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Rules of attraction: Networks of innovation policy makers in the EU

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Abstract

Policy networks are an important source of information for policy making. Yet, we have only a limited understanding of how policy networks are structured among innovation policy makers and which factors shape their structure. This paper studies how proximities can explain what drives the connections in policy networks. More specifically, we look at innovation policy networks between EU member states. We use social network analysis based on our own data to map the networks of the 28 EU innovation policy directors, consisting of 756 potential connections, and study the proximities shaping these networks. Geographical and cultural proximity turn out to be strong predictors for symmetric and asymmetric ties, but we do not find a relationship between policy proximity (in terms of similarities in business environment regulations and innovation policy) and policy network formation between countries.

1. Introduction

The field of innovation policy has been a remarkable testbed for initiatives fostering knowledge exchange between countries. The European Commission has made significant efforts to advance learning between its member states (Borrás and Jacobsson, 2004; Kerber and Eckardt, 2007), starting with the early peer-reviews under the Open Method of Coordination, followed by ERAC mutual learning exercises and now with a range of actions under the Policy Support Facility. In parallel, the OECD has carried out its own peer learning exercises and made significant investments into its knowledge sharing platforms.

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This flurry of activity has contributed to what can be conceived of as 'policy networks' among innovation policy makers. Policy networks are commonly defined as relationship structures between the different actors in a policy setting (Knoke, 2011; Rhodes, 2008). The concept is based on the assumption that "policymaking is affected by a variety of organized governmental and nongovernmental actors, who maintain relations like information or resource exchange, influence attribution, or common group membership" (Leifeld & Schneider, 2012, p. 731). These relationships can take various forms, ranging from communication and information sharing to negotiations and interest mediation. The current paper looks at one subsection of policy networks – the cross-border interactions between government officials –, with a focus on information and knowledge exchange.

In order to understand the role that policy networks play in the policy making process, it is crucial to consider what drives the connections in policy networks. The policy networks literature has made significant progress in studying drivers related to policy and power (Henry, 2011; Stokman & Berveling, 1998), including ideology, preference similarity, institutional roles of actors, perceived influence and social trust (Leifeld & Schneider, 2012). However, one could argue that these factors are mostly related to the more immediate policy (-related) interests of actors, while not necessarily covering the more fundamental characteristics of the actors and their surrounding environment.

At the same time, the innovation studies literature provides an opportunity to move beyond these immediate policy-related factors, by introducing a layer of these fundamental characteristics – proximities –, that influence the connections in a policy network. Taking a proximities' perspective allows for a better understanding of what drives the connections in policy networks, such as the ones between EU innovation policy makers.

The innovation studies literature has an established tradition of studying the networked interactions of innovation actors. Networks have been shown to provide an important route for access to knowledge (Boschma & Ter Wal, 2007; Cantner & Rake, 2014; Deichmann et al., 2020), notably through knowledge sharing in regional clusters (Giuliani, 2007, 2013), inventor collaboration (Guan, Zhang, & Yan, 2015), government agencies (Sun & Cao, 2018), and firm R&D networks (Rojas, Solis, & Zhu, 2018). The existence and extent of access is shaped by a range factors. Acknowledging the need to study proximities beyond geographical distance (Boschma, 2005; Torre & Rallet, 2005), factors such as institutional, cognitive, cultural-ethnic, linguistic and social proximity (Boschma & Frenken, 2010; Cantner & Rake, 2014; Crescenzi,

Nathan, & Rodríguez-Pose, 2016; Graf & Kalthaus, 2018; Marek, Titze, Fuhrmeister, & Blum, 2016) have been suggested and empirically tested over the years. This has been done across a diverse set of empirical cases, such as knowledge networks in the photovoltaic industry (Graf and Kalthaus, 2018) and pharmaceuticals (Cantner & Rake, 2014), scientific cooperation (Hoekman, Frenken and Tijssen, 2010) and inventor networks (Crescenzi et al., 2016; De Noni, Orsi and Belussi, 2018; Morescalchi et al., 2015).

We seek to bring closer these two literatures. The aim is to cast light on networks in innovation policy as a source of information and knowledge, by studying their structures and their contributing factors. This allows for a discussion on their effect on knowledge exchange and implications for policy interventions.

We use social network analysis for mapping the connections between policy makers. Earlier studies have shown that social network analysis can be particularly useful for studying the interactions and knowledge-flows between organisations (Giuliani & Bell, 2005; Ter Wal & Boschma, 2009). We then use regression analysis to test which proximities impact on transnational connections between policy makers. Our analysis is based on own data from interviews with the national innovation policy directors in all 28 EU member states and the resulting 756 potential connections. In order to study the factors behind the networks, we test three types of proximities: geographical, policy and cultural proximity. We draw special attention to the concept of policy proximity, as it estimates the overlap or similarity between (innovation) policy features.

In our analysis of the network structures, we draw on the distinction between symmetric ties (a tie confirmed by both nodes) and asymmetric ties (a tie mentioned by one node). We see the symmetric ties as an indicator for more established patterns of interaction, based on the exchange of tacit/uncodified knowledge. The asymmetric ties are considered as an indicator for more spontaneous interactions, based on an exchange of uncodified knowledge. For symmetric ties we find a structure of three separate clusters. For asymmetric ties we find a core-periphery pattern, with a small group of member states closely connected in the middle and the rest of the member states orbiting them at a distance. Regarding proximities we find that for both symmetric and asymmetric ties, the likelihood of connecting is determined by a shared border and linguistic proximity, but policy proximity does not play a role when controlled for differences in levels of innovative performance, GDP per capita levels and population size between countries.

This research makes two contributions to the existing literature. First, it uses the concept of proximities and deploys social network analysis to study innovation policy networks. Second, it introduces policy proximity as a new concept to understand the formation of innovation policy networks between countries.

The paper is structured as follows. We start by providing an overview of the literature and develop the hypotheses. Then we introduce the methodology and data. Subsequently, we present the variables and regression results. And finally, we discuss the results and conclude with notes for further research.

2. Theoretical framework

2.1 Policy networks

Policy networks can be defined as "sets of formal institutional and informal linkages between governmental and other actors" (Rhodes, 2008, p. 425), based on shared interests in policy making (Rhodes, 2008). More specifically, the "linkages between the actors serve as communication channels for the exchange of information, expertise, trust, and other political resources" (Kenis & Schneider, 1991, pp. 41–42). The actors in a policy network can be individuals or organisations. As such, it is possible to distinguish between several types of interorganisational relations, for example "resource exchange, information transmission, power relations, boundary penetration, and sentimental attachments" (Knoke, 2011, p. 211).

Policy networks are potentially an important source of knowledge and information. The information transmission among organisations can be quite diverse in its content, as it "ranges from scientific and technical data to policy advice and opinions" (Knoke, 2011, p. 211). Schrama (2018, p. 569) states that the primary reason for networked interactions in a policy context is "the exchange of specialised information". More specifically, "the exchange of specialised information" related to policy issues is the primary reason for interaction among the variety of organised governmental and nongovernmental actors (Knoke, 2011; Leifeld & Schneider, 2012). This is because "one actor cannot possibly be knowledgeable about all policy facets and is therefore in need of information from other actors dealing with the same policy issues, possibly with a different expertise and an alternative point of view" (Schrama, 2018, p. 569).

A crucial aspect to discuss is what explains these connections in a policy network, i.e. which actors are more likely to engage in networked interactions? In other words, what are the drivers behind policy networks? Several such drivers have been suggested in the policy network literature, including: shared ideology (Henry, Lubell, & McCoy, 2011; Weible, 2005; Zafonte & Sabatier, 1998), social capital (Carpenter, Esterling, & Lazer, 2004; Henry et al., 2011), preference similarity (Gerber, Henry, & Lubell, 2013; Stokman & Berveling, 1998), institutional interdependence (König & Bräuninger, 1998; Lee, Lee, & Feiock, 2012; Zafonte & Sabatier, 1998), perceived influence (Ingold & Leifeld, 2014; Weible, 2005) as well as transaction costs (Lee et al., 2012; Leifeld & Schneider, 2012).

These different drivers reflect to a great extent the classic dichotomy between policy and power (Stokman & Zeggelink, 1996). On one hand, there are the policy oriented drivers of shared ideology and preference similarity (Henry et al., 2011). More specifically, the concept of shared ideology relates to the advocacy coalition framework (Sabatier & Jenkins-Smith, 1999) and refers to a similar system of beliefs and values among policy actors that can be an important driver of collaboration (Henry, 2011; Sabatier & Jenkins-Smith, 1999). Preference similarity is closely related to the concept of political homophily and is often defined as the "tendency to form connections with others who are politically similar" (Gerber et al., 2013). To a certain extent this is also related to social capital, which suggests that cooperative relationships are facilitated by trust and norms of reciprocity (Coleman, 1990; Putnam, Leonardi, & Nanetti, 1993).

On the other hand, there are the power-related drivers of interdependence and influence (Weible, 2005). Institutional interdependence means that policy actors are inclined to collaborate because their actions affect each other or they are part of a larger system that has authority over them (Zafonte & Sabatier, 1998). The concept of perceived influence shows the extent to which an actor is seen as possessing "informal structural power or access to political influence" (Ingold & Leifeld, 2014, p. 2). These power-related factors link also to the transaction cost argument suggesting that developing network connections help mitigate costs and alleviate various risks otherwise involved in international cooperation (Lee et al., 2012).

While the drivers of collaboration in the policy network literature are mostly related to the issues of policy and power, what remains largely hidden in the policy network literature is how these factors are themselves influenced by broader contextual factors, such as geography or culture. The proximities literature can be helpful by adding such layer of analysis. In addition

to the classical geographic proximity, it would also allow for the consideration of other factors, such as cognitive, cultural-ethnic, linguistic and social proximity. Such an approach also enables to move institutional similarity from the more abstract issues of ideology and preferences, towards a proximity in institutional contexts, such as regulatory frameworks. Thus, linking the policy network literature to the proximities perspective could provide a more comprehensive picture of the factors that shape policy networks.

2.2 The role of proximities

Central to the studies of networks is the understanding that network connections are more likely to occur between actors who are in some way similar to each other, i.e. the concept of homophily (McPherson, Smith-Lovin, & Cook, 2001). Being similar reduces transaction costs and therefore makes it more likely for individuals or organisations to cooperate (Lee, Lee and Feiock, 2012). This is closely related to the concept of proximity (Boschma, 2005; Torre & Gilly, 2000), which has been widely discussed and used in innovation studies (Balland, Boschma, & Frenken, 2022). Building on the recognition that geographical proximity alone is not sufficient to explain connections within networks (Boschma, 2005; Boschma & Ter Wal, 2007; Torre & Rallet, 2005), alternative proximities have been suggested and empirically tested over the years. These include institutional, cognitive, cultural-ethnic, linguistic and social proximity, among others (Cantner & Rake, 2014; Crescenzi et al., 2016; Marek et al., 2016; Paier & Scherngell, 2011).

Arguably, being similar can have both a positive or negative impact on the exchange of information and knowledge (Boschma, 2005). The effect can be positive, when being similar creates favourable conditions for transferring knowledge, and negative, when being too similar to leads to lock-ins and hinders acquiring new knowledge (Boschma, 2005).

This study focuses on three groups of similarities or proximities that are likely to carry a particular relevance in a transnational policy-setting: physical proximity that refers to the geographic closeness of countries; policy similarity that focuses on the regulatory environment and the nature of innovation policies employed; and cultural similarity which is based on the linguistic closeness of countries.

2.2.1 Geographical proximity

Geographical proximity between countries can make it easier for countries to interact (Boschma 2005) and exchange information and knowledge (Boschma & Frenken, 2010). Owing to the costs associated with travel and communication, physical distance has been considered an obstacle for cooperation (Morescalchi et al., 2015). While it can be argued that with the development of advanced means of communication, distance now plays a smaller role, physical co-presence is still considered important for interactions regarding complex, knowledge-related matters (Hoekman et al., 2010), such as research, public policy and business administration.

This is mostly because communication does not entail language alone, but much of the information in face-to-face interaction is passed on indirectly via different means (Hoekman et al., 2010; Storper and Venables, 2004). This carries particular importance in building common reference frames among actors, *inter alia* through real-time feedback, subtle and informal communication and shared local context (Olson and Olson, 2000). These elements of interaction are crucial for creating the necessary trust between partners for building sustained cooperation and transferring sophisticated, tacit knowledge (Gertler, 2003; Hansen, 1999; Reagans & McEvily, 2003).

Studies have looked at the role of geographical distance from different angles and, while mostly agreeing that distance matters (Boschma, 2005; Hoekman, Frenken and Van Oort, 2008), their conclusions differ on the extent to which it does. Research on patterns of scientific cooperation has shown that, while geographical proximity still matters, territorial borders have become less important over time (Hoekman et al., 2010). There has also been evidence to the contrary – studying the cooperation patterns of innovators in the EU over time, Morescalchi et al. (2015) showed that the constraint imposed by country border and distance decreased until a certain point in time and then started to increase again. In the same way, research on inventors' cooperation provided evidence that geographical proximity is still relevant for their network development (Crescenzi et al., 2016).

In this paper we distinguish between symmetric and asymmetric ties (Knoke & Yang, 2008; Wellman, 1983). This is based on the classic typology of relational forms in a social network, where a tie can be either null, asymmetric or mutual (Wasserman, 1980; Wassermann & Faust,

1994). Symmetric ties represent reciprocal/mutual relationships[3] where "actors who receive resources or information from others are expected to return them in some other form" (Lee et al., 2012, p. 554). Accordingly, asymmetric ties are non-reciprocal directed relationships with more uneven benefits.

Arguably, the type of tie (symmetric or asymmetric) can influence the kind of information and knowledge exchanged. From previous research we know that the transfer of codified/tacit knowledge involves higher transaction costs (Hansen, 1999; Reagans & McEvily, 2003), thus requiring strong reciprocal relationships (i.e. symmetric connections). For the transfer of uncodified knowledge, the transaction costs are lower and therefore weaker, asymmetric connections would suffice. This relates well to the classic argument on 'the strength of the weak ties' (Granovetter, 1973), whereby different types of ties serve different purposes in a network, despite their strength in terms of time, intensity, intimacy or reciprocity. In the context of our paper[4] this means that despite the symmetric ties carrying potentially more weight in facilitating the exchange of tacit/codified knowledge, the asymmetric ties should not be discounted as irrelevant, but as serving a different purpose – that of exchanging uncodified knowledge. Thus we have included both types in our analysis.

Relating the transaction cost argument to geographic proximity, we can expect the transaction costs to be higher for symmetric ties. As argued by Maskell and Malmberg (1999, p. 180): "the more tacit the knowledge involved, the more important is spatial proximity between the actors taking part in the exchange". Earlier studies have also shown that reciprocal (strong) ties demand a significant investment in terms of time and effort (Ingold, 2017; Schaefer, Light, Fabes, Hanish, & Martin, 2010). At the same time, asymmetric (weak) ties can be sustained over time with less effort (Abrams, Cross, Lesser, & Levin, 2003; Hansen, 1999). As geographical proximity would thus provide a way for mitigating these costs, we suggest the following hypotheses:

- Hypothesis 1a. Geographical proximity enhances the formation of symmetric ties between policy makers

[3] In our network analysis, we consider ties confirmed by both nodes as symmetric ties and ties confirmed by one node asymmetric ties. See also Sections 3.2.1 and 3.3.1.

[4] While there are many different ways of defining tie strength, we follow an approach based on Friedkin (1982), whereby symmetric ties can be considered 'strong' and asymmetrical ties 'weak'.

- Hypothesis 1b. Geographical proximity does not enhance the formation of asymmetric ties between policy makers

2.2.2 Policy proximity

Research into policy networks has demonstrated the importance of several drivers behind networked interactions among policy makers. Reflecting the general differentiation between power and policy (Stokman & Zeggelink, 1996), these different drivers include shared ideology (Henry et al., 2011; Weible, 2005; Zafonte & Sabatier, 1998), social capital (Carpenter et al., 2004; Henry et al., 2011), preference similarity (Gerber et al., 2013; Stokman & Berveling, 1998), institutional interdependence (König & Bräuninger, 1998; Lee et al., 2012; Zafonte & Sabatier, 1998), perceived influence (Ingold & Leifeld, 2014; Weible, 2005) and transaction costs (Lee et al., 2012; Leifeld & Schneider, 2012).

We consider policy proximity as another enabler of policy network formation. Policy proximity indicates the degree to which countries share a similar policy setting. Similarities related to the policy setting provide both a common frame of reference for any policy discussions and facilitate interactions. Based on previous research on knowledge flows (Gertler, 2003; Maskell & Malmberg, 1999), we can expect that a shared perspective on policies makes exchanges easier and reduces the transaction costs, given that less time has to be spent on mapping or explaining the issue. A lack of such a common framework can render interactions more difficult and raise their cost for the participants.

Starting with similar institutions and policies in facilitating interactions between innovation actors, it has been argued that "the effective transmission of knowledge may be facilitated by the presence of a common institutional framework" (Marrocu, Paci, & Usai, 2013), while "institutional friction arising from country-to-country differences creates challenges for collaboration across national systems of innovation" (Morescalchi et al., 2015, p. 652). On the organisational level, Sun and Cao (2018) have shown that policy networks between government agencies are conditioned by an evolving policy agenda, power concentration and heterogeneity dependence. Studies on regional innovation networks have demonstrated that the efficiency of knowledge transfer between regions depends on the structuring of the regional innovation systems (De Noni et al., 2018; Fritsch, 2000; Tödtling and Trippl, 2005). With a specific regard to policy, Graf and Kalthaus (2018) showed that both the structure of national

research systems (i.e. how the system is set up and its functionality) as well as the overall policy mix act as important factors for determining countries' positions in international knowledge networks.

It is important to make a distinction between the effect of policy proximity on the more established interactions represented by symmetric ties and the more casual interactions represented by asymmetric ties. For the former, we expect that a higher level of similarity is necessary in order to facilitate the interaction over a longer period. For the latter, where the threshold for establishing a tie is lower, we may expect that the same level of similarity is not required.

Given the discussion above, we propose two hypotheses:

- Hypothesis 2a. Policy proximity enhances the establishment of symmetric ties between policy makers
- Hypothesis 2b. Policy proximity does not enhance the formation of asymmetric ties between policy makers

2.2.3 Cultural proximity

Cultural proximity (Capello, 2014; Gertler, 1995; Guiso, Sapienza, & Zingales, 2009) indicates the extent to which countries have a shared understanding of different aspects related to their societies, common values and the world at large.

Sharing cultural traits is relevant for cooperation and knowledge sharing between countries, because it can create a common frame of reference for understanding each other and thus reduce the transaction costs of mutual exchanges (Nilsson, 2019; Nilsson & Mattes, 2015). While cultural similarity is difficult to capture directly owing to its complexity, a proxy that closely reflects it is language (Cantner & Rake, 2014; Hutchinson, 2005; Isphording & Otten, 2013). As it is widely recognised that language plays an important role in both structuring and communicating our understanding of the world (Balconi, Pozzali and Viale, 2007), we can think of the linguistic closeness between two countries being beneficial in two ways. First, if the policy makers from two countries speak the same language as a mother tongue, it is likely to reduce transaction costs and allow for a faster as well as more nuanced communication. In addition, speaking another common language fluently, such as English, the *lingua franca*

among European policy makers, can ease communication to a great extent. Second, sharing a linguistic background can also reflect a deeper cultural proximity, e.g. sharing important codes and norms of communication (Gertler, 1995). Even if two countries' native speakers do not fully understand each other's native language, they are likely to share a common frame of reference, facilitating interactions between them. Moreover, sharing a deeper understanding of each other's culture helps to navigate the more complex layers of communication and thus extract more meaning from the communication as well as avoiding possible misunderstandings. For example, sharing a common cultural background can lead to a shared 'logic of appropriateness' (March and Olsen, 2004) and thus contribute to more efficient communication.

Several of the previous studies on cooperation networks have looked at culture or language as a possible factor influencing interactions between actors. Studying research collaboration across European regions, Hoekman et al. (2010) found that linguistic borders have an effect on cooperation ties, with higher co-publication rates between researchers in linguistically similar areas. In their study of interregional industrial linkages in China, Qiliang and Xianzhuang (2023) demonstrated that cultural proximity favours both the formation of transregional connections and the "cognition of localised tacit knowledge" (p.1). Moreover, Luukkonen et al. (1992) and Zitt et al. (2000) demonstrated the importance of culture when choosing collaboration partners for international scientific cooperation.

All in all, we expect cultural proximity to act as an important driver of policy network formation. In a similar vein to the previous hypotheses, we can expect the deep-rooted cultural factors to have a stronger effect on symmetric connections and a lesser effect on asymmetric connections. We therefore suggest two hypotheses:

- Hypothesis 3a. Similar cultural background enhances the formation of symmetric ties between policy makers
- Hypothesis 3b. Similar cultural background does not enhance the formation of asymmetric ties between policy makers

3. Data and research methodology

3.1 Data

This study is based on data purposefully gathered through interviews with national policy makers from the 28 EU member states. The interviews were part of a larger data collection effort to study how policy makers use different sources of learning, including both formal analytical sources and informal social interactions. The current paper aims at studying the latter – who tends to discuss policy with whom –, serving as a basis for the subsequent network and regression analyses.

The interviews were conducted with innovation policy directors from each of the member states. We aimed at reaching the management level, as managers are arguably well positioned to have the best overview of interactions with policy makers from other countries. While the networks of individual policy officials in a national innovation policy team may vary to some extent, the directors are likely to have a strategic perspective on the most important cross-border exchanges. Altogether, we reached the head of innovation policy in 22 member states, while in the remaining 6 cases the interview was conducted with the head of international cooperation, the head of innovation policy analysis or a senior innovation policy expert (Appendix 1). In each country, we targeted the ministry responsible for developing national innovation policy. In a few countries where the innovation policy competences were equally divided between two ministries (for example the ministry of economic affairs and the ministry of research), we merged the answers of the two directors.

The interviewees were asked who they would consider "the most important external partners in developing and evaluating innovation policy". In particular, they were presented with a list of EU member states and asked to mark "how often do you exchange views on innovation policy with the following countries" on a four-point scale: 'often', 'sometimes', 'rarely' or 'never' (Appendix 2). The aim of this question was to receive information on to what extent different countries, and not particular persons, were considered important sources of policy-related knowledge by their peers. The question aimed at targeting the informal connections between countries – i.e. voluntary contacts taking place outside the formalised settings of the EU, OECD or other organisations. These connections could range between a one-off phone conversation to quasi-regular consultations between countries. Where necessary, the respondents were provided additional explanation on the substance of the question.

In order to reduce the potential subjectivity in the respondents' perceptions of these categories, we converted the responses into a binary system, with 'often' and 'sometimes' counting as 1 and 'rarely' and 'never' counting as 0. It was considered that while this might reduce the overall level of detail of the data, it would likely return a more coherent picture distinguishing between solid and weak/non-existent connections.

3.2 Variables

3.2.1 Dependent variables

The two dependent variables are symmetric ties and asymmetric ties.

A symmetric tie signifies a reciprocal connection, that is, both countries have mentioned each other as an important partner. An asymmetric tie is a connection between two countries based on whether one country has been mentioned by the other as an important partner, but not *vice versa*.

Symmetric ties are seen as a source for more established and long-lasting interactions, based on the exchange of tacit, uncodified knowledge (see discussion in section 2.2.1). Asymmetric ties are seen as a source for spontaneous interactions, based on swift exchanges of codified knowledge.

3.2.2 Independent variables

Geographical proximity

Geographical proximity is proxied by whether two countries in our population of 28 share the same border, either a land border, or a maritime border.

Policy proximity

Policy proximity indicates the degree to which countries share a similar policy setting. We will use three variables to assess the policy proximity between the 28 EU member states. The first measures the degree of similarity between the overall business environment of countries and is based on the Doing Business[5] scoreboard developed by the World Bank. It consists of 11

[5] https://www.doingbusiness.org/

indicators focusing on different aspects of the national business regulation environment. As such, it provides a broad view of the regulatory environment in a country and how proximate countries are in this respect.

The two other variables of policy proximity refer more to the case of innovation policy. We consider the similarity between the innovation policies of countries by distinguishing between two broad categories of innovation support: direct support to R&D, and indirect support to R&D (both as percentage of GDP). Direct support refers to grants, loans and procurement; indirect support refers to tax-related instruments, such as R&D tax credits, R&D allowances (Rodríguez-Pose & Wilkie, 2016). Using these two indicators allows for a benchmarking of innovation policy both in quantitative (volume of resources invested) and qualitative terms (type of R&D support).

Cultural proximity

In order to look at cultural proximity of countries, we use language as a proxy. More specifically, we determine whether countries belong to the same linguistic area, based on the main language spoken. Overall, we distinguish between six main language groups in Europe, following Bloomfield (1984).

3.2.3 Control variables

We included three control variables. The first considers the difference between the innovation performance of countries, which is proxied by the Global Innovation Index (GII).[6] This index uses 81 indicators to assess the innovation performance of countries. When two countries have a similar innovation performance, we expect them to face similar innovation policy issues, and therefore, they may be more likely to interact. We did not use the European Innovation Scoreboard,[7] because of its weak methodological underpinnings (Edquist and Zabala, 2015).

The second control variable concerns GDP per capita as a proxy for the wealth of a country. The data is derived from the National Accounts of the Eurostat database. We look at the difference of this value for each pair of countries, as similar levels of GDP per capita might make them more likely to collaborate.

[6] https://www.globalinnovationindex.org/.
[7] http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en.

The third control variable refers to differences in the number of inhabitants between two countries according to the Eurostat database. The rationale behind this variable is that countries with a similar population size may face similar policy challenges and therefore are more likely to interact.

Table 1. Overview of the variables

	Proximity factor	**Measure**	**Source**	**Type**
Dependent variables				
Asymmetric tie		A tie between two countries that is reported by one country only	Own data set, based on interview data	Binary
Symmetric tie		A tie between two countries that is confirmed by both countries	Own data set, based on interview data	Binary
Independent variables				
Shared border	Geographic proximity	Whether two countries have a shared border or not (inc. maritime borders), binary variable	World Borders Dataset	Binary
Business environment	Policy proximity	Difference in country scores in the Doing Business scorecard	Doing Business 2018	Continuous
Innovation policy	Policy proximity	Difference in the level of Direct Support to R&D (% of GDP)	European Commission (2018)	Continuous
Innovation policy	Policy proximity	Difference in the level of Indirect Support to R&D (% of GDP)	European Commission (2018)	Continuous
Language	Cultural proximity	Language group by the main language spoken, binary variable	Bloomfield (1984)	Binary
Control variables				

Innovation performance	Performance distance	Difference in country scores in the Global Innovation Index (GII)	Global Innovation Index 2017	Continuous
Income	Structural distance	Difference in GDP per capita	Eurostat, National Accounts	Continuous
Population	Structural distance	Difference in the number of inhabitants	Eurostat, Population	Continuous

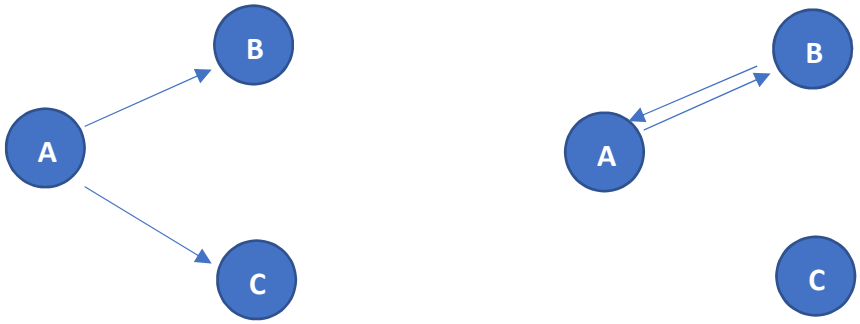
3.3 Methodology

3.3.1 Social network analysis

Social network analysis aims at highlighting the interactive relationships between actors in a system (Scott, 2017; Wassermann and Faust, 1994). In our study, the nodes are countries – the 28 EU member states, while ties signify the connections between these countries, more specifically the flows of information between them. The combination of the nodes and connecting ties allows us to establish the general structure of the network, by revealing who is connected to whom and which (if any) clusters emerge from that. Therefore, social network analysis allows us to establish an overview of the connections between countries in the EU, thus providing information on the overall cross-border flows of information and knowledge in the field of innovation policy.

Our data allow for a distinction between symmetric and asymmetric ties. Asymmetric ties are all the instances where a country mentions another country, but not vice versa. For example, as shown in Figure 1, when Country A mentions Country B and Country C, then we identify two asymmetric ties. Symmetric ties, on the other hand, reflect the instances where countries' reports match with each other. If Country A mentions Country B and Country B also mentions Country A, then we identify a symmetric connection between Countries A and B. As Country C has not mentioned anyone, or has not been mentioned by anyone, it does not have any connections in Figure 1.

Figure 1. Examples of an asymmetric connection (left) and a symmetric connection (right, between A and B)



3.3.2 Regressions

We use regression analysis to analyse whether there is a relationship between different similarities and the existence and type of policy connections between countries. As our dyadic relationships are expressed via binary dependent variables (0/1), with 1 denoting the presence and 0 denoting the absence of a link between two nodes, we use logistic regressions (Broekel & Boschma, 2012). Since the variables in our dataset are not vectors but adjacency matrices, these matrices are vectorised by concatenating columns into a single vector with n^2 elements. A standard logistic model is then used to regress the dependent variable. Given the frequent autocorrelation issues associated with this kind of network data (Krackhardt, 1987), we tested the results using the Quadratic Assignment Procedure (Hubert & Schultz, 1976), specifically the 'semi-partialling plus' procedure suggested by Dekker et al. (2003).

Altogether, 756 connections are possible among the set of 28 countries. Out of these potential connections, we identified 236 asymmetrical connections and 45 symmetrical connections between countries. The average number of asymmetric ties between countries is 8.4, and the average number of symmetric ties is 3.2, i.e. each country has on the average 8.4 asymmetric connections and 3.2 symmetric connections to other countries.

We analyse the extent to which the independent variables affect the likelihood of having a connection between each of the possible pairs by employing logistic models of generalised linear regressions. We estimate six models with variables added one at a time in order to see the robustness of the coefficients of previous models with the inclusion of each new variable.

4. Empirical results

4.1 Network patterns

Figure 3 shows the mapping of symmetric ties. We see a clearly clustered structure, characterized by a tightly connected group of 'northern' member states. We also find a relatively less dense group of 'central-eastern' member states, while the 'southern' member states form a loosely connected group of their own. All three groups are connected to each other through 'bridging' ties, in which countries like Poland and Italy are involved. Two countries (Cyprus and Romania) rest apart with no symmetric ties.

Figure 4 shows the policy network graphing the asymmetric ties. It looks very different from the previous policy network that consisted of symmetric ties. It reveals a centre-periphery pattern with a group of core actors in the middle and others surrounding them. The central cluster consists of countries with a large number of asymmetric ties directed at them (indegrees).

Figure 3. Symmetric ties between policy makers (weighted by the number of indegrees)

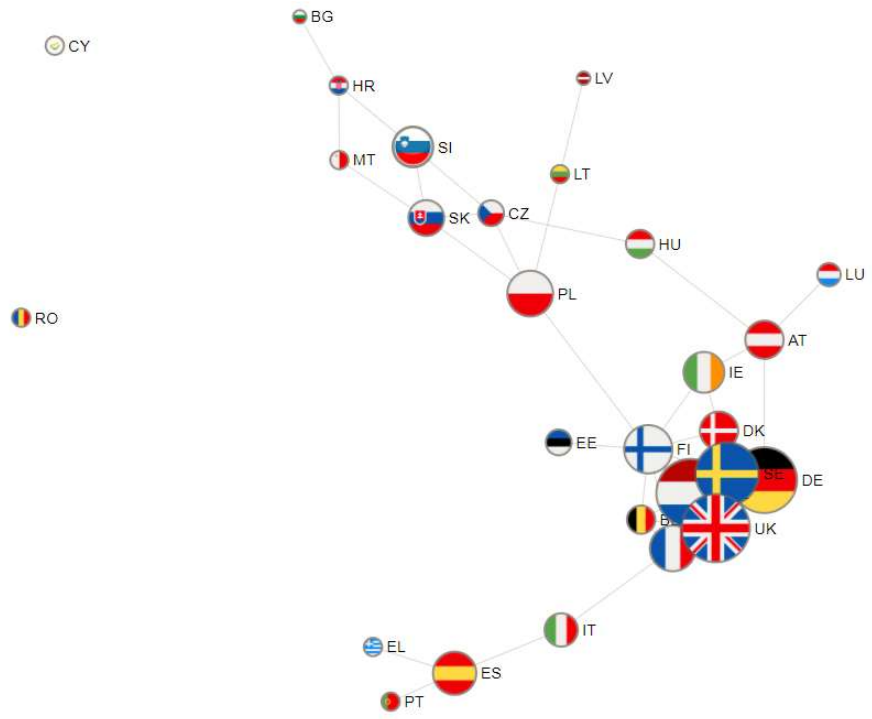


Figure 4. Asymmetric ties between policy makers (weighted by the number of indegrees)

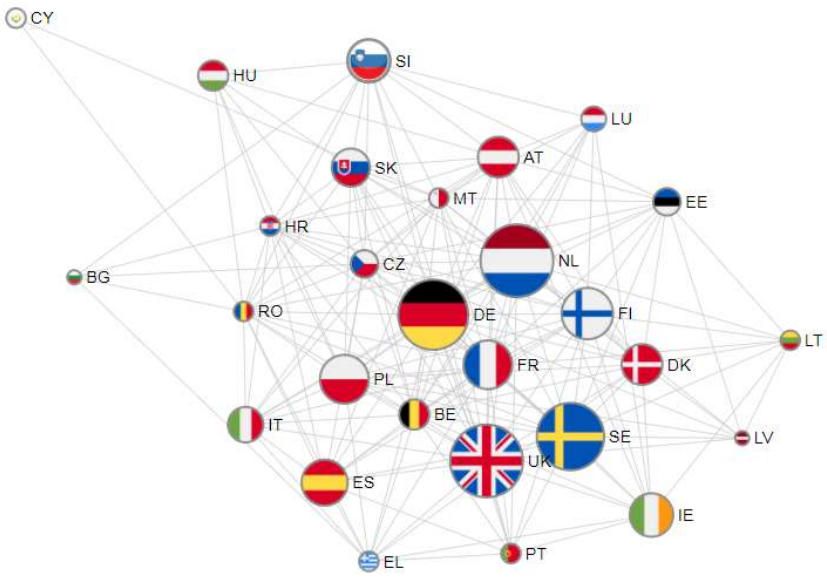


Table 2 presents some basic network measures. The average number of connections is significantly higher in the case of asymmetric than for symmetric connections. This hints at a wide discrepancy between how policy makers see their network and how their peers see it. This is also reflected in the average path length – a measure of how many nodes one would need to pass to reach a destination (Scott, 2017). We see that connections are much shorter for the network based on asymmetric than for symmetric ties, suggesting that the graph based on asymmetric ties is much more 'tightly knit'. The density measure assesses the extent to which all the potential ties are actually present. Its value is roughly similar for both the asymmetric and the symmetric ties, demonstrating a relatively similar intensity of interaction in the networks for both types of tie.

Table 2. Network measures for symmetric and asymmetric ties

Measure	Value based on symmetric ties	Value based on asymmetric ties
Average path length	3.38	2.18
Average number of connections	3.21	8.42
Density	0.12	0.15

4.2 Symmetric ties

The regression results for symmetric ties are presented in Table 3. Geographical proximity (in terms of having a shared border) has a significant and positive relationship with the development of symmetric ties, confirming Hypothesis 1a. This is consistent with the idea that developing and maintaining symmetric ties involve high transaction costs, and therefore countries being physically close to each other may help to reduce those costs.

The coefficients of all three policy proximity variables (having a similar business environment and similar levels of direct and indirect support to R&D) are insignificant. This implies that Hypothesis 2a is rejected: policy proximity between countries did not have any impact.

The coefficient of the variable same language turned out to be positive and significant. Belonging to the same language family mattered for countries to establish symmetric ties. This finding confirms Hypothesis 3a: similar cultural background enhances the formation of symmetric ties between policy makers. This is in line with previous accounts that have demonstrated the relevance of linguistic ties for facilitating cross-border cooperation in various innovation-related activities (Hoekman et al., 2010; Luukkonen et al., 1992).

Difference in innovation performance initially returns a significant and negative coefficient, indicating that the smaller the gap between the innovation performances of two countries, the more likely a symmetric connection occurs between them. However, when adding the other two control variables (different levels of income and population size between countries), difference in innovation performance loses its significance. Only difference in population size turns out to matter. The negative coefficient indicates that the more similar the population size of countries, the more likely a symmetric tie occurs between them.

Overall, these findings tend to indicate that symmetric ties in innovation policy networks are enhanced by similarities in fundamental characteristics between countries, such as geographical and cultural proximity as well as their population size, rather than policy proximities.

Table 3. Regression results for symmetric ties

	1	2	3	4	5	6
Shared border	2.449***	2.476***	1.933***	1.767***	1.748***	1.861***
	(0.355)	(0.425)	(0.458)	(0.460)	(0.477)	(0.492)
Difference in business Environment		-0.072	-0.060	-0.021	0.001	0.008
		(0.070)	(0.073)	(0.075)	(0.080)	(0.082)
Difference in levels of direct support to R&D		-3.152	-1.931	-1.436	-2.518	-3.241
		(3.455)	(3.464)	(3.491)	(3.693)	(3.631)
Difference in levels of indirect support to R&D		2.955	2.774	3.032	4.950 .	5.265 .
		(2.219)	(2.386)	(2.426)	(2.704)	(2.805)
Same language			1.833***	1.756***	1.721***	1.693***
			(0.438)	(0.441)	(0.452)	(0.459)
Difference in innovation performance				-0.110*	-0.083	-0.095
				(0.053)	(0.057)	(0.058)
Difference in income level					-0.019*	-0.013
					(0.009)	(0.010)
Difference in population size						-1.404*
						(0.594)
Constant	-2.673	-2.529	-3.061	-2.481	-2.285	-1.647
	(0.226)	(0.506)	(0.556)	(0.605)	(0.605)	(0.669)

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

4.2 Asymmetric ties

Table 4 demonstrates the regression results for asymmetric ties. Again, a shared border has a positive and significant effect on the likelihood of having an asymmetric tie between two countries. This finding rejects Hypothesis 1b which stated that geographical proximity does not enhance the formation of asymmetric ties, as asymmetric ties are relatively easier to create and maintain. The regression results show that geographical proximity does matter. This tells us that even for cases where the threshold for exchanging information might be already low, policy makers are still inclined to prioritise countries geographically close to them.

Contrary to the case of symmetric ties, the coefficient of difference in the regulatory environments of countries (according to their scores in the Doing Business scoreboard) is positive and significant in the first 4 models, but when the control variables are included, the variable loses its significance. This could partly be explained by the fact that the GII Index on innovation performance also contains some indicators on the business environment. On the other hand, it might also indicate that policy makers are not so much concerned about the institutional set-up in a country when forming asymmetric policy ties. Also the two other policy proximity variables (differences in levels of direct and indirect support to R&D) show a positive coefficient, but they are not significant. This implies our Hypothesis 2b is confirmed – policy proximity does not enhance the formation of asymmetric ties.

The regression shows that the effect of two countries belonging to the same language family is positive and significant. This result rejects our Hypothesis 3b, which predicted that a similar cultural background does not enhance the formation of asymmetric ties. This is surprising, since we could expect that, with English being effectively the *lingua franca* among policy makers, the role of language in shaping cross-border connections would be less important. However, the results showing the importance of language are consistent with those showing the importance of geographical proximity, as both are, to a certain extent, proxies for shared socio-cultural ties.

Table 4. Regression results for asymmetric ties

	1	2	3	4	5	6
Shared border	1.930***	2.102***	1.794***	1.932***	1.980***	1.990***
	(0.228)	(0.271)	(0.283)	(0.293)	(0.300)	(0.299)
Difference in business Environment		0.086***	0.091***	0.023	-0.018	-0.009
		(0.018)	(0.018)	(0.022)	(0.026)	(0.027)
Difference in levels of direct support to R&D		1.090	1.083	2.122	2.559 .	2.313 .
		(1.272)	(1.260)	(1.314)	(1.333)	(1.343)
Difference in levels of indirect support to R&D		2.002*	2.150	0.244	0.049	-0.227
		(0.851)	(0.869)	(0.944)	(0.953)	(0.975)
Same language			1.104***	1.225***	1.261***	1.268***
			(0.254)	(0.264)	(0.267)	(0.267)
Difference in innovation performance				0.083***	0.128***	0.115***
				(0.014)	(0.021)	(0.023)
Difference in income levels					-0.008**	-0.005 .
					(0.003)	(0.003)
Difference in population size						0.224
						(0.154)
Constant	-1.109	-1.289	-1.465	-1.634	-1.665	-1.673
	(0.091)	(0.113)	(0.125)	(0.140)	(0.143)	(0.144)

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Difference in innovation performances of two countries, as estimated by their GII scores, is both positive and significant. This is surprising, as one would expect that similarity in

innovation performance would enhance (asymmetric) policy tie formation between countries. Difference in income levels (as measured by GDP per capita) between two countries returns a significant, but negative coefficient. Difference in population size does not show a significant effect. The former indicates that the smaller the difference between the income of two countries, the more likely it is that we will see an asymmetric tie between them. However, this effect is diluted once population size is introduced to the model.

The findings of asymmetric ties provide an interesting case. On the one hand, there is a tendency towards more similarity in terms of physical and cultural closeness. On the other hand, countries are more inclined to have a connection based on differences regarding their innovation performance. Combining the two outcomes, countries seem to be reaching beyond their comfort zone for the prize of access to knowledge from superior performers, but, on the other hand, they are still pulled towards countries that are fundamentally proximate geographically and culturally. This is a model that very much depicts policy makers as actors who are seeking to balance the gains and pains of acquiring new knowledge.

Overall, despite the fact that the innovation policy networks looked quite different for symmetric and asymmetric ties, we did not find a large difference between the drivers of both types of policy ties. Being physically close and belonging to the same language group are strong predictors for both symmetric and asymmetric ties, but we could not find a relationship between policy proximity and tie formation.

5. Discussion and conclusions

This paper set up to study the innovation policy networks between EU member states and how proximities can explain what drives the connections in policy networks. By introducing the concept of proximities to the analysis of policy networks, we were able to analyse fundamental factors that drive the connections, going beyond the immediate policy or power related factors usually tested. Distinguishing between asymmetric and symmetric ties allowed for testing the factors behind both types of ties separately.

First of all, what have we learned about policy networks in general and innovation policy networks in particular? For asymmetric ties we found that geographic and cultural proximity are important factors, showing that deep-rooted similarities play a significant role. Also differences between countries in terms of innovation performance mattered: the more different

countries are in innovation performance, the higher their probability to be engaged in asymmetric ties. However, this is the picture for asymmetric ties, which possibly include many short-term and not reciprocated interactions, among more established ties. In order to see what determines the latter, we checked, whether a connection was symmetric (reciprocal) and looked at these separately. For symmetric ties we found that only geographic and cultural proximity tend to matter. This reinforces our argument that symmetric ties probably present more established cooperation patterns, based on fundamental closeness. The argument could also be reversed, that established, long-term cooperation is only possible between fundamentally proximate partners. At the same time, neither policy proximity nor innovation performance do seem to matter. Controlling for a difference in country size revealed that countries of similar size are more likely to be reciprocally connected. This makes sense, since important differences in country size would also lead to different policy and governance issues, that would not necessarily provide the common ground necessary for sustained cooperation.

Secondly, what have we learned about the usefulness of using proximities for studying policy networks? To start with, using policy proximity as a distinct variable allowed to assess the role of overlap in policy features between countries for policy network formation. We could not find evidence for the significance of policy proximity for policy cooperation. This shows that having similar policy interests or approaches is not enough for establishing/maintaining networked interactions with peers. Instead, it requires closeness based on cultural and geographical proximity. This is similar to the classic transaction costs argument, that a deeper level of (cultural) closeness mitigates the transaction costs associated with exchanging knowledge, especially tacit knowledge that is more cumbersome to transfer.

Thirdly, what does this imply for innovation policy in the EU and for the several mutual learning initiatives by the European Commission? Our findings build on the underlying argument that the more proximate partners are, the more learning can potentially take place. The findings thus demonstrate the need to build connections between clusters of member states to allow for a better access to tacit/uncodified knowledge, otherwise available only to the 'inner circle' of countries. Continued efforts are needed to foster mutual learning between member states. Bringing together policy makers through structured and well-prepared formats, such as peer-reviews or mutual-learning exercises, would help bridge the gaps in the existing networks between countries and allow access to peer knowledge that is otherwise unavailable to them. It is important though, that these exercises are systematic and thorough, to allow for sufficient time for the transfer of tacit/uncodified knowledge.

Furthermore, efforts are still needed to establish the initial connections between policy makers. Even though the asymmetric connections are plentiful among countries, the national policy makers are in constant rotation and the networks therefore need to be constantly updated. These initial contacts can be created through various networking opportunities and short-form mutual learning exercises, such as topical seminars or policy workshops. In addition, national learning capabilities need to be reinforced, both to be able to develop the connections necessary and to apply the obtained knowledge in an effective manner. This would require targeted and possibly long-term policy assistance missions to reinforce the capabilities of the host countries.

This research has provided new knowledge on the structures of networks between countries as a source of policy learning and the proximities behind them. Still, several avenues remain to be explored in further research. First, we need to explore further the concept of policy proximity and why we did not find evidence of policy proximity in our particular case. We need to understand better what policy proximity really means, how it may affect ties between policy makers, and how these ties might impact the performance of policy makers in terms of learning and implementing better policies. At the same time, it requires more thinking about the types of indicators that might be useful to show its relevance. Second, we need to move closer to the process of learning itself, by studying in greater depth the questions of what is actually learned through these connections and to what effect? I.e. how do we know if the networked interactions lead to learning by looking at its outcome, and how it boosted policy change. Novel methods, such as automated textual analysis of policy documents, could provide useful to explore this further.

On the other hand, research should also address the more fundamental question of whether more interaction and learning leads to better performance in the long run. The latter is also complemented by a need for research on the conditions, such as national capacities, that influence the effectiveness of learning and its long-term impact. Pursuing these avenues would take us closer to a more comprehensive understanding of information and knowledge exchange between policy makers.

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Bibliography

Abrams, L. C., Cross, R., Lesser, E., & Levin, D. Z. (2003). Nurturing interpersonal trust in knowledge-sharing networks. *Academy of Management Perspectives*, *17*(4), 64–77.

Balconi, M., Pozzali, A., & Viale, R. (2007). The "codification debate" revisited: a conceptual framework to analyze the role of tacit knowledge in economics. *Industrial and Corporate Change*, *16*(5), 823–849. https://doi.org/10.1093/icc/dtm025

Balland, P.-A., Boschma, R., & Frenken, K. (2022). Proximity, innovation and networks: A concise review and some next steps. *Handbook of Proximity Relations*, 70–80.

Bloomfield, L. (1984). *Language*. University of Chicago Press.

Borrás, S., & Jacobsson, K. (2004). The open method of co-ordination and new governance patterns in the EU. *Journal of European Public Policy*, *11*(2), 185–208. https://doi.org/10.1080/1350176042000194395

Boschma, R. (2005). Proximity and Innovation: A Critical Assessment. *Regional Studies*, *39*(1), 61–74. https://doi.org/10.1080/0034340052000320887

Boschma, R., & Frenken, K. (2010). The spatial evolution of innovation networks. A proximity perspective. *The Handbook of Evolutionary Economic Geography*, 120–135.

Boschma, R., & Ter Wal, A. (2007). Knowledge networks and innovative performance in an industrial district: the case of a footwear district in the South of Italy. *Industry and Innovation*, *14*(2), 177–199.

Broekel, T., & Boschma, R. (2012). Knowledge networks in the Dutch aviation industry: the proximity paradox. *Journal of Economic Geography*, *12*(2), 409–433.

Cantner, U., & Rake, B. (2014). International research networks in pharmaceuticals: Structure and dynamics. *Research Policy*, *43*(2), 333–348. https://doi.org/10.1016/J.RESPOL.2013.10.016

Capello, R. (2014). Proximity and regional innovation processes: is there space for new reflections. In A. Torre & F. Wallet (Eds.), *Regional development and proximity relations* (pp. 163–194). Edward Elgar, Cheltenham and Northampton MA.

Carpenter, D. P., Esterling, K. M., & Lazer, D. M. J. (2004, February 19). Friends, Brokers, and Transitivity: Who Informs Whom in Washington Politics? *Journal of Politics*. Cambridge University PressNew York, USA. https://doi.org/10.1046/j.1468-

2508.2004.00149.x

Coleman, J. S. (1990). Foundations of Social Theory. In *Foundations of Social Theory* (Vol. 69, p. 993). https://doi.org/10.2307/2579680

Crescenzi, R., Nathan, M., & Rodríguez-Pose, A. (2016). Do inventors talk to strangers? On proximity and collaborative knowledge creation. *Research Policy*, *45*(1), 177–194. https://doi.org/10.1016/J.RESPOL.2015.07.003

De Noni, I., Orsi, L., & Belussi, F. (2018). The role of collaborative networks in supporting the innovation performances of lagging-behind European regions. *Research Policy*, *47*(1), 1–13. https://doi.org/10.1016/J.RESPOL.2017.09.006

Deichmann, D., Moser, C., Birkholz, J. M., Nerghes, A., Groenewegen, P., & Wang, S. (2020). Ideas with impact: How connectivity shapes idea diffusion. *Research Policy*, *49*(1), 103881. https://doi.org/10.1016/j.respol.2019.103881

Dekker, D., Krackhardt, D., & Snijders, T. (2003). Multicollinearity robust QAP for multiple regression. In *1st annual conference of the North American Association for Computational Social and Organizational Science* (pp. 22–25). NAACSOS Pittsburgh, PA.

Edquist, C., & Zabala, J. M. (2015). The Innovation Union Scoreboard is Flawed: The case of Sweden – not being the innovation leader of the EU. *CIRCLE Papers in Innovation Studies*, *16*. Retrieved from https://lup.lub.lu.se/search/publication/ebbc9ff9-cf85-4871-891f-39b42d6cc11c

European Commission. (2018). *Science, Research and Innovation Performance of the EU 2018, Strengthening the Foundations for Europe's Future*. RTD-PUBLICATIONS Luxembourg.

Friedkin, N. E. (1982). Information flow through strong and weak ties in intraorganizational social networks. *Social Networks*, *3*(4), 273–285.

Fritsch, M. (2000). Interregional differences in R&D activities—an empirical investigation. *European Planning Studies*, *8*(4), 409–427.

Gerber, E. R., Henry, A. D., & Lubell, M. (2013). Political homophily and collaboration in regional planning networks. *American Journal of Political Science*, *57*(3), 598–610. https://doi.org/10.1111/ajps.12011

Gertler, M. S. (1995). "Being there": proximity, organization, and culture in the development and adoption of advanced manufacturing technologies. *Economic Geography*, *71*(1), 1–26.

Gertler, M. S. (2003). Tacit knowledge and the economic geography of context, or The undefinable tacitness of being (there). *Journal of Economic Geography*, *3*(1), 75–99. https://doi.org/10.1093/jeg/3.1.75

Giuliani, E. (2007). The selective nature of knowledge networks in clusters: evidence from the wine industry. *Journal of Economic Geography*, *7*, 139–168. https://doi.org/10.1093/jeg/lbl014

Giuliani, E. (2013). Network dynamics in regional clusters: Evidence from Chile. *Research*

Policy, *42*(8), 1406–1419. https://doi.org/10.1016/j.respol.2013.04.002

Giuliani, E., & Bell, M. (2005). The micro-determinants of meso-level learning and innovation: Evidence from a Chilean wine cluster. *Research Policy*, *34*(1), 47–68. https://doi.org/10.1016/j.respol.2004.10.008

Graf, H., & Kalthaus, M. (2018). International research networks: Determinants of country embeddedness. *Research Policy*. https://doi.org/10.1016/j.respol.2018.04.001

Granovetter, M. (1973). The strength of weak ties. *American Journal of Sociology*, *78*(6), 1360–1380.

Guan, J., Zhang, J., & Yan, Y. (2015). The impact of multilevel networks on innovation. *Research Policy*, *44*(3), 545–559. https://doi.org/https://doi.org/10.1016/j.respol.2014.12.007

Guiso, L., Sapienza, P., & Zingales, L. (2009). Cultural biases in economic exchange? *The Quarterly Journal of Economics*, *124*(3), 1095–1131.

Hansen, M. T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly*, *44*(1), 82–111.

Henry, A. D. (2011). Ideology, Power, and the Structure of Policy Networks. *Policy Studies Journal*, *39*(3), 361–383. https://doi.org/10.1111/j.1541-0072.2011.00413.x

Henry, A. D., Lubell, M., & McCoy, M. (2011). Belief Systems and Social Capital as Drivers of Policy Network Structure: The Case of California Regional Planning. *Journal of Public Administration Research and Theory*, *21*(3), 419–444. https://doi.org/10.1093/jopart/muq042

Hoekman, J., Frenken, K., & Tijssen, R. J. W. (2010). Research collaboration at a distance: Changing spatial patterns of scientific collaboration within Europe. *Research Policy*, *39*(5), 662–673. https://doi.org/10.1016/J.RESPOL.2010.01.012

Hoekman, J., Frenken, K., & Van Oort, F. (2008). *Collaboration networks as carriers of knowledge spillovers*. KITeS Working Papers 222.

Hubert, L., & Schultz, J. (1976). Quadratic assignment as a general data analysis strategy. *British Journal of Mathematical and Statistical Psychology*, *29*(2), 190–241.

Hutchinson, W. K. (2005). "Linguistic distance" as a determinant of bilateral trade. *Southern Economic Journal*, *72*(1), 1–15.

Ingold, K. (2017). How to create and preserve social capital in climate adaptation policies: A network approach. *Ecological Economics*, *131*, 414–424.

Ingold, K., & Leifeld, P. (2014). Structural and Institutional Determinants of Influence Reputation: A Comparison of Collaborative and Adversarial Policy Networks in Decision Making and Implementation. *Journal of Public Administration Research and Theory*, *26*(1), muu043. https://doi.org/10.1093/jopart/muu043

Isphording, I. E., & Otten, S. (2013). The Costs of Babylon—Linguistic Distance in Applied Economics. *Review of International Economics*, *21*(2), 354–369.

Kenis, P., & Schneider, V. (1991). Policy networks and policy analysis: scrutinizing a new analytical toolbox. In *Policy networks: Empirical evidence and theoretical considerations* (pp. 25–59). Campus Verlag.

Kerber, W., & Eckardt, M. (2007). Policy learning in Europe: the open method of co-ordination and laboratory federalism. *Journal of European Public Policy*, *14*(2), 227–247. https://doi.org/10.1080/13501760601122480

Knoke, D. (2011). Policy Networks. In J. Scott & P. J. Carrington (Eds.), *The SAGE Handbook of Social Network Analysis* (pp. 210–222). 1 Oliver's Yard, 55 City Road, London EC1Y 1SP United Kingdom: SAGE Publications Ltd. https://doi.org/10.4135/9781446294413.n15

Knoke, D., & Yang, S. (2008). *Social network analysis*. SAGE publications.

König, T., & Bräuninger, T. (1998). The Formation of Policy Networks. *Journal of Theoretical Politics*, *10*(4), 445–471. https://doi.org/10.1177/0951692898010004004

Krackhardt, D. (1987). Cognitive social structures. *Social Networks*, *9*(2), 109–134.

Lee, Y., Lee, I. W., & Feiock, R. C. (2012). Interorganizational Collaboration Networks in Economic Development Policy: An Exponential Random Graph Model Analysis. *Policy Studies Journal*, *40*(3), 547–573. https://doi.org/10.1111/j.1541-0072.2012.00464.x

Leifeld, P., & Schneider, V. (2012). Information Exchange in Policy Networks. *American Journal of Political Science*, *56*(3), 731–744. https://doi.org/10.1111/j.1540-5907.2011.00580.x

Luukkonen, T., Persson, O., & Sivertsen, G. (1992). Understanding Patterns of International Scientific Collaboration. *Science, Technology, & Human Values*. Sage Publications, Inc. https://doi.org/10.2307/689852

March, J. G., & Olsen, J. P. (2004). The logic of appropriateness. In *The Oxford handbook of political science*.

Marek, P., Titze, M., Fuhrmeister, C., & Blum, U. (2016). R&D collaborations and the role of proximity. *Regional Studies*. https://doi.org/10.1080/00343404.2016.1242718

Marrocu, E., Paci, R., & Usai, S. (2013). Proximity, networking and knowledge production in Europe: What lessons for innovation policy? *Technological Forecasting and Social Change*, *80*(8), 1484–1498. https://doi.org/10.1016/j.techfore.2013.03.004

Maskell, P., & Malmberg, A. (1999). The Competitiveness of Firms and Regions. *European Urban and Regional Studies*, *6*(1), 9–25. https://doi.org/10.1177/096977649900600102

McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a Feather: Homophily in Social Networks. *Annual Review of Sociology*, *27*(1), 415–444. https://doi.org/10.1146/annurev.soc.27.1.415

Morescalchi, A., Pammolli, F., Penner, O., Petersen, A. M., & Riccaboni, M. (2015). The evolution of networks of innovators within and across borders: Evidence from patent data. *Research Policy*, *44*(3), 651–668. https://doi.org/10.1016/J.RESPOL.2014.10.015

Nilsson, M. (2019). Proximity and the trust formation process. *European Planning Studies*,

27(5), 841–861.

Nilsson, M., & Mattes, J. (2015). The spatiality of trust: Factors influencing the creation of trust and the role of face-to-face contacts. *European Management Journal*, *33*(4), 230–244.

Olson, G. M., & Olson, J. S. (2000). Distance matters. *Human-Computer Interaction*, *15*(2), 139–178.

Paier, M., & Scherngell, T. (2011). Determinants of collaboration in European R&D networks: Empirical evidence from a discrete choice model. *Industry and Innovation*, *18*(1), 89–104. https://doi.org/10.1080/13662716.2010.528935

Putnam, R. D., Leonardi, R., & Nanetti, R. Y. (1993). *Making democracy work: Civic traditions in modern Italy*. Princeton University Press.

Qiliang, M., & Xianzhuang, M. (2023). Cultural proximity and interregional industrial linkages: knowledge diffusion or transaction costs? *Regional Studies*, 1–16.

Reagans, R., & McEvily, B. (2003). Network Structure and Knowledge Transfer: The Effects of Cohesion and Range. *Administrative Science Quarterly*, *48*(2), 240. https://doi.org/10.2307/3556658

Rhodes, R. A. W. (2008). Policy Network Analysis. In R. E. Goodin, M. Moran, & M. Rein (Eds.), *The Oxford Handbook of Public Policy*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199548453.003.0020

Rodríguez-Pose, A., & Wilkie, C. (2016). Context and the role of policies to attract foreign R&D in Europe. *European Planning Studies*, *24*(11), 2014–2035. https://doi.org/10.1080/09654313.2016.1226783

Rojas, M. G. A., Solis, E. R. R., & Zhu, J. J. (2018). Innovation and network multiplexity: R&D and the concurrent effects of two collaboration networks in an emerging economy. *Research Policy*. https://doi.org/10.1016/J.RESPOL.2018.03.018

Sabatier, P. A., & Jenkins-Smith, H. C. (1999). The Advocacy Coalition Framework: An Assessment. In P. A. Sabatier (Ed.), *Theories of the policy process*. Westview Press.

Schaefer, D. R., Light, J. M., Fabes, R. A., Hanish, L. D., & Martin, C. L. (2010). Fundamental principles of network formation among preschool children. *Social Networks*, *32*(1), 61–71.

Schrama, R. (2018). Swift, brokered and broad-based information exchange: how network structure facilitates stakeholders monitoring EU policy implementation. *Journal of Public Policy*, *39*(4), 1–21. https://doi.org/10.1017/S0143814X1800017X

Scott, J. (2017). *Social network analysis*. Sage.

Stokman, F. N., & Berveling, J. (1998). Dynamic Modeling of Policy Networks in Amsterdam. *Journal of Theoretical Politics*, *10*(4), 577–601. https://doi.org/10.1177/0951692898010004009

Stokman, F. N., & Zeggelink, E. P. H. (1996). Is politics power or policy oriented? A comparative analysis of dynamic access models in policy networks. *Journal of*

Mathematical Sociology, *21*(1–2), 77–111. https://doi.org/10.1080/0022250X.1996.9990175

Storper, M., & Venables, A. J. (2004). Buzz: face-to-face contact and the urban economy. *Journal of Economic Geography*, *4*(4), 351–370.

Sun, Y., & Cao, C. (2018). The evolving relations between government agencies of innovation policymaking in emerging economies: A policy network approach and its application to the Chinese case. *Research Policy*. https://doi.org/https://doi.org/10.1016/j.respol.2018.01.003

Ter Wal, A. L. J., & Boschma, R. A. (2009). Applying social network analysis in economic geography: framing some key analytic issues. *The Annals of Regional Science*, *43*(3), 739–756.

Tödtling, F., & Trippl, M. (2005). One size fits all?: Towards a differentiated regional innovation policy approach. *Research Policy*, *34*(8), 1203–1219.

Torre, A., & Gilly, J.-P. (2000). On the analytical dimension of proximity dynamics. *Regional Studies*, *34*(2), 169–180.

Torre, A., & Rallet, A. (2005). Proximity and Localization. *Regional Studies*, *39*(1), 47–59. https://doi.org/10.1080/0034340052000320842

Wasserman, S. (1980). Analyzing social networks as stochastic processes. *Journal of the American Statistical Association*, *75*(370), 280–294.

Wassermann, S., & Faust, K. (1994). Social Networks. Cambridge, Cambridge University Press.

Weible, C. M. (2005). Beliefs and Perceived Influence in a Natural Resource Conflict: An Advocacy Coalition Approach to Policy Networks. *Political Research Quarterly*, *58*(3), 461–475. https://doi.org/10.1177/106591290505800308

Wellman, B. (1983). Network Analysis: Some Basic Principles. *Sociological Theory*, *1*, 155–200. https://doi.org/10.2307/202050

Zafonte, M., & Sabatier, P. (1998). Shared Beliefs and Imposed Interdependencies as Determinants of Ally Networks in Overlapping Subsystems. *Journal of Theoretical Politics*, *10*(4), 473–505. https://doi.org/10.1177/0951692898010004005

Zitt, M., Bassecoulard, E., & Okubo, Y. (2000). Shadows of the Past in International Cooperation: Collaboration Profiles of the Top Five Producers of Science. *Scientometrics*, *47*(3), 627–657. https://doi.org/10.1023/A:1005632319799