds-one-billion-euro-target-european-funding-horizon-2020/

2. Anastasi, A., & Urbina, S. (1997). *Psychological testing* (7th ed.) Upper Saddle River, NJ: Prentice Hall.

3. Belur, J., Tompson, L., Thornton, A., & Simon, M. (2021). *Interrater Reliability in Systematic Review Methodology: Exploring Variation in Coder Decision-Making. Sociological Methods & Research, 50* (2), 837-865. https://doi.org/10.1177/0049124118799372

4. Csomós, G., & Lengyel, B. (2020). *Mapping the efficiency of international scientific collaboration between cities worldwide. Journal of Information Science*, 46(4), 575-578. https://doi.org/10.1177/0165551519842128

5. Dangles O., Loirat J., & Le Roux X. (2016). *Mapping the collaboration between Europe and Latin America/Caribbean for research on biodiversity. ALCUE NET- BiodivERsA report.*

6. Department for Business, Energy & Industrial Strategy. (2017, November 27). *Industrial strategy: Building a Britain fit for the future.* BEIS. https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future

7. Elsevier (2020). *Bibliometric analysis of publications funded by the STFC.* UKRI. https://www.ukri.org/wp-content/uploads/2021/12/091221-STFC-BibliometricAnalysisPublicationsFundedBySTFC.pdf

8. European Commission, Directorate-General for Research and Innovation. (2021a). *Mission area : adaptation to climate change, including societal transformation: foresight on demand brief in support of the Horizon Europe mission board.* https://data.europa.eu/doi/10.2777/53790

9. European Commission, Directorate-General for Research and Innovation, Giesecke, S., Jongh, T., Wasserbacher, D., et al. (2021b). *Mission area : cancer : foresight on demand brief in support of the Horizon Europe mission board.* https://data.europa.eu/doi/10.2777/17186

10. European Commission, Directorate-General for Research and Innovation, Lacroix, D., Boero, F., Ligtvoet, A., et al. (2021c). *Mission area, healthy oceans, seas, and coastal and inland waters : foresight on demand brief in support of the Horizon Europe mission board.* https://data.europa.eu/doi/10.2777/054595

11. European Commission, Directorate-General for Research and Innovation, Borsboom, J., Haindlmaier, G., Dinges, M., et al. (2021d). *Mission area : climate-neutral and smart cities : foresight on demand brief in support of the Horizon Europe mission board.* https://data.europa.eu/doi/10.2777/123417

12. European Commission, Directorate-General for Research and Innovation, Voglhuber-Slavinsky, A., Bisoffi, S., Helming, K., et al. (2021e). *Mission area : soil health and food: foresight on demand brief in support of the Horizon Europe mission board.* https://data.europa.eu/doi/10.2777/038626

13. FCT. (n.d.). *Cooperação Internacional.* https://www.fct.pt/apoios/cooptrans/parceriaseei.phtml.pt

14. García-Villar, C., & García-Santos, J. M. (2021). *Bibliometric indicators to evaluate scientific activity. Indicadores bibliométricos para evaluar la actividad científica. Radiologia,* 63(3), 228-235. https://doi.org/10.1016/j.rx.2021.01.002

15. Gazni A., Sugimoto C., & Didegah F. (2012). *Mapping World Scientific Collaboration: Authors, Institutions, and Countries. Journal of the American Society for Information Science and Technology.* DOI:10.1002/asi.21688

16. GOV.UK. (2022, June 13). *Policy paper: UK–Portugal Joint Declaration on Bilateral Cooperation.* https://www.gov.uk/government/publications/uk-portugal-joint-declaration-on-bilateral-cooperation/uk-portugal-joint-declaration-on-bilateral-cooperation

17. IEA. (2021, June). Portugal 2021. https://www.iea.org/reports/portugal-2021

18. Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2006). *Using Mixed-Methods Sequential Explanatory Design: From Theory to Practice. Field Methods,* 18(1), 3-20. https://doi.org/10.1177/1525822X05282260

19. Lyra, F. (2021). *UK Science & Innovation Network Country Snapshot: Portugal.* Lisbon: British Embassy.

20. Nicholson, C. (2022, January 4). *Portuguese government plans to double R&D spending. Research Professional News.* https://www.researchprofessionalnews.com/rr-news-europe-other-nations-2022-1-portuguese-government-plans-to-double-r-d-spending/

21. Office for National Statistics. (2022, April 8). *Research and development expenditure by the UK government. ONS.* https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/ukgovernmentexpenditureonscienceengineeringandtechnology/2020

22. PARSUK (2019, July 07). *PARSUK assina protocolo com FCT.* https://www.parsuk.pt/post/parsuk-assina-protocolo-com-fct

23. PARSUK (2020, January 8). *Bilateral Research Fund: financiamos a tua ideia.* https://www.parsuk.pt/post/bilateral-research-fund-financiamos-a-tua-ideia

24. PARSUK (n.d.). *Scientific Advisory Board.* https://en.parsuk.pt/cc

25. Patricio, M. T. (2010). Science Policy and the Internationalisation of Research in Portugal. *Journal of Studies in International Education*, 14(2), 161-182. https://doi.org/10.1177/1028315309337932

26. República Portuguesa. (2020). *Portugal 2030: Documento de Enquadramento Estratégico. Ministério do Planeamento.* https://www.portugal.gov.pt/download-ficheiros/ficheiro.aspx?v=%3D%3DBQAAAB%2BLCAAAAAAABAAzNDC3NAEAkBRcpAUAAAA%3D

27. Schiermeier, Q. (2020, December 22). *Horizon 2020 by the numbers: How €60 billion was divided up among Europe's scientists. Nature.* https://www.nature.com/articles/d41586-020-03598-2

28. UKRI. (2022, November 4). *Connecting with the ocean to protect the marine environment. UKRI – UK Research and Innovation.* https://www.ukri.org/about-us/how-we-are-doing/research-outcomes-and-impact/esrc/connecting-with-the-ocean-to-protect-the-marine-environment/

29. UKRI. (n.d.). *Responding to climate change. UKRI – UK Research and Innovation.* https://www.ukri.org/news-and-events/responding-to-climate-change/

30. UUK. (2021). *International facts and figures.* London: Universities UK. https://www.universitiesuk.ac.uk/sites/default/files/field/downloads/2021-12/International%20Facts%20and%20Figures%202021_0.pdf

31. Wisdom, J., & Creswell, J. W. (2013). *Mixed Methods: Integrating Quantitative and Qualitative Data Collection and Analysis While Studying Patient-Centred Medical Home Models. AHRQ and PCHM.* Rockville, MD: Agency for Healthcare Research and Quality. AHRQ Publication No. 13-0028-EF.

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