

ENCOURAGING RESEARCH AND DEVELOPMENT COLLABORATION AMIDST GEOGRAPHICAL CHALLENGES IN LESS DEVELOPED REGIONS OF THE EUROPEAN UNION: A SYSTEMATIC LITERATURE REVIEW

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Pécs, capital of Southern Transdanubia, Hungary, is one of the European Capital of Culture cities and UNESCO Global Learning City. A region characterized by less developed industry, research and development, and innovation.

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Encouraging research and development collaboration amidst geographical challenges in less developed regions of the European Union: a systematic literature review

ABSTRACT: This study explores the growing literature on research and development (R&D) collaboration in the context of less developed regions (LDRs) in the European Union (EU) and examines the opportunities for LDRs to successfully collaborate with developed regions. A systematic review of the literature shows that studies on R&D collaboration in LDRs are at the forefront of regional innovation research in the EU and that opportunities to explore this research topic are still wide open. A critical review and synthesis of the selected articles shows that LDRs have equal opportunities to collaborate and build successful relationships with developed regions by paying attention to at least five motivational drivers and critical factors to enhance the success of their R&D collaborations.

KEY WORDS: R&D collaboration, geographical challenges, less developed regions, European Union, systematic literature review, motivational drivers, critical factors

Spodbujanje sodelovanja na področju raziskav in razvoja v manj razvitih regijah Evropske unije, ki se spopadajo z geografskimi izzivi: sistematični pregled literature

POVZETEK: Avtor v članku proučuje rastočo literaturo o sodelovanju na področju raziskav in razvoja v manj razvitih regijah Evropske unije ter možnosti njihovega uspešnega sodelovanja z razvitimi regijami. Na podlagi sistematičnega pregleda literature ugotavlja, da so raziskave o tovrstnem sodelovanju v ospredju proučevanja regionalnih inovacij v Evropski uniji in da je prostora za nadaljnje raziskave na tem področju še veliko. Kritični pregled in sinteza izsledkov izbranih člankov kaže, da imajo vse manj razvite regije enake možnosti za sodelovanje in vzpostavljanje uspešnih odnosov z razvitimi regijami, če upoštevajo vsaj pet motivacijskih gonil in ključnih dejavnikov, ki lahko izboljšajo uspešnost njihovega sodelovanja na področju raziskav in razvoja.

KLJUČNE BESEDE: sodelovanje na področju raziskav in razvoja, geografski izzivi, manj razvite regije, Evropska unija, sistematični pregled literature, motivacijska gonila, ključni dejavniki

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1 Introduction

Compared to more developed regions, less developed regions (LDRs) face more challenges in scaling up their innovation, especially when it comes to their geographical location, e.g. due to their peripheral location (Grillitsch and Nilsson 2015; Amoroso, Coad and Grassano 2018) or sparsely populated areas (Dubois, Kristensen and Teräs 2017; Sörvik et al. 2019). To increase the intensity of knowledge spillovers and research and development (R&D) investments from more advanced neighbors (Caragliu and Nijkamp 2016; Lavoratori, Mariotti and Piscitello 2020), collaboration is one of the key drivers of innovation in LDRs (Tödting, Lehner and Kaufmann 2009; Capello and Cerisola 2021). Unfortunately, even though the European Union (EU) has launched flagship programs based on research and innovation to reduce the development gap in Europe, such as the EU Framework Program (Cecere and Corrocher 2015; Proskuryakova, Meissner and Rudnik 2017; Ulnicane 2022) or the Smart Specialization place-based innovation policy strategy (McCann and Ortega-Argilés 2014; Hassink and Gong 2019), many studies show gaps in collaboration patterns between regions. This is because the selection of collaboration partners based on similarity or proximity between partners is still an influential factor for project applicants (Schwartz et al. 2012; Capone and Lazzeretti 2018).

The related literature continues to grow, although it is still segmented by field and expertise. Studies by Filippopoulos and Fotopoulos (2022) and Neuländtner (2020), which examine constraints to innovation collaboration due to geographic barriers in disadvantaged regions of Europe, suggest that creating and increasing the intensity of collaborative networks can increase opportunities for collaboration and innovation. Lalrindiki and O’Gorman (2021) highlight the important role of non-spatial proximity in substituting for the effects of spatial proximity. Badillo and Moreno (2018) highlight the importance of the capacity to absorb external knowledge and experience in collaborations between non-contiguous regions. Barzotto et al. (2019) highlight that specific motivations for collaboration are essential to distinguish LDRs from other types of regions. The results of this study suggest that even with significant geographic constraints, LDRs can successfully collaborate with more developed regions if they have the relevant motivation and the keys to success that support the motivation. However, understanding different cases in different regions, despite the same regional context, is quite challenging. Therefore, a systematic understanding and representation is needed to make these conditions easy to understand so that these problems can be overcome.

This study aims to fill the gap in the literature that has yet to explore the development and present the systematic results of studies related to the geographical challenges of R&D collaboration in the LDRs of the EU. The study also addresses relevant research questions related to how LDRs can develop R&D collaboration amidst the geographical challenges they face, the most pertinent motivations that can drive collaboration, and the critical factors that can support these motivations to increase the chances and success of collaboration. A systematic literature review approach was used to investigate all these questions.

The remaining part of the paper is organized as follows. The second section outlines the methodological procedures used to systematically conduct the literature review. The third section outlines the research findings based on the selected articles, which consist of a systematic distribution, critical reviews, and presents the motivations and critical points for improving R&D collaboration in LDRs. The fourth section concludes the study.

2 Material and methods

This study builds on the methodological approach recently conducted by Wibisono (2022) and Razpotnik Visković and Logar (2022), who conducted a systematic literature review and applied a three-step protocol in conducting the study, including 1) an initial scoping search; 2) searching, finding, and retrieving articles; and 3) conducting a systematic review.

The *first protocol* began with an initial scoping process based on the research objectives or questions. The initial scoping process referred to the PICOC concept (Roehrs et al. 2017; Mengist, Soromessa and Legese 2020). The population (P) of this study focused on LDRs in EU member states. The intervention (I) was conducted on articles relevant to the research question, highlighting the critical findings of the studies. The comparative factor (C) is represented by the synthesis of articles addressing the issue of R&D collaboration in LDRs and what factors can foster R&D collaboration in LDRs. The outcome of this study (O)

is expected to provide insights on how to address the geographical challenges related to R&D collaboration in the EU context (C).

The *second protocol* searches and retrieves literature from the Web of Science database. The keywords used in the database search were 'geograph*'; 'collaborati*'; 'network*'; 'region*'; 'innovati*'; 'europ*'. An asterisk next to each keyword indicates that the exact spelling of the word was included in the search, e.g., geography, geographical; collaboration, collaborative; network, network; region, region, regional; innovation, innovative; Europe, European. Several other restrictions were also applied (as inclusion factors), including topic limitations, language (English), document type (article), publication year (2015–2022), and Web of Science category/field (economics, geography, management, business, urban and regional planning). In terms of keywords and their relation to the research objectives, I did not use the terms 'challenge' in relation to 'geography' or 'less developed' in relation to 'region' in the search process. The aim was to find as much literature as possible on R&D collaboration in the EU region. In addition to the broad meaning of the term 'challenge', 'less developed' is not yet a standardized term to describe specific regions in the EU. Other terms such as 'peripheral regions', 'sparsely populated areas' and 'lagging regions' are often used in the literature on the same research topic.

The initial scoping process with these details resulted in 34 potentially relevant articles. The screening process was then continued by matching the attributes of the articles (especially the titles and abstracts) with the research questions/objectives. When reading the titles and abstracts, besides referring to the research objectives, to find the most eligible or highly relevant articles, attention was also paid to the content of articles related to 'geographical challenges' and 'less developed regions'. Of the 34 articles, 23 had a broad focus and were not explicitly related to the research objectives (despite having one or more

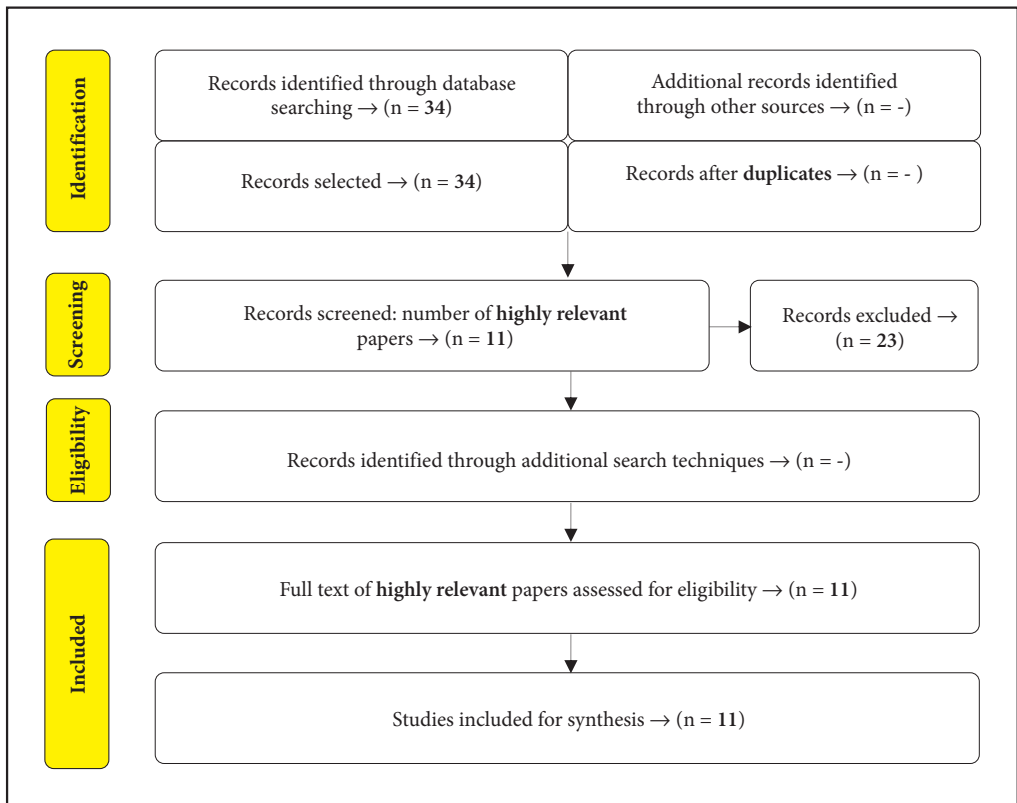


Figure 1: PRISMA diagram.

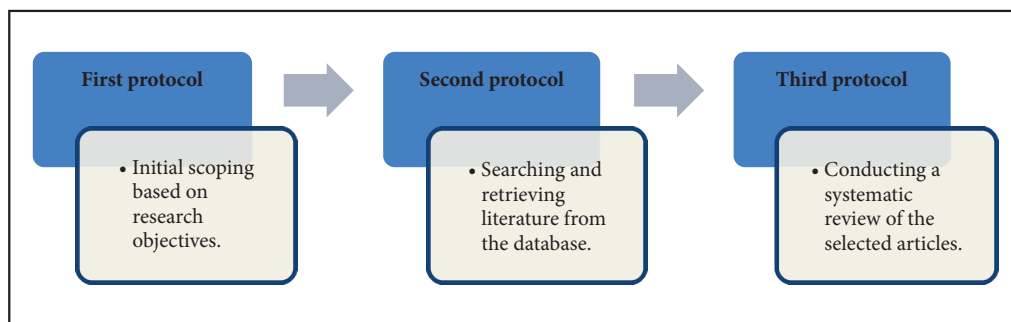


Figure 2: The research protocol.

combinations of the search terms). The articles generally addressed, for example, the relationship between innovation and economic growth or regional governance, university-industry collaboration (UIC), the evolution of regional innovation, critical resources of regional innovation, and comparative studies of Europe with other regions or countries (Asia and Africa). After excluding these irrelevant articles, only the remaining 11 eligible articles were considered for inclusion and synthesis in this study.

The PRISMA diagram (de Barcelos Silva et al. 2020; Page et al. 2021; Bejjani, Göcke and Menter 2023) in Figure 1 summarizes the article search and selection process.

The *third protocol* consists of a systematic review of the eleven selected articles. This set of articles will first be analyzed descriptively to see the characteristics, patterns, distribution of the articles, the specific focus of each article, including the journal that published it, the quality of the journal, and the scientific field or subject category of the journal. The next step was to analyze the content of the eleven selected articles according to the research objectives. This stage is the essential part of the study, which presents the critical findings of the selected articles and synthesizes them in such a way as to achieve the research objectives.

The three research protocols are presented in Figure 2.

3 Systematic literature review

3.1 Systematic distribution of selected articles

This subsection shows the systematic distribution of the selected articles. The articles are grouped by year of publication, journal and publisher, and journal topic category. Table 1 shows that from 2017 onwards, despite the initial scope limitation for 2015-2022, studies specifically addressing R&D collaboration as part of regional innovation have been published in leading journals. In 2017, two authors wrote on this topic. In 2018, studies related to this research objective were published in four articles, the most compared to previous years. In 2019, two articles were published. In the following three years, one article was published each year.

Table 1: List of selected literature.

No.	Year of Publication	No. of Articles	Authors
1	2017	2	Berge (2017), Marek et al. (2017)
2	2018	4	Amoroso, Coad and Grassano (2018), Badillo and Moreno (2018), De Noni, Orsi and Belussi (2018), Lata, von Proff and Brenner (2018)
3	2019	2	Barzotto et al. (2019), Miguelez (2019)
4	2020	1	Neuländtner and Scherngell (2020)
5	2021	1	Lalrindiki and O'Gorman (2021)
6	2022	1	Filippopoulos and Fotopoulos (2022)

Table 2 shows the distribution of articles by journal and publisher and the quality or quartile (Scimago Journal Rank) of the journal. Three articles were published in *Annals of Regional Science* – Springer Verlag, followed by *Research Policy* – Elsevier B.V. with two articles, and the remaining six were published in different journals. From this distribution, the selected articles were published in journals of high quality or the top quartile.

Of the eleven articles selected, seven (64%) were published in top-quartile (Q1) journals. This indicates that research on R&D collaboration is at the forefront of regional innovation studies. However, there are still many opportunities for research on this topic. While other research on innovation has increased and found that collaboration is crucial for innovation, research specifically addressing R&D collaboration and its interaction with factors such as spatial and non-spatial proximity and knowledge networks still needs to be improved, especially in the context of the LDRs of the EU. Such studies, published in leading journals, provide ample opportunities for future researchers to further explore how R&D collaboration can foster regional innovation in LDRs of the EU.

Looking at Figure 3, the articles are distributed across several subject categories of the journal, namely: Social Sciences (37%), Technology and Innovation Management (27%), Economics, Econometrics and Finance (18%), and Geography, Planning and Development (18%). This chart may help guide future research in finding studies relevant to R&D collaboration in the context of LDRs of the EU.

Table 2: Sources of publications.

No.	Publication Source & Publisher	No. of Articles	Quartile (SJR 2022)
1	<i>Annals of Regional Science</i> – Springer Verlag	3	Q2 – Social Sciences
2	<i>Economics of Innovation and New Technology</i> – Routledge	1	Q1 – Economics, Econometrics and Finance
3	<i>Papers in Regional Science</i> – Wiley-Blackwell	1	Q1 – Geography, Planning and Development
4	<i>Regional Studies</i> – Routledge	1	Q1 – Social Sciences
5	<i>Research Policy</i> – Elsevier B.V.	2	Q1 – Management of Technology and Innovation
6	<i>Technovation</i> – Elsevier Ltd.	1	Q1 – Management of Technology and Innovation
7	<i>Cambridge Journal of Regions, Economy and Society</i> – Oxford University Press	1	Q1 – Geography, Planning and Development
8	<i>Triple Helix</i> – Brill Academic Publishers	1	Q2 – Economics, Econometrics and Finance

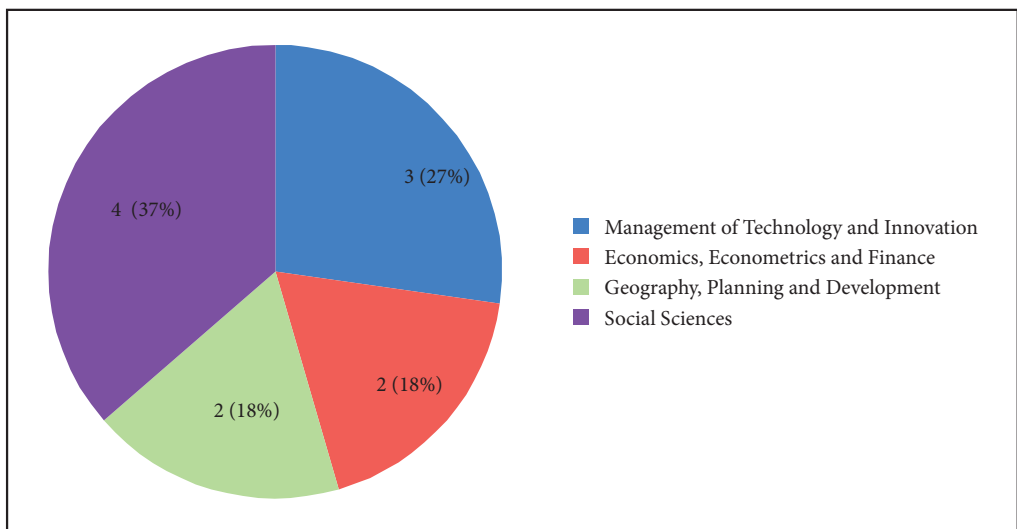


Figure 3: Journal subject categories.

3.2 Critical findings of selected articles

This subsection critically reviews the main content of the selected articles. The articles are divided into two groups (Figure 4). It should be noted that the second group of articles does not explicitly consider the type of region (in this case, LDR) as the first group of articles does. However, as the geographical challenges in the second group of articles are also discussed in the context of R&D collaboration for innovation at the regional level, it can be assumed that LDRs also face similar challenges.

Filippopoulos and Fotopoulos (2022) addressed the issue of differences in innovation performance between developed and LDRs in 183 NUTS (Nomenclature of Territorial Units for Statistics) 2 regions in the EU. The study applied the Fuzzy-set Qualitative Comparative Analysis (FsQCA) method to address methodological gaps in innovation studies that are difficult to address using econometric approaches. The critical findings of this study show that LDRs are characterized by public R&D-driven innovation mechanisms and actively participate in collaborative R&D networks with more developed regions. However, LDRs are also characterized by innovation at a more superficial technological level, which is one of the reasons why these regions have low patent production. Not to mention that they also lack knowledge spillovers from neighboring regions due to unfavorable geographical conditions.

In line with this, Barzotto et al. (2019) show that collaboration between LDRs and developed regions, while motivated by technological upgrading, is not essentially driven by technological proximity. This condition causes more developed regions to benefit less from technology upgrading when they collaborate with LDR, which becomes a challenge for LDR to attract them into collaboration. In the context of smart specialization, Barzotto et al. (2019) emphasize that technological proximity should not be the primary goal of collaboration for LDRs, but rather other strategic or public policy goals, such as collaboration in the entrepreneurial discovery process (EDP), which allows LDRs to involve stakeholders or other partners from more developed regions.

In the context of research networks in the EU Framework Program, Amoroso, Coad and Grassano (2018) point to the spatial clustering of knowledge networks, which creates an imbalance between developed regions and LDRs. The geographical barriers and limited capacity of R&D resources in LDRs contribute to low technology absorption in the region. Meanwhile, collaboration is easier for developed regions because they are more flexible in choosing collaboration partners with a background of proximity or similar innovation characteristics. Even after considering all geographic and non-geographic proximity factors, geographic distance remains an essential consideration for collaboration in developed regions. Not surprisingly, the intensity of collaboration in LDRs is low.

To foster innovation in LDRs, De Noni, Orsi and Belussi (2018) highlight the importance of strengthening organizational and institutional capacities to generate collaborative networks. Analyzing a seven-year dataset of 205 EU regions shows that collaborative R&D networks in LDRs can be fostered by continuously

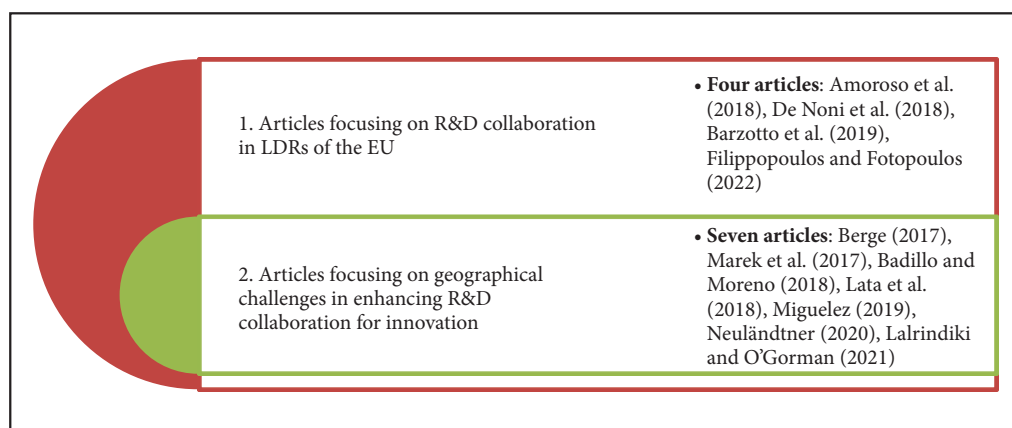


Figure 4: Grouping of articles by study focus.

creating and strengthening links between LDRs and other regions with broader knowledge by improving their organizational and institutional capacity. In absorbing external knowledge, LDRs should involve key innovation actors as one of the stakeholders, such as inventors or senior researchers. The combination of these factors has the potential to create a solid internal knowledge network that can attract developed regions to collaborate with LDRs.

Regarding geographic constraints, Lalrindiki and O’Gorman (2021) examined the interaction and interdependence of non-geographic factors in the collaboration of triple helix actors in non-contiguous European regions. They recommended an interregional innovation system (iRIS) framework that integrates various non-geographic proximity factors to foster collaboration. The interdependence of non-geographic proximity, such as cognitive proximity and social proximity, tends to increase the effectiveness of iRIS through a process of openness to learning and knowledge sharing based on mutual trust, understanding, respect, and intensive communication between partners. Meanwhile, organizational proximity can enhance collaboration by improving organizations’ management quality and leadership spirit. It has much to do with the planning, structuring, and distributing of tasks in collaborative projects.

On the same issue, Badillo and Moreno (2018) proved the positive significance of domestic-international collaborative alliances of Spanish firms. Innovation collaborations with high-tech global firms in the United States (US), India, and China significantly impact the technological change of Spanish domestic firms. The most significant impact is due to innovation collaborations with the US. Meanwhile, the results of collaborations with India and China, although less significant than those with the US, are still more impactful than collaborations with domestic firms or other EU members. In these collaborations, domestic firms are highly motivated to absorb external knowledge and technology effectively and efficiently from partner firms. The results of this study highlight the importance of enhancing the absorptive capacity of local partners to achieve optimal impact from innovation collaborations, especially if they have to cross geographically distant boundaries.

With respect to smaller firms, such as small and medium-sized enterprises (SMEs), Marek et al. (2017) investigated the interaction of spatial and proximity factors in German National Collaboration Program projects from 2006 to 2012 that heavily involved the private sector. The unique finding of this study is that the impact of geographic and organizational proximity on collaboration forms an inverted U-curve or has a negative direction at saturation or a certain threshold. Organizational proximity cannot simply replace geographic proximity, but the two are interdependent. Similarly, cognitive proximity cannot directly replace geographic proximity, but the link between them can potentially strengthen collaboration. Organizational proximity and cognitive proximity in interregional collaboration in Germany require a high level of knowledge absorption by collaborating firms, which is one of the keys to the success of this program.

Geographic distance is still a serious problem in patent collaboration in Europe. Lata, von Proff and Brenner (2018) point this out in their study and compare it with the US. While in the US distance between locations can weaken collaboration, in Europe this geographic distance is more related to language and national borders. In this respect, R&D collaboration in Europe is still possible for short to medium distances, such as a maximum of 300 km. Beyond this distance, collaboration opportunities are further reduced, especially when language and national borders are already dominant constraints. In Europe, cognitive proximity is more conducive to collaboration as R&D and innovation policies grow from mature knowledge (Tödtling and Trippl 2005; Ranga and Etzkowitz 2013). The challenge, however, is how cognitive proximity can counteract the negative effects of geographic proximity.

Migueluez (2019) explores collaboration and social proximity among inventors from different regions who share the commonality of having previously worked in the same field and location. The study uses microdata of biotechnology inventors from the European Patent Office (EPO) from 1978 to 2005. Assuming that these social relationships are long-lasting, the results of the conditional fixed effects logit model estimation suggest that such relationships can accelerate the formation of collaborative relationships in their current spatial context and give rise to joint patents. The positive effect of past co-location factors is even more significant when the spatial distance between regions becomes larger (e.g., at the NUTS 2 regional level) or when knowledge workers have crossed national borders. Indeed, there will be higher transaction costs when there are cultural and organizational differences in extra-regional or international collaborations to make these collaborations happen. However, the social relationships that have developed between them in the past are expected to overcome these barriers.

Berge (2017) investigated the impact of R&D collaboration networks in overcoming geographical barriers in five major EU countries (Germany, France, Spain, Italy, and the United Kingdom). The main idea of the study is that network connectivity can compensate for increased geographical distance in R&D collaboration. Using gravity and Poisson regression modeling of 17,292 regionally paired chemical science co-publication data (as a measure of network proximity between regions) from 132 NUTS 2 regions in 2001–2005, the results of his study show that network proximity can increase as geographical distance increases, both in the sense of physical space and through the influence of national borders. This finding suggests that interregional collaboration remains possible over large distances by creating network connectivity or increasing network proximity between potential collaboration partners.

Neuländtner (2020) combines the two dimensions of geographic and technological proximity and collaborative networks in a unified model. A dataset of 505 EU metropolitan and non-metropolitan regions that have received EU Framework Program projects was grouped by Key Enabling Technologies (KETs) into six interregional R&D networks. By analyzing a negative binomial spatial interaction modeling approach, the results show that geographical barriers of distance and borders are still a significant challenge in building collaborative networks and that the negative effect of national borders on collaboration by the KET group in the EU is profound, even though the EU Framework Program is designed to minimize such risks (Koschatzky and Stahlecker 2010; Pandza, Wilkins and Alfoldi 2011; Arnold 2012; Varga and Sebestyén 2017). With respect to technology-motivated collaborations, the negative effects of geographic distance tend to drive nanotechnology collaborations, while the negative effects of national geographic boundaries tend to drive R&D collaborations in microelectronics and advanced materials technologies. On the other hand, network effects across regions enable collaboration in all technology groups regardless of geographical barriers. Regions with high network embeddedness are more likely to form collaborations, especially if they have sufficient network centrality. This study contributes to R&D policy advice for motivating regional technological capacity building. The data configuration in this study shows that if geographical factors can cluster regional collaboration by specific technology groups, network effects open up collaboration for all regions across all technology categories. Therefore, regional innovation policies should be encouraged to overcome geographical barriers by creating new knowledge networks. The creation of local knowledge networks can be fostered by cooperation between local R&D institutions and those with experience in extra-regional or international cooperation.

3.3 Motivational drivers and critical factors for successful R&D collaboration in LDRs of the EU

This subsection is designed to answer the main research question of this study, i.e., how R&D collaboration can be realized in LDRs of the EU, given their geographical challenges, and what motivations and critical factors can support these motivations and enhance the success of LDR collaboration. Like other regions, LDRs have the necessary capital to develop their regions, although innovation is not necessarily a top development priority. To activate regional resources for innovation, LDRs are first encouraged to have internal knowledge networks supported by adequate organizational and institutional capacities (De Noni, Orsi and Belussi 2018). As a first step, LDRs need to build linkages with other more developed regions that are appropriate to their resources. Furthermore, LDRs are expected to have the capacity to absorb diverse external knowledge and experience of more developed regions in managing innovation organizations and institutions as the main capital to create internal knowledge networks (Capello and Lenzi 2018; Trippel, Zukauskaitė and Healy 2019; Marques and Morgan 2021; Wibisono 2022). The involvement of critical actors in innovation should also be encouraged to create interregional linkages (Gertler and Levitte 2005; Yoon and Park 2017).

According to Barzotto et al. (2019), the main motivation for innovation collaboration in LDRs should not be technologically driven only, as is the case for collaboration between more developed regions. LDRs are still at a more basic technological stage, which may be less attractive for more advanced regions. Therefore, the motivations for LDR collaboration could be more strategic or for policy-making purposes. For example, regional domain specialization through the Entrepreneurial Discovery Process (EDP) is identified in the policy context of the Smart Specialization Strategy (S3). Collaboration in the context of smart specialization enables inter-organizational and inter-regional cooperation to improve the success of its implementation (Di Cataldo, Monastiriotis, and Rodríguez-Pose et al. 2020; Foray, Eichler and Keller 2021; Ghinoi et al. 2021).

However, it is important to consider that collaboration must also be mutually beneficial (Silva et al. 2021). Providing incentives to developed regions that may not be related to knowledge or innovation can encourage them to consider collaborating with LDRs (Foray 2014; Uyarra 2019; Meyer, Gerlitz and Klein 2022). This description leads us to the *first motivation* for R&D collaboration in LDRs, which is driven by strategic or policy objectives. The critical factor is creating a mutually beneficial relationship between the collaboration partners.

Technological similarity and cognitive proximity offer many advantages for collaboration, especially for those with geographical proximity (Lazzeretti, Capone and Cinti 2010; Bathelt and Henn 2014). As explained in the study by Marek et al. (2017), regional collaboration projects in Germany benefit from the geographical proximity of regions, coupled with their technological level and absorptive capacity. These factors are essential for planning the project schemes to be developed. In the case of LDR, this experience can be instructive. Given that, according to Lata, von Proff and Brenner (2018), collaboration is still possible at short and medium distances (up to 300 km), LDRs that fit this category have a great opportunity to realize collaboration. Cognitive proximity can be fostered by increasing absorptive capacity when the initial connection is established (Badillo and Moreno 2018; De Noni, Orsi and Belussi 2018). If technology is a strong motivation for collaboration in LDRs, they should strongly consider absorptive capacity to attract more advanced neighboring regions to collaborate (Hellsmark et al. 2016; Meissner 2019; Tang et al. 2020). This description suggests a *second motivation* for R&D collaboration in LDRs that is driven by cognitive or technological proximity, and the critical factor is increased regional absorptive capacity.

For geographically distant regions, organizational and institutional proximity further compensates for the barriers of geographic distance. Establishing initial links, strengthening organizations and institutions, and learning from the experiences of more advanced regions are essential processes in collaboration (Gertler and Levitte 2005; Ranga 2018; Lalrindiki and O’Gorman 2021). These processes create mutual trust and understanding between collaborative partners. For organizational and institutional proximity to be a factor that can offset the negative effects of geographic distance, leaders of organizations in the region must have good leadership and management skills, as these skills will be very influential in planning, implementing, and developing the collaboration. The mutual trust and understanding created in the process will lead to openness and ease of communication. This description shows the *third motivation* for R&D collaboration in the LDR, which is driven by organizational and institutional proximity, and an important factor is leadership and management skills.

The study by Neuländtner and Scherngell (2020) is one of the few empirical studies that combines several proximity factors and network effects in one analytical framework, which are analyzed separately in other studies (e.g., Cantner and Graf 2006; Allen, James and Gamlen 2007; Fritsch and Kauffeld-Monz 2010; Marrocu, Paci and Usai 2013). According to the results of these studies, cooperation in LDRs is likely to be

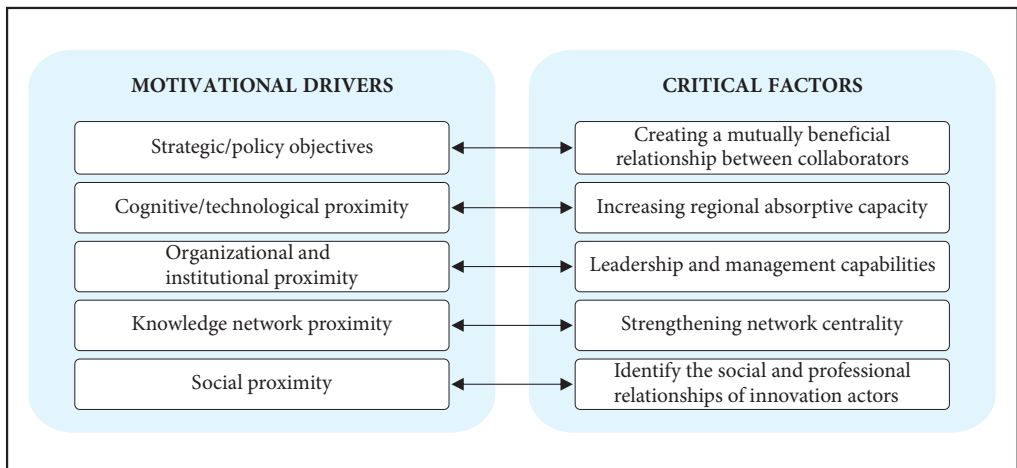


Figure 5: Motivational drivers and critical factors for R&D collaboration in the LDRs of the EU.

successful when interregional networks are formed and various network effects occur, supported by a combination of proximity factors. Under these conditions, network centrality becomes crucial, as it will attract other regions to collaborate with LDRs. As Berge (2017) argues, network proximity is inversely proportional to geographic distance, implying that geographic barriers can be overcome by increasing network connectivity. The network proximity effect ultimately removes geographic distance when network proximity is optimal (Chen and Lin 2014; Janssen, Bogers and Wanzenböck 2020; Pires et al. 2020; Komlósi et al. 2022). This description suggests a *fourth motivation* for R&D collaboration in LDRs, driven by knowledge network proximity, and an important factor is to strengthen network centrality.

The mobility of knowledge workers is important because the social interactions and relationships formed in the process will benefit the region in the future, even over long geographical distances. Long-term social interactions are also thought to create proximity and foster collaboration (Agrawal, Cockburn and McHale 2006; Torre 2008; Breschi and Lissoni 2009; Lavie, Kang and Rosenkopf 2011). Using a dataset spanning three decades, Miguelez (2019) provides evidence that innovation actors who have worked in the same field and location in the past have social ties, potentially opening up opportunities for future collaboration. Certain less developed regions are likely to have at least some of these innovation actors. The challenge for the region is to find and identify them and explore opportunities for collaboration through this social proximity. As suggested by Lalrindiki and O’Gorman (2021), social proximity is related to cognitive proximity, which assumes that social relationships can open up opportunities for knowledge exchanges. This description suggests a *fifth motivation* for R&D collaboration in LDRs driven by social proximity, and a critical factor is the identification of past social interactions and relationships of innovation actors.

Five motivational drivers and critical factors for R&D collaboration in the LDRs of the EU are presented in Figure 5.

4 Conclusion

This study aims to fill the literature gap on R&D collaboration for innovation in the context of a less developed region of the EU characterized by geographical challenges. The exploration and investigation of relevant literature through the systematic literature review protocol shows that this topic is developing and is at the forefront of the EU innovation studies. On the other hand, the limited research on this topic opens opportunities for future research to explore further. The critical review of the selected articles reveals two crucial emphases. *First*, if LDRs are to establish successful collaborative relationships with developed regions, three things need to be prioritized, namely, openness to external knowledge that can be used to enhance regional innovation, the ability to absorb knowledge and experience from partner regions, and the ability to identify critical actors to engage in collaboration for innovation. *Second*, five motivational drivers need to be reinforced by five critical factors to improve the success of LDR collaboration with developed regions, namely, collaboration motivated by strategic and public policy objectives needs to be supported by mutually beneficial relationships between partners, collaboration motivated by cognitive proximity needs to be strengthened by knowledge absorption capabilities and capacity, collaboration motivated by institutional proximity needs to be supported by leadership and organizational management capabilities, collaboration motivated by knowledge network proximity requires strengthening the centrality of knowledge networks, and collaboration motivated by social proximity can be focused on past relationships between innovation actors.

This study is expected to have practical and academic implications for the implementation of innovation policy through R&D collaboration between LDRs and developed regions, by considering the challenges and factors supporting its success and encouraging future studies focusing on innovation development in LDRs of the EU. Given the limited current literature explicitly addressing related issues in the databases searched, it is inevitable that the results of this study cannot be generalized to broader issues of R&D collaboration. The study also recognizes its limitations in robustly justifying and comprehensively presenting the interrelation between geographically challenged and less developed regions. Therefore, categorizing or differentiating between less developed and other types of regions, such as peripheral, sparsely populated, lagging, and underdeveloped, may suggest different interpretations of the study results. Finally, the points presented in this study regarding motivational drivers and critical factors are still propositions, and therefore further research needs to be conducted to validate them empirically.

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