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A preliminary study of science diplomacy networks in Central, Eastern and South-Eastern Europe

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Science diplomacy (SD) is an emerging field of study at the intersection of international relations and science policy. Despite such a growing interest, the region of Central, Eastern and South-Eastern Europe has received limited attention by the scholars studying this increasingly significant topic. This article presents the preliminary results of a research focusing on international scientific collaborations between the countries that are members of the Central European Initiative (CEI), an intergovernmental forum for regional cooperation spanning across this broad region of Europe. Using social network analysis (SNA), the paper explores which countries are the most prominent in these cooperation networks and whether the countries sharing EU membership are clustered into separate, distinct subgroups, with fewer or weaker ties with Non-EU members.

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Introduction

The importance of S&T for public policy and international affairs (Krige and Barth, 2006; Simon, 2019; Weiss, 2015; Weiss, 2005) and the quest for international collaborations in this domain of activities has fostered an increasing interest in the ‘mutual influence’ between science and diplomacy (Kaltofen and Acuto, 2018: p. 8), thus helping ‘facilitate the emergence of science diplomacy’ (Flink and Schreiterer, 2010: p. 3), as ‘the particular field of international relations where the interests of science and those of foreign policy intersect’ (Ruffini, 2017: p. 3).

As a result, science diplomacy (SD) represents a paradox. Diplomacy is a ‘non-violent approach to the management of international relations characterised by dialogue, negotiation and compromise’ (Turekian et al., 2015: p. 4). It originates from the division of global space into sovereign nations. It is, therefore, a national issue reflecting the interests of governments. Science is a borderless enterprise whose public image is still based on its ‘reliable disinterestedness’ (Ziman, 1996) and centred on the Mertonian norms of universalism, communality, personal disinterest and organised scepticism (Merton, 1968). The convergence of science and diplomacy has been made possible by the challenge that the increased international interconnections represent for the modern sovereign state, making SD ‘an urgent, arguably inevitable strategy for governments to continue ‘to serve the global public good’ (Miller, cited in Kaltofen and Acuto, 2018: p. 10) and to tackle increasingly common challenges (Turekian et al., 2015: p. 3). Yet, SD remains a hybrid endeavour, the result of a mutual relation where diplomacy is used as a tool to bring scientific progress, while science is a facilitator for public policy and for overcoming deadlocks in traditional diplomatic relations (Royal Society and AAAS, 2010).

This article contributes to the growing scholarship on SD by exploring the existing international scientific collaborations between the ministries of foreign affairs (MFA) of the Central, Eastern and South-Eastern European countries, which are member states (MS) of the Central European Initiative (CEI). The CEI is a ‘regional intergovernmental forum committed to supporting European integration and sustainable development through cooperation between and among [seventeen] Member States and with the European Union, international and regional organisations as well as with other public or private institutions and non-governmental organisations’ (CEI, n.d.).

This work adds to the existing scholarship in two ways. Empirically, it examines an area of Europe that has attracted limited attention so far, as researchers have focused primarily on countries that have established programmes, institutions, and networks supporting international collaborations in S&T. Accordingly, leading global powers such as the US and China or other countries in the Global North, such as France, Germany, Japan, Switzerland and the United Kingdom (UK) have been more frequently researched, while developing countries or, as is the case in this paper, post-socialist economies in Europe have been relatively neglected. Methodologically, the article builds on the results of a survey about the diplomatic tools for international science and technology cooperation used by the MFAs in each CEI MS to explore their positions and connections in the cooperation networks among them. In doing so, the paper adds to the focus on the national institutionalisation of SD, which is dominant in the literature, by introducing an interest in SD networks characteristics. This choice is based on the acknowledgement that the differential outcomes in terms of frequency, intensity and directionality of collaborations of and among different actors involved in SD are affected by the position they have in collaboration networks, and on the structural pattern of relations emerging among these positions.

While our empirical results are preliminary in nature due to the small number of nodes in the network (15 out of 17 CEI MS), the manuscript shows that SNA can be effectively applied to analyse SD collaboration networks and to explore the relations between the attributes of actors, their positions, and their connections in the network. The paper showcases this approach by addressing two distinct research questions.

First, the paper examines whether larger economies, with larger material resources, have a more prominent position in SD networks, or smaller countries can ‘punch above their weight’ in SD, as a specific domain of international relations. The selection of this aspect reflects a well-established assumption in international relations theory that links material resources with importance, power and status (Hafner-Burton et al., 2009). Moreover, this point of view seems implicitly shared by SD literature, as far as it focuses mostly on leading economies and powers, as briefly explained above. Drawing from SNA methodology, this article introduces two different metrics (indegree and proximity prestige) to account for both direct and indirect links between States in the network. The relation between countries’ GDP and their scores on these metrics is then examined in order to assess whether higher economic output is coupled with more central positions in the network.

Second, the paper examines whether shared institutional membership affects cooperation patterns. This interest is consistent with the idea that countries’ position in the inter-/supra-national context affects the direction and strength of ties between states. From this perspective, inter-governmental organisations (IGOs) can be viewed as an institutional context that helps define the conditions under which members can develop their international networks of collaborations (Hafner-Burton and Montgomery, 2006). This analysis was operationalised by using a community detection algorithm to identify subgroups of countries sharing denser ties in the overall network of CEI MS. As CEI members include EU members, as well as candidate and third countries, the composition of the resulting subgroups was reviewed to see whether EU members and non-members are clustered into or belong to distinct subgroups. By describing the composition of the groups, we will provide an initial, albeit intuitive assessment on whether shared membership in the EU affects collaboration ties in a way that excludes non-members (candidate and third countries)¹.

The paper develops this analysis in four sections. Section ‘The Central European Initiative (CEI)’ introduces the CEI as the institutional backdrop of this research. Section ‘The rationale of this study: a network-based perspective on science diplomacy’ provides further details on the rationale of the study, specifying how it attempts to innovate the current scholarship, thus elaborating on its theoretical and methodological framework. Section ‘Research design and research questions’ presents the research design and methodology of this research, including details about the data collection process. After presenting the research results (section ‘Results’), a brief concluding section summarises the main findings, clarifies the limitations of the study and introduces suggestions for further research.

The Central European Initiative (CEI)

This article presents the theoretical premises, methodology and results of a pilot project researching SD networks in Central, Eastern and South-Eastern Europe. This study explores the existing international scientific collaborations between the ministries of foreign affairs (MFA) of the member states (MS) of the Central European Initiative (CEI). The CEI is a ‘regional intergovernmental forum committed to supporting European integration and sustainable

development through cooperation between and among [seventeen] Member States and with the European Union, international and regional organisations, as well as with other public or private institutions and non-governmental organisations' (CEI, n.d.).

The CEI, originally known as the Quadrilateral Initiative, was launched immediately after the fall of the Berlin Wall through a swift diplomatic move promoted by Austria, Hungary, Italy and the then Yugoslavia. When they met in Budapest on 11 November 1989 at the level of foreign ministers, the four countries expressed very different positions on the international arena: Italy was a member of NATO; Yugoslavia led the Non-Aligned Movement; Austria had declared its neutrality with respect to international disputes back in 1955; and Hungary was a full-fledged member of the Warsaw Pact, which would be dissolved only in 1991.

Nonetheless, a joint declaration was released after the meeting, stating that 'the development of sub-regional, regional and inter-regional cooperation could significantly contribute to the gradual creation of a common economic area [...] in Europe'.

These words mark not only the establishment of the Quadrilateral Initiative, but also the emergence of regional cooperation as a distinct foreign policy tool in the post-Cold War era. The purpose behind the Quadrilateral Initiative was twofold: on the one hand, the objective was to promote the re-integration of Eastern Europe by supporting political reform and economic transition; on the other hand, regional cooperation seemed to provide for the necessary multilateral space to address transnational and cross-border issues (environment, border management and organised crime).

Indeed, the end of the bipolar order brought to light the weakness of the nation state vis-à-vis several transboundary topics, which on the contrary called for agreed solutions identified and developed by multi-level and multi-actor partnerships. This made diplomacy a more complex activity, participated in by an increasing number of actors, including non-state ones, actively involved in the making of international relations. Within this dynamic and fragmented context, the Central European Initiative, as the Quadrilateral Initiative was renamed in 1992, has been able to evolve and adapt its structure, goals and tools, while managing to keep alive the strong commitment of its member states.

Today, the CEI represents not only the first intergovernmental forum for regional cooperation ever initiated in Europe, but also the broadest in terms of geographic extension. With a membership of seventeen countries covering a large portion of Central, Eastern and South-Eastern Europe, the CEI is the largest multilateral platform for policy dialogue between and among EU members (Bulgaria, Croatia, Czech Republic, Hungary, Italy, Poland, Romania, Slovakia and Slovenia), countries involved in the EU accession process (Albania, Bosnia and Herzegovina, Montenegro, North Macedonia and Serbia) and countries targeted by the EU Eastern Neighbourhood policy (Belarus, Moldova and Ukraine). This 'hybrid' constituency shares a political mission that can be summarised as follows: 'regional cooperation for European integration and sustainable development'.

Considering the several lines of geopolitical tension, either potential or already underway, crossing this region, the CEI has traditionally played a 'bridging role' over the last 3 decades, supporting connections between—and interactions among—the 'ins' and the 'outs' (in and out of the EU; in and out of NATO; in and out of various EU macro-regional strategies; etc.) in order to strengthen cohesion along the Eastern and South-Eastern borders of the EU, via a combination of intergovernmental policy dialogue, project-oriented cooperation and confidence-building measures.

From this perspective, science—as an effective vector of soft power—and SD—as an emerging and promising dimension of

international relations—are powerful tools both to implement the CEI political mission and to reinforce inter-state relations along the East-West axis, although, until now, this broad portion of Europe has been generally ignored by the (growing) debate on SD at global and European level. This neglect is particularly important at a moment when the effort to outline an 'EU Science Diplomacy' is underway, supported also by recent projects funded under the EU Research and Development Framework Programme Horizon 2020². Indeed, such an achievement could also determine the creation of a potential new 'dividing line' between the 'ins' and the 'outs' of the forthcoming EU Science Diplomacy policy framework. In order to mitigate this risk, the involvement of non-EU countries of Eastern and South-Eastern Europe in the discourse on SD becomes ever more urgent. This can be facilitated through analysis assessing the reality and potential of their contribution to SD collaboration networks in Europe.

The rationale of this study: a network-based perspective on science diplomacy

SD is experiencing an increasing interest in scholarship and public policy (Rungius et al., 2018; van Langenhove, 2016). Recent research on SD has focused on the institutionalisation of SD national 'apparatuses' (Ruffini, 2017; Berg, 2010; Flink and Schreiterer, 2010), on the use and effectiveness of instruments of international SD collaborations, such as science attachés in embassies (Brown et al., 2014) and S&T agreements (Dolan, 2012), and on the analysis of specific cases of scientific collaboration, in particular multilateral ones, such as the management of the Arctic (Shah and Hashim, 2012) or climate change (Ruffini, 2018). Looking at the countries studied by scholars in SD, most of the attention has focused on leading global powers such as the US and China or countries located in the Global North, such as Germany, France, Switzerland, UK and Japan (e.g., Flink and Schreiterer, 2010; Ruffini, 2017; Krasnyak, 2018; Su and Mayer, 2018), although exceptions can be found too (e.g., Gupta et al., 2015; Hornsby and Parshotam, 2018).

This article complements existing research from two points of view. The first point of view is a methodological one. As we briefly commented above, the literature on SD has primarily provided insights into the attributes and features of national SD apparatuses in search of possible 'national types' of SD structures, programmes and institutions. This article integrates this perspective by applying social network analysis (SNA) to study SD activities and actors from a relational point of view. With distant roots in the formal sociology of Georg Simmel and the innovative graphical representations of social relations introduced by Jacob L. Moreno in the 1930s (Erikson, 2013), SNA refers 'to the study of the relationships among actors or nodes that give rise to a corresponding network', aiming 'to measure and accurately represent structural relations, explain why they occur, and examine their consequences' (Baxter et al., 2018: p. 199). In international relations, a network approach expands the focus of analysis from the attributes and material capabilities of political actors to the way in which the 'persistent patterns of relations among agents' in a network can define, enable, and constrain those agents (Hafner-Burton et al., 2009: p. 561), for instance affecting states' international status (Baxter et al., 2018), orienting their diplomatic networks (Kinne, 2014), influencing how they collaborate internationally (Kinne, 2013) and how they share information, beliefs, or norms (Hafner-Burton et al., 2009). Also, international political sociology has used SNA, for instance to analyse transnational networks and their role in policy formation (Bigo, 2016; De Graaff and Van Apeldoorn, 2019; Bernhard, 2011). Finally, SNA is featured in an immensely vast literature studying international collaborations in academia and research

(e.g., Mazaris et al., 2018) and network-based approaches are used to study public diplomacy, its strategies and its effects (Wu, 2016; Park et al., 2019). However, SNA has found little or no application to the study of SD activities. To the best of our knowledge, the sole exception to this rule is the work of Paar-Jakli (2014) on transatlantic S&T collaborations. Applying SNA, the Author maps and explores a S&T specific subnetwork within the larger network of transatlantic relations, assessing the prominence of different types of actors in the subnetwork (e.g., state actors and science, technology and innovation organisations) and evaluating their role in international cooperation and policy formation. This article takes a similar point of view, albeit with a much narrower focus both in terms of the types of actors considered (Ministries of Foreign Affairs) and in terms of its geographical focus (Central, Eastern and South-Eastern Europe).

While more modest in ambition, the geographical region studied in this work is not without interest. However, this geographical region has attracted limited attention so far from scholars and analysts: to the best of our knowledge, there is little research on SD in these regions of Europe (Konarzewski and Żebrowska, 2012), apart from very recent work in EU-funded projects (Young et al., 2020) and some studies on specific SD activities of some (larger) countries in the area (Łuszczuk, 2015). Therefore, while the primary intent of this paper is to showcase SNA as an apt methodological approach to study SD, the empirical results of this research, though preliminary in nature, contribute to improving our knowledge of the state and prospects of SD in this broad portion of Europe.

Research design and research questions

This research is based on an online survey that was administered to officials working on SD in CEI Member States' ministries of foreign affairs (MFA). One official in each ministry was designated to answer the survey questionnaire on behalf of the ministry. The questionnaire was aimed at exploring various topics of relevance to SD in Central, Eastern and South-Eastern Europe, such as:

1. organisation of SD activities at the national level, focusing on the organisation of SD in the MFA, the type and degree of inter-ministerial coordination, the goals pursued by SD activities;
2. diplomatic tools for international science and technology cooperation, focusing on the diplomatic instruments and activities used in promoting international collaboration in science, technology and innovation (STI), such as deployed attachés, cooperation agreements and other joint initiatives and participation of science stakeholders (e.g., universities) in international collaboration networks; and
3. development of SD capabilities in CEI member states, focusing on the integration of SD in national innovation strategies, on the actions and partnerships needed to strengthen a country's capacity in the field, and on priority topics for such a development.

A first wave of the survey was administered between September and November 2019. In total, 11 out of 17 CEI countries completed the survey, namely Albania, Belarus, Czech Republic, Hungary, Italy, Montenegro, North Macedonia, Poland, Romania, Serbia and Slovakia. In order to collect responses from a larger number of countries, a second round of questionnaires was sent out to the missing CEI MS in December 2020. Four additional countries (Bulgaria, Croatia, Moldova and Slovenia) returned this second questionnaire. In total, 15 out of 17 CEI MS participated in the survey.³

Using data collected in this survey, the article examines two distinct networks: (1) *current* cooperative relations between the

MFAs of CEI MS in the domain of S&T and (2) partner countries among CEI MS that are nominated to develop *future* collaborations in the same policy area. To define the current relations, the questionnaire asked to report about the use of three SD tools: (a) scientific attachés assigned to the diplomatic missions of each country; (b) active cooperation protocols/agreements in the field of S&T; and (c) the implementation of other joint international initiatives, such as joint programmes, ad hoc funding instruments, working groups. To identify partners for future activities, respondents were asked to name priority partners among CEI Members for developing international collaboration activities in S&T.

Using the SNA software Pajek⁴, data were analysed to answer two main research questions:

Research Question 1: Are larger economies more prominent in collaboration networks? This first question regards the prominence of different CEI member countries in SD cooperation networks. We will examine whether larger countries with higher economic output have a more prominent position in SD networks, or smaller countries can 'punch above their weight' in SD, as a specific domain of international relations in this geographical region.

Research Question 2: Do European Union members form a separate subgroup in the broader network of CEI MS, characterised by denser in-group ties? We will examine the composition of the subgroups of countries within the network and see whether EU members and non-members are clustered into or belong to separate subgroups. By describing the composition of the groups, we will provide an initial, albeit intuitive assessment on whether shared membership in the EU affects collaboration ties in a way that excludes non-members (candidate and third countries)

For the purpose of this research, 'prominence' was operationalised as an actor's centrality in the collaboration network of CEI MS. We will use two distinct measures of prominence: indegree and proximity prestige. The so called indegree of each vertex is the number of arcs each of them receives in a directed network (Nooy et al., 2005: p. 189), a choice that is in line with our focus on 'prominence': when many actors send their direct ties to other actors, it indicates their importance, or popularity (De Lange, 2010; Hanneman et al., 2005)⁵. However, indegree centrality 'is a very restricted measure of prestige because it takes only direct choices into account. [Therefore, several] efforts have been made to extend prestige to indirect choices. The first idea that comes to mind is to count all people by whom someone is nominated directly or indirectly, that is, without or with go-betweens' (Nooy et al., 2005): p. 193). 'Proximity prestige' is the index, which we use to map both direct and indirect nominations. This index 'attaches more importance to a nomination if it is expressed by a closer neighbour. In other words, a nomination by a close neighbour contributes more to the proximity prestige of an actor than a nomination by a distant neighbour, but many 'distant nominations' may contribute as much as one 'close nomination'.' (Nooy et al., 2005: p. 197).

In this paper, we calculate both indexes for *current* cooperative relations between the MFAs of CEI MS in the domain of S&T and for the network resulting from the selection of partner countries among CEI MS to develop *future* collaborations.

To answer question 2 about the influence of shared EU membership on the collaboration ties, we will observe the distribution of ties in the network, to see whether one or more subgroups whose members are predominantly or entirely EU members should be distinct from other groups whose members are predominantly or entirely candidate or third countries. A community detection algorithm was used to determine these subgroups. 'Qualitatively, a community is defined as a subset of nodes within the graph such that connections between the nodes

are denser than connections with the rest of the network' (Radicchi et al., 2004: p. 2558). We considered a positive answer to our second question if the detected communities are homogeneous according to the EU membership of their nodes (EU members or non-EU members).

Results

Respondents. MFA officials from 15 CEI member states returned the questionnaire: Albania, Belarus, Bulgaria, Croatia, Czech Republic, Hungary, Italy, Moldova, Montenegro, North Macedonia, Poland, Romania, Serbia, Slovakia, Slovenia. The questionnaire was administered online in two waves, over three months from September to November 2019 and then in December 2020. Overall, all respondents have an academic background in the social sciences and humanities, with most of them saying they were trained in diplomacy and international relations (9), but also in classics (3), and literature (1). One respondent was trained in economics and management (1), while another one declined to answer this question. In terms of their professional seniority in SD, the panel is distributed among junior (7), mid-career (3), and senior (5) professionals, respectively, with 0–4, 5–9 and 10+ years of professional experience.

Research question 1: are larger economies more prominent in collaboration networks? The first research question regards the link between the attributes of the countries and their prominence in SD cooperation networks. We are interested in assessing, albeit preliminarily, whether larger CEI MS, with greater material resources, as measured by the countries' Gross Domestic Product (GDP), have a more prominent position in SD networks than smaller countries. Drawing from SNA methodology, this article will examine the 'prominence' of the different MS in the CEI SD collaboration networks, by calculating two indexes: indegree (or indegree centrality) and proximity prestige for each of the network's node.

First, we calculate the measure of centrality for the network of existing cooperative relations between the MFAs of CEI MS. The network is considered a binary network, meaning that the presence of any of the three SD tools listed above (scientific attachés, bilateral protocols/agreements and joint international initiatives) counts as one link between two nodes. We calculate indegree centrality and proximity prestige for the CEI MS based on the returned questionnaires, which admittedly makes the results contingent on the partial information we received, as we did not receive a response from two CEI MS (Bosnia and Herzegovina, Ukraine). Having in mind this limitation, we can preliminarily notice nonetheless that eight countries (Bulgaria, Czech Republic, Hungary, Italy, Montenegro, Poland, Serbia, Slovenia) attract most nominations, both when only direct nominations are considered (indegree centrality) and when indirect ones are computed too (proximity prestige) (see Table 1). All other countries have a below average score for both measures of prominence. As we can see from the list, Italy and Poland, which have larger economies, fare alongside smaller economies such as Bulgaria, Montenegro, Serbia and Slovenia. On the contrary, other countries with a larger economic output such as Romania have a less central position. Similarly, while the majority of non-EU members have indegree and proximity prestige values that are lower than the average (Albania, Belarus, Moldova, North Macedonia), there are exceptions (Montenegro and Serbia) and various EU members have lower scores, too (Croatia, Romania, Slovakia).

Overall, the value of indegree centrality and the value of proximity prestige are closely associated, as one can intuitively understand looking at the two lists. The tight coupling of these two variables likely depends on the limited size and shape of the

network, as the number of vertices is small and many of them are directly connected.

A similar comparison can also be made for the network resulting from the nominations of priority partners for future cooperation. When partners for future collaborations are considered, the picture is less straightforward. Four countries have a score above average for both indegree and proximity prestige (Italy, Montenegro, Slovak Republic, Slovenia), two have scored above average only for direct nominations (Moldova, Romania) and three (Hungary, Poland, Serbia) only when indirect nominations are computed too (see Table 2). This difference between indegree and proximity prestige scores represents a noticeable difference when future priorities for collaboration are compared with current cooperation networks. However, overall larger economies such as Italy and Poland fare alongside smaller economies such as Hungary, Moldova, Montenegro, Serbia, Slovakia and Slovenia in this case, too. In a way that is similar to what we discovered about current

Table 1 Indegree, proximity prestige and GDP of CEI MS: current cooperation.

Country	GDP (millions) ^a	Indegree	Proximity prestige
Albania	15.279,18	8	0,6706
Belarus	63.080,46	7	0,6353
Bulgaria	68.558,82	10	0,7544
Croatia	60.752,59	9	0,7100
Czech Republic	250.680,50	10	0,7544
Hungary	163.469,04	10	0,7544
Italy	2.003.576,15	12	0,8622
Moldova	11.968,71	5	0,5748
Montenegro	5.542,58	10	0,7544
North Macedonia	12.547,04	9	0,7100
Poland	595.858,21	11	0,8047
Romania	250.077,44	9	0,7100
Serbia	51.475,02	12	0,8750
Slovak Republic	105.079,67	9	0,7100
Slovenia	54.174,23	10	0,7544
Average	247474,64	9,4	0,7356

^aWorld Bank, 2019 Current US\$.

Table 2 Indegree, proximity prestige and GDP of CEI MS: priorities for future cooperation.

Country	GDP (millions) ^a	Indegree	Proximity prestige
Albania	15.279,18	4	0,5600
Belarus	63.080,46	2	0,4516
Bulgaria	68.558,82	5	0,5384
Croatia	60.752,59	4	0,5000
Czech Republic	250.680,50	5	0,5185
Hungary	163.469,04	5	0,6666
Italy	2.003.576,15	9	0,8235
Moldova	11.968,71	6	0,4516
Montenegro	5.542,58	11	0,6086
North Macedonia	12.547,04	2	0,5833
Poland	595.858,21	5	0,7368
Romania	250.077,44	9	0,5185
Serbia	51.475,02	3	0,7000
Slovak Republic	105.079,67	9	0,6086
Slovenia	54.174,23	7	0,7000
Average	247474,64	5,7	0,5977

^aWorld Bank, 2019 Current US\$.

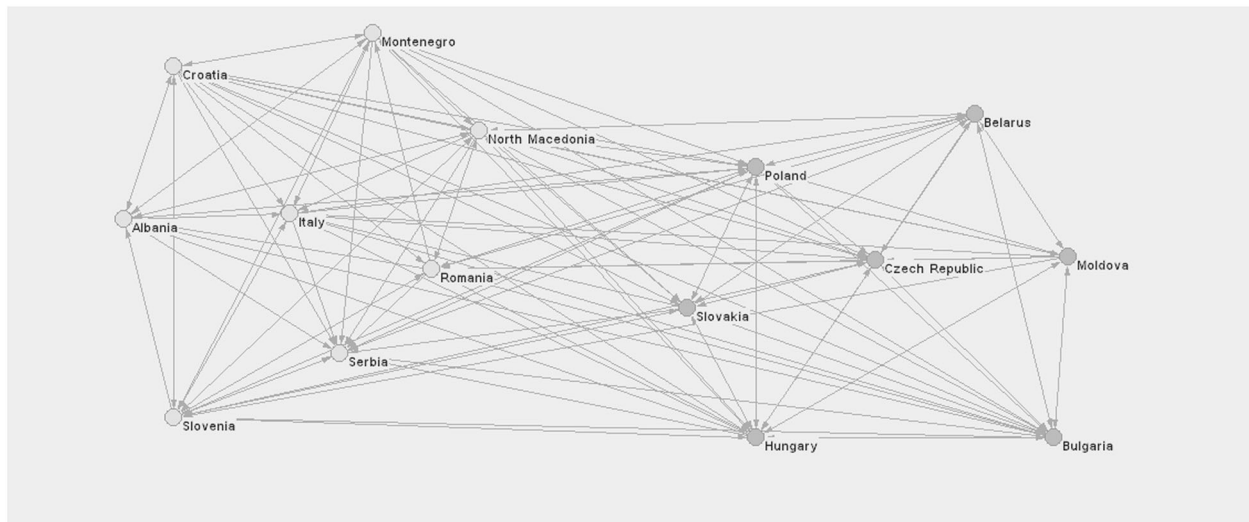


Fig. 1 Current networks of international scientific cooperation among CEI Member States. Two subgroups of countries with denser in-group ties are detected. The two subgroups are represented by dots of lighter and darker grey, respectively.

collaborations, the majority of EU members have indegree and proximity prestige values that are higher than the average, but there are exceptions for both proximity prestige (Bulgaria, Croatia, Czech Republic, Romania) and indegree (Bulgaria, Croatia, Czech Republic, Hungary, Poland), while, on the contrary, other non-EU members score above average either on both (Montenegro) or one of the metrics (Serbia).

Do European Union members form a separate subgroup in the broader network of CEI MS, characterised by denser in-group ties? The second research question regards whether CEI MS that are also EU members have more intense and frequent ties among them than with non-EU members, thus constituting a distinct subgroup in the network. We explored this aspect and searched for denser clusters of countries characterised by stronger ties within the overall CEI MS network, as defined by the diplomatic instruments that are used to establish those ties (science attachés, bilateral agreements and other joint initiatives). As for calculating indegree and proximity prestige, we considered the network a binary one, meaning that the presence of any of the three SD tools listed above (scientific attachés, bilateral protocols/agreements and joint international initiatives) counts as one link between two nodes of the network.

As described above, we used one of the community detection algorithms that are built into the Pajek software (Louvain Method) to identify these denser subgroups of countries⁶. As illustrated in Fig. 1, two groups of countries seem to emerge from this analysis. On the one hand, a first group includes eight countries (Subgroup 1): Albania, Croatia, Italy, Montenegro, North Macedonia, Romania, Serbia, Slovenia. On the other hand, a second group includes seven countries (Subgroup 2): Belarus, Bulgaria, Czech Republic, Hungary, Moldova, Poland, Slovakia.

The composition of the two subgroups supports the view that both of them are not formed exclusively or predominantly by EU and/or non-EU members, which do not seem isolated because of their status. Rather, cooperation subnetworks seem essentially regionalised, with two groups of countries broadly corresponding to South/South-Eastern Europe (Subgroup 1), on the one hand, and to Central/Eastern Europe (Subgroup 2), on the other hand, with the exception of Bulgaria, which belongs to the latter group despite its geographical position.

Interestingly, the same pattern occurs when the network of priority CEI MS to develop future collaborations is considered. Indeed, all countries were assigned to the same cluster as before, but there is an exception with Bulgaria moving from Subgroup 2, gathering Central and Eastern European countries, to Subgroup 1, gathering South and South-Eastern European countries. This shift suggests that the subregional partitions emerged when examining existing cooperation networks largely holds when target countries for future cooperation are considered (Fig. 2).

Discussion and closing remarks

The manuscript presents an application of SNA to explore the relations between the attributes of actors, their positions, and their connections in SD collaboration networks. The article tests this approach by analysing collaboration networks between the Central, Eastern and South-Eastern European countries that are members of the Central European Initiative (CEI). Although the results are certainly preliminary due to the thin empirical base of the paper, the research questions and their operationalisation clearly indicate the heuristic potential of this research approach.

First, the paper operationalises this analytic perspective by examining whether countries with larger economies have a more prominent position in SD networks, or smaller economies can 'punch above their weight' in this domain of foreign policy. The choice to focus on economic resources is consistent with the acknowledgement by international relations and international political sociology scholarship that diplomatic activities and initiatives are resource-constrained, stating the existence of a positive relation between resources, power, and influence (Hafner-Burton et al., 2009). National economic output as measured by GDP represents a pragmatic choice to begin an exploration of this aspect and to examine whether material resources either affect or are affected by network characteristics, so that international actors can either over-perform (Baxter et al., 2018) or underperform their status (Røren and Beaumont, 2019), or fail to translate their position into influence (Røren, 2020). The application of SNA offers the opportunity to apply these broader insights to SD, adding to our understanding of the collaborations in this field not only as the result of national actors' attributes, but also of their positions and connections in cooperation networks.

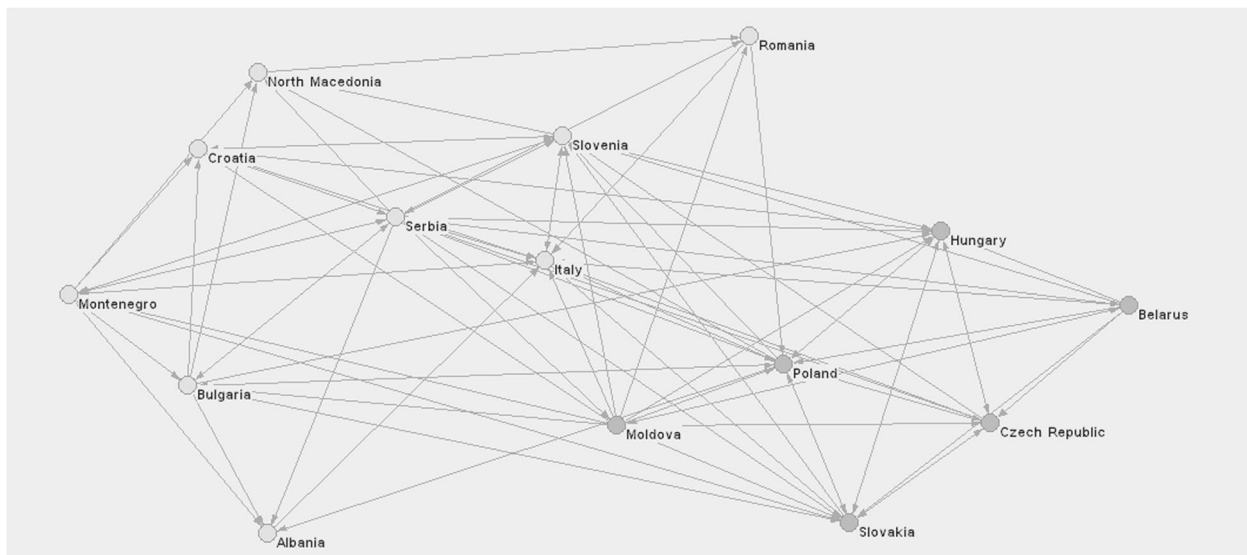


Fig. 2 Preferred partners in future networks of international scientific cooperation among CEI Member States. Two subgroups of countries with denser in-group ties are detected. The two subgroups are represented by dots of lighter and darker grey, respectively.

Second, we have explored whether features shared by subgroups of members can influence their position and relations in the network, creating distinct, homogeneous subgroups of nodes. Common membership of supra-/inter-national organisations represents a case in point: ‘strategies of membership in international institutions may reflect more than simple calculations of interest in a particular organisation or its benefits. The access that international institutions and agreements grant to larger networks may be as important as the content of the agreement itself’ (Hafner-Burton et al., 2009: p. 573), though the effects of the institutionalised context of cooperation can vary according to the different attributes of members (Hafner-Burton and Montgomery, 2006). In this research, EU membership is examined to explore the extent to which such context influence the density and direction of collaborations in SD.

As we said above, CEI MS are the empirical cases to which SNA was applied. Our results show that the link between economic output and prominence, as measured by the incoming ties in the network, is not entirely straightforward. This is the case for Italy and Poland, but, when the rest of the MS is considered, results are mixed at best, featuring countries such as Bulgaria, Montenegro, Serbia and Slovenia as having high prominence in the network, while other countries with a larger economic output have below average scores. Interestingly, the countries positions are quite similar both in current collaboration and expected collaboration networks, the latter based on the priorities for future cooperation in this domain. Regarding the influence of shared institutional membership on the density of current relations, the two subgroups of CEI MS we identified were split between EU members and non-members (4 out of 8 in Subgroup 1 and 5 out of 7 in Subgroup 2). The division of the two groups looked more a geographical one between South and South-Eastern countries (Subgroup 1) vs Central and Eastern countries (Subgroup 2). This partition is reflected not only in the existing ties, but also in the preferred partners in international scientific cooperation, with the sole exception of Bulgaria that switches groups (from Subgroup 2 to Subgroup 1) when future priorities are considered.

As we have said above, these results rest on a thin empirical basis and, therefore, have an initial and preliminary nature. Nonetheless, the method we adopted aptly illustrates the potential

of applying SNA to the analysis of SD. To further test the methodological approach and to improve the robustness of the empirical results, additional data should be collected beyond the survey of diplomatic instruments that is presented in this article. Administering the questionnaires to stakeholders other than MFA of CEI members and incorporating the subnational levels of governance in this analysis of SD, for instance by exploring either regional initiatives or regional collaborations within national framework agreements, are key steps to validate the picture this article provides. In a similar way, collecting data on a longer period of time, for instance before and after the countries joined the EU, can help assess in a clearer manner whether a relation exists between actors’ attributes, such as institutional memberships, and their positions in collaboration networks. Further research along these directions can significantly improve our knowledge of SD in this region of Europe and, with reference to the CEI, which is the institutional setting this research focuses upon, can provide an input to develop and implement SD policies and activities strengthening existing relations, bridging identified gaps, and supporting CEI MS priorities for cooperation.

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Notes

- 1 A Candidate Country is defined as ‘an applicant country for European Union membership may be granted candidate country status by the European Council on the basis of a recommendation by the European Commission’ (European Commission, 2016a). A Third Country is defined as ‘a country that is not a member of the European Union as well as a country or territory whose citizens do not enjoy the European Union right to free movement, as defined in Art. 2(5) of the Regulation (EU) 2016/399 (Schengen Borders Code)’ (European Commission, 2016b).
- 2 The three Horizon 2020-funded projects are namely EL-CSID (<https://www.el-csid.eu/>), InsSciDE (<https://www.insscide.eu/>), and S4D4C (<https://www.s4d4c.eu/>).
- 3 In order to increase the number of responses, the second questionnaire was shorter than the previous one and it was aimed to collect information directly relevant to this article. The full text of the two questionnaires is available online in the Supplementary Materials (Supplementary Notes S1 and S2).
- 4 The software can be downloaded from: <http://mrvar.fdv.uni-lj.si/pajek/>.

5 The logic holds true if a positive social relation is considered, as it is in this paper.
 6 The Louvain method is a popular community detection algorithm (Blondel et al., 2008). While the algorithm was designed for application to the analysis of large networks, the partitioning quality of the algorithm has been positively assessed also in the case of small networks (see Menardi and De Stefano, 2021). In this research, the modularity score (Q) is $Q = 0.100679$ for the network of priority partners for future collaborations and $Q = 0.053191$ for the network of current collaborations. 'A value of $Q = 0$ indicates that the community structure is no stronger than would be expected by random chance and values other than zero represent deviations from randomness' (Newman, 2004, p. 327). We can therefore notice that the community structure of these networks is a weak one.

References

- Baxter P, Jordan J, Rubin L (2018) How small states acquire status: a social network analysis. *Int Area Stud Rev* 21(3):191–213. <https://doi.org/10.1177/2233865918776844>
- Berg L-PB (2010) Science diplomacy networks. *Politorbis* 49(2):69–74
- Bernhard S (2011) Beyond constructivism: the political sociology of an EU policy field: beyond constructivism. *Int Polit Sociol* 5(4):426–445. <https://doi.org/10.1111/j.1749-5687.2011.00143.x>
- Bigo D (2016) Sociology of transnational guilds. *Int Polit Sociol* 10(4):398–416. <https://doi.org/10.1093/ips/olw022>
- Blondel VD, Guillaume J-L, Lambiotte R, Lefebvre E (2008) Fast unfolding of communities in large networks. *J Stat Mech* 2008(10):P10008. <https://doi.org/10.1088/1742-5468/2008/10/P10008>
- Brown MD, Mackey TK, Shapiro CN, Kolker J, Novotny TE (2014) Bridging public health and foreign affairs: the tradecraft of global health diplomacy and the role of health attachés. *Science & Diplomacy* 3(3). <http://www.sciencediplomacy.org/article/2014/bridging-public-health-and-foreign-affairs>.
- CEI-Central European Initiative About us. In: CEI-Central European Initiative. <https://www.cei.int/about-us>. Accessed 6 Jul 2020
- De Graaff N, Van Apeldoorn B (2019) The transnationalist US foreign-policy elite in exile? A comparative network analysis of the Trump administration. *Global Networks*. <https://doi.org/10.1111/glob.12265>
- De Lange DE (2010) Power and influence; The embeddedness of nations. Palgrave Macmillan, Basingstoke
- Dolan BM (2012) Science and technology agreements as tools for science diplomacy: A U.S. Case Study. *Science & Diplomacy* 1(4). <http://www.sciencediplomacy.org/article/2012/science-and-technology-agreements-tools-for-science-diplomacy>.
- Erikson E (2013) Formalist and relationalist theory in social network analysis. *Sociolog Theory* 31(3):219–242. <https://doi.org/10.1177/0735275113501998>
- European Commission (2016a) Candidate countries. In: European Neighbourhood Policy And Enlargement Negotiations-European Commission. https://ec.europa.eu/neighbourhood-enlargement/policy/glossary/terms/candidate-countries_en. Accessed 6 Jul 2020
- European Commission (2016b) Third country. In: Migration and Home Affairs-European Commission. https://ec.europa.eu/home-affairs/what-we-do/networks/european_migration_network/glossary_search/third-country_en. Accessed 6 Jul 2020
- Flink T, Schreiter U (2010) Science diplomacy at the intersection of S&T policies and foreign affairs: toward a typology of national approaches. *Sci Public Policy* 37(9):665–677. <https://doi.org/10.3152/030234210x12778118264530>
- Gupta H, Kohli RK, Ahluwalia AS (2015) Mapping 'consistency' in India's climate change position: dynamics and dilemmas of science diplomacy. *Ambio* 44(6):592–599. <https://doi.org/10.1007/s13280-014-0609-5>
- Hafner-Burton EM, Kahler M, Montgomery AH (2009) Network analysis for international relations. *Int Organ* 63(3):559–592. <https://doi.org/10.1017/S0020818309090195>
- Hafner-Burton EM, Montgomery AH (2006) Power positions: international organizations, social networks, and conflict. *J Conflict Resolut* 50(1):3–27. <https://doi.org/10.1177/0022002705281669>
- Hanneman RA, Riddle M (2005) Introduction to social network methods. An online textbook. https://faculty.ucr.edu/~hanneman/nettext/C10_Centrality.html. Accessed 9 Jul 2020
- Hornsby DJ, Parshotam A (2018) Science diplomacy, epistemic communities, and practice in sub-Saharan Africa. *Glob Policy* 9(S3):29–34. <https://doi.org/10.1111/1758-5899.12565>
- Kaltofen C, Acuto M (2018) Science diplomacy: introduction to a boundary problem. *Glob Policy* 9(S3):8–14. <https://doi.org/10.1111/1758-5899.12621>
- Kinne BJ (2013) Network dynamics and the evolution of international cooperation. *Am Polit Sci Rev* 107(4):766–785. <https://doi.org/10.1017/S0003055413000440>
- Kinne BJ (2014) Dependent diplomacy: signaling, strategy, and prestige in the diplomatic network. *Int Stud Q* 58(2):247–259. <https://doi.org/10.1111/isqu.12047>
- Konarzowski M, Żebrowska G (2012) Rediscovering eastern europe for science diplomacy. *Sci Diplomacy* 1:1
- Krasnyak O (2018) National styles in science, diplomacy, and science diplomacy: a case study of the united nations security council P5 countries. *Brill Res Perspect Diplom Foreign Policy* 3(1):1–100. <https://doi.org/10.1163/24056006-12340009>
- Krige J, Barth K (2006) Introduction: science, technology, and international affairs. *Osiris* 21(1):1–21. <https://doi.org/10.1086/507133>
- van Langenhove L (2016) Science diplomacy: new global challenges, *New Trend*
- Łuszczuk M (2015) Evolution of Poland's approach towards the Arctic: from international scientific cooperation to science diplomacy. In: Jensen L, Hønneland G (eds) *Handbook of the politics of the Arctic*. Edward Elgar Publishing, pp. 573–586
- Mazaris AD, Gkazinou C, Almpandou V, Balazs G (2018) The sociology of sea turtle research: evidence on a global expansion of co-authorship networks. *Biodivers Conserv* 27(6):1503–1516. <https://doi.org/10.1007/s10531-018-1506-1>
- Menardi G, De Stefano D (2021) Density-based clustering of social networks. Preprint at <https://arxiv.org/abs/2101.08334>
- Merton RK (1968) The normative structure of science. In: Robert K (ed.) *Merton*. The Free Press, New York, NY, pp. 588–598
- Newman MEJ (2004) Detecting community structure in networks. *Eur Phys J B Condens Matter* 38(2):321–330. <https://doi.org/10.1140/epjb/e2004-00124-y>
- Nooy W, de, Mrvar A, Batagelj V (2005) *Exploratory social network analysis with Pajek*. Cambridge University Press, New York, NY
- Paar-Jakli G (2014) *Networked governance and transatlantic relations: building bridges through science diplomacy*. Routledge, New York, NY
- Park S, Chung D, Park HW (2019) Analytical framework for evaluating digital diplomacy using network analysis and topic modeling: comparing South Korea and Japan. *Inform Process Manage* 56(4):1468–1483. <https://doi.org/10.1016/j.ipm.2018.10.021>
- Radicchi F, Castellano C, Cecconi F, Loreto V, Parisi D (2004) Defining and identifying communities in networks. *Proc Natl Acad Sci USA* 101(9):2658–2663. <https://doi.org/10.1073/pnas.0400054101>
- Røren P (2020) On the social status of the European Union. *J Common Mark Stud* 58(3):706–722. <https://doi.org/10.1111/jcms.12962>
- Røren P, Beaumont P (2019) Grading greatness: evaluating the status performance of the BRICS. *Third World Q* 40(3):429–450. <https://doi.org/10.1080/01436597.2018.1535892>
- Royal Society, AAAS (2010) *New frontiers in science diplomacy. Navigating the changing balance of power*. RS Policy document 01/10. Royal Society, AAAS
- Ruffini P-B (2017) *Science and diplomacy: a new dimension of international relations*. Springer, Berlin.
- Ruffini P-B (2018) The intergovernmental panel on climate change and the science-diplomacy nexus. *Glob Policy* 9(S3):73–77. <https://doi.org/10.1111/1758-5899.12588>
- Rungius C, Flink T, Degelsegger-Márquez A (2018) State-of-the-art report: summarizing literature on science diplomacy cases and concepts. Deliverable 2.2 of the project S4D4C – Using science for/in diplomacy for addressing global challenges. https://www.s4d4c.eu/wp-content/uploads/2018/08/S4D4C_State-of-the-Art_Report_DZHW.pdf. Accessed 6 July 2021
- Shah RM, Hashim R (2012) Advancing “antarctica science diplomacy” beyond traditional boundaries in developing state environmental protection law for better quality of life. In: 2012 IEEE Symposium on Business, Engineering and Industrial Applications. IEEE, Bandung, Indonesia, pp. 452–457
- Simon D (2019) Introduction: science and public policy-relations in flux. In: Dagmar S, Kuhlmann S, Stamm J, Canzler W (Eds.) *Handbook on science and public policy*. Edward Elgar Publishing, Cheltenham, pp. 1–10
- Su P, Mayer M (2018) Science diplomacy and trust building: 'Science China' in the Arctic. *Glob Policy* 9:23–28. <https://doi.org/10.1111/1758-5899.12576>
- Turekian VC, Macindoe S, Copeland D, Davis LS, Patman RG, Pozza M (2015) The emergence of science diplomacy. In: Davis LS, Patman RG (Eds) *Science diplomacy. New Day or False Dawn?* World Scientific, Singapore, pp. 3–24
- Weiss C (2005) Science, technology and international relations. *Technol Soc* 27(3):295–313. <https://doi.org/10.1016/j.techsoc.2005.04.004>
- Weiss C (2015) How do science and technology affect international affairs? *Minerva* 53(4):411–430. <https://doi.org/10.1007/s11024-015-9286-1>
- Wu D (2016) Assessing resource transactions in partnership networks: US 100,000 Strong network of public diplomacy. *Public Relations Review* 42(1):120–134
- Young M, Flink T, Dall E (2020) Science diplomacy in the making: case-based insights from the S4D4C project. Vienna: S4D4C. https://www.s4d4c.eu/wp-content/uploads/2020/03/S4D4C_REPORT_Science-Diplomacy-in-the-Making.pdf. Accessed 6 July 2021
- Ziman J (1996) Is science losing its objectivity? *Nature* 382(6594):751–754. <https://doi.org/10.1038/382751a0>

Author contributions

All authors designed the survey questionnaire. A Lombardo and A Tessorolo conducted the data collection. SA performed the data analysis. SA wrote sections 'The rationale of

this study: a network-based perspective on Science Diplomacy', 'Research design and research questions' and 'Discussion and closing remarks'; A Lombardo wrote section 'The Central European Initiative (CEI)'; A Tessarolo wrote sections 'Introduction' and 'Results'. All authors have read and approved the final manuscript.

Competing interests

SA has received funding from the Central European Initiative to conduct this research. A Lombardo is employed by the Central European Initiative.

Additional information

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