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The Science Diplomacy Digital Index: new ways of measuring science diplomacy—the Lisbon study case in the year of 2021

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Science and technology have extended the diplomatic agenda beyond traditional issues, leading countries to develop networks of science diplomacy. Studying science diplomacy practices in science, technology and innovation hubs can reveal trends, useful for countries planning to establish a future diplomatic presence with a focus on science. Comparing best practices between city hubs can also inform education, research and innovation about international opportunities. This article explores systematically, and for the first time, how countries have been establishing an active presence regarding science diplomacy in Lisbon (Portugal), a city with a flourishing science, technology and innovation ecosystem. More importantly, it uses the Lisbon case study to contribute to the development of a pioneering approach to quantify and compare science diplomacy activities across geographical units by creating a “Science Diplomacy Digital Index” (SDDI), based on content analysis of websites and social media. The top 10 performers of the SDDI in this work include France (index of 78), Germany, Norway and the United States of America (all with 57), Brazil, Finland and Israel (all with 52), China (48), Russia (44), and India (39). By quantifying science diplomacy activities, the SDDI also allows comparisons with other known indices and quantitative measures. For example, a high SDDI score is a common feature between countries with the highest joint publication percentages. A similar correlation can be observed between the SDDI and the S&T component of the Global Soft Power Index. The mapping performed in this work demonstrates the transversal digital publicizing of science diplomacy practices by the diplomatic representations with residency in Lisbon, thus revealing the potential for the creation of networks and/or hubs around this theme in Lisbon, as existent in other cities. While compilation of practices into the SDDI clearly facilitates the reading of efforts of representations by synthesizing complex information, we strongly advise using the index as a starting point for a more in-depth perspective for each representation.

KEYWORDS

science diplomacy, Science Diplomacy Digital Index, science and technology, innovation, Lisbon

1 Introduction

Science and technology (S&T) have increasingly extended the diplomatic agenda beyond the traditional issues that diplomats have been addressing for centuries (Ittelson and Mauduit, 2019, p. 4), leading countries to develop new diplomatic approaches and techniques. After the Second World War, several countries started to build networks of science attachés at their

embassies to inform, represent and negotiate matters of scientific relevance. Later, these roles also encompassed technology and innovation (Leijten, 2017, pp. 1–2) and required establishing an active presence in S&T and innovation hubs worldwide. The specific actions and agendas at the nexus of S&T and foreign affairs developed by countries, led to the coining of the concept of “science diplomacy” in the first decade of 2000s (Royal Society and American Association for the Advancement of Science, 2010, pp. 1–4; Ruffini, 2017, pp. 11–16; Aranda, 2019, p. 2; S4D4C, 2019). Science diplomacy is caught between idealist aspirations and realist necessities. On the idealist side, its objectives may include fostering cooperation between states to address common problems (e.g., pandemics, migration, climate change, natural catastrophes), sharing global responsibility and governance, based on ideas and perceptions of universal good and on how the world should be. On the realist side the concept of science diplomacy focuses on national interest, pragmatic statecraft, gaining influence, and maintaining the balance of power, making use of its hard and soft modalities (Ruffini and Krasnyak, 2023, pp. 2–3; Krasnyak, 2018, pp. 4–5, 84).

States approach science diplomacy with different styles depending greatly on their history, values, culture and institutions (Krasnyak, 2018, p. 5) and on the overall power (im)balances between states and regions. Contemporary science diplomacy is an Anglo-Saxon concept, headed by the USA and largely dominated by the Global North experiences (EUSDA, 2025, p. 4, Ruffini, 2017, p. 72). The national styles in science diplomacy have been studied for a variety of countries with different levels of detail, approaches and analytical grids. Forerunners in science diplomacy and/or countries with particular power dimension in international relations have received significant attention in the literature (e.g., Flink and Schreiterer, 2010, pp. 665–677; Ruffini, 2017, pp. 47–83; Krasnyak, 2018, pp. 1–100; Ruffini, 2020, pp. 1–10; Krasnyak, 2020, pp. 118–134; Reinhardt, 2021, pp. 92–106; Saric et al., 2025, pp. 298–316). The transversal relevance of science diplomacy and its prioritization in many other countries, added to the new cultural, economic and political trends have also motivated the emergence of literature about national practices of countries labeled as Global South, or of Eastern and Southern Europe countries (Ruffini and Krasnyak, 2023, pp. 1–11; Pandey et al., 2022, pp. 1–12; EUSDA, 2025, p. 4; Szkarlat, 2020, pp. 1–10; Olšáková, 2024, pp. 7–30; Abrantes and Vaz-Pinto, 2024, 1–18). Typically, these studies offer in-depth perspectives on the science diplomacy of one country or perform comparative analysis between a small group of countries.

While states approach science diplomacy with different styles, a general framing for countries’ engagement in this sector has been proposed (e.g., Flink and Schreiterer, 2010, pp. 667, 676; Ruffini and Krasnyak, 2023, pp. 4–6). This framing indicates three categories of motivation for investment in science diplomacy (designated as strategic drivers): (1) cooperation or collaboration (sharing goals and resources); (2) attraction and access (to knowledge, people, infrastructure, funding), and (3) influence (ability to weigh in on decisions made by others). Additionally, it divides science diplomacy objectives into S&T objectives (aimed at advancing scientific knowledge and building capacity) and non-S&T objectives (political-diplomatic, economic and development). It also offers a classification on how countries implement science diplomacy (tools) (Ruffini and Krasnyak, 2023, pp. 4–5).

Identifying science diplomacy practices in S&T and innovation hubs and comparing best practices across them may reveal trends that

could be useful for countries to plan and establish a future scientific diplomatic presence, but may also inform education, research and innovation stakeholders about international opportunities. It could also serve to develop a network of multilateral players, active in science diplomacy with the objective of addressing local challenges with global impact. Due to the potential high number of diplomatic presences in S&T and innovation hubs, conducting this analysis implies the development of additional and specific methodological approaches. Ittelson and Mauduit (2019, pp. 1–31) and Gota et al. (2020, pp. 1–12) have characterized how diplomatic representations of the Greater Boston area conduct science diplomacy in interaction with the city’s innovation ecosystem, revealing a vibrant activity in this area with a variety of practices, including the presence of science attachés. Of notice is also the existence of a S&T diplomatic circle, an association of diplomatic missions and affiliated organizations in the Boston area offering a platform for networking interacting with regional government, academia and private sector stakeholders with the focus on S&T (S&T DC Boston, 2024). Similar associations exist in New York, Singapore, Shanghai and Kansai (S&T DC New York, 2024; S&T DC Singapore, 2023; S&T DC Shanghai, 2025; S&T DC Kansai, 2025). Interestingly, initiatives may also be driven by cities, as in the case of SciTech DiploHub in Barcelona (Roig et al., 2020, pp. 4–7). This hub is “a nonprofit public-private partnership backed by leading research centers, universities, non-profits, startups, corporations and public institutions” that “(...) has the mandate to elevate the role of science, technology and cities in foreign policy and make Barcelona a more influential player on the global stage.” The hub also includes a S&T Diplomatic Circle which organizes representation events in other cities and fosters capacitation activities (SciTech DiploHub, 2021).

In this article, we focus on Lisbon, the capital of Portugal, a country with 10 million inhabitants and the European Union’s Atlantic gateway with unique relations with Portuguese speaking countries (250 million people worldwide). The city of Lisbon has around 500,000 inhabitants (more than doubled by daily commuters) and hosts more than 300,000 companies, concentrating a significant number of companies with a high degree of R&D. It has 89 higher education institutions with 146,000 students (15% of which were international) (CML, 2021, pp. 7–8, 53). In the last years, Lisbon has been positioning itself as an innovation city, recognizing innovation as a driver not only for economic development but also for transformative public action. The city is envisaged as a “living laboratory where public bodies, companies, universities, research centers, technological institutes and citizens collaborate in developing, testing, and experimenting new products and services.” Diversity, openness and emphasis on international markets are considered fundamental pillars of this strategy (CML, 2025). In 2023, Lisbon was the winner of the European Capital of Innovation Awards, a recognition by the European Innovation Council under Horizon Europe (EC, 2023). Between 2021 and 2023, Lisbon rose 98 positions in the Innovation City Index from number 158 to number 60 (2Thinknow, 2025).

To the best of our knowledge, Lisbon has not yet a S&T diplomatic circle or a science diplomacy hub, that associates diplomatic representations and other possible local active stakeholders in science diplomacy into a platform for networking and cooperation. Furthermore, no studies have explored the science diplomacy activities of countries within Lisbon. Additionally, an open question in science diplomacy is the evaluation of its practices and impact (Ruffini, 2017, p. 130; Flink, 2022, pp. 6–7). This includes

understanding if the motivations for investment in science diplomacy (strategic drivers), such as, cooperation or collaboration, attraction and access, and influence are in fact realized into measurable indicators.

In this context, the following questions could be raised: (1) Which states develop science diplomacy practices in Lisbon? (2) Which practices are prevalent? (3) Is there a critical mass of stakeholders for the development of a S&T diplomacy circle (or equivalent) in this city? (4) Is it possible to systemize the variability of science diplomacy practices conducted by a high number of representations to enable straightforward cross-time and cross-geography comparisons in an index? (5) Is it possible to measure the impact of science diplomacy activities by relating a science diplomacy index with performance indicators for its drivers, namely access and attraction, collaboration or influence?

The present work aims to answer these questions by mapping science diplomacy practices of the diplomatic representations based in Lisbon and by developing an innovative and pioneering approach to systematize and quantify the various types of interventions in science diplomacy done by different states. This may also enable comparing science diplomacy activities across different geographical and time units while opening new paths to evaluate its impact.

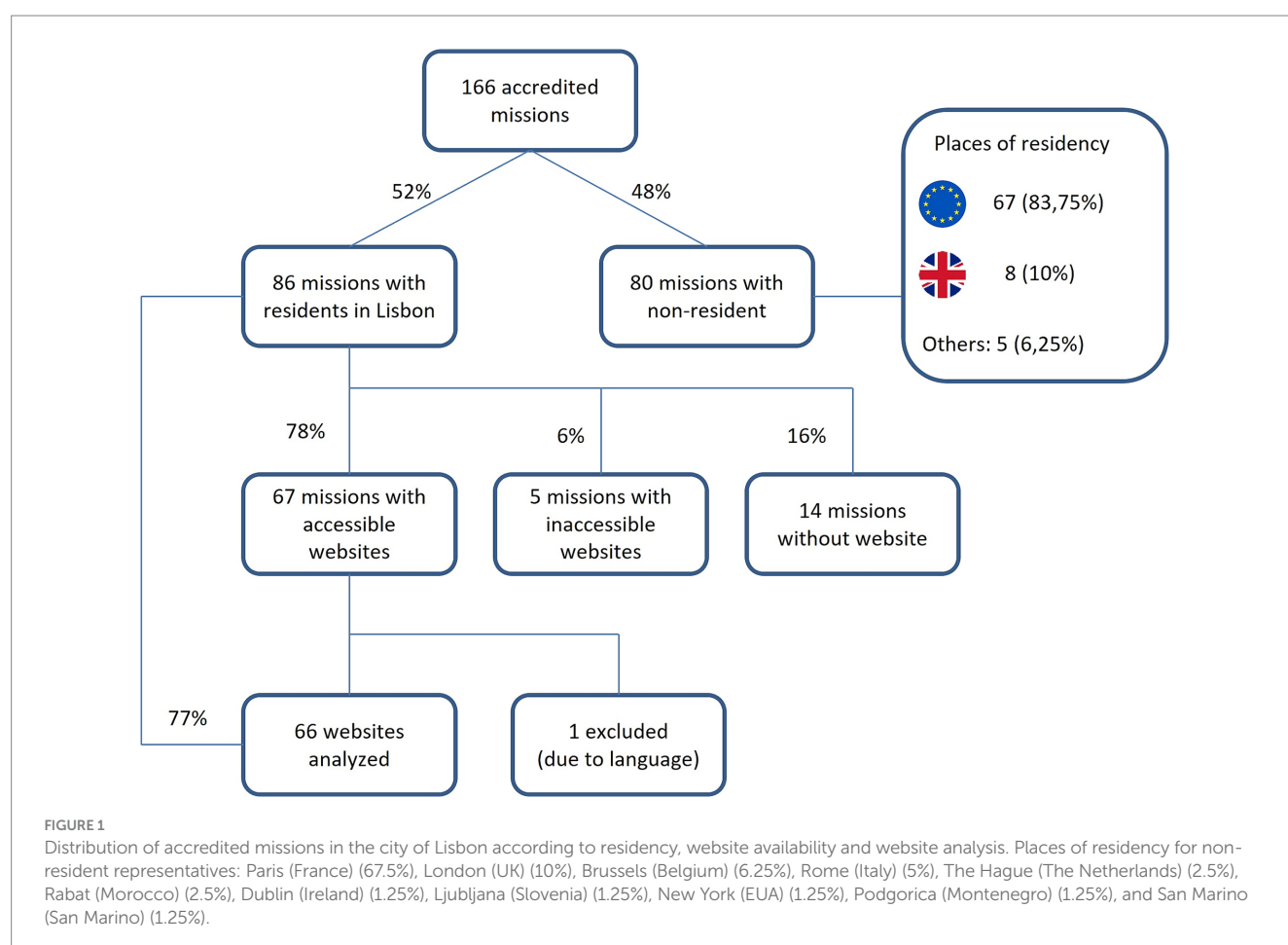
2 Materials and methods

The present work collected data from websites and social media of diplomatic representations with residency in Lisbon. Digital

resources and social media form an ever-larger part of both state-to-state diplomacy and public diplomacy since they have proven to be useful tools to reach wider audiences in different parts of the world in real time. They enable individuals, organizations, media, and civil society groups to access useful information and also offer networking opportunities (Bjola and Manor, 2024, p. 4). The relevant accredited Diplomatic Corps in Lisbon were identified by using the “Book of the Diplomatic Corps” issued by the Foreign Affairs Ministry of Portugal (MNE, 2020, pp. 10–213). Only diplomatic missions with resident representatives in Lisbon were selected. Non-resident accredited diplomatic missions were not further investigated for the mapping (but were listed and their residency place identified).

2.1 Sample characterization—websites and social media

In December 2020 Lisbon hosted 166 accredited diplomatic missions of countries. Of these, 86 (52%) missions had resident representatives. The vast majority of non-resident representatives were based in other EU Member States (84%) and in the UK (10%) (Figure 1). All missions of countries with resident representatives were embassies or equivalent (for example, apostolic nunciature for the Holy See). Of the total 86 embassies in Lisbon, 67 (78%) had accessible official websites. It was not possible to retrieve a



website for 14 embassies (16%) and 5 embassies (6%) had sites that were found inaccessible (“login needed,” “page not found”) (Figure 1).

A preliminary visit to the 67 official accessible websites showed that 66 sites were published in at least one of the following languages: Portuguese, Spanish, Italian, German, English and French. Many of the websites were bilingual and some even multilingual in a clear effort to reach different audiences (noting however that the content in the different languages was often not the same). Thus, we conducted a detailed content analysis of 66 websites, which account for more than $\frac{3}{4}$ (77%) of the total embassies in Lisbon (Figure 1). In terms of the geographical origin of the representations in our sample, Europe stands out with 32 (47%) websites, of which 22 (33%) are of European Union (EU) member states. Further distribution includes Asia with 14 websites (21%), America with 12 websites (18%), Africa with 8 websites (12%) and Oceania with 1 website (1.5%).

Investigation of the social media activity of all the 86 missions with resident representatives in Lisbon identified 66 missions (77% of the resident missions) with an official presence on Facebook, LinkedIn and or Twitter (known as X since, 2023). Interestingly, although this percentage was similar to one of the embassies that have accessible official websites (as described above and in Figure 1), they have not always co-existed, which means that social media were used both by the missions that had a website, as well as by those that did not have one.

2.2 Data collection in websites and social media of diplomatic representations

The methodology for collecting data from websites was adapted from the report elaborated for the Boston area, USA (Gota et al., 2020, pp. 17–20). As in the Boston study, only publicly available information was used. The raw data collected were compiled in a form for each country and combined in Supplementary Annex 1 (including detailed information, links and contacts as available and considered relevant).

Using the “Book of the Diplomatic Corps” (MNE, 2020, pp. 10–213), we started by identifying: (a) the type of diplomatic presence (embassy, consulate, permanent mission, apostolic nunciature); (b) any relevant contacts (address, phone, email) and (c) their official website. If no official website was registered in the ‘Book of the Diplomatic Corps’ or if the provided link did not afford any result, an internet search was made.

A visit to each official website was conducted during the months of January and February of 2021 with the following search routine:

1. Identification of the language(s) of the website. The following languages were used to retrieve information: Portuguese, Spanish, Italian, German, English and French (only one website was discarded due to these language requirements). When websites were multilingual, an analysis was made in the different languages available, since the content of the information was not always the same across the languages.
2. Identification of science diplomacy practices according to categories adapted from the report elaborated for the Boston

area, USA (Gota et al., 2020, pp. 17–20) (retrieving links and contacts whenever possible):

- a Presence of science attaché or equivalent;
- b Link/section for science, and/or higher education and/or innovation and/or science diplomacy;
- c Government science representation (for example: Swissnex);
- d Profit/non-profit science representation;
- e Presence of counselors/section dealing with specific issues such as trade and economy, or others related to S&T;
- f News about activities and events related to S&T:
 - i search through the first 30 news, if news feed available, or
 - ii search by keywords “Science,” “Technology” and “Innovation” if only a repository with search function was available.

The main content of the news articles was noted. Contents related to S&T are highlighted in bold in the form of each country in Supplementary Annex 1. They were then classified in the following categories: (1) higher education, fellowships opportunities and scientific/academic prizes; (2) networking/scientific events; (3) own achievements in science, technology and innovation; (4) cooperation actions in science, technology and innovation; (5) scientific and academic diaspora; (6) S&T topics. COVID-related topics were not considered S&T if they only covered bureaucratic or practical issues around COVID management.

3. Date of information retrieval. The precise date on which the data were retrieved was noted.

On the same date, the identification of presence in social media (Facebook, LinkedIn and Twitter) was made, either by links in the official website or by search in each social media. Each social media profile was scrutinized and the main topics covered in the feed identified (first 30 posts), with posts classified by topic. Topics related to S&T were highlighted in bold terms in each country’s form. Pages with no activity for more than 1 year were classified as inactive. The following languages were used to retrieve information about social media: Portuguese, Spanish, Italian, German, English and French. In the case of Facebook, the automatic translation tool was used when posts were available only in other languages.

2.3 “Science Diplomacy Digital Index”

To be able to summarize and quantify the information above, we built a “Science Diplomacy Digital Index” (SDDI) by summing the occurrence of science diplomacy practices in websites and the occurrence of S&T-related posts in social media (where “0” means no occurrence and “1” indicates the occurrence of a practice). Since the identified practices imply a significantly different effort in terms of investment, these were further weighted with a numerical factor based on our own qualitative evaluation of the effort for each practice (from very high to very low) and converted to a 1–5 quantitative weight (Table 1). The value obtained was then normalized in relation to the

TABLE 1 Definition of weighting factors for the construction of the “Science Diplomacy Digital Index.”

Science diplomacy practices identified	Qualitative weight	Quantitative weight
Government science representation	Very high ¹	5
Presence of science attaché or equivalent	High ²	4
Profit/non-profit science representation	High ²	4
Link/section for science, and/or higher education and/or innovation and/or science diplomacy	Medium ³	3
Counselors/ section-trade, economy	Medium ³	3
News/events related to S&T	Very low ⁴	1
Social media presence with S&T content (3 possible social media in this study)	Very low ⁴	1
Maximum possible score	–	23
Maximum possible score (after normalization)		100

¹Indicates government-backed high capacity & focus on science diplomacy. ²Indicates both capacity and focus on science diplomacy. ³Indicates capacity (counselors for Trade/Economy) or focus (Link/section for science diplomacy) on science diplomacy (but not both). ⁴Implies only limited capacity and focus.

maximum possible score and presented on a scale from 0 to 100%, rounded to the unit. Equation 1 shows the resulting SDDI.

$$SDDI = \frac{(GSR \times 5 + SA \times 4 + SR \times 4 + LS \times 3 + CSTE \times 3 + NE \times 1 + SM1 \times 1 + SM2 \times 1 + SM3 \times 1)}{23} \times 100 \quad (1)$$

in which,

SDDI: “Science Diplomacy Digital Index.”

GSR: Government science representation. If occurrence GSR = 1; if no occurrence GSR = 0.

SA: Science attaché or equivalent. If occurrence SA = 1; if no occurrence SA = 0.

SR: Profit/non-profit science representation. If occurrence SR = 1; if no occurrence SR = 0.

LS: Link/section for science, and/or higher education and/or innovation and/or science diplomacy. If occurrence LS = 1; if no occurrence LS = 0.

CSTE: Counselors/section-trade, economy. If occurrence CSTE = 1; if no occurrence CSTE = 0.

NE: News/events related to S&T. If occurrence NE = 1; if no occurrence NE = 0.

SM1: Social media presence (Facebook) with S&T content. If occurrence SM1 = 1; if no occurrence SM1 = 0.

SM2: Social media presence (LinkedIn) with S&T content. If occurrence SM2 = 1; if no occurrence SM2 = 0.

SM3: Social media presence [Twitter (known as X since 2023)] with S&T content. If occurrence SM3 = 1; if no occurrence SM3 = 0.

For example, for France, all science diplomacy practices with exception to Government Science Representations were displayed on the website and it was possible to identify the occurrence of S&T posts in three social media. Thus, the corresponding SDDI is 78, as calculated in Equation 2. Detailed data for all representations investigated is available in [Supplementary Annex 2](#).

$$SDDI_{France} = \frac{(0 \times 5 + 1 \times 4 + 1 \times 4 + 1 \times 3 + 1 \times 3 + 1 \times 1 + 1 \times 1 + 1 \times 1 + 1 \times 1)}{23} \times 100 = 78,3 \approx 78 \quad (2)$$

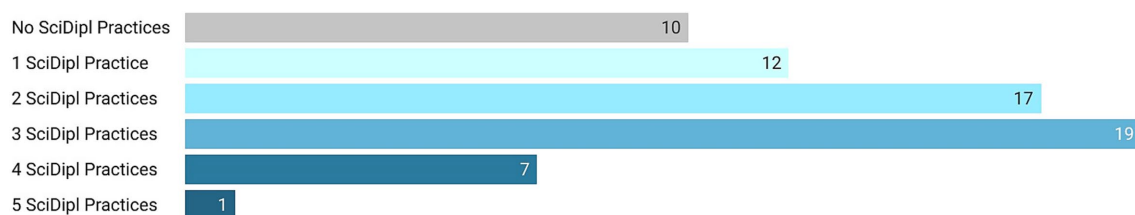
2.4 Co-authorship on publications and global soft power index

The number of joint papers published in co-authorship with Portuguese institutions was obtained by using the [Web of Science™ database \(2023\)](#). A search routine was conducted combining the target years and “Portugal,” refined by an analysis by country, which affords a list of the number of papers per country published in co-authorship with Portuguese institutions. The number of papers was normalized in relation to the total number of papers published in Portugal for the target year. The data for the Global Soft Power Index (specific component of education and science) was obtained through [Brand Finance \(2025\)](#).

3 Results

3.1 Mapping of science diplomacy practices in websites

Mapping of the science diplomacy practices of the diplomatic representations based in Lisbon was done by content analysis of the representation's official websites during 2021 (see methodology for details). Of the total 86 embassies with resident representatives in Lisbon, 67 (78%) had accessible official websites. All continents were represented, but Europe stood out with 32 (47%) websites, of which 22 (33%) were of EU member states. One website was excluded due to the language, thus 66 websites (77%) were available for data collection. Science diplomacy practices publicly displayed by diplomatic representations in their websites were classified according to categories adapted from the study conducted in the Boston area ([Gota et al., 2020](#), pp. 17–20): (1) the presence of science attaché or equivalent; (2) a link/section for science, and/or higher education and/or innovation and/or science diplomacy; (3) a government science representation; (4) a profit/non-profit science representation; (5) the presence of counselors/section dealing with specific issues such as trade and



Created with Datawrapper

FIGURE 2

Distribution of analyzed websites per number of science diplomacy practices identified (in number of websites). Created with Datawrapper®.

economy or others related to S&T; (6) news of activities and events related to S&T. From the 66 official websites investigated, 56 (85%) featured at least one practice of science diplomacy (Figure 2, all columns in blue). Most of the websites featured 1–3 practices [together accounting for 48 websites (73%)]. Only 1 website (1.5%) totaled five practices. No website included all six possible practices. The number of practices per website does not seem to be correlated with the world region (continent) of the diplomatic representation as shown by Figure 3.

The 56 websites with science diplomacy practices were also analyzed according to the type of practice (Figure 4). Website information about the existence of a science attaché or equivalent was present on 5 websites (9%). Different nomenclatures, such as attaché, counselor, secretary or, simply, contact point were identified as relevant descriptions of S&T representatives. Additionally, some contacts had roles encompassing other associated tasks. Examples include “Attaché de coopération scientifique et universitaire,” “Secretary for the academic and education section” and “Counselor for economy and EEA Grants.” It is important to note that some representations may have science attachés (or equivalent) but may choose not to publicize their existence on their Embassy website (which means that they were therefore not accounted for in this study due to our methodology). For example, it is known to the authors that a Science and Innovation Officer is present at the Embassy of the United Kingdom in Lisbon (as part of the extensive network of the Science and Innovation Network and listed on the Science and Innovation Network website) but for some reason did not appear on the Embassy’s website.

The presence on the website of a link/section for science, and/or higher education and/or innovation and/or science diplomacy was the most frequent practice, with 45 (80%) of websites with practices publishing at least one of these sections. Many links/sections redirected readers to general national websites dedicated to foreigners interested in the S&T and higher education activities (typically named, “Study in ...” or “Study and Research in ...”). Other links/sections were dedicated to the existing bilateral agreements or cooperation actions between Portugal and the represented country in the areas of higher education and S&T. Some other links/sections were devoted to the connection to students and research diaspora of the representation in Portugal. Interestingly, some websites had links and sections about priority topics, such as “Climate” or “Sustainability” or “Oceans,” using them to redirect the reader to the technological and scientific expertise of the country in those areas.

Only one website displayed information about government science representation (Rossotrudnichestvo Representation), but 5 websites (9%) had information about profit/non-profit science representations. Examples include the “Finish Ibero-American Institute,” “French Tech Lisbon,” “Fraunhofer Portugal Research Association” and the “Luso-American Development Foundation.” A high number of websites showcased their S&T achievements through the lens of trade and economy. The presence of counselors or a section dealing with trade and economy that are based or related to S&T was the second most prevalent practice (in 43 websites, 77%). In many websites the reader was redirected to trade websites that showcase areas of expertise in S&T of countries. Finally, 37 websites (66%) published news about activities and events related to S&T. Although news items are ephemeral, they may be a good indicator of the relevance of S&T in the representation. These may include news about (1) higher education, fellowships opportunities and scientific/academic prizes (in 43% of the websites with news), (2) networking/scientific events (24%), (3) the country’s own achievements in science, technology and innovation (22%), (4) cooperation actions in science, technology and innovation (11%), (5) scientific and academic diaspora (8%). Interestingly, many news articles/sections also cover specific S&T topics, showcasing priorities of the different countries. These include Energy, Climate, Environment, Sustainability, Agriculture and Forestry, Food, Fishing, Water, Arctic, Space, Digitalization, Information Technologies and Health (including COVID). These topics illustrate the growing importance of global challenges, which requires the development of international and multilateral solutions with an emphasis on S&T. This increasing entanglement between science and international relations has been extensively discussed in the science diplomacy literature (e.g., Ruffini, 2017, p. 13; Kaltöfen and Acuto, 2018, p. 15). It is important to mention that news archives on websites varied considerably in the timelines they cover (some spanned several years, some only recent news).

3.2 Social media and S&T

The social media presence of diplomatic missions was also analyzed due to its relevance to communication actions. From the 66 missions for which presence in social media was noted, 2/3 (44 missions, 67%) were identified as being present on only one social media. Presence on social media varied considerably, with Facebook

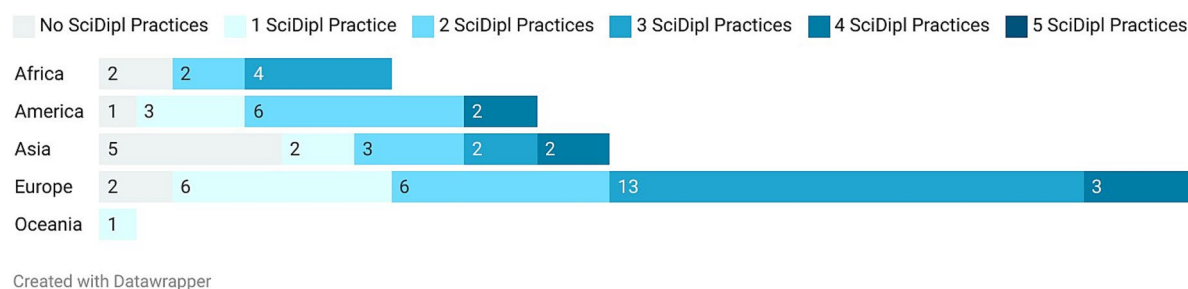


FIGURE 3
Distribution of analyzed websites per geographical distribution and per number of science diplomacy practices (in number of websites). Created with Datawrapper©.

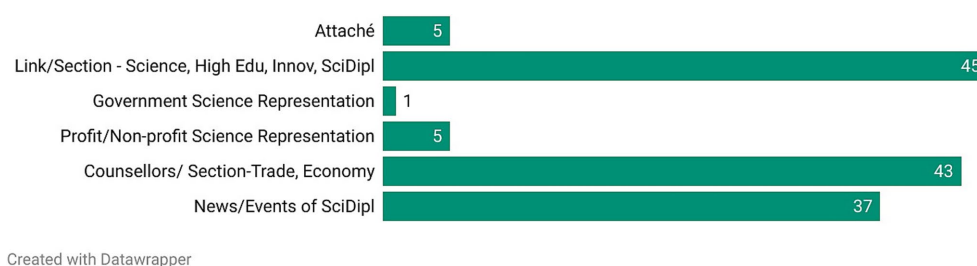


FIGURE 4
Number of websites in which a specific type of science diplomacy practice was identified. Created with Datawrapper©.

leading (58 presences, 88%), followed by Twitter (28 presences, 42%) and with less presence on LinkedIn (4 presences, 6%). Analysis of the content of the social media feed showed that posts about activities and events related to S&T were available: (a) for Facebook in 37 missions (56%); (b) for Twitter in 18 missions (27%); (c) for LinkedIn in 2 missions (3%). A residual number of pages were found inactive (no activity for more than 1 year) (Figure 5). As in the case of news on websites, the format of posts related to S&T events and activities varied considerably. For embassies that had both social media and official websites, social media often mirrored the news feed of the official websites. However, this practice was not always universal, and the information retrieved was sometimes very different.

3.3 The “Science Diplomacy Digital Index”

When considering only the number of science diplomacy practices featured on websites, the top “performers” were France (with 5 practices), Brazil, China, Finland, Germany, Israel, Norway and the United States of America (with 4 practices). Countries with 4 practices stated to have either an attaché or a profit/non-profit science representation, and France, with 5 practices, stated to have both. Identified practices imply very different levels of engagement by stakeholders. Indeed, the presence of a science attaché or of science representations requires a significant investment over simply publishing news about activities and events related to S&T or posting about S&T in social media. To encompass all different activities in one indicator, a new index, designated as a “Science Diplomacy Digital Index” (SDDI) was created. This index results from a weighted sum of all the stated practices in websites and social media for the missions with resident

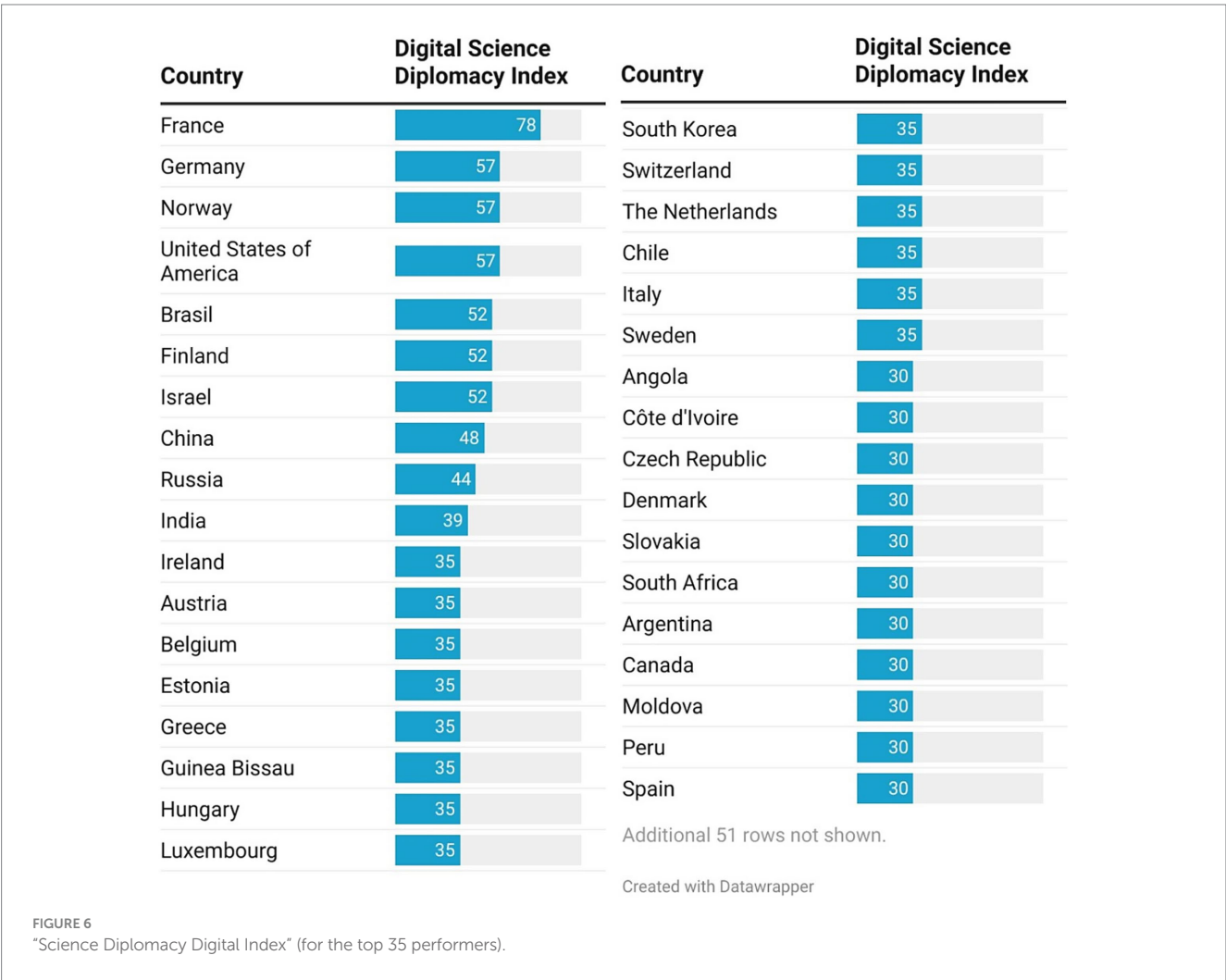
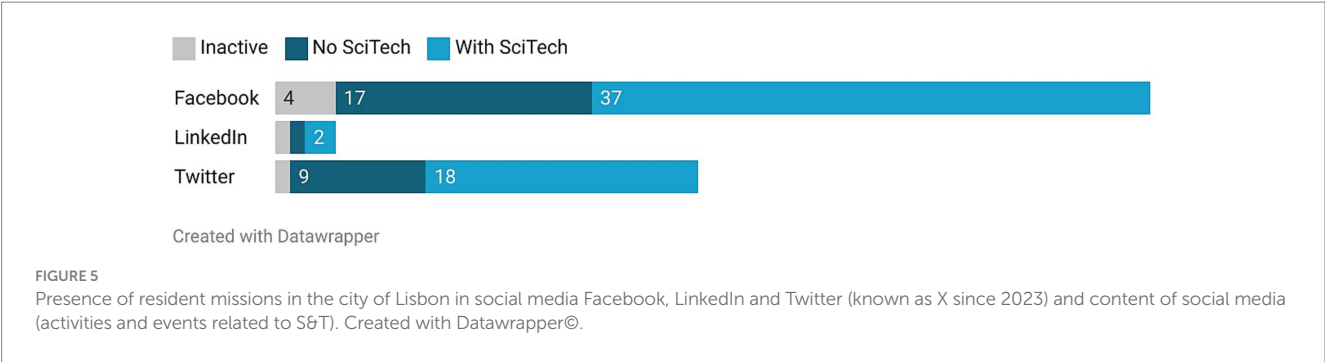
representatives in Lisbon, which is then normalized for the total possible practices (as detailed in section 2). Results are shown in Figure 6, with the top 10 performers including France (index of 78), Germany, Norway and the United States of America (all with 57), Brazil, Finland and Israel (all 52), China (48), Russia (44), and India (39).

3.4 Exploring applications of the SDDI

To showcase possible applications of the SDDI, this work explored its relations within two different types of related concepts: (1) scientific collaboration, represented by the co-authorship of publications; and (2) soft power, represented by the S&T component of the Global Soft Power Index. Both these indicators may be considered measurable indicators for the realization of two of the motivations of countries to invest in science diplomacy, namely cooperation or collaboration (expressed in co-authorship of publications), and influence (expressed as Global Soft Power Index), both in the S&T perspective. However, they can also be seen not only as outcomes of science diplomacy, but also as tools that contribute to science diplomacy, in a continuous positive/negative cycle.

The relation between the SDDI and papers published by each country in co-authorship with Portuguese institutions is depicted in Figure 7 (both in the year before the study: 2020, and in the year of the study: 2021). While there is no clear correlation between the two variables, it is possible to identify 3 main groups of countries (squares in Figure 7). Until 2% of joint publications, countries may score in a variety of SDDI from 0 to 52. Between 2 and 4% of joint publications, the SDDI is at least 17 and between 4 and 11% of joint publications, at least 35.

The Global Soft Power Index measures the world perception of nation brands with a multiple criteria index which includes a specific



component for education and science (with a maximum score of 10) (Brand Finance, 2025). Its relation to the SDDI of representations based in Lisbon enables to identify the gap between the publicly displayed digital science diplomacy practices and the global perception of the education & science performance of countries (Figure 8). Despite the non-linear relation between the two indices, a perception of the education & science of countries above 4 corresponds to a SDDI above 20 (and mostly above 30). Countries with a perception of the education & science of countries below 4 have the opposite tendency.

4 Discussion

The number, accessibility and content of websites and social media of diplomatic representations with resident representatives in Lisbon show that these digital resources offer a rich source of data to measure science diplomacy activities. Although the data set has been collected only for the year 2021, this work has to be considered as *proof of concept* for developing a new approach to quantifying and comparing science diplomacy activities. Furthermore, we would like to stress that prior to this work no study has been reported for the city

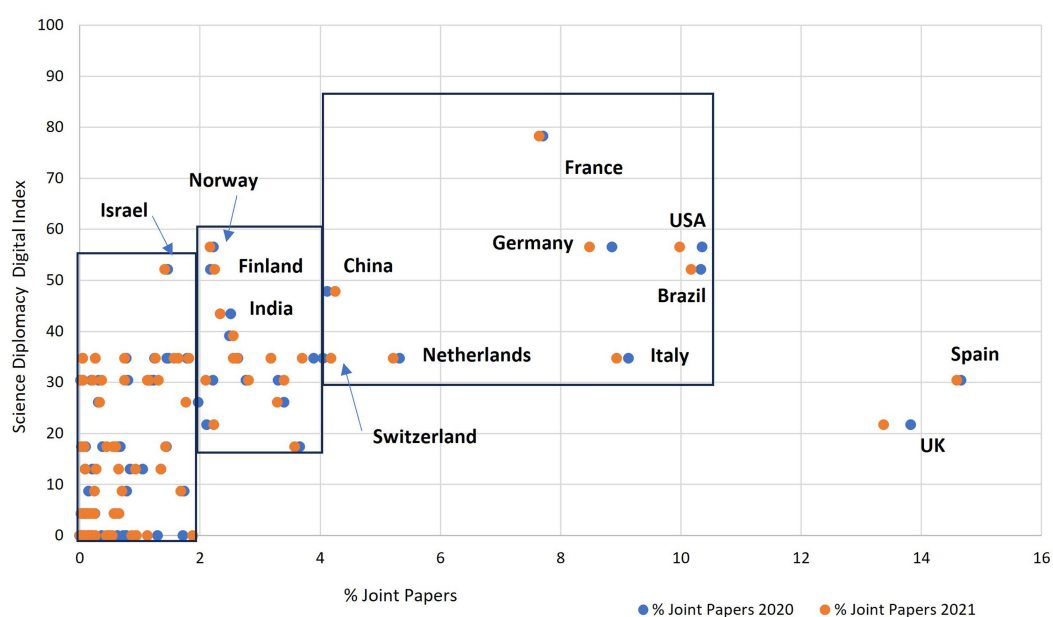


FIGURE 7

Representation of “Science Diplomacy Digital Index” versus joint papers published with co-authorship with Portuguese institutions (in % to the total of papers published by Portugal in the designated year). Blue dots: 2020; Orange dots: 2021.

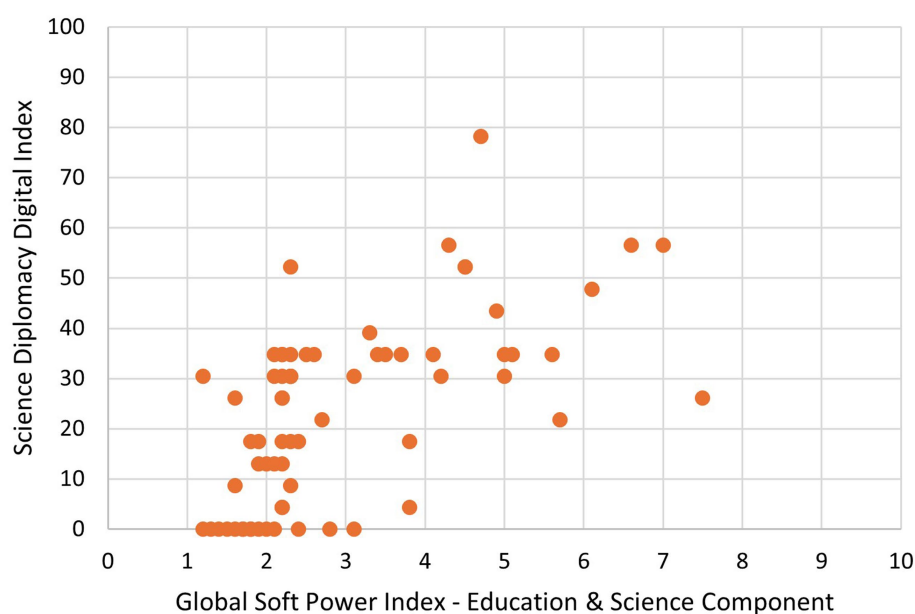


FIGURE 8

Representation of “Science Diplomacy Digital Index” versus the education & science component of the Global Soft Power Index for 2021.

of Lisbon, and this mapping can be used as a comparison for future studies using the same methodology (reproducible throughout time).

In comparison to data obtained for Boston (Gota et al., 2020, p. 22), Lisbon presents a higher number of accessible websites for data collection [76% of all representations (66 websites) vs. 58% (39 websites)]. We are aware that using websites and social media as data source reveals only a partial perspective of the science diplomacy practiced by the diplomatic representations, since not all the science

diplomacy efforts will be reported online (e.g., due to confidentiality issues, adequacy to the media, “digital culture” of representations). However, this methodology has the advantage of granting access to a large sample and easily enables the replication of the studies throughout time or geographies. As described in the results section, our mapping demonstrated the transversal publication of science diplomacy practices by the diplomatic representations with residency in Lisbon, revealing the potential for the creation of networks and/or

hubs around this theme in Lisbon, such as a S&T diplomatic circle. In comparison to Boston, Lisbon has a lower relative number of representations with at least one science diplomacy practice 85% in Lisbon (56 websites) vs. 90% in Boston (35 websites) (Gota et al., 2020, p. 104).

Grouping practices into categories implies losing the details of the retrieved information. A good example of this information “flattening” are the different nomenclatures given to S&T representatives (as mentioned above). This simplification is, however, useful to make greater sense of the diversity identified and to facilitate an overall and comparative reading of the scientific diplomacy practices. Our study also identified that science diplomacy efforts may be underrepresented by the chosen methodology, if states have dedicated channels to science diplomacy initiatives not linked to embassies websites. An overall comparison of the different categories of science diplomacy practices between Lisbon and Boston is not straightforward due to the adaptations of the methodology (with, for example, the inclusion of expanded categories in this work). However, in Boston, representations invest more (in relative and absolute terms) in science diplomacy categories, revealing higher capacity for, and focus on, science diplomacy. This can be seen in the numbers of science attachés in Lisbon vs. Boston [9% (5) versus 51% (18)], government science representation (1.5% (1) vs. 26% (9)) or a profit/non-profit science representation [9% (5) vs. 54% (19)] (Gota et al., 2020, p. 22). In Lisbon, representations invest in categories that require less capacity and focus, such as a link/section for science, and/or higher education and/or innovation and/or science diplomacy (see other options in Table 1).

To summarize, in comparison with Boston, in Lisbon countries invest more on websites of diplomatic representations but less in publicizing science diplomacy. This might be related to what represented countries might want from radically different countries (and cities) such as Portugal (Lisbon) and USA (Boston). Since the USA are a leading international power, and Portugal a relatively small EU country, one would expect a higher availability of states to invest in accessible websites for their representations in Boston. However, this difference can be explained by a wider inclusion criterion of this study, which considered six European languages for inclusion of websites (and not only English) and by the fact that Lisbon is a capital. The difference between investment in science diplomacy could be explained by the general leading position of the USA as an international power but also by the fact that the USA are classified as pioneers and leaders in science diplomacy (Ruffini, 2017, p. 72), which could be a determinant factor in investment in this area. Portugal is still in a growing phase for science diplomacy, despite its remarkable evolution since its accession to the EU in 1986 (Abrantes and Vaz-Pinto, 2024, pp. 13–14). Additionally, although Lisbon is an EU city well integrated as a S&T player from the Global North, in which science diplomacy investment could be equally important for representations, the difference in investment could also be explained by the gap between the innovation profile of cities. For 2021, the Innovation City Index ranked Boston as number 2 and Lisbon as number 158 in their global innovation ranking (for 2022–2023 Boston was ranked as number 7 and Lisbon as number 60) (2Thinknow, 2025). Independently from the investment level in Lisbon, all categories of

practices offer rich information about activities developed and thematic priorities in science diplomacy. Results regarding social media presence of representations reveal that these are also interesting sources to complement information from websites, clearly justifying their inclusion in our methodology.

Our results have also shown that, as in Boston (Gota et al., 2020, p. 101), the European region has a prominent weight regarding geographical origin of the websites with science diplomacy practices, which can be explained by the predominance of the Global North experience in this area and the high number of European states included among the Global North.

While compiling science diplomacy practices into the SDDI clearly facilitates the reading of efforts of representations by synthesizing complex information, it is important to note that the index is built on the subjective weighting of each practice according to capacity and focus of each representation. As such, the SDDI should not be used as a performance ranking and should only be a starting point for a more in-depth study of each representation. Of relevance might also be the use of the index to unravel patterns and tendencies in science diplomacy and to understand how different countries advertise their science diplomacy locally, depending on their scientific and geopolitical profile. The SDDI index for Lisbon seems to indicate that the top 10 positions are dominated by world or S&T powers and to a minor extent by countries with particular connections to Portugal or Lisbon. France (78), Germany (57), and the USA (57) are “world powers and well-known adopters of the term science diplomacy in their political and institutional vocabulary,” known to make “the necessary efforts of reflection and organization for implementing what they see as a strategic issue” (Ruffini, 2017, p. 72). Additionally, “France stands out by the high investment in the area with the placement of more scientific counselors and attachés than those posted in the embassies of other world powers” and, as mentioned before, the US are considered pioneers and leaders in science diplomacy (Ruffini, 2017, p. 72, Ruffini, 2020, p. 10). Norway and Finland (57 and 52) are known for their history in science diplomacy associated with arctic cooperation and climate change (Sabzalieva et al., 2021, pp. 154–155; Caymaz et al., 2022, p. 3). Unlike all the other countries in this top 10 list, Israel has a small size in land but is also known for its “well-designed science diplomacy,” its innovative profile and its top performance in R&D investment (Szolnoki and Papp-Váry, 2019, pp. 480, 485; OECD, 2025).

The remaining countries are the founding member states of BRICS (Brazil, Russia, India, and China). Brazil (52) stands out by promoting the concept of ‘innovation diplomacy’ as a way to contribute to its ongoing development and to strengthen South–South cooperation (Ruffini and Krasnyak, 2023, pp. 6–8). Additionally, it is worth mentioning that Brazil is part of the Community of Portuguese Language Countries having historic ties with Portugal. This might also explain its positioning in this list, independently of its overall investments and merits in science diplomacy. China (48) is the number one competitor with the USA, also in S&T, due to its rapid and ongoing development of its research capacity. It fosters a vast and distributed network science representatives in Europe although its comparative advantage lies more in its relations with developing countries (Ruffini, 2017,

pp. 68–69). Russia (44) is a classical stakeholder in science diplomacy and the high competitor with the USA during the Cold War. However, science diplomacy has lost importance as an instrument of Russia's foreign policy (Krasnyak, 2020, p. 41). Its positioning in the SDDI is essentially due to the government science representation (Rossotrudnichestvo Representation) (see results section), which, according to Ruffini (2017, pp. 70–71) “are centers with only limited involvement in science and technology.” Lastly, India also has been experiencing fast growth since the early 2000, including in R&D. It includes science diplomacy in its national policies, which is focused on the importance of the acquisition, exchange and development of technologies through strategic alliances (Ruffini, 2017, pp. 69–70). India also has historic ties with Portugal although without sharing a common language. An explanation for the notable absences from the top performers of the Lisbon SDDI of countries such as Switzerland, Canada and Japan may be the prioritization of locations other than Portugal. As made clear by this discussion, future research in this area is needed and will have to take account historical patterns in this field and power imbalances between states and different regions of the planet, namely in the context of colonialism or the Cold War.

Regarding the relation between the SDDI and the indicator associated with collaboration, our results show that a high SDDI score is not enough to guarantee joint publications (e.g., Israel and Norway) but is a common feature between countries with the highest joint publication percentages. Although it is not possible to draw conclusions about the impact of science diplomacy, it is nonetheless still interesting to note that above a certain level, joint publications and science diplomacy activities go hand in hand. Two outliers, Spain and the UK, are clearly identifiable, having joint publication rates with Portugal between 13 and 15%. The relatively high joint publication rate of Spain could be explained by its unique neighboring position to Portugal. In the case of UK, the SDDI might suffer from an underrepresentation of reality in terms of its science diplomacy presence, since some of the science diplomacy practices (such as the Science and Innovation Officer in Portugal) were not publicly displayed on the Embassy website, but in an alternative specific website dedicated to the Science and Innovation Network (and were therefore not accounted for the index as such due to our methodology). Portugal (...) and the UK (...) have the oldest bilateral alliance with mature ties in science and innovation which may also explain the high joint publication rates (Martins et al., 2023, p. 12).

Results regarding the relation between the SDDI and the indicator associated with influence, show again that a high SDDI score is not enough to guarantee a specific outcome, such as science and education influence. However, it is a common feature among countries with the highest Education & Science Global Soft Power Index. In Figure 8, countries (represented by points), that lie above the imaginary diagonal starting from the origin that divides the chart into two equal blocks, suggest a higher investment in science diplomacy of countries in Lisbon than their perceived education and science influence. This might be explained by the efforts of some countries to improve their general influence in S&T, or by their level of prioritization of Portugal for science diplomacy. The opposite is true for the points lying below the same line.

While this work showed the possibility to use the SDDI in relations with other S&T metrics, the potential interrelationships need to be investigated further since there are natural time delays between science diplomacy practices and outcomes. Practices identified in a certain year (and reflected in the SDDI) might be the result of accumulated efforts throughout years or decades which might complicate the analysis. Therefore, studies across a greater span of time will be needed to understand the evolution of the index and its possible relation with other metrics. Additionally, the dual nature of S&T metrics as outcome and tool of science diplomacy needs to be considered when analyzing data.

Future work would benefit from including testimonials from actors involved in science diplomacy of the Lisbon eco-system to complement the purely documentary nature of this study. In addition, cross-referencing the data in this study with strategic science diplomacy documents of states may bring additional depth to the results. Both strategies might also help identify potential mismatch between publicly available information and agendas. Finally, in future work we would like to apply the SDDI to other cities and at different timescales, which would be made possible by developing automation tools that facilitate the scraping of websites and social media of diplomatic representations.

Data availability statement

The datasets presented in this study can be found in the supplementary material of this article.

Author contributions

MA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. LL: Conceptualization, Methodology, Validation, Writing – review & editing. J-CM: Conceptualization, Methodology, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpos.2025.1597142/full#supplementary-material>

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