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Science diplomacy in the European Union: mapping the Portuguese case (1986–2021)

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Science diplomacy has been assuming a growing importance in the actions of states due to their need to respond to global challenges and to strengthen their power and influence through competitive advantage based on science and technology. Within the European Union (EU), science diplomacy can be seen as an instrument for the integration of the European project and for the projection of EU influence, standards, and values in the relationship with third countries. In this context, the present work aims at understanding and characterizing Portugal's science diplomacy model and its relationship with the European project from 1986 (the moment of Portugal's accession to the European Economic Community) to 2021. To this end, we mapped the science diplomacy designed and implemented by the Portuguese State by identifying its different instruments based on a methodology suggested by the European Commission, Directorate-General for Research and Innovation and Van Langenhove in 2017 and using a timeframe suggested by Heitor in 2015. The obtained dataset was subjected to a combination of analytical frameworks, including the general framing analysis proposed by Ruffini and Krasnyak in 2023, which allowed us to identify the objectives, strategic drivers and implementation approach of the Portuguese science diplomacy model. In the period under study Portugal has been developing a science diplomacy in parallel with the European project without ever losing a global vision of the relations in the field of science and technology.

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Introduction

States have long considered science and technology in their policy of influence and power. However, it is only recently that science diplomacy has become a claimed approach. The emergence of science diplomacy as a more autonomous field of action, as a concept and as an object of study, happened during the first decade of the 2000s and is associated with the growing importance of global challenges in international relations and the increasing use of science and technology as elements of soft power (Ruffini, 2017, pp. 8, 9, 11, 13; Kaltofen and Acuto, 2018, p. 15).

Despite its popularity, the emergence of science diplomacy has brought with it intense debates around conceptual aspects and historical readings, as well as aspects of its critical evaluation (Riordan and Jarrín, 2020, p. 4; Rungius and Flink, 2020, p. 1; Flink, 2020, p. 362; Kunkel, 2021, pp. 483-484; Ruffini, 2017, p. 130; Flink, 2021, pp. 4-6). The history of science diplomacy prior to the coining of the concept is generally traced back to the Second World War (Aranda, 2019, pp. 28-29; Gamito-Marques, 2020, pp. 473-474). Some authors, however, begin their analysis in the 18th century with the exploratory journeys associated with colonization (Ruffini, 2017, p. 18). In 2019, The Madrid Declaration on Science Diplomacy defined science diplomacy as a series of practices at the intersection of science, technology, and foreign policy (S4D4C, 2019, n.d.). While states approach science diplomacy with different styles depending greatly on their history, values, culture and institutions (Krasnyak, 2018, p. 5), a general framing for countries engagement in science diplomacy has been proposed (e.g., Flink and Schreiterer, 2010, pp. 667, 676; Ruffini and Krasnyak, 2023, pp. 4-6).

In the European Union (EU), science diplomacy can be considered from an internal point of view, as an integration tool, and from an external point of view, as a way of projecting its influence, standards and values in relations with third countries (Rungius, 2018, p. 29; Ruffini 2017, pp. 43, 97). In 2021, the EU decided to start preparing a European Agenda for Science Diplomacy (European Research Area and Innovation Committee-Strategic Forum for International Scientific and Technological Cooperation (ERAC-SFIC), 2020, p. 1). In addition, an increasing number of recent EU policy documents, in the foreign and security policy domain (on topics such as multilateralism, the Arctic, climate, energy and digital diplomacy) have made explicit or implicit reference to science diplomacy. Following the acknowledgement by the EU, Member States, academics, and practitioners that a concerted approach to science diplomacy was needed, an European framework for science diplomacy is now under preparation (European Commission, n.d. g, n.n.).

The challenges of science diplomacy in the EU include the usual challenges of coordinating EU policies with national ones (with various speeds and priorities, lacking synergies), the absence of an homogeneous understanding of the concept of science diplomacy and of an EU-wide approach, the limitation of professional structures dedicated to the area and the focus on bilateral relations by Member States (Rungius, 2018, p. 29; Müller and Bona, 2018, n.n.; European Commission, n.d. g, n.n.). Furthermore, the fact that science, technology and the economy are now at the forefront of rivalry between major powers, with other international actors using science diplomacy in a much more targeted manner than the EU, will certainly affect how Europe develops its science diplomacy (Fägerston, 2022, pp. 7-9; European Commission, n.d. g, n.n.).

Thus, understanding and characterizing the science diplomacy of each Member State, its evolution, and its relationship with the European project under common methodologies is of the utmost importance, both to support the development of a common policy and to fine-tune the policies of each Member State in this

area (European Commission, Directorate-General for Research and Innovation and Van Langenhove, 2017, p. 26). In the recent literature, it is possible to find a comparative study of the current strategic options for science diplomacy in Portugal, Spain, France, Switzerland, and Germany (Aranda, 2019, p. 15) and an exploratory survey on current science diplomacy strategies, activities and actors in EU Member States and associated countries (ERAC-SFIC, 2021, pp. 9-11, 14, 18-21, 24, 29). However, there still doesn't seem to exist an in-depth study of the Portuguese science diplomacy and its long-term evolution in the light of the European project. Thus, one question arises: "Which science diplomacy model has Portugal adopted and how does it relate to the European project?" To answer this question the present work aims at mapping the Portuguese science diplomacy, identify its objectives, strategic drivers and implementation approach and understand their connection to the European project throughout time.

Methods

The characterization of the science diplomacy designed and implemented by the Portuguese state was done by mapping its different instruments, according to the methodology suggested by the European Commission, the Directorate-General for Research and Innovation and Van Langenhove (2017, pp. 12-13). This considers three categories of science diplomacy instruments: strategic, support and operational. The instruments were mapped for the period between 1986 (year, in which Portugal joined the European Economic Community (EEC)) and 2021. Data were collected in a structured way, using primary and secondary sources, to which a mixed analysis (qualitative and quantitative) was applied. Portuguese legal diplomas were cited using their original Portuguese title.

Strategic instruments. Documents regarding strategic instruments were obtained from the *Diário da República Eletrónico* (n.d., n.n.) [the online Portuguese Official Gazette]. A search was made for the period under study, i.e. from 1986 to 2021, of the *Grandes Opções do Plano* [major planning options], since these gather the policy options and budget programming of the Portuguese government. They were complemented by science and technology laws or plans, often cited in the major planning options, and by legal diplomas with explicit mention of science diplomacy. The full list of documents analyzed can be found in Supplementary Data S1 and extracts from the documents considered relevant to Portugal's science diplomacy strategy have been compiled in Supplementary Data S2. The documents were analyzed by time intervals, aggregating the contents at the intersection of science and technology and Portuguese foreign policy into lines of action, to which the general framework of Ruffini and Krasnyak (2023, pp. 4-6) was applied.

Support instruments. According to the methodology followed, support instruments include the creation or funding of specific agencies that support the organization of operational science diplomacy instruments, dialog and consultation platforms, and training/awareness-raising activities in science diplomacy for diplomats and/or scientists. Data on the creation or funding of specific agencies that support the organization of operational science diplomacy instruments was collected using *Arquivo de Ciência e Tecnologia of Fundação para a Ciência e Tecnologia* (FCT) (n.d., n.n.) [the Science and Technology Archive of the Portuguese Foundation for Science and Technology¹]. In the description of each agency, its mission and functions were analyzed to identify elements that constituted science diplomacy

practice. For the older agencies, annual activity reports and legal diplomas associated with their creation, organization or extinction were also consulted to complement the information obtained above. The historical archives of Portuguese constitutional governments were used to identify the names of the ministries associated with science and technology and foreign policy (República Portuguesa, n.d., n.n.).

Considering the centrality of the Ministry of Foreign Affairs (MFA) in foreign policy issues and its constant mention in the strategic instruments, the Directorates-General/institutions of the MFA possibly associated with science and technology were also identified through the organic laws of the MFA obtained from the *Diário da República Eletrónico* (n.d., n.n.) and through the issuers of cooperation agreements including science and technology.

Data collection on dialog platforms that promote or facilitate science diplomacy was based on the website page of FCT, specifically dedicated to science, technology, and innovation policy dialogs (and the respective links available on that source) (FCT, 2022, n.n.). Since many of these support instruments are linked to EU initiatives, a search was also made for information on policy dialogs mentioned on the EU's international cooperation website (European Commission, n.d. c, n.d.). The dialogs identified were classified based on their starting date.

Data on training or awareness-raising activities in science diplomacy for diplomats and/or scientists was collected by searching for events (conferences, seminars, publications) in the websites of *Instituto Diplomático*,² the Portuguese MFA and FCT. Whenever necessary, the data collection was complemented with a search engine query. Initiatives with intersecting themes between foreign policy and science and technology (in which the concept of science diplomacy may or may not be explicit) were considered.

Operational instruments. Operational instruments of science diplomacy include cooperation agreements in science and technology between two or more states and/or international organizations, funding schemes with international involvement, science and technology advisory councils to support governance, and science and technology attachés/advisors associated with diplomatic missions. To this last category, this work has added other tools for promoting science and technology in an international context.

Data on cooperation agreements in science and technology was collected by searching the international cooperation section of FCT (n.d. c; n.n.). This was complemented by a search on the website page of the Portuguese MFA dedicated to Portugal's bilateral relations with third countries, which includes, agreements of different kinds, including those of a scientific nature (MNE, n.d. b; n.n.). A search was also made in the webpage dedicated to the Portuguese membership of international organizations (MNE, n.d. a; n.n.). This was complemented by a visit to each organization's website to identify Portugal's year of membership and to confirm the organizations' scientific activities. A search was also carried out on the ERA-LEARN database, which aggregates cooperation partnerships in the area of science and technology promoted by the EU since the Sixth Framework Program (ERA-LEARN, n.d. b, n.n.). Finally, a search was made in the *Diário da República Eletrónico* (n.d., n.n.) for "agreement" and "scientific" or using the identification of the legal diploma obtained from the previous sources.

For the period of study, agreements expressed in legal diplomas (whenever identified), memorandums of understanding and expressions of associations in more flexible typologies in which the Portuguese state is involved in the field of science and

technology (for example, "platforms" or "networks" or "frameworks") were considered. Agreements dating from 1974 to 1985 were additionally identified, since they will have remained in force during the period covered by this study. This identification began in 1974 with a view to identifying international relations in a post-April 25 context, with the 1974–1985 phase being referred to as phase 0.

Moreover, bilateral agreements that do not mention cooperation at the scientific level were excluded.³ In the case of agreements concerning membership of international organizations, economic funds and organizations, courts and organizations dedicated to raw materials were excluded.⁴ If identified, agreements relating to associate and full membership were included. The date (year) considered for the classification of agreements corresponds to the date of approval of the agreement of the legal diploma.⁵ The issuer of the legal diploma was identified in the document header.⁶

Data on funding schemes was collected by searching the international cooperation section of the FCT website (FCT, n.d. c, n.n.), the advanced training grants section of the FCT website (FCT, n.d. a, n.n.; FCT, n.d. b, n.n.), the website of the observatory on national participation in European programs of the Portugal in Europe Research and Innovation Network (PERIN) and the National Innovation Agency (ANI) (PERIN, n.d., n.n.; ANI, n.d., n.n.) and in documents reporting on different funding programs organized by Portugal (Heitor, 2015, pp. 12–29). Programs in which it was not possible to identify investment by the Portuguese state were excluded, although there may have been support in communicating funding opportunities.⁷

Lastly, data on the advisory councils was collected through a general search on the FCT website, followed by the respective collection of legal documents in the *Diário da República Eletrónico* (n.d., n.n.), or on the websites of the initiatives (especially in the case of the structures associated with the EU). Information on scientific attachés/advisors based in Portuguese diplomatic representations and on the instruments dedicated to promoting science and technology was collected from strategic documents. This was complemented by a search on the websites of the mechanisms implemented and news published in the media on the same subject.

Results and discussion

To identify the Portuguese science diplomacy model and its connection with the European project, this work started by an extensive mapping of the Portuguese science diplomacy throughout time. In this way, this study aimed, not only at obtaining information to answer the research question, but also at making available a dataset about the Portuguese science diplomacy (fully available as supplementary data), particularly relevant due to the current absence of aggregated information sources about the topic. The mapping of the Portuguese science diplomacy was based on the methodology suggested by the European Commission, the Directorate General for Research and Innovation and Van Langenhove (2017, pp. 12–13), which considers strategic, support and operational instruments of science diplomacy. In this work, these were mapped between 1986 (when Portugal joined the European Economic Community) and 2021. This period was divided into five phases (1 to 5), according to the phases of the Portuguese science and technology proposed by Heitor (2015, pp. 5–6), which were outlined based on Portugal's expenditure on research and development activities (as GDP%) (Fig. 1) (OCDE 2022, n.n.). The phase prior to the period under study, from 1974 (transition to democracy) to 1985, was referred to as phase 0.

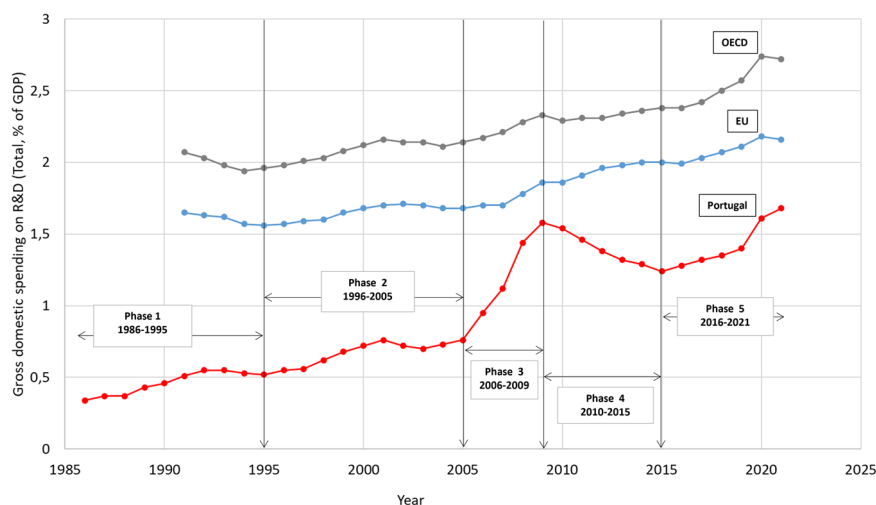


Fig. 1 Expenditure on research and development activities (% GDP) and definition of time phases used in this work. Phases proposed by Heitor (2015, pp. 5-6): Phase 1 (1986–1995), Phase 2 (1996–2005), Phase 3 (2006–2009) and Phase 4 (2010–2015). Analysis of the evolution of the same expenditure over the period under study allowed the identification of an additional phase between 2016 and 2021, named Phase 5. Data for Portugal (red), EU (blue) and OECD (gray). Figure built from data obtained at OCDE (2022, n.n.).

Mapping of strategic instruments—objectives, drivers and areas of interest of the Portuguese science diplomacy strategy.

By mapping strategic instruments, it is possible to identify the objectives, the drivers and the areas of interest of the Portuguese science diplomacy. Following the methodology and time frame indicated above 34 strategic documents were retrieved (list in Supplementary Data S1). All include contents that aim to give indications about objectives in the intersection between science and technology policies and foreign policy (collected in Supplementary Data S2).

Dividing the number of documents identified by the number of years in each phase, between 1986 and 2009 (Phases 1, 2 and 3) the publication of documents with strategic science diplomacy content occurred at a rate of approximately 1 document per year. Between 2010 and 2015 there was a significant decrease (0.33 documents/year), which can be explained by the preference for publishing three-year major planning options and the absence of science laws/plans (most likely due to constraints associated with the serious social and economic crisis that affected Portugal). Between 2016 and 2021, there was a significant increase in the publication of strategic documents (1.7 documents/year) due to the reappearance of the annual major planning options, rise in science laws and plans, including one about the internationalization of the Portuguese science and technology system, and the emergence of thematic strategic plans, namely about Space and the Portuguese Diaspora.

The collected contents (Supplementary Data S2) were divided into different categories and summarized in a table (Supplementary Table S1), thus creating a classification grid that groups strategic objectives of science diplomacy into different Portuguese lines of action by time phase. The first line of action considered contents which aimed at improving the science and technology system and developing Portugal through international contributions in the area of science and technology, i.e. international contributions to Portugal. Another line of action considered the inverse of the first, i.e. Portugal's contributions to the international science and technology structure. The third line of action considered content related to the projection of Portugal through science and technology (and which was not included in the two previous categories). These first three lines of action clarify "what" Portugal wants to achieve (objectives) and "why" (drivers). Thus, going beyond the national perspective, this work

also analyzed the collected strategic contents using the general framing proposed by Ruffini and Krasnyak (2023, pp. 4-6) which revisits and deepens the 2010 conceptualization of Flink and Schreiterer (2010, pp. 669-670). The contents of the three lines of actions were classified according to their drivers, which may include cooperation, access and attraction, and influence (see also Supplementary Table S1). Additionally, contents were also classified according to the typology of objectives which may be scientific and non-scientific. The former include objectives to enhance science and technology capacity (national/international) or to advance knowledge and problem solving in science. The latter include political/diplomatic objectives and economic/development objectives.

Three additional lines of action were identified as relevant during the analysis of the strategic contents: thematic areas of the international agenda, geographical regions and international organizations. These inform on areas of interest of the Portuguese science diplomacy, or on "what topics" and "where" (geographically and institutionally) the Portuguese science diplomacy intends to act.

An analysis of the contents for the different lines of action shows a clear evolution over the phases studied, with an increase in the number of different objectives and an increase in the detail and complexity of each objective. It is therefore possible to state that Portugal has been publishing strategic indications around science diplomacy throughout the period covered by this study (1986–2021) and has been expanding and refining its strategies in this area.

The analysis of the contents aimed at improving the science and technology system and developing Portugal through international contributions is an excellent example of the evolution over the different phases studied. Between 1986 and 1995 (Phase 1) the strategic contents focus on looking abroad for training, networks and resources. This is a phase of national capacity building with a view to laying the foundations for a structured science and technology system, closely associated with the first years of Portugal's accession to the Communities. The next phase, between 1996 and 2005 (Phase 2), adds the attraction of foreign scientists, the evaluation using international criteria and the technological internationalization of companies. Thus, it can be stated that, in addition to capacity building, Portugal moves on to a next phase of building its new science and

technology system through international contributions, advocating quality and increased excellence, and involving companies. Between 2006 and 2009 (Phase 3) the contents are very similar to the previous ones, including some additional detail regarding international evaluation criteria (including funding levels and science management) and the internationalization of technology companies (with the possibility of opening to new markets). At this stage the offer of international-level programs in Portugal appears as novelty. This seems to be another contribution to the consolidation of the Portuguese science and technology system, with the ambition of bringing international practices into the national system. Between 2010 and 2015 (Phase 4), the strategy for human resources includes to attract foreign researchers to Portugal, as well as Portuguese researchers (in a sign of some “brain drain”). The ambition for the quality of the science and technology system is at the level of the most developed countries in Europe and gives way to a strategic commitment to the development of national science and technology infrastructures (of international standard). Finally, between 2016 and 2022 (Phase 5) the attraction of human resources also includes the Portuguese scientific diaspora. The importance of national scientific and technological infrastructures is maintained (with their reinforcement and capacity building), and the relevance of industrial involvement in partnerships, partnerships between sectors, the promotion of scientific/skilled employment and the importance of international funding (also for technology companies) are added. The contents in this line of action reflect a competitive resource seeking strategy, both by accessing resources located abroad and by attracting external resources to the national territory, thus corresponding fundamentally to the access and attraction strategic driver of Ruffini and Krasnyak (2023, pp. 4-6). Other motivations (cooperation and influence drivers) may not be excluded but seem collateral to the main one. Evolution throughout different time phases shows an incremental rise in objectives motivated by access and attraction. These include a mixture of scientific objectives focused on capacity enhancement and non-scientific objectives focused on trade and competitiveness (economic/development). Throughout time phases the scientific objectives dominate the agenda.

Regarding Portugal's international contributions a constant strategy of participating in international initiatives was identified. Noticeable over time is the level of ambition, with which the country aims to participate. Transversal to all phases are Portugal's contributions to the European project, both for science and technology initiatives (projects, networks, framework programs) and for political/diplomatic objectives. These include competitiveness, common policies, EU international cooperation (Phase 1), boosting European science and technology, reinforcing political priorities, and supporting the construction of the European Research Area (Phase 2), contributions to EU science and technology policy (Phase 3) and contributing to the circulation of qualified human resources (Phase 5). Cooperation with Portuguese-speaking countries is also explicitly present through cooperation and training of human resources (Phases 1, 4 and 5). Also noteworthy, are the contributions to international infrastructures since 2010 (Phases 4 and 5). Phase 5 (2016–2022) is marked by a significant broadening of strategic objectives which can be characterized by an additional contribution to the development agenda, e.g. integration of migrants and refugees into the science and technology and higher education system, and the science for development agenda. In summary, in this line of action, contents described are scientific objectives with focus on advancing knowledge and problem solving in science through contributions in scientific international organizations, networks and programs (dominating in phase 5). They also include non-scientific objectives with political/diplomatic focus. The contents

described correspond mainly to the cooperation strategic driver since they seem to be orientated by the will of sharing goals and resources for common challenges (Ruffini and Krasnyak, 2023, pp. 4-6). As in the previous line of action the intertwining of the other drivers (in this case, access and attraction, and influence) may be possible as side drivers.

In the category of projecting Portugal through science and technology, as of 2016 (Phase 5) an explicit mention of science diplomacy is made, as an essential dimension in the relation with other countries, with science and technology being prioritized in foreign policy with a very broad and detailed description of the objectives to be achieved. However, it should be noted that in the previous phases, science and technology are already mentioned as instruments of external action (Phase 1), as a component of the brand Portugal (Phase 3) or as a fundamental “asset” (Phase 4), in a clear assumption of science diplomacy also before the concept became popular. It should also be noted that the concept of science diplomacy is no longer explicit in the last two major planning options analyzed (2020–2023 and 2021–2023), although it continues to have an implicit presence in both documents. From 1986–2009 (Phases 1–3) a series of objectives related to Portugal's projection are also mentioned, namely by attracting science and technology structures, networks, and events. From 2006–2009 (Phase 3) the participation in technology fairs and the valorization of the Portuguese community appear, along with the Portugal Brand, already mentioned above. From 2016–2021 (Phase 5) objectives increase, with reference to the specialization of professionals in the area (creation of scientific advisor positions and training in science diplomacy), the affirmation of the Portuguese language and the valorization of the diasporas and qualified immigrants in the context of science and technology. It seems that while Portugal's projection strategy was initially focused on attracting initiatives to its territory (Phases 1–3), from 2006 onwards (Phases 3 and 5) it embarked on a strategy of promoting its science and technology abroad. The contents included in this line of action focus on the use of science and technology as an “asset” for national promotion, branding and soft power falling into the strategic driver of influence. Objectives can be classified as non-scientific with political/diplomatic focus with a strong occurrence in the last time phase (Ruffini and Krasnyak, 2023, pp. 4-6).

The contents about the thematic areas of the international agenda begin by mentioning the relevance of science and technology in their definition and solving (Phase 1). There is then an evolution towards the explicitness of concrete themes, for example oceans and space (Phase 2), with great expansion and detail of themes in the following phases (particularly in Phase 3 and 5), many of which are EU “flagships” (e.g., climate, energy, food, space, ocean). It is interesting to note how thematic areas are seen not only as areas that can be identified and advised by science and technology, but also as a possible vehicle for the development of external relations (Phase 4).

Regarding the regions mentioned in the strategic contents, it can be concluded that the EEC/EU, Portuguese-speaking countries (under various names), the USA and Asian states (namely China and India) appear almost constantly in the different phases considered. Between 1986 and 1995 (Phase 1) the Russian Federation and the regions formerly associated with the USSR are mentioned, in the aftermath of the fall of the Berlin Wall and the end of the USSR. In this phase it is also interesting to note the focus on bilateral partnerships, both with “developed” European countries and with other regions of the world. Between 2006 and 2015 (Phases 3 and 4) it is also worthy of mention, the attention given to partnerships with neighboring Spain. In the last phase (2016–2021 - Phase 5) there seems to be a preference for broader regions such as the Atlantic (North and South), the

Mediterranean, China and the “Asian market” and India, Africa, and Latin America, in what appears to be a generic opening to partnerships on a global basis, and probably in a multilateral mode.

The mention of international organizations does not seem to have a pattern of evolution. In some phases, international organizations of a general nature (North Atlantic Treaty Organization (NATO), Organization for Economic Cooperation and Development (OECD), United Nations Educational, Scientific and Cultural Organization (UNESCO)) and international scientific organizations of a specific thematic nature are listed (e.g. European Organization for Nuclear Research (CERN), European Space Agency (ESA), European Southern Observatory (ESO), Atlantic International Research Center (AIR Center), Square Kilometer Array Observatory (SKAO)) (Phases 1, 2 and 5). In other phases, attention is focused on Iberian international organizations (e.g., International Nanotechnology Laboratory) without reference to the previous ones (Phases 3 and 4).

While the concept of science diplomacy emerged during the first decade of the 2000s (Ruffini, 2017, pp. 8, 9, 11, 13), its explicit use began in 2016 in the strategic documents analyzed. The non-use of the term does not mean, however, that Portugal did not previously look at its science and technology in intersection with foreign policy, which led us to retrospectively classify the strategic objectives identified in this area since 1986. This option will certainly give rise to debate because, it may seem to be a construction that attempts to attribute a relevant past to a very recent concept (Flink, 2021, p. 8), in this work applied to the Portuguese case. However, the literature shows that states have long considered science and technology to be part of their policy of influence, and that many authors have recognized science diplomacy practices since at least the Cold War, with some even recognizing them since the 18th century (as described in the introduction). Portugal was not expected to diverge significantly from this model, with the necessary adaptations associated with its development. Indeed, this work has shown that the Portuguese strategy for this area, as of 2016, clearly has its foundations in previous decades, with a gradual increase in the number and complexity of scientific and non-scientific objectives. It could be said that the Portuguese state has been adopting a LEGO® type model in which levels of strategic objectives are added while maintaining the previous ones. These are motivated by a mix of access and attraction, cooperation and influence drivers. Considering the notable evolution of the Portuguese science and technology system from 1986 to 2021 (as shown, e.g. by the expenditure on research and development activities in Fig. 1), one could expect a relative reduction of the access and attraction driver in comparison to the cooperation and influence drivers, which have a higher focus on power projection and inclusion of science and technology in a country geopolitical approach. However, throughout the different phases the strategy mix of Portugal is maintained with apparent similar distribution. The continuous and significant presence of the access and attraction driver may be explained by the continuous motivation of Portugal to improve its scientific system and overcome its gap to the EU average (as seen for expenditure on research and development activities in Fig. 1) and by the increase in international competition for science and technology associated resources. In parallel, Portugal invests on cooperation and influence drivers as a way of international positioning and continuous integration effort in the European project. This evolution is certainly not unrelated to the European project and its science and technology policies. In the period covered by this study, the EU's competences in science and technology gradually increased, from the Single European Act in 1987 to the Lisbon Treaty in 2009. Likewise, from 1986 to 2022, the framework programs and

coordination of policies have evolved, also reflecting the priorities of the European project in science and technology (Reillon, 2017, p. 19; Ulnicane, 2023, p. 2, 8).

While it is true that in Europe (including Portugal) the community approach to science and technology has gained prominence (Ulnicane, 2023, p. 2–3), Portugal does not fail to mention in its strategic documents a series of international scientific organizations that operate according to the intergovernmental model, thus also giving importance to this type of organization. Many of them are associated with the European continent and have links to the EU but operate autonomously from the European project.

Moreover, to its alignment with the EEC/EU, Portugal's science diplomacy strategic objectives also target other complementary geographies. Of note are the Portuguese-speaking countries and the Atlantic connection to the USA, in line with Portuguese foreign policy priorities (Pereira, 2019, pp. 273–276), and India and China, certainly due to the growing importance of these states in the international order.

Mapping of support instruments—governance of the Portuguese science diplomacy. The strategy described in the previous section is designed and implemented by an array of governance structures, identified in this section by the mapping of support instruments. Following the indicated methodology above and in the period under study (1986–2021) it was possible to identify a series of structures/agencies whose mission included to organize operational science diplomacy instruments by screening archives, reports and legal diplomas of the Ministries associated to Science and Technology and the MFA, and issuers of cooperation agreements including science and technology. The information is summarized in Fig. 2 together with the name of the ministries responsible for science and technology and for foreign policy (which suffered changes through the studied period).

The identification of the support structures for science diplomacy is in line with Council of Ministers Resolution, which sets out the framework for science diplomacy in Portugal, defining that it requires “coordination between the Ministry of Science, Technology and Higher Education, responsible for internationalization policy in its sectoral field, and the MFA, responsible for the general coordination of government action on the European and external fronts” (Resolução do Conselho de Ministros, 78/2016, n.d.; 30 Novembro). This type of science diplomacy governance can be classified as a combination of a science-centered model (driven by a science related organizations) and a science-outsourcing model (driven by the MFA), as described by Lee (2015, pp. 90–91), which we suggest designating as a hybrid science-foreign affairs model. In the case of the structures associated with the supervision of science and technology, the numerous changes, mergers and transfers of competencies reveal some institutional instability that may be associated with the changes in ministry level. Nevertheless, the constant effort to create structures with missions at the intersection between science and technology and foreign policy reveals the importance of science diplomacy throughout the period under study. This study has not looked at the resources (financial and human) made available to these structures. Therefore, it is difficult to assess their importance and relative weight over time. Since 2012, the maintenance of these attributions within the same agency (FCT) seems to reveal a more defined structural direction for science diplomacy, which may have facilitated increased ambition in the definition of strategic instruments, as described above.

In the case of the MFA's directorates-general (DG), references to science and technology seem to be more limited. Considering,

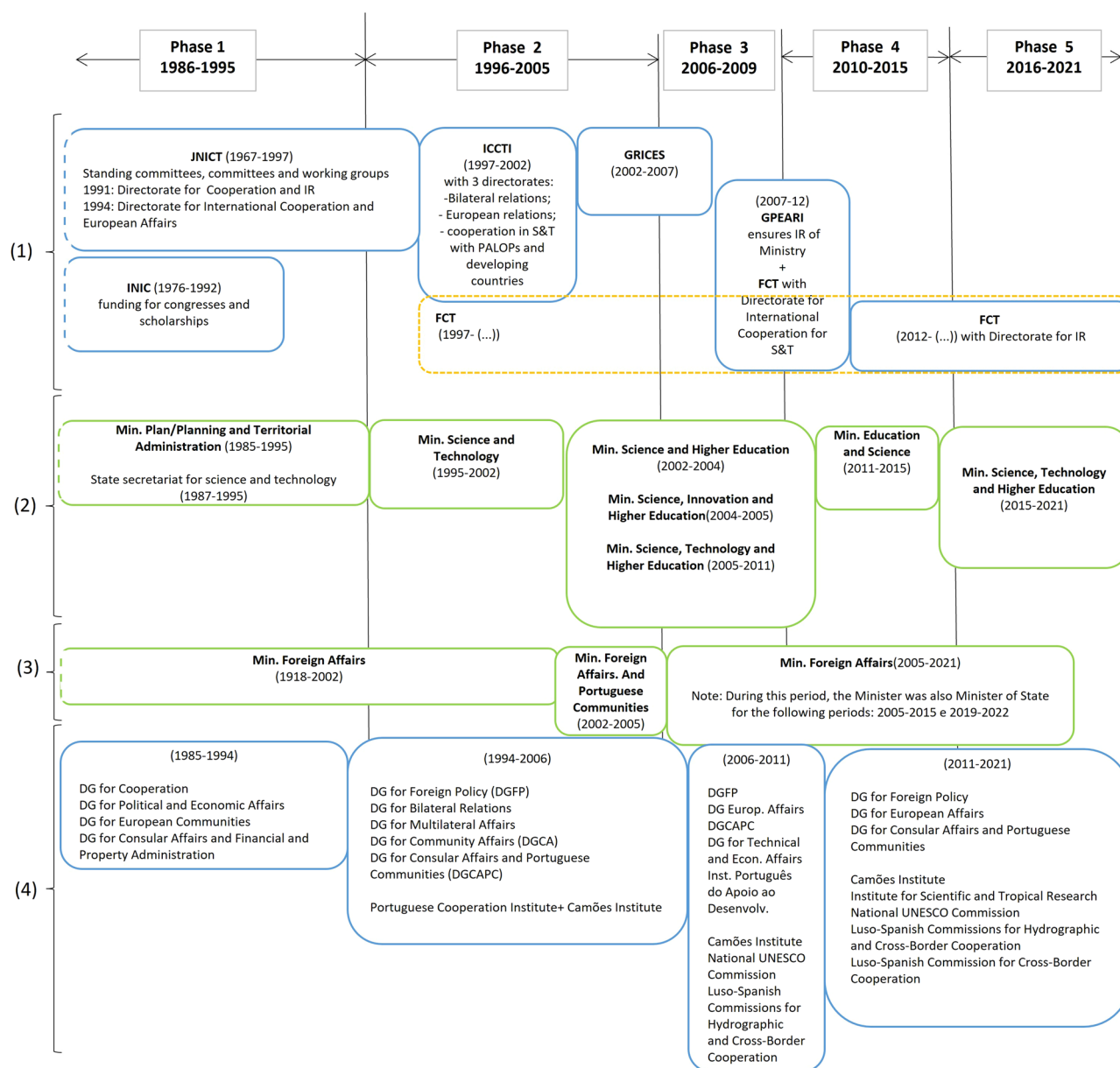


Fig. 2 Framework of the structures associated with the organization of operational science diplomacy instruments (between 1986 and 2021). From top to bottom: (1) science and technology agencies associated with the organization of operational science diplomacy instruments, (2) ministry responsible for science and technology, (3) ministry responsible for foreign policy and (4) directorates general/structures of the foreign affairs ministry identified as relevant in science diplomacy processes. Abbreviations: JNICT: Junta Nacional de Investigação Científica e Tecnológica [National Board for Scientific and Technological Research]; INIC: Instituto Nacional de Investigação Científica [National Institute for Scientific Research]; ICCTI: Instituto de Cooperação Científica e Tecnológica Internacional [Institute for International Scientific and Technological Cooperation]; GRICES: Gabinete de Relações Internacionais da Ciência e do Ensino Superior [International Relations Office for Science and Higher Education]; GPEARI: Gabinete de Planeamento, Estratégia, Avaliação e Relações Internacionais [Planning, Strategy, Evaluation and International Relations Office]; FCT: Fundação para a Ciência e a Tecnologia [Portuguese Foundation for Science and Technology]; IR: International Relations; DG: Directorate general. Sources: Arquivo de Ciência e Tecnologia da FCT, [n.d.](#), n.n.; Portaria nº 209/91 de 14 de Março, [n.d.](#); Lei nº 52B/96 de 27 de Dezembro, [n.d.](#); República Portuguesa, [n.d.](#), n.n.; Decreto-Lei nº 214/2006 de 27 de Outubro, [n.d.](#); Decreto-Lei nº 152/2007 de 27 de Abril, [n.d.](#); Portaria nº 149/2012 de 16 de Maio, [n.d.](#); Portaria nº 216/2015 de 21 de Julho, [n.d.](#); Decreto-Lei nº 529/85 de 31 de Dezembro, [n.d.](#); Decreto-Lei nº 48/94 de 24 de Fevereiro, [n.d.](#); Decreto-Lei nº 204/2006 de 27 de Outubro, [n.d.](#); Decreto-Lei nº 121/2011 de 29 de Dezembro, [n.d.](#)

however, the information gathered on the issuers of cooperation agreements signed by Portugal, this absence may be related to the fact that the MFA essentially has a general coordination role in this area. Added to this is the fact that science and technology is probably distributed among the different directorates-general, which are organized by diplomatic typology rather than by theme (bilateral DG, multilateral DG, EU affairs DG, consular DG, among others). It is worth noting, however, the (brief

existence of structures whose mission explicitly includes science and technology, such as the DG for Cooperation between 1986 and 1995 (Phase 1) and the DG for Technical and Economic affairs between 2006 and 2011. It is also important to note the existence from 2006–2021 (Phases 3, 4 and 5) of a series of structures outside the directorates-general focusing on issues associated with science and technology, such as the National UNESCO Commission, the Institute for Scientific and Tropical

Research and the Luso-Spanish Commissions for Hydrographic and Cross-Border Cooperation.

Science diplomacy dialogs may be defined as “informal high-level forums of which a group of countries are members, with a view to promoting policy dialog and cooperation in the area of science, technology and innovation, encouraging the efficient use of resources and strengthening the development and regional interdependence of the region in which it is inserted” (FCT, 2022, n.n.). Portugal’s direct involvement in dialog platforms that promote or facilitate science diplomacy is entirely associated with EU initiatives and focuses on the Mediterranean, Latin America and the Caribbean, and Africa. In 1995 (the final year of Phase 1) the Union for Mediterranean (UfM) Regional Platform in Research and Innovation⁸ was created to monitor and promote cooperation in research, technology and development bringing together EU countries and Mediterranean partner countries⁹ (European Commission, n.d. e, n.n.). Between 2010 and 2015 (Phase 4) it is possible to register the beginning of the Western Mediterranean Forum, also known as the 5 + 5 Dialog: Research, Innovation and Higher Education, a sub-regional dialog forum to encourage closer cooperation in the areas of science, technology, and higher education between 5 EU Member States and 5 Arab Maghreb countries¹⁰ (5+5 Dialog, 2017, n.n.). In the same period the EU-Community of Latin American and Caribbean States (CELAC) dialog also initiated its activity. This was set up in 2010 with the aim of strengthening EU-CELAC cooperation in science and research and aims to facilitate bi-regional dialog on common priorities, encouraging exchange of knowledge on policies and ensuring cooperation through bi-annual action plans (European Commission, n.d. d, n.n.). In parallel, the African Union-European Union High Level Policy Dialog on Science, Technology and Innovation was established, a forum where regular exchanges on research and innovation policy take place and where long-term priorities for strengthening cooperation between the EU and the AU are decided. This high-level dialog was adopted at the third AU-EU Summit in Tripoli in 2010 as an important element of the Joint Africa-EU Strategy (European Commission, n.d. a, n.n.).

The participation of Portugal in these initiatives seems to have impact in the following phases in the geographies considered in the strategic contents for the Portuguese science diplomacy. In the phase following the start of the dialogs with the Mediterranean UfM (Phase 1), it is possible to note the mention of the Mediterranean, North Africa and Morocco among the regions considered in the Portuguese strategic orientations (Supplementary Table S1, Regions mentioned, Phase 2). In the case of the dialogs involving AU, CELAC and a selection of Mediterranean countries (Phase 4), the documents mention the African, Latin American and Mediterranean regions in the next phase (Supplementary Table S1, Regions mentioned, Phase 5). In this case, there also seems to be an influence on the thematic areas considered priorities, especially those related to the Mediterranean, with the emergence of the thematic areas of food value chains, water management and energy sustainability of agricultural systems. Portuguese participation in these dialogs may also have been an important catalyst for increasing ambition throughout the diplomacy strategy and for defining objectives associated with global science for development.

Identifying events or activities for training/awareness-raising in science diplomacy was done by screening the websites of the Portuguese MFA, of its training institute (*Instituto Diplomático*) and of FCT. This search revealed a dozen of initiatives compiled in Table 1.

Training/awareness-raising activities in science diplomacy are concentrated mainly between 2016 and 2021 (Phase 5), following initiatives by the diplomatic community and the scientific

community (including the scientific diaspora), and with the presence of actors from both communities (including high-level representatives), both from Portugal and abroad. The presence of the EU in different activities, for example through the European Commissioners for Science and Technology, demonstrates the relevance of this theme also in connection with the context of the European project. In addition, the organization of this type of activity is in line with the strategy described for this phase, which includes training in science and technology policies for diplomats and scientific advisors and the enhancement of Portuguese scientific diasporas (Supplementary Table S1, Projection of Portugal, Phase 5). The activities described are a further contribution to the dissemination and development of science diplomacy in Portugal and an important contribution to the training of potential players in the field.

Mapping of operational instruments—implementation of the Portuguese science diplomacy. Operational instruments of science diplomacy are those used to implement it and following the indicated methodology above include three main areas: cooperation agreements; funding schemes; and advisory councils, scientific attachés, and instruments for promoting science and technology.

Cooperation agreements. Firstly, data regarding cooperation agreements was collected crossing sources from FCT, the MFA and online Portuguese Official Gazette (see details in Methods). While collecting data for the period of this study (1986–2021), the authors have identified that many cooperation agreements were automatically renewed. Thus, agreements dating from 1974 to 1985 were additionally identified, since they will have remained in force during the period covered by this study. This extended collection began in 1974 to identify international relations in a post April 25th context,¹¹ with the 1974–1985 phase being referred to as phase 0 (as previously described). The collected agreements were classified at a first level as bilateral or multilateral, and at a second level in different subcategories described in Table 2.

The list of bilateral agreements can be found in Supplementary Data S3. Considering the period from 1986 to 2021, it was possible to identify a total of 75 bilateral agreements. Between 1974 and 2021 it was possible to identify a total of 114 bilateral agreements between Portugal and 55 geographies, the vast majority of which were states¹² (Fig. 3a). Europe dominates the partnerships with almost half of the agreements established (44%), followed by Africa and the Mediterranean (38%). Agreements were also established on the American continent (Latin and North America) and the Asian continent (Fig. 3b).

Most of the bilateral agreements (74%) correspond to general cooperation agreements with a variety of designations. While some designations indicate that the agreements are specific to science and technology (“scientific cooperation” or “scientific and technical/technological cooperation”), others indicate agreements with a more general scope that combine science and technology with areas such as the economy, education and higher education, culture, sport, youth, tourism, and the media, in different configurations. The agreements classified as dedicated to specific themes (23%) deal with diverse subjects such as oceans, space, agronomy, the environment, scientific equipment, and meteorology. The remaining agreements (4%) relate to research infrastructures and the creation of research centers.

Figure 3c depicts the number of agreements per phase and detailed geographical areas. In Europe, the EEC/EU have a significant weight in the partnerships established. The

Table 1 Events/activities for training or awareness-raising in science diplomacy.

Year (Phase)	Event/activity	Reference
2013	Conference about Climate Diplomacy	Instituto Diplomático, n.d. a, n.n.
Phase 4	organized by <i>Instituto Diplomático</i> and Alliance Française	
2015	Diplomatic Seminars	Instituto Diplomático, n.d. b, n.n.
Phase 4	organized by <i>Instituto Diplomático</i>	
2017	2015: with session about "Ciência, Tecnologia e Inovação na Diplomacia Europeia" by European Commissioner for Research, Science and Innovation and sessions about Oceans and Energy.	
Phase 5	2017: with sessions about "Technology and Innovation" with the participation of the European Commissioner for Research, Science and Innovation, the Portuguese Minister for Science and Technology and the WebSummit Director General.	
2019	2019: with a session about Digital Transformation	
Phase 5	Videoconference "Challenges of the Covid-19 pandemic for the international health structure"	Instituto Diplomático, n.d. c, n.n.
2021	organized by <i>Instituto Diplomático</i>	
Phase 5	21st European Diplomatic Program	Instituto Diplomático, 2021 , n.n.
2021	organized by EEAS in cooperation with Portuguese EU Presidency	
Phase 5	on the theme "Science Diplomacy" with the presence of the European Commissioner for Innovation, Research, Culture, Education and Youth and the Portuguese Ministry of Foreign Affairs	
2019	Support by Instituto Diplomático to the publication of the book "Diplomacia Científica - Saber é Poder" ["Science Diplomacy - Knowledge is Power"]	Aranda, 2019 , p. 4
Phase 5	Foreword by the Minister for Science, Technology and Higher Education	
2016–2021	Encontros Ciência	RTP, 2016 , n.n.
Phase 5	promoted by the FCT, in collaboration with the National Agency for Scientific and Technological Culture - <i>Ciência Viva</i> 2016 : panel on science diplomacy for the Atlantic with the administrator of NASA's oceanography program and the ambassadors of the United States, Canada, Brazil, Ireland, France and South Africa. The European Commissioner for Research, Science and Innovation was also present at the opening session of the event;	<i>Ciência Viva</i> , 2017 , n.n. <i>Ciência Viva</i> , 2018 , n.n. <i>Ciência Viva</i> , 2019 , n.n. <i>Ciência Viva</i> , 2021 , n.n.
	2017: Guest country 2017, India	
	2018: panel "Portugal: perspectives for science diplomacy" with interventions from the Portuguese, Cape Verdean and US academic community, the Portuguese Ministers of Foreign Affairs and Science, Technology and Higher Education and the Minister of Education, Culture, Science and Communication of São Tomé and Príncipe; session on Science Diplomacy for the Atlantic with academic and diplomatic representative. Guest country: South Africa	
	2019: panel on a European project dedicated to science diplomacy "H2020 InsSciDE - Inventing a Shared Science Diplomacy for Europe"; Guest country: the United Kingdom.	
	2021: Guest country: France	
2021	Science Diplomacy - a dialog between stakeholders	MNE, 2021 , n.n.
Phase 5	organized by the Association of Portuguese Graduates in France (AGRAFr), in collaboration with the France Alumni organization, the FCT and the Secretary of State for Portuguese Communities	

Table 2 Classification of bilateral/multilateral agreements (2nd level).

Agreement classification	Description
Cooperation	General agreements including science and technology
Specific topic	Agreements that address a specific topic of cooperation in the field of science and technology (e.g. meteorology)
International research centers	Documents aimed at setting up an international research center or Portugal joining an existing international center
International organizations	Agreements referring to Portugal's accession to an international scientific organization or to an international organization that states to develop scientific activities in order to pursue its main mission
Platforms/networks	Data indicating Portugal's participation in scientific platforms or networks
Infrastructures	Agreements and data indicating Portugal's participation in scientific and international facilities, equipment and services

significance of other European states is greater between 1976 and 1985 (Phase 0), probably due to the small number of countries in the Communities, and between 2010 and 2015 (Phase 4), a period with a very small number of agreements. It is interesting to note that there is an evolution of agreements from the Portuguese-speaking African countries (in the phases between 1976 and 2005—Phases 0, 1 and 2) to the Mediterranean states (in the phases between 2006 and 2015—Phases 3 and 4). Finally, the number of agreements with states on the Asian continent between 1996 and 2005 (Phase 2) is noteworthy.

The list of multilateral cooperation agreements in science and technology identified in this study can be found in Supplementary Data S4. Considering the same period as bilateral agreements

(1974–2021), a total of 214 multilateral partnerships were identified, corresponding to agreements: for participation in international organizations, for cooperation (general and thematic), for participation in scientific infrastructures and for participation in scientific networks or platforms (Fig. 4a). Due to their very diverse nature and to the different level of commitment they entail, we will analyze them by type of subcategory.

In the period under study, it was possible to identify 31 agreements for the participation of Portugal in international organizations of scientific nature (or which express to develop activities of a scientific nature to pursue their main mission) (Fig. 4a—orange columns—and Fig. 4b). Most of these agreements are concentrated in the phases up to 2005 (Phase 0 to 2) Regarding

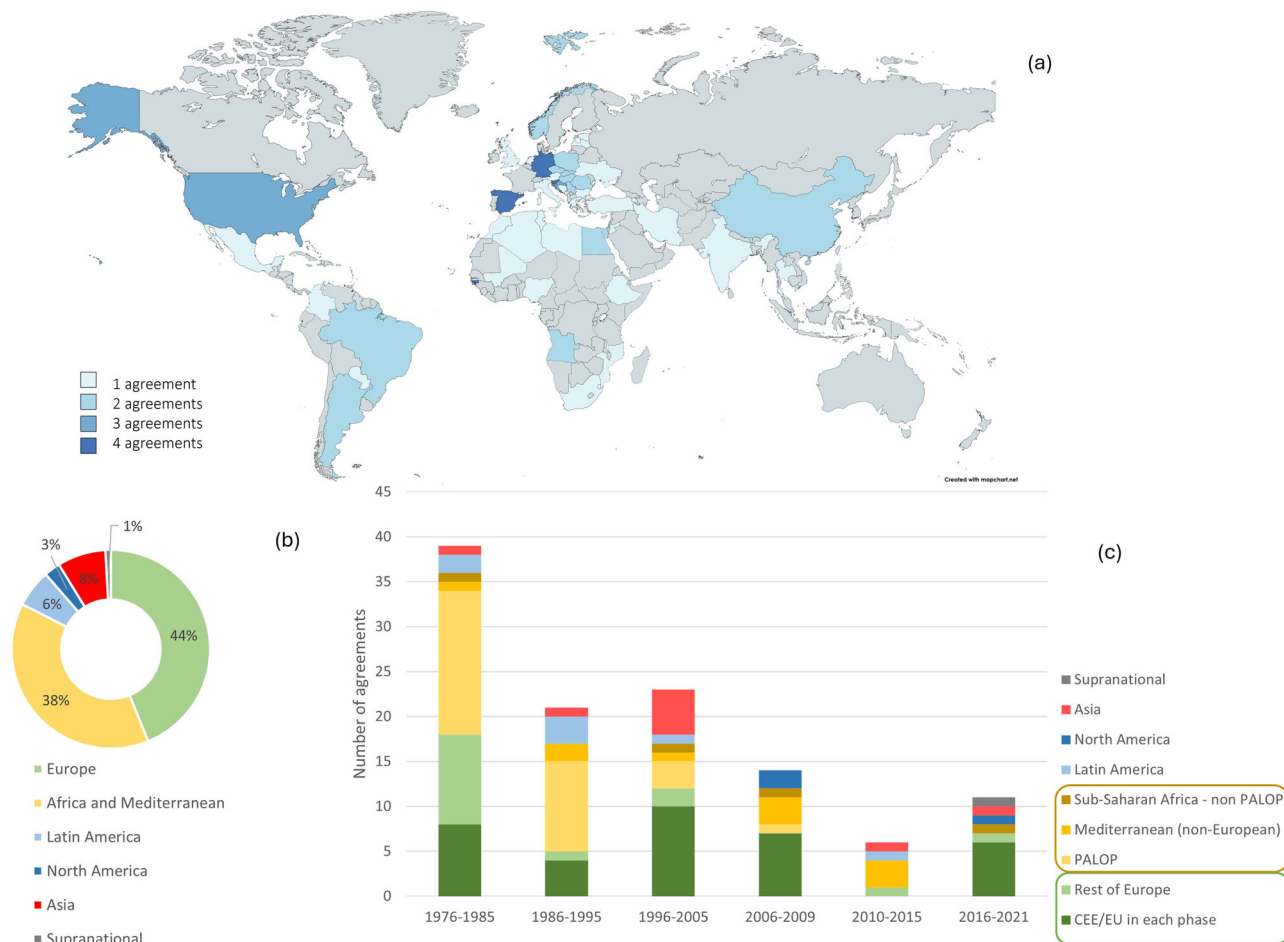


Fig. 3 Bilateral agreements. **a** States with which Portugal signed bilateral science and technology agreements between 1976 and 2021. The intensity of the blue color increases with the number of agreements signed. Comments: States that are not very visible due to their size on the map: Cape Verde (12 agreements), São Tomé and Príncipe (6 agreements), Macau region (2 agreements), Singapore (1 agreement), Luxembourg (2 agreements). Yugoslavia's agreements were added to the agreements made with the new states that resulted from its dissolution. One of the agreements was with a supranational entity (Imamat Ismaili). Map prepared with mapchart.net. **b** Distribution by world region of bilateral science and technology agreements signed by Portugal between 1976 and 2021 (in % of total number of agreements). Comment: The supranational entity refers to a partnership with Imamat Ismaili. **c** Representation of the number of bilateral agreements signed by Portugal by time phase and by detailed geographical area. PALOP: Portuguese-speaking African countries. Europe EEC/EU in the period: corresponds to states that were part of the EEC or the EU in the phase under analysis. Comment: The supranational entity refers to a partnership with Imamat Ismaili.

the regional focus of international organizations, and considering the whole period, the European continent leads with more than half of the partnerships (55%). This is followed by organizations with a global focus (35%) and a focus on Latin America (10%). It is important to mention that of the organizations with a European focus, only one, EUROATOM, has a direct link to the European Communities. All the other organizations (for example, CERN or ESA), follow the intergovernmental approach, including (naturally) members who are part of the European project, but with a geography of action that goes far beyond this and allows for very *à la carte* membership, generating a wide variety of geographical configurations in the different organizations. It is also important to note that many of these international organizations offer varying degrees of participation (full members, associates, cooperation) and have links to states outside Europe.

Diametrically opposed to the agreements relating to international organizations, the other agreements relating to multilateral partnerships (general and thematic cooperation agreements, participation in scientific infrastructures and participation in scientific networks or platforms) are intrinsically linked to the European project and

have been more significant since 1996 (Phase 2). During the period studied, 10 general and thematic cooperation agreements were identified (Fig. 4a—blue columns), 90% of which were between the EU, its Member States and a third country.¹³

In the case of the 21 partnerships related to access or contribution to scientific infrastructures (Fig. 4a—gray columns), more than 80% are associated with EU initiatives. They include the International Thermonuclear Experimental Reactor (ITER)¹⁴ and the EU-CELAC partnership for research infrastructures and the partnerships associated with the European Research Infrastructure Consortiums (ERICs) initiative.¹⁵ The geographical combinations of partnerships can be consulted for each partnership in Supplementary Data S4 ("Partnership States" column). Partnerships relating to scientific infrastructures not directly associated with the EU include the European synchrotron partnership (ESRF), the Global Biodiversity Information Facility, the AIR Center¹⁶ and SKAO. However, it is important to mention that these also include EU Member States.

The partnerships relating to networks and platforms identified in this work correspond entirely to the European Research Area Partnerships in which Portugal participated from their launch

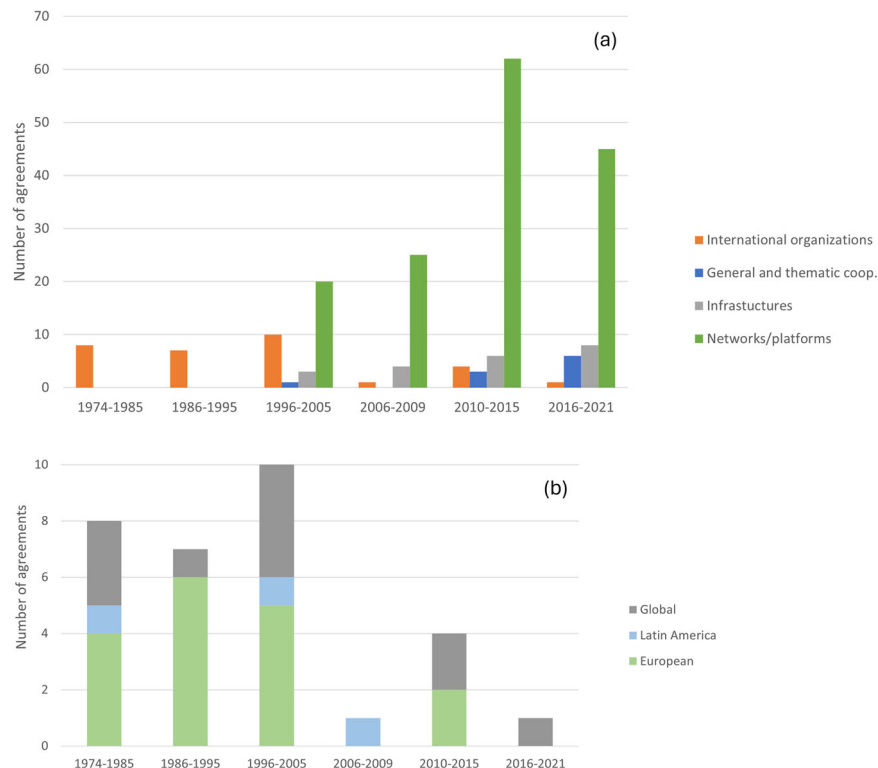


Fig. 4 Multilateral agreements. **a** Representation of the number of multilateral agreements signed by Portugal by time phase and type of agreement. Columns from left to right: participation in international organizations (orange), cooperation agreements (general and thematic) (blue), participation in scientific infrastructures (gray) and scientific networks or platforms (green). **b** Representation of multilateral agreements for the participation of Portugal in international organizations of a scientific nature or which express to develop activities of scientific nature to pursue their main mission. Distribution by time phase and by regional focus of the organization: European (green), Latin America (blue) and global (gray).

during the Sixth Framework Program (first partnership identified in 2003) until 2021. Using the ERA-LEARN database, it was possible to identify a total of 152 partnerships in which Portugal participates (Fig. 4a—green columns) out of a total of 333 registered partnerships, which means that Portugal is represented in almost one out of every two partnerships (ERA-LEARN, n.d. b, n.d.).¹⁷

In the period under study, Portugal developed bilateral agreements including science and technology with a wide geographical scope, a fact that reveals a global ambition in this area. Considering the number of agreements signed, the states associated with the European project have a very significant weight in the total number of agreements. It can be said that bilateral agreements are used to consolidate cooperative relations within the European project in line with the strategic objectives described above, in which the EU has a transversal presence. While the weight of bilateral agreements with Portuguese-speaking countries (until 2005) can be explained by Portugal's historical ties with these states, the agreements for the Mediterranean region (non-European) can be associated with the platforms for dialog with this region promoted within the EU (UfM and 5 + 5).

The diversity of instruments analyzed does enable a quantitative comparison between bilateral and multilateral instruments. However, it is possible to analyze the evolution of each multilateral instrument. The concentration of memberships of international intergovernmental organizations associated with science and technology in the early stages of this study can be seen as an important effort to bring Portugal closer to international intergovernmental organizations (many of which are European in nature), soon after the transition to democracy. Over time, the number in which Portugal does not participate is

reduced, which explains the decrease in new agreements. In the case of the other multilateral instruments, essentially linked to the European project, the trend seems to be the opposite, with an increase in Portuguese participation over time. This can be explained by a growing number of opportunities under the incentive mechanisms for building the European Research Area. Many of these multilateral instruments include partnerships with partners outside the EU. This means that Portugal is accessing partnerships that go far beyond the European project and encompass the whole world. It is also important to note that the new types of multilateral instruments such as partnership networks and infrastructures are more flexible and focused on very specific areas of action. These instruments allow each member state to join *à la carte* according to its interests and priorities in what seems to us an approximation to the intergovernmental model within the European project.

Funding schemes. Funding schemes are financial support that enables science and technology activities with international involvement, such as grants for the mobility or exchange of scientists, support for cooperation programs between states and support for bilateral or multilateral scientific projects (European Commission, Directorate-General for Research and Innovation and Van Langenhove, 2017, p. 13). The list of funding schemes identified in this study can be found in Supplementary Data S5. It was obtained by screening the documents of other instruments, namely the strategic instruments (which mention macroscopic programs for science and technology) and of the cooperation agreements (which often anticipate or have prepared for the existence of funding schemes) (more details in Methodology). In this list, the financing schemes were classified, at first level, as unilateral, bilateral or multilateral. In the case of the former, the

Table 3 Illustrative funding schemes.	
Classification (1st level)	Classification (2nd level) and description of programs
Unilateral	Major funding schemes (national) (with information about internationalization of researchers) a. Mobilizing Program for Science and Technology (<i>Programa Mobilizador de Ciência e Tecnologia</i>) (1987–1990) (Phase 1): included funding for training of human resources in science and technology abroad. Ref: Arquivo de Ciência e Tecnologia da FCT, n.d. , n.n. b. Science Program (<i>Programa Ciência</i>) (1990–1993) (Phase 1): included more than 3,000 grants, half of which for PhD. Of these, half were used abroad. Ref: Heitor 2015 , p. 12. c. PRAXIS Program (<i>Programa PRAXIS</i>) (1994 e 1999) (Phases 1/2): maintained scholarships for training abroad. Ref: Heitor 2015 , pp. 33, 44. d. FCT manages funding for human resources from 1997. Ref: Heitor 2015 , pp. 28–29. See also Fig. 5a , e, b. In the statistical data provided by the FCT on projects, it is not possible to identify the number of projects or funding associated with actions involving joint scientific projects (with foreign institutions). Ref: FCT, n.d. d, n.n.
	Bilateral Funding schemes for the internationalization of researchers Exchange of researchers between Portugal and 14 other countries in: EU, Mediterranean, Latin American. At least as of 2016. 6 programs with EUA: FLAD, Fullbright, specific institutions (CMU, MIT, UT Austin), National Health Institutes. Various dates. Ref: Heitor, 2015 , p. 33 and references in Supplementary Data S5. Funding schemes for joint projects Joint projects between Portugal and 7 countries in Europe (with Spain standing out for having various funding schemes - Catalonia and the La Caixa Foundation), and between Portugal and the USA with specific institutions (CMU, MIT, UT Austin since 2006 and Harvard Medical School). Ref: Supplementary Data S5.
Multilateral	Funding schemes for the internationalization of researchers Mobilities in the context of international scientific organizations (CERN, EMBL, ESA ESO) and funding schemes associated with the NATO Science for Peace and Security Program. Ref: Supplementary Data S5. Funding schemes for joint projects Projects in cooperation with 8 international scientific organizations: CYTED, CERN, ESA, European Center for Information on Marine Science and Technology (EurOcean), International Atomic Energy Agency, European Consortium for Ocean Research Drilling (ECord), International Union of Pure and Applied Chemistry (IUPAC) and NATO Science for Peace and Security Program. Ref: Supplementary Data S5. Major funding schemes (EU) EU framework programs covering research projects in priority thematic areas for the EU but also in any area of knowledge, advanced training and mobility of human resources, infrastructures, regional structures, innovation, industrial development and international cooperation with the area outside the EU. EU Funding schemes for specific and priority thematic areas (Nuclear Energy (EURATOM), Space and Digital Transition) and a large program dedicated to the mobility of EU youth (and not researchers), the Erasmus+ program, essentially dedicated to mobility up to the master's stage. Ref: PERIN, n.d. , n.n.; ANI, n.d. , n.n. See also Fig. 6a , b.

Portuguese state finances activities with international involvement without a specific agreement. In the case of bilateral and multilateral financing, the investment is made on the basis of a bilateral and multilateral partnership agreement. The multilateral category includes financing schemes associated with international organizations in which Portugal participates. In the multilateral context, it is also important to consider financing schemes associated with the EU. On a second level, funding schemes have been classified into three main groups. The first includes the major science and technology funding schemes (national and EU programs). The second includes funding schemes associated with grants for the internationalization of researchers (mobility, exchange, attracting foreign researchers, with specific institutions, linked to international organizations). Finally, the last group includes funding schemes associated with science and technology projects with a collaborative internationalization component (with states, specific institutions, and international organizations).

Identifying funding schemes has proved challenging due to the large number and variety of existing instruments, the non-centralized way in which information is available and the difficulty in obtaining information, especially for older funding schemes. Table 3, Figs. 5, 6 summarize the funding schemes identified with an illustrative perspective.

The funding schemes identified, associated with the internationalization of human resources and joint projects, are in line with the strategic instruments described above. Throughout

the different phases, they advocate the training of human resources abroad, access to international science and technology networks, the mobility of scientists, the creation of international programs in Portugal and the attraction of scientific human resources to Portugal. Based on the information obtained on the number of human resources involved and the volume of funding, the macroscopic science and technology programs promoted by Portugal and the EU seem to be responsible for a large part of the operationalization of this type of instrument. However, given the limitations in collecting information on many programs, it is difficult to define the effective contribution of each one to the promotion of Portuguese science diplomacy over the period under study. Regardless of their weight, the identification of different types of schemes signals the additional importance of establishing bilateral relations with other states (European, Mediterranean, Latin American, US and Chinese) and with international scientific organizations, in line with what had already been identified for science and technology agreements and strategic definitions. Since funding instruments in bilateral and multilateral cases are a shared effort between states, it would also be very important to understand what Portugal's contribution is and what its external contribution is to these instruments.

Advisory councils, scientific attachés and instruments for promoting science and technology. Lastly, we must also briefly

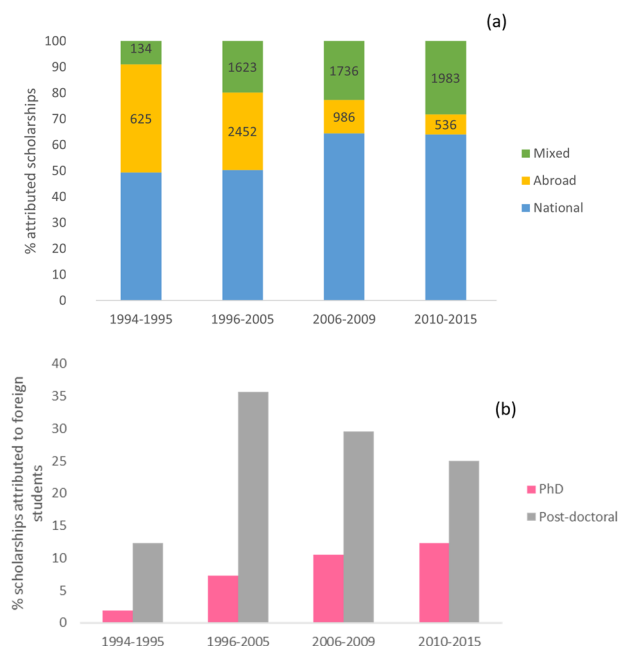


Fig. 5 Funding: Doctoral and postdoctoral fellowships. **a** Doctoral scholarships awarded by location of training (national, foreign and mixed) (% of total) by time phase of this work. The values indicated in the columns correspond to the absolute number of grants awarded for foreign and mixed grants. **b** Doctoral and post-doctoral scholarships awarded to foreigners (% of total) by time phase. Sources: The data used to build the figure were obtained from FCT (n.d. a, n.n.) and FCT (n.d. b, n.n.) and were only available from 1994 to 2015.

mention the role of advisory councils, scientific attachés, and instruments for promoting science and technology. Between 1986 and 2021, it was possible to identify 3 national science and technology advisory councils that existed in sequence (Table 4). These cover the entire period under study, thus demonstrating the recognition of the importance of this type of advice, having a general advisory nature that also includes issues at the intersection between science and technology and foreign policy.

Within the EU, it was also possible to identify a series of advisory groups that include Portuguese participation through FCT and that advise EU structures (the Council and the European Commission) and Member States on topics related to science and technology within the European Research Area (Table 5).

It is noteworthy that one of the EU advisory councils, the SFIC, has contributed recommendations to the ongoing construction of the European Agenda for Science Diplomacy (Council of the EU 2021, p. 3). It should be noted that Portugal's involvement in these structures is provided for throughout the strategic instruments (described above) that foresee Portugal's contributions to the European project, also at a political level.

With regard to scientific attachés and instruments for promoting science and technology, information was gathered from strategic documents and complemented by a search on the websites of the mechanisms implemented and news published in the media. We have summarized the information in Table 6.

The implementation of scientific attachés and instruments to promote science and technology only appears in the last phase of the period under study as an additional level of investment in science diplomacy. Science attachés positions (under the title of scientific advisors) were foreseen in strategic documents of 2016 but were later transformed into scientific councils of diaspora

scientific organizations, currently only implemented in the United Kingdom. While they have the merit of involving the scientific diaspora, they might reflect a certain decrease in commitment in relation to the previous plan. Alternatively, the Study & Research in Portugal and PERIN promotional instruments are important tools for the Portuguese positioning Portugal with potential to be used by the entire network of diplomatic representations, both bilaterally and multilaterally.

Study limitations

All the results described above must be considered in the light of the limitations of this study. These include the difficulty of collecting data on some of the instruments. Much of the public data available online is particularly rich, but it doesn't always offer institutional "memory" because it is hosted on pages that are linked to the present, offering information only on recent periods or only for certain periods, as we observed when searching for information on financing instruments. There is also a wide dispersion of information which makes it difficult to compile and does not allow it to be obtained systematically over time. For example, in the case of cooperation agreements, it was necessary to cross-reference five different sources to complete the mapping. This kind of gap could be filled by making information on this subject (and associated subjects) available in public databases, if not for the past, at least for the future.

The second limitation of this work is associated with the lack of evaluation of the instruments mapped. For example, since the financing instruments in bilateral and multilateral cases are a shared effort between states, it would also be very important to understand the Portuguese and foreign contributions to these instruments. In addition, since so many bilateral and multilateral agreements have been signed, it would be important to understand whether they are truly active and what impact can be attributed to them. In the case of governance agencies, as we have not looked into the resources (financial and human) made available to these structures, it is difficult to assess their importance and relative weight over time. Therefore, this study maps, but is unable to give each instrument the weight of its actual relevance, given the macroscopic perspective of this work. More detailed studies by instrument are therefore suggested for the future.

Finally, the third limitation of this study is its purely documentary nature not having collected testimonials from actors involved in science diplomacy. Although this methodology can give this work a more objective slant, it may fail to capture information that is not available in documentary sources. It is therefore suggested that future work should include interviews with actors associated with Portuguese and European diplomacy.

Conclusion

On balance, in the period under study Portugal has been developing its science diplomacy in parallel with the European project without ever losing a global vision of relations in the field of science and technology. Its science diplomacy model has continuously relied on a strategic mix to satisfy scientific and economic domestic needs, while contributing to the positioning of Portugal on the international scene. It is based on a science-foreign affairs hybrid governance structure in close contact to EU science diplomacy. The Portuguese science diplomacy implementation model is strongly based on cooperation agreements and funding schemes with an evolution throughout time from bilateral to multilateral instruments and with a strong connection to the EU initiatives. The Portuguese model also favors advisory councils both at national and EU level. Investment in science

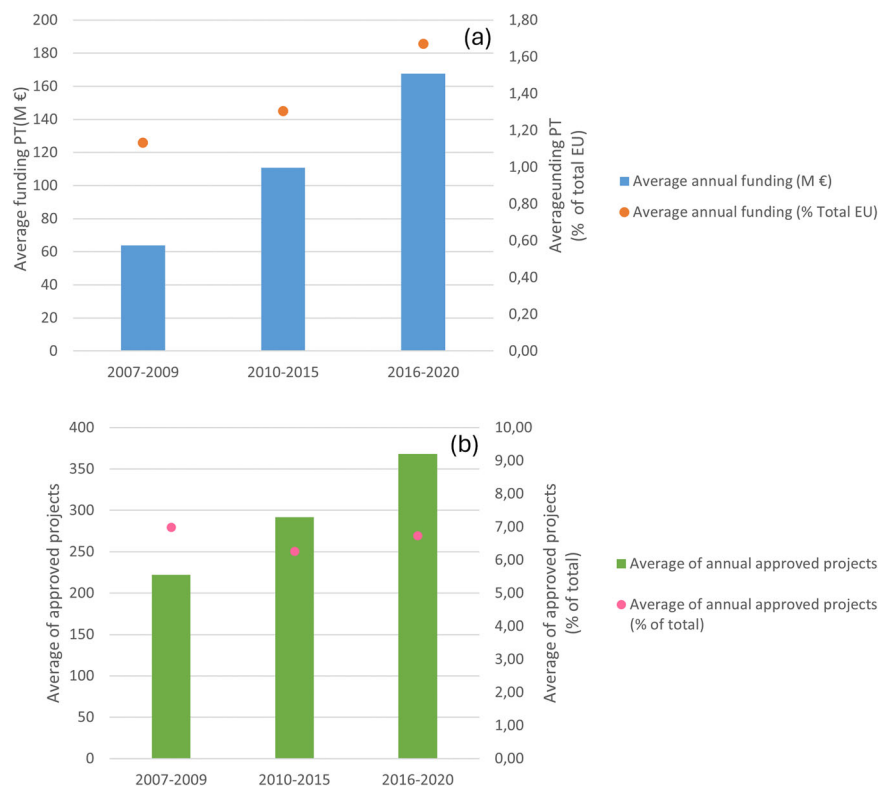


Fig. 6 Funding: VII Framework Program and Horizon 2020. **a** Funding raised by Portugal in the VII Framework Program and Horizon 2020. Average annual funding in M€ (columns) and % of total funding made available by the EU (points). **b** Projects approved with Portugal's participation in the VII Framework Program and Horizon 2020. Annual average of approved projects (columns) and % of total projects approved by the EU (points). Comments: The data obtained from 2007 to 2020 made it necessary to shorten the phases 2006–2009 (Phase 3) and 2016–2021 (Phase 5) in these representations. Data: ANI, [n.d.](#), n.n.; PERIN, [n.d.](#), n.n.

Table 4 National science and technology advisory councils.		
Starting year (Phase)	Advisory council	Reference
1986 Phase 1 + 2	High Council for Science and Technology (Conselho Superior de Ciência e Tecnologia) Members: JNICT, the government and autonomous regions, science and technology and higher education institutions, the Academy of Sciences, foundations and companies. Mission includes: advise on the “global policy for external scientific and technological cooperation”	Decreto-Lei nº 22/86 de 17 de Fevereiro, n.d.
2003- . Phase 2	High Council for Science, Technology and Innovation (Conselho Superior de Ciência, Tecnologia e Inovação) Members: FCT, the government and autonomous regions, science and technology and higher education institutions, the Academy of Sciences, foundations and companies, business associations, national agencies, and personalities of recognized business or academic merit. Mission includes: to advise about European scientific and technological policy and the coordination of national policies in the context of the EU, and bilateral and multilateral scientific and technological cooperation policy	Decreto-Lei nº 150/2003 de 11 de Julho, n.d.
2019 Phase 5	National Council for Science, Technology and Innovation (Conselho Nacional de Ciência, Tecnologia e Inovação) Members: FCT, the National Innovation Agency (ANI), the Agency for Competitiveness and Innovation (IAPMEI) and 20 individuals of merit from research and development units, the business community and the international scientific community. Mission includes: collaboration in the development and internationalization of the science and technology system, the provision of scientific advice to public policies and services and the promotion of cross-cutting and inter-ministerial coordination of science and technology policies.	Decreto-Lei nº 63/2019 de 16 de Maio, n.d.

attachés (or equivalent) or promotion instruments are recent and still frugal.

For the future, studies focusing on the Portuguese science diplomacy with specific states (e.g. USA, China, Russia, Portuguese speaking-countries) or on critical issues (e.g. climate, oceans, cybersecurity, critical raw materials, pandemics) are suggested. The fact that science, technology, and the economy are now at the forefront of rivalry between major powers will

Table 5 EU science and technology advisory groups that include Portuguese participation.

Starting year (Phase)	Advisory council	Reference
2002 Phase 2	European Strategy Forum on Research Infrastructures (ESFRI) Members: ESFRI delegates are appointed by the Ministers of Science and Technology of the Member and Associated Countries, and include a representative of the Commission Mission: support for the development of policies on science and technology research infrastructures in Europe with the aim of developing Europe's scientific integration and strengthening its international projection	ESFRI, n.d. , n.n.
2008 Phase 3	High Level Group on Joint Programming Members: The participation of Member States and associated countries in joint programming is voluntary, and in accordance with the principle of variable geometry and open access Mission: intensify cooperation in the area of research and development and better tackle major societal challenges on a European or global scale	ERA-LEARN, n.d. a, n.n.
2016 Phase 5	Strategic Forum for International S&T Cooperation (SFIC) Mission: facilitates the development, implementation and monitoring of the international dimension of the European Research Area, with emphasis on the external dimension of the EU and the research and innovation activities of the Member States; shares information and holds consultations between its members (Member States and the Commission) with a view to identifying common priorities that could lead to initiatives, activities and positions vis-à-vis third countries and in international forums; has a working group dedicated to EU science diplomacy	European Commission, n.d. f, n.n.
2016 Phase 5	Working Group on Open Science and Innovation Mission: advise on the development and implementation of policies and initiatives to improve access to scientific information and the circulation and use of knowledge for research and innovation for the benefit of scientists, research, institutions, education, businesses, citizens and society in general, and in particular end users	European Research Area and Innovation Committee (ERAC), 2016 , pp. 1–5
2019 Phase 5	Standing Working Group on Human Resources and Mobility Mission: helps promote cross-border mobility and career opportunities for EU researchers by addressing concrete obstacles that researchers face in cross-border mobility and cooperation, such as: employment rules, funding procedures and access to research infrastructures	ERAC, 2019 , n.n.

Table 6 Scientific attachés and instruments for promoting science and technology.

Starting year (Phase)	Instrument	Reference
2019 Phase 5	Scientific attachés In 2016, the scientific representation in Portuguese diplomatic missions is foreseen in a strategic document by the placement of PhD researchers as Scientific Advisors. In 2018, it was announced that the Scientific Advisors would be recruited from researchers working abroad and belonging to associations of the Portuguese scientific diaspora, with the first representation in London. In 2019, the Scientific Council of the Portuguese Association of Researchers and Students of UK (PARSUK) was established, funded by FCT to fulfill that purpose. The seems to be expected to be replicated by other Portuguese diaspora associations, namely the Portuguese American Postgraduate Society (PAPS), the Association of Portuguese Graduates in France (AGRAfr) and the Association of Portuguese Postgraduates in Germany (ASPPA).	Resolução do Conselho de Ministros, 78/2016, n.d. 30 Novembro LUSA, 2018 , n.n. PARSUK, n.d. LUSA, 2019 , n.d. University of Coimbra, 2019 AGRAfr, 2019 , n.d.
2018 Phase 5	Study & Research in Portugal Gateway for students and researchers wishing to pursue their training or careers in Portugal and base for information on activities promoted by Portuguese diplomatic missions around the world. The portal includes practical information on life in Portugal, testimonials from foreign researchers, databases on academic degrees, institutions and the structure of the science and technology system in Portugal, statistical data on science and technology and higher education and information on the areas of impact of research carried out in Portugal. It has versions in Portuguese, English, Spanish, French, German and Chinese. Launched in with the collaboration of FCT, the Directorate-General for Higher Education, Ciência Viva, the Directorate-General for Education and Science Statistics, Agência Nacional de Inovação (ANI) and Turismo de Portugal.	Study & Research in Portugal, 2023

Table 6 (continued)

Starting year (Phase)	Instrument	Reference
2019 Phase 5	Portugal in Europe Research and Innovation Network (PERIN) Aims to increase Portuguese participation in EU Programs associated with science and technology and higher education and to prepare, articulate and implement the opportunities in this context. It is an evolution of the R&TD Framework Program Promotion Office and has: “national delegates/experts/contact points for European programs, a research and innovation liaison network, with liaison officers from Portugal in Europe, and a network of research and innovation promotion centers. It involves FCT, Agência Nacional de Inovação, Portugal Space, Agência de Investigação Clínica e Inovação Biomédica, Ciência Viva and the National Erasmus Agency.	PERIN, <i>n.d.</i> , n.n.; Despacho nº 5911/2019, <i>n.d.</i> of June 27

certainly affect the way Europe, and consequently Portugal, develops science diplomacy. While the focus on domestic needs will probably require higher efforts at a national level, the international positioning may benefit immensely from a concerted approach at the EU level. Considering the limited resources available, Portugal may be an important contributor as a pivotal country in connecting the EU to other geographies, and to mediate the resolution of specific global challenges for which Portugal has a long-standing tradition, such as climate or oceans. The European framework for science diplomacy currently being prepared will already take into account the new international geopolitical situation. It will be up to Portugal to be aware of its potential and resources in order to make a full contribution to this pillar of the European project.

Data availability

All data generated or analysed during this study are included in this published article [and its supplementary information files].

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Notes

- 1 The Foundation for Science and Technology is the Portuguese governmental entity responsible for funding and evaluating the scientific and technological system.
- 2 Instituto Diplomático ensures the high-level training of the staff of the Ministry of Foreign Affairs, maintains the Library and the Diplomatic Historical Archive and promotes the preparation of strategic analysis studies relevant to Portuguese foreign policy.
- 3 Examples include agreements on education, the Portuguese language, defense and the security forces which do not explicitly mention training or cooperation at the scientific level.
- 4 E.g. the International Monetary Fund, the International Criminal Court, the International Tropical Timber Organization.
- 5 This may differ from the date it was signed by the parties (earlier) and the date it was ratified (later). In the absence of a legal diploma, the date on which the memorandum of understanding was signed, or the cooperative mechanism was implemented, was used. The date on which each agreement was eventually terminated was not identified.
- 6 In the absence of a legal diploma, the signatory of the agreement or the Portuguese government representative in the cooperation mechanism was considered as issuer.
- 7 E.g. funding associated with the National Aeronautics and Space Administration (NASA).
- 8 Previously known as the Euro-Mediterranean Monitoring Committee on Research and Innovation.
- 9 Including Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, Israel, Jordan, Lebanon, Malta, Mauritania, Monaco, Morocco, Syria (until 2011), Tunisia and Turkey.
- 10 Including Algeria, France, Italy, Libya, Malta, Mauritania, Morocco, Portugal, Spain and Tunisia.

- 11 The April 25th1974 Revolution (also known as the Carnation Revolution) marked the beginning of the transition to a democratic regimen in Portugal.
- 12 In a limited number of cases, the agreements established by Portugal were with specific regions or institutions, and these agreements have been classified under the state to which they belong. For example, partnerships under the go Portugal initiative established with USA universities (MIT, CMU, UT Austin) have been grouped under the USA. In a single case, an agreement was reached with a supranational entity (Imamat Ismaili).
- 13 These include South Africa (2), South Korea, Ukraine, Canada, New Zealand, Japan, Australia and Switzerland.
- 14 Associated with EURATOM, a global partnership in the field of nuclear fusion involving China, India, Japan, Korea, Russia and the United States, as well as the EU.
- 15 These consortia are legal forms for the establishment and operation of science and technology infrastructures of interest to the EU (with streamlined legal and fiscal implementation). This type of multilateral partnership can take in various combinations of Member States (with Member States hosting the initiative) and can also include States outside the EU (European Commission, *n.d.* b, n.n.).
- 16 Atlantic partnership for climate, ocean and space.
- 17 These European partnerships are initiatives in which the European Commission and private and/or public partners jointly support the development and implementation of research and innovation programs in a given thematic area (with varying degrees of initiative, funding and institutional structure). These partnerships aim to make a significant contribution to achieving the EU’s political priorities, to help overcome the fragmentation of the research and innovation landscape in the European area, to avoid duplication of national or regional research activities and to promote competitiveness and innovation (ERA-LEARN, *n.d.* b, n.n.).

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Author contributions

Contributors of authors include, for MA, conceptualization, methodology selection, data collection, treatment and analysis, and writing—original draft, and for RV-P, conceptualization, writing—review & editing, and supervision.

Competing interests

The authors declare no competing interests.

Ethical approval

Ethical approval was not required as the study did not involve human participants.

Informed consent

Informed consent was not required as the study did not involve human participants.

Additional information

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