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# Gatekeepers in regional innovation networks: Evidence from an emerging economy

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## Abstract

This paper contributes to the growing literature on innovation networks exploring two understudied topics: the role of gatekeepers in innovation networks and the distinctive character of their linkages especially relating to their ability to overcome cognitive, institutional and geographical distances among network participants in the context of a developing country economy. We address two questions: (1) Which organizations play the regional gatekeeper role in innovation networks? (2) How are gatekeeper linkages affected by different kinds of proximity (geographical, institutional, cognitive and social)? The empirical analysis employs co-patenting data from Brazilian organizations. Universities and public research organizations are shown to be more likely to perform the regional gatekeeper role. Gatekeepers are able to overcome geographic and institutional distance. They also balance cognitive distance with other organizations when geographical or institutional proximities are present. Given their critical role in innovation networks, universities and other public research organizations deserve special attention in policies designed to foster technological upgrading and regional development.

**Keywords** Innovation networks · Gatekeeper · Proximity · Regional innovation system

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## 1 Introduction

This paper deals with the role of innovation network gatekeepers in an emerging economy and the ability of these organizations to overcome various types of "distance" in networking. We address the following research questions: (1) Which organizations play the regional gatekeeper role in innovation networks? (2) How are gatekeeper linkages affected by different kinds of proximity (geographical, institutional, cognitive and social)?

We produce evidence on the role of proximity in diverse contexts which are not typically addressed by the extant empirical literature that tends to concentrate on Europe, the United States and China. Moreover, to the best of our knowledge, the different kinds of inter-organizational proximities have not yet been broadly applied to innovation networks in Brazil, except for Garcia et al. (2018) and Santos et al. (2021) who investigated only geographical and cognitive dimensions of proximities in industry-university partnerships. We also contribute by analyzing heterogeneous linkages, in a stepwise approach, while the vast majority of papers applying the proximity framework employ average links, not accounting for the hierarchical position of some nodes, such as gatekeepers, in innovation networks.

The growing literature on innovation networks has shown how collaboration between different organizations contributes to the innovation process, renewing regional knowledge and contributing to new paths creation. In this interactive process, some organizations stand out, acting as intermediaries between different sets of actors across different clusters, industrial districts, or regional innovation systems (RIS). These organizations are called gatekeepers (Giuliani & Bell, 2005; Graf, 2011; Morrison, 2008; Munari et al., 2012).

The importance of gatekeepers arises from the understanding that while the interactions taking place within regional agglomerations are very important for innovation and learning processes, actors in such locations must also access non-redundant knowledge externally generated to avoid the lock-in (Bathelt et al., 2004) as well as access resources and markets. However, not all organizations are equally good in accessing external knowledge and resources. Those that manage to do it may contribute disproportionately to their respective region and network. For instance, several studies on this subject have highlighted how universities and public research organizations (PROs) might play an important role, especially in laggard regions (Graf, 2011; Kauffeld-Monz & Fritsch, 2013; Roesler & Broekel, 2017).

Studies under the proximity framework have discussed how the proximities between different actors, such as same location, institutional and organizational setting, social closeness and cognitive similarity contribute to the formation of links in research and innovation networks (Boschma, 2005). However, not all actors have the same role in networks, as they differ in terms of absorptive capacity, technological endowment and so on. Heterogeneity implies that different actors may be affected by proximities in different ways when they are establishing linkages with each other, leading to different patterns of connection. Moreover, innovation networks are not all formed in the same environment, thus, distinct innovation system settings may also affect connection patterns. Therefore, considering the heterogeneity of actors in specific innovation system settings can point out policy possibilities which would not appear in one-size-fits-all types of investigation.

Hitherto relatively few works have focused on the characteristics and the role of gatekeepers in the context of emerging economies, most of them looking at particular organizations or clusters (Giuliani, 2011; Giuliani & Bell, 2005; Morisson, 2019). Few have explored the role of proximities considering heterogeneous organizations (Broekel & Mueller, 2018). Our aim herein is to combine the gatekeeper and proximity frameworks in order to investigate the role of regional gatekeepers in innovation networks and the particular character of their linkages, focusing on the different dimensions of proximity among network participants, in the context of an emerging economy, Brazil.

We report the results of a quantitative study, based on co-patenting from 2010 to 2019, to identify the organizations that are regional gatekeepers in Brazil and how their linkages are affected by the different kinds of proximity. Our main hypotheses are, first, that the gaps of the innovation systems in developing countries make it more likely for universities and PROs to play the gatekeeper role and, second, that gatekeepers have an important role in accessing geographically, institutionally, socially and cognitively distant organizations in the network.

Our results confirm the first hypothesis and partially confirm the second, as we have verified that gatekeepers tend to connect with institutionally and geographically distant organizations. However, they are more likely to connect with cognitively distant organizations when they share geographical or institutional proximity, evidencing the complementary character of proximities. Social proximity showed no statistical significance in our empirical analysis.

Policy implications arise from the important role of universities and PROs as gatekeepers in the innovation networks of an emerging economy such as Brazil. Policies aiming at fostering inter-organizational networking and regional knowledge exchange should be cognizant of the fact that gatekeepers are well positioned to overcome geographical, institutional and, in some cases, cognitive distances among partners thus facilitating network formation, decreasing transaction costs of collaboration, and expanding knowledge communication among participants.

The rest of the paper is organized into four sections. Section 2 presents the theoretical background of the study. Section 3 presents the research design, data and the methodological approach. Section 4 presents and discusses the results. Finally, section 5 concludes and draws policy implications.

## 2 Conceptual framework

### 2.1 Proximity

The growing literature on innovation networks is grounded on the interactive aspects of innovation, highlighting the importance of linkages between different organizations to facilitate the innovation and learning processes (Cantner & Rake, 2014; Vonortas & Zirulia, 2015). Those linkages are herein treated as partnerships, in which different actors exchange knowledge and learn with each other, in a joint research effort. The structures emerging from the way different organizations are connected in networks have two important features. First, connections are strongly influenced by network specific processes, such as homophily, in which similar nodes are more likely to connect than dissimilar ones (Newman et al., 2011), and also by general characteristics of the environment where these organizations are located (Acs et al., 2002). Second, these structures provide evidence on the variable role of different organizations, some of them centrally located and most peripherally located in the network. Network centrality has been linked to the generation and diffusion of knowledge, thus pointing at the strategic role of a limited number of organizations in a specific network (Graf & Kalthaus, 2018).

The tendency of linkages between similar nodes has, to some extent, been addressed by the proximity framework. In the 1990s, many empirical studies focused on how geographical proximity enables face-to-face contact and trust-building, facilitating the collaboration between different actors in the innovation process. Arguing that collaborations are not only mediated by geographical proximity, but also by different kinds of similarities between nodes, the proximity framework discussed that the establishment of linkages in networks is conditioned by different kinds of proximities, which are not necessarily all present at once, but have a complementary character as the absence of one may be compensated by the other (Boschma, 2005; Crescenzi et al., 2017).

In addition to geographical, which essentially reflects the physical proximity between two actors, the framework address other kinds of proximities between actors, which are not defined by their location, but by their characteristics. These proximities are defined in terms of organizational, social, institutional, and cognitive factors.

Organizational proximity is related to agents being under the same formal organizational arrangements, such as working in the same company or different facilities under the same multinational company rules. Social proximity is based on trust and informal relations, deriving from common past experiences. Institutional proximity has to do with a similar set of cultural and social norms guiding actors' actions and behavior (Boschma, 2005). Cognitive proximity is related to the capacity of different actors to understand each other when they share a similar knowledge base. This proximity is the root of an important trade-off (Boschma, 2005; Broekel & Boschma, 2012). A high degree of cognitive proximity between organizations presents them with lower transaction costs but also lower learning opportunities and possible lock-in, as the partners are not exposed to an extensive knowledge pool (Bathelt et al., 2004). In contrast, organizations will struggle to learn from one another when their knowledge bases are very distant, thus raising transaction costs (Breschi et al., 2003; Nooteboom, 2011). Therefore, an optimal level of cognitive similarity is necessary, as communication is more likely to occur when different organizations share a common knowledge background (Vonortas & Okamura, 2009).

The proximity framework has been gaining the attention of studies focused on innovation networks, with many studies empirically showing the importance of different types of proximity for network formation. Broekel & Bednarz (2018) evaluate the role of proximity to collaboration in R&D subsidized networks, evidencing that institutional, cognitive and geographical proximities impact the collaboration between organizations. In addition, Bednarz & Broekel (2019) use the proximity framework to evaluate the effects of subsidized R&D policy on knowledge diffusion, empirically showing that geographical, cognitive and social proximities positively impact inter-regional knowledge diffusion. Capone & Lazzeretti (2018) review the importance of different proximities on different kinds of networks, including informal networks. Garcia et al. (2018) evidence the complementary character of proximities, showing that cognitive proximity compensates geographical distance in university-industry interactions in Brazil.

Physical closeness implies that geographical proximity also implies sharing the same environment, an aspect captured by the RIS approach. Many authors give innovation networks a regional focus, based on empirical evidence that knowledge and spillovers are geographically bounded. Thus, the interaction between different actors in a region, such as universities, research organizations and private firms, allied with policy support infrastructures and the institutional environment, might lead to incrementally higher levels of knowledge creation, acquisition and exploitation based on accelerator benefits due to inter-organizational networking (Asheim & Coenen, 2006; Asheim & Isaksen, 2002; Malmberg & Maskell, 2002; Trippl et al., 2018).

Although knowledge generation and transmission are sensitive to geographical distance, geographical proximity *per se* is not a sufficient condition for a region to succeed. Knowledge generation and transmission also depend on several other factors such as the cognitive proximity between organizations, the engagement of local actors in regional innovation networks, and their ability to access, absorb, diffuse and exploit external knowledge (Acs et al., 2002; Garcia et al., 2018; Giuliani, 2005; Kauffeld-Monz & Fritsch, 2013).

## 2.2 Knowledge gatekeepers

The importance of local interactions notwithstanding, access to external knowledge is also critical for regions because it enables contact with a more extensive knowledge pool (Bathelt et al., 2004). External knowledge sourcing, of course, requires organizations capable of engaging in the requisite external innovation networks. When organizations manage to combine strong local and external interactions, being embedded in both regional and inter-regional networks, they contribute to avoiding lock-in and preventing the loss of knowledge variety over time (Broekel & Mueller, 2018). As not all organizations manage to establish both local and external linkages, the ones who do succeed have a pivotal role in the network, as they act as intermediaries between regional and external innovation networks, contributing to the diversification of knowledge in their respective regions.

Simultaneously collaborating with local and external knowledge sources is not a trivial task, as it implies a trade-off between benefits and costs, the building and maintenance of solid relationships with both geographically proximate and non-proximate organizations, and strong absorptive capacity relying on resources, routines and specific capabilities that are path-dependent and not easy to build (Crespo & Vicente, 2016; Fontes, 2005; Kauffeld-Monz & Fritsch, 2013; Morrison, 2008). It is such organizations, connecting to external networks and also embedded in regional networks, that are called gatekeepers.

They were defined by Gould & Fernandez (1989) as actors who mediate the contact between two other actors, belonging to different groups. Initially conceived for transaction networks, this definition was successfully adapted to the context of regional/city innovation networks by scholars such as Gallo & Plunket (2020), Breschi & Lenzi (2015) and Graf (2011). Gatekeepers typically differ from other actors in terms of high absorptive capacity, distinct technological profile (Breschi & Lenzi, 2015; Broekel & Mueller, 2018), large size (Giuliani & Bell, 2005; Munari et al., 2012), and influential position in their respective networks (Gould & Fernandez, 1989).

According to Graf (2011:186), in a regional context, “gatekeepers would be local actors that have non-redundant contacts to internal and external nodes in the regional network”, that is, gatekeepers are organizations mediating the contact between two different organizations, a local and an external one, which are not directly connected. In such a position, gatekeepers are able to mediate knowledge flows from different places, as they have connections to the knowledge generated outside their regions and contribute to diffuse it within their region, as they are strongly embedded in local innovation networks (Broekel & Mueller, 2018; Gallo & Plunket, 2020). Considering the benefits and costs involved in partnerships, RIS mediated by gatekeepers are considered better positioned for success because of external knowledge flows into the region through key interactions, reducing the costs and risks associated with geographically distant research partnerships (Crespo & Vicente, 2016; Vicente et al., 2011).

Looking at specific clusters, prior work has highlighted the importance of multinationals and large local companies for performing the gatekeeping role. According to Morrison (2008), lead firms would be more prone to access external knowledge, because of their technological endowment and capabilities. However, they would not necessarily feel the need and willingness to share this knowledge with other regional organizations. Munari et al. (2012) also argue that some firms, characterized by large size and strong innovation capabilities, are crucial to mediate knowledge creation and diffusion into industrial districts, acting as gatekeepers. Bell & Giuliani (2007), Giuliani (2011) and Giuliani & Bell (2005) discussed the broker role performed by firms with strong knowledge bases for wine clusters, both in developed and in developing contexts.

Some scholars looked at the broader RIS picture and showed that, for some regions, non-private sector organizations are especially important to mediate the contact with knowledge external to the region. Graf (2011) considers that universities and PROs have the intrinsic mission to diffuse knowledge, which makes them more prone to access external knowledge and to diffuse it to local actors. Crespo & Vicente (2016) empirically show that PROs usually connect different RIS based on science-intensive knowledge in Europe. Roesler & Broekel (2017) evidence that, besides being key actors in local networks, universities are also able to connect local organizations to interregional networks, intermediating knowledge flows between different regions. Kauffeld-Monz & Fritsch (2013) argue that laggard regions lack lead firms, and PROs compensate for it, performing a knowledge broker role. Similarly, Morisson (2019) argues that peripheral knowledge regions lack general knowledge infrastructures, and public institutions, such as innovation agencies, end up playing an important gatekeeper role, adapting external knowledge to facilitate its absorption by other RIS actors.

Combining the gatekeeper definition with the proximity framework, we can infer that the ability of gatekeepers to mediate flows between different groups may be translated into a capacity to overcome distances and to be less conditioned by proximities in networking than other actors. Due to their distinctive characteristics and position in networks, gatekeepers would be more likely to develop the necessary routines and skills to enable the connection and the dialogue with other actors, even if they do not share the same location, institutional and organizational setting, previous trust-based relationships, or a common knowledge base. Therefore, gatekeepers stand out because they are able not only to establish connections based on proximity but also connections which are less likely among other actors due to significant distances among them (Broekel & Mueller, 2018).

The role of gatekeepers has already been investigated in inventor networks (Breschi & Lenzi, 2015; Gallo & Plunket, 2020; Schiffauerova & Beaudry, 2012) as well as in organization networks, both considering smaller spatial settings, such as clusters and industrial districts (Bell & Giuliani, 2007; Giuliani, 2005, 2011; Giuliani & Bell, 2005; Morrison, 2008; Munari et al., 2012), and also considering the broader RIS perspective (Graf, 2011; Kauffeld-Monz & Fritsch, 2013; Morisson, 2019). However, there have been few prior attempts to substantiate the characteristics of gatekeepers in the immature innovation system settings of developing countries (Albuquerque, 1999).

Paying attention to the role of different actors in the context of different innovation systems can also generate new insights into the role of proximity. When considering immature innovation systems, such as those in developing countries, it is possible to discuss the role of proximities and gatekeepers featuring institutional settings different from those found in the Global North, the area in which the vast majority of studies on this topic have concentrated. The next subsection discusses specific aspects of innovation systems in developing countries that impact the formation of innovation networks.

### 2.3 Developing countries context

Developing countries face structural problems in their immature innovation systems, impacting the environment in which inter-organizational linkages take place. Immature innovation systems are characterized by limited absorptive capacity and weak institutions, factors that hinder collaboration and research partnerships (Albuquerque, 1999; Chaves et al., 2016; Ernst, 2002). Moreover, the low perceived demand for knowledge by the insufficiently innovative productive sector leads to weak commitment to R&D (Arocena & Sutz, 2010). In such contexts, universities and PROs that have the intrinsic mission of transfer knowledge may stand out.

In many emerging economies, such as Brazil, Argentina, Uruguay and Mexico, for instance, most of the research activities are concentrated in universities and PROs (Arocena & Sutz, 2016; Brundenius et al., 2009; Chaves et al., 2016; Fischer et al., 2019). Looking specifically at the Brazilian case, empirical evidence has shown that universities and PROs research not only complements private sector R&D but often substitutes for it. Studies have also indicated that, although Brazilian firms' internal R&D activities have increased, there is still a predominance of firms with weak competencies and lack of skilled personnel in the productive sector, which complicates communication with other organizations and hinders the formation of linkages (de Moraes Silva et al., 2018; Rapini et al., 2017; Rapini et al., 2009).

The discussions in the conceptual framework section leads to two hypotheses to be investigated in the rest of the paper specifically for the case of Brazil:

1. Universities and PROs are more likely to be regional gatekeepers in an emerging economy context, such as Brazil;
2. Regional gatekeepers are better able to overcome "distances" in network formation, whether these distances are geographical, social, institutional or cognitive.

## 3 Data and analytical methodology

Our analysis follows a stepwise approach: (1) We identify the knowledge gatekeeper organizations in regional innovation networks and calculate their gatekeeper scores; (2) We use the gatekeeper scores as the dependent variable to estimate the factors contributing to an organization to perform a gatekeeper role; (3) We use the established connections in the network to investigate how different kinds of proximities affect gatekeepers' linkages.

### 3.1 Data

We use patent applications filed by Brazilian applicants from 2010 to 2019, collected from Orbit Intelligence, and co-patenting as a proxy for the linkages between different organizations[1]. Although patents are often considered a non-ideal indicator, as they do not encompass all the R&D efforts in an economy, patents are a formal measurable output of the innovation system, allowing to track the production of knowledge and technologies (Bergé et al., 2017; Leydesdorff et al., 2015).

Our search on Orbit Intelligence used the organization nationality as the query criterium. Then, patents involving at least one Brazilian organization as applicant were tracked. Initially, the search returned 39,946 patents[2], filed at different intellectual property offices over the world.

These documents were then filtered, using some criteria. As we are interested in organizations performing the gatekeeper role, we refined the sample, taking only patents that involved co-applications, resulting in 5,056 documents. Second, we eliminated patents that had individuals, and not organizations, as applicants, reducing our sample to 4,060 patents. Then, as the gatekeeper concept employed here is based on spatial location, we eliminated patent documents that did not display inventors' location, as this data is widely used by the geography of innovation literature to locate the production of technologies and knowledge. This procedure further reduced our sample to 1,307 patents.

Patents filed exclusively at the Brazilian intellectual property office (INPI) do not openly display the inventor's location, so we had to eliminate those patents from our sample, as they did not provide all the details we needed. Filing patents in offices other than the national one generally has to do with the expectation of better gains from the new technology and strategic aspects (Schaefer & Liefner, 2017). Thus, filtering the patents that display inventor's details also implies filtering the patents that are expected to generate better profits and have higher strategic importance for organizations. Considering the high hierarchical position of gatekeepers in innovation networks, we understand that restricting the analysis to patents applied to multiple offices does not harm the analysis, but rather reinforces its hierarchical character. Finally, as we are interested in the regional role of gatekeepers, we eliminated the patents involving only international interactions, that is, interactions between one Brazilian organization and one foreign organization only, and obtained the final sample of 939 patents.

Next, we assigned each organization to a region, following an approach similar to Bergé et al. (2017) and Graf (2011). Regional units correspond to the mesoregions as classified by the Brazilian Institute of Geography and Statistics (IBGE). Due to data limitations and unavailability of a specific regionalized dataset, we had to follow some procedures in order to localize the organizations and construct the dataset. To locate the organizations, first, we looked at the inventors' location, because many organizations have more than one facility, and the applicant address does not reflect necessarily where the technology was developed, but rather the organizational structure of the organization (Eslami et al., 2013).

[1] Brazilian organizations include both domestic and foreign companies located in Brazil.

[2] Patents used in this analysis are grouped into families. According to EPO (European Patent Office), "A patent family is a collection of patent applications covering the same or similar technical content. The applications in a family are related to each other through priority claims." Available in: https://www.epo.org/searching-for-patents/helpful-resources/first-time-here/patent-families.html.

We then checked if the inventors' location matched the location of the applicant organization. If it did not, it was an indication that the place that conducted the research leading to the patent application was not the same as the place that applied for it. Then, we investigated if there was any facility of the organization in the same region as the inventor. For instance, if an inventor is located in São Paulo and the applicant organization's address is in Rio de Janeiro, that is, applicant organization and inventor appear to be located in different regions, we checked if there was a facility of such organization in São Paulo. If so, we attributed the location of the organization to São Paulo. If there is no facility of the applicant organization in the same region as the inventor, we checked how far is the city the inventor lives from the closest facility of the organization. If the distance is up to 50 km, we attributed the patent to the applicant's location, assuming that, even from different regions, the inventor probably works at that facility, as people usually live close to where they work (Eslami et al., 2013). If the distance between the inventor's address and the facility is higher than 50 km, we attributed the patent to the inventor's location. This approach is used to get as close as possible to the real picture in terms of the location where the technology was developed.

We use co-patenting, that is, the fact that more than one organization is the assignee of the same patent, to establish the linkages between different organizations. A network was designed using these connections. To account for variations in periods, we divided our sample into two non-overlapping periods: from 2010 to 2014 and from 2015 to 2019, forming two different networks. We split the sample because from 2010 to 2014 R&D expenditures in Brazil followed a consistent growing trajectory while from 2015 to 2019 this trajectory involved some years of decreasing expenditures (MCTI, 2019).

It is worth mentioning that although patent data allows tracking formal linkages between organizations, it is also subject to well-known limitations as not all research efforts result in patents and patenting propensity varies across sectors. Thus, the fact that an organization may not appear as a gatekeeper in our analysis does not necessarily mean that it does not play an important role, as its contribution may not be captured by patent data.

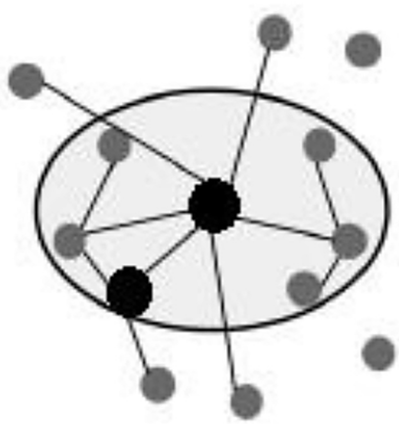

**Fig. 1** Gatekeepers in regional innovation networks (Source: Adapted from Crespo & Vicente 2016)

### 3.2 Gatekeeper identification

Gatekeepers are identified based on Gould & Fernandez (1989) definition. Thus, as we are focused on regional networks, gatekeepers are characterized as organizations which connect two other organizations, one from its region and another from an external region, considering that those organizations are not directly connected. Gatekeepers are illustrated on Fig. 1.

Figure 1 illustrates nodes with a gatekeeper function. For instance, consider that the organizations inside the circle are from the same region and the ones outside are from different regions. The linkages between them represent co-patenting. The gatekeepers in this case are the two darker nodes, as they are intermediaries between nodes from their region and external nodes, which are not directly connected. However, the two gatekeepers have different scores, because the most central node is performing more gatekeeper roles than the other one.

To identify the gatekeepers, we use the co-patenting networks and construct a vector attributing each organization to a geographical region, according to the locations previously identified. We then use the SNA R package, already employed by Gallo & Plunket (2020), to obtain the gatekeeper score. The score shows the number of times an organization mediated the connection between an organization in its region (internal) with an external organization, considering that those are not directly connected.

The gatekeeper score is our dependent variable in the first econometric modeling, and it is a count variable of the number of gatekeeper roles played by an organization, assuming limited and nonnegative values. We, then, employ a Poisson estimation, using dummy variables to control for region and time fixed effects (Wooldridge, 1999, 2002).

To explain the factors contributing to an organization to be a gatekeeper, our main explanatory variable is the institutional nature of the organization, that is, if the organization is a university or a PRO, or not. Based on what the literature discuss as characteristics of gatekeepers, we controlled for the number of patents filed, as a *proxy* of size, as in Graf (2011); and for the variety of technological domains in which an organization has applied patents, based on Schmoch (2008) classification, as a *proxy* for the distinct technological profile. As both variables are correlated, we transformed variety in a binary, with the value of 1 when variety is greater than the sample average.

Taking into consideration that different regions have different needs, attractiveness, and absorptive capacity for external knowledge sourcing (Trippl et al., 2018), we add a control for the level of development of the RIS in which the organization is located. To control for it, we conducted a cluster analysis, based on Euclidean distance, to classify the sixty regions in which organizations are located, into three different categories: developed, intermediate and less developed RIS. To carry out the analysis, we used standardized data referring to the number of applied patents per million inhabitants, proportion of workers with tertiary education, number of organizations that co-patent in the region and number of technologies in which the region has revealed technology advantage—RTA.

To calculate the RTA, we used Schmoch (2008) technological domains classification and Balland & Rigby (2017) approach to define if a region has RTA on a certain technology: if the share of a specific technology is higher in the region's patent portfolio than the share of the same technology in the whole country, the region is considered to have RTA on it. Then, we set the cluster analysis to generate three different categories. These clusters were transformed into categorical variables, with less developed RIS as the reference. Table 1 summarizes the variables:

### 3.3 Proximity analysis

Our second estimation focuses on how the different kinds of proximities affect gatekeeper linkages. To define the gatekeepers according to the previously calculated gatekeeper score, we set a threshold of 2% highest gatekeeper scores, following Broekel & Mueller (2018) and Graf (2011). Thus, our dependent variable is 1, if the linkage involves a gatekeeper inside the top 2%, and 0 otherwise.

As we are not modeling the likelihood of tie-formation but rather a specific categorical characteristic of the linkage, we estimate logit and ordinary least square (OLS) models. Cases where the dependent variable is binary are usually estimated by nonlinear models, such as logit and probit. However, these models' outcomes may be biased and inconsistent when there are a large number of dummy variables (Cortinovis et al., 2017; Greene, 2012). Then, we will estimate both logit and OLS models, as a robustness check.

To define the different proximity dimensions, we employed measures that were already used in similar studies. For geographical proximity, we followed Broekel & Mueller (2018), Capone & Lazzeretti (2018) and Roesler & Broekel (2017), and used a binary structure assuming the value of 1 if the organizations in the linkage are located in the same region and 0 otherwise. This way, we capture not only the geographical distance *per se* but also the effect of locating in the same environment.

To account for institutional proximity, we divided the organizations into two different groups: universities and PROs, and private sector organizations. The first group is driven by the production and dissemination of knowledge, while the second is driven by profits and market share. Then, we accounted the value of 1 if the organizations involved in the linkage are from the same group and 0 otherwise. This measure aims to capture if organizations are working under the same basic structures and objectives, and was already employed by Broekel & Mueller (2018), Capone & Lazzeretti (2018) and Roesler & Broekel (2017).

To account for social proximity, we followed Roesler & Broekel (2017) and tracked if the pair of organizations interacting in period t had already interacted in the previous period t-1. For instance, if two organizations establishing a link in the period 2010–2014 have also

**Table 1** Variables in the gatekeeper score estimation

| Variable | Type | Measure |
|---|---|---|
| Gatekeeper score | Dependent variable | Number of times an organization played the regional gatekeeper role |
| University/PRO | Binary | If the organization is a university or PRO |
| N. of patents | Discrete | Number of patent applications |
| Variety_b | Binary | If the number of technological domains in which the organization has applied patents is greater than the sample average variety |
| High developed RIS | Binary | If the organization is located in a high developed region, according to the cluster analysis |
| Intermediary RIS | Binary | If the organization is located in an intermediary region, according to the cluster analysis |

Source: Authors' draft

interacted in the period 2005–2009, social proximity assumes a value of 1. If this interaction has not happened in the previous period, it assumes the value of 0.

Finally, to model cognitive proximity we estimated the cosine similarity index between organizations, based on their technological portfolio, as in Bednarz & Broekel (2019). To do so, we counted, for each organization, the number of patent applications in the different technological domains, generating an 'organization x technology' incidence matrix, used as input for cosine similarity index calculus. This index generates normalized values ranging from −1 to 1, in which cognitive similar organizations present a value close to 1, while cognitive distant organizations present values close to −1.

As we are working with a network formed through co-patenting, the vast majority of connections in our sample involves organizational distance. Therefore, the organizational proximity is not part of the econometric estimation. Table 2 summarizes the variables used in the proximity estimation:

# 4 Results and discussion

## 4.1 Data description

Some features of our data are summarized on Table 3.

Our data is separated into two periods, to address time variations. Those are evident when we look at Table 3. Comparing the periods, we see there was a drop in the number of co-patenting organizations, from 360 to 261. Out of these, 110 organizations were classified as universities and PROs in period 1 and 75 in period 2. These organizations estab-

**Table 2** Variables in the proximity estimation

| Variable | Type | Measure |
|---|---|---|
| Linkage attribute | Dependent variable (binary) | If the linkage involved at least one gatekeeper (1), or not (0) |
| Geographical proximity | Binary | If the organizations involved in the linkage are located in the same region |
| Institutional proximity | Binary | If the organizations involved in the linkage share the same institutional orientation |
| Cognitive proximity | Continuous | Cosine similarity index, based on the technological portfolio of the organizations involved in the linkage |
| Social | Binary | If the organizations involved in the linkage have patent co-applications in the previous period |

Source: Authors' draft

**Table 3** Data description

| | Period 1 (2010–2014) | Period 2 (2015–2019) |
|---|---|---|
| Total number of organizations | 360 | 261 |
| Universities and PROs | 110 | 75 |
| Number of linkages | 732 | 365 |
| Number of gatekeepers | 7 | 6 |
| Linkages involving at least one gatekeeper | 278 | 190 |

Source: Authors' draft

lished 1097 linkages, and most of them were concentrated in period 1. Using the established threshold, in period 1 we have 7 gatekeeper organizations involved in 38% of the linkages in that period. In period 2, we have 6 gatekeeper organizations and their importance in linkages increased, as 52% of the linkages in that period involved gatekeepers. In both periods all organizations performing the gatekeeper role were universities, except for one. Correlation matrices and more descriptive statistics can be found in Appendix 1.

### 4.2 Econometric results

First, we present the results of the gatekeepers modeling (Table 4). We estimate three models: one with regional and time fixed effects; one with RIS controls and no fixed effects; and one with RIS controls and time-fixed effects. Here, we search for the factors that contribute to an organization assuming a gatekeeper role in the network.

In all three models the dummy for universities and PROs presents a positive and statistically significant result, indicating that the nature of an organization as a university or PRO impacts positively the gatekeeper score. H1 is confirmed.

This finding corroborates the results of Graf (2011) and Kauffeld-Monz & Fritsch (2013) for Eastern and laggard regions in Germany: universities and PROs were found to be more capable to access and diffuse knowledge. This result also reflects the trade-off between accessibility and appropriability in partnerships. On the one hand, organizations may benefit from accessing complementary resources and knowledge spillovers, which may enhance their competitiveness and innovative performance. On the other hand, partnerships imply a risk of undesirable spillovers and partners' opportunistic behavior. In an environment of weak institutions, such as in emerging economies, the perceived risks involved in partnerships may be even higher. Universities and PROs are less influenced by those risks since knowledge diffusion is institutionalized as their "third mission" (Crespo & Vicente, 2016).

This result arguably has important implications for technological diversification strategies. As shown in Balland & Boschma (2021), linkages established between regions have a positive effect on the probability of regions diversifying, especially when we consider

**Table 4** Gatekeeper identification

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| Universities/PROs | 1.047941** (0.3883789) | 1.283349* (0.5512718) | 1.405861* (0.599101) |
| N. of patents | 0.0136742*** (0.0009848) | 0.0093846*** (0.0009778) | 0.0094878*** (0.0009107) |
| Variety_b | 2.515994*** (0.3734295) | 2.645887*** (0.4719751) | 2.633662*** (0.4836935) |
| High developed RIS | | 1.37673** (0.4726875) | 1.297911** (0.4383866) |
| Intermediary RIS | | −0.58651 (0.6797215) | −0.5500463 (0.6272202) |
| Constant | −3.426036*** (0.8060548) | −3.26656*** (0.5790218) | −2.985595*** (0.557368) |
| Time fixed effects | Yes | No | Yes |
| Region fixed effect | Yes | No | No |
| pseudo $R^2$ | 0.8545 | 0.7301 | 0.7530 |
| Obs | 621 | 621 | 621 |

Robust standard errors reported

***$p<0.001$, **$p<0.01$, *$p<0.05$

peripheral regions. The gatekeeping role of universities and PROs in terms of accessing interregional technological knowledge and diffusing it regionally places them as central actors for policy design aiming at technological diversification and regional catching up.

The number of patents registered by an organization, the technological variety in its patent portfolio, and the organization's location in a high developed RIS also had positive and statistically significant effects on gatekeeping across all three models. Larger research portfolios arguably indicate organizations that are probably more resourceful and more likely to create the routines and abilities to enable the interaction with different kinds of actors.

The importance of variety in the patent portfolio is in line with studies arguing that variety increases the possibilities for recombining knowledge (Boschma et al., 2015), thus facilitating the dialogue between different actors. Finally, the positive effect of being located in a developed region is also in line with the literature, as some authors argue that more advanced and diversified regions are characterized by the geographical openness of innovation networks and the diversity of industries, technologies and organizations, which increase the opportunities to interact and exchange knowledge (Isaksen et al., 2014; Isaksen & Trippl, 2016).

Moving to the effect of the four different types of proximity on gatekeeper linkages, we estimate a model in which the dependent variable is 1 if at least 1 gatekeeper is part of the linkage. The results of three versions of logit and OLS estimations are displayed in Table 5. The difference between the three versions is the interaction terms Inter1(geog and cog) and Inter2 (inst and cog) corresponding to the interaction of cognitive proximity with geographical proximity and with institutional proximity respectively.

Institutional and geographical proximities are found to be statistically significant and have a negative effect on the likelihood of a linkage involving a gatekeeper. In other words, gatekeeper connections are more likely to involve geographical and institutional distant partners. In contrast, cognitive proximity is statistically significant and positive in all models, indicating that gatekeepers are more likely to connect with cognitively similar organizations. Social proximity was not statistically significant in any model.

Following, based on the complementary character of proximities discussed in the literature, we inserted interaction terms to see if the cognitive distance can be overcome when other proximities exist between actors. Then, we interacted cognitive proximity with institutional and geographical proximities, as these are the two statistically significant ones. Both interaction terms were found to be negative and statistically significant. This indicates that, although in general gatekeepers tend to connect with cognitively close organizations, the cognitive distance may be bridged by other proximities between the partners. Thus, gatekeepers are more likely to interact with cognitively distant partners when they are spatially co-located or if they share similar institutional orientation. Therefore, H2 is partially confirmed: gatekeepers seem able to overcome geographical and institutional distance, but they seem able to overcome cognitive distance only when institutional or geographical proximity is present.

These findings also may have policy implications. Investigating subsidized R&D networks, Broekel & Bednarz (2018) argue that several empirical studies have already proven how proximity positively impact the formation of linkages between different organizations. Then, public policies for promoting research partnerships should focus on links that are less likely to occur, and not on those that would already occur naturally. Crespo & Vicente (2016) argue that targeting specific links may have better outcomes than just inject public

**Table 5** Gatekeeping and proximity

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | Logit | OLS | Logit | OLS | Logit | OLS |
| Institutional | −1.668605*** (0.1546589) | −0.3265743*** (0.0265425) | −1.718345*** (0.1561221) | −0.3306616*** (0.0265458) | −1.025845*** (0.2285546) | −0.2369056*** (0.0382347) |
| Geography | −0.4294662** (0.1518231) | −0.0755453** (0.0274113) | 0.254047 (0.224411) | 0.0180143 (0.0386505) | −0.4549298** (0.1541746) | −0.0802999** (0.0272437) |
| Cognitive | 81.6548*** (7.325629) | 15.05777*** (1.086352) | 104.2412*** (9.795708) | 14.23603*** (1.368409) | 132.3578*** (14.11112) | 20.47045*** (1.500524) |
| Social | −0.0815071 (0.2274088) | −0.0005935 (0.0388194) | −0.0663234 (0.2285415) | 0.0068166 (0.0383376) | −0.2300066 (0.2416014) | −0.019557 (0.0387326) |
| Constant | −0.38728** (0.1386379) | 0.4225178*** (0.029944) | −0.06531255*** (0.1567172) | 0.3939632*** (0.0308122) | −0.7578204*** (0.1757081) | 0.3693001*** (0.0336114) |
| Inter1 (geog and cog) | | | −57.31161*** (14.09194) | −7.984852** (2.360687) | | |
| Inter2 (inst and cog) | | | | | −66.24132*** (18.68509) | −7.731563*** (1.969155) |
| pseudo $R^2$ | 0.1788 | 0.2171 | 0.1902 | 0.2249 | 0.1887 | 0.2248 |
| Obs | 1097 | 1097 | 1097 | 1097 | 1097 | 1097 |

Robust standard erros reported.

***$p<0.001$, **$p<0.01$, *$p<0.05$

funds into any collaboration. Various types of proximity can then provide useful policy targets. Regional gatekeepers can also provide useful policy targets. Active public policy to mitigate distances among prospective partners, especially between public and private sector organizations, could be to fund research projects that involve gatekeepers. In countries like Brazil, the majority of such knowledge gatekeepers would be universities and PROs.

## 5 Conclusions

This article purported to identify the organizations that play the role of regional gatekeeper in innovation networks and to verify how the different kinds of proximity impact their connections. To that effect, the article empirically analyzed the case of an emerging economy, Brazil, based on co-patenting data for the period 2010–2019. To date, relatively little attention has been paid to the study of regional gatekeepers in the context of developing countries, specifically exploring the role of various types of proximity in inter-organizational collaboration while taking into account the heterogeneity of partners involved in these linkages.

Our main empirical findings are that universities and PROs are more likely to play the regional gatekeeper role in Brazil; and gatekeepers are able to overcome institutional and geographical distances, and also cognitive distance when geographical and institutional proximities are present. The finding that universities and PROs are key agents connecting regional innovation networks in Brazil, contributing significantly not only to connecting agents within their own regions but also to accessing non-redundant external technological knowledge, corroborates with earlier expectations in the literature. Universities and PROs conduct most of the research in developing countries, including Brazil, due to the institutional weakness of immature innovation systems that hinder R&D collaboration involving the private sector (Albuquerque, 1999; Rapini et al., 2009). In environments that do not encourage research collaborations, universities and PROs stand out. This reflects the "third mission" of such institutions which leverages their role in local development strategies (Fischer et al., 2019; Jonkers et al., 2018).

Our results indicate that regional gatekeepers are important agents in the formation of networks. They seem to be able to overcome geographical and institutional distances which are usually important conditioning factors in tie-formation, according to empirical evidence. Similarity in institutional settings and spatial co-location assist knowledge gatekeepers to also bridge cognitive distance with their partners.

One can consider policy implications for regional technological catching up and diversification strategies. Policies and incentives focusing on promoting interregional collaboration and regional knowledge diversification must be cognizant of the key role played by universities and PROs in connecting organizations from different regions, and also the importance of linkages involving regional gatekeepers.

Gatekeepers tend to establish connections that would be less likely to occur otherwise, including linkages characterized by dissimilarity between nodes. Therefore, instead of targeting all types of collaborations, limited resources could be targeted to supporting linkages involving knowledge gatekeepers, as they are better able to mitigate the geographical, institutional and cognitive distances impeding network collaboration. Organizations aiming at diversifying and acquiring new knowledge not available in their regions could target

**Table A1** Gatekeepers estimation—correlation

| | Universities_PROs | Npatents | Variety | Highdev | Interm |
|---|---|---|---|---|---|
| Universities_PROs | 1 | | | | |
| Npatents | 0.3438 | 1 | | | |
| Variety | 0.554 | 0.8309 | 1 | | |
| Highdev | −0.2365 | 0.0147 | −0.0458 | 1 | |
| Interm | 0.2022 | −0.0053 | 0.0361 | −0.7043 | 1 |

universities and PROs to establish new linkages, exchanging knowledge and learning from and with them. Thus, mechanisms fostering university-industry linkages may be crucial to build regional innovation networks.

In closing, we must mention an important limitation of our study related to the utilized data: patenting activity. It is well known that not all research translates into patents and that patenting propensity varies across sectors. Second, due to information reporting differences, we could not use the patents filed exclusively with the Brazilian intellectual property office. Hence, we are working with a subsample of the interactions between organizations as reflected in "important" patents also filed abroad. The fact that an organization does not appear as a gatekeeper in this analysis does not necessarily mean that it does not contribute to the access of external knowledge, as it may contribute in other ways, not captured when we analyze patenting activity.

**Table A2** Gatekeepers estimation—descriptive statistics

| | Observations | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Universities_PROs | 621 | 0.2979066 | 0.4577049 | 0 | 1 |
| Npatents | 621 | 20.579 | 4.930.925 | 1 | 406 |
| Variety | 621 | 5.206.119 | 6.407.608 | 1 | 33 |
| Highdev | 621 | 0.6586151 | 0.4745565 | 0 | 1 |
| Interm | 621 | 0.2045089 | 0.4036674 | 0 | 1 |

**Table A3** Proximity estimation—correlation

| | Institutional | Geographical | Cognitive | Social |
|---|---|---|---|---|
| Institutional | 1 | | | |
| Geographical | −0.1486 | 1 | | |
| Cognitive | 0.1486 | −0.1177 | 1 | |
| Social | −0.0679 | 0.0108 | 0.1876 | 1 |

**Table A4** Proximity estimation—descriptive statistics

| | Observations | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Institutional | 1097 | 0.6089335 | 0.4882118 | 0 | 1 |
| Geographical | 1097 | 0.3564266 | 0.4791617 | 0 | 1 |
| Cognitive | 1097 | 0.0129106 | 0.0121826 | 0 | 0.0791788 |
| Social | 1097 | 0.1130356 | 0.3167807 | 0 | 1 |

## 6 Appendix 1—Correlation and descriptive statistics

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