Knowledge Drivers, Business Collaboration and Competitiveness in Rural and Urban Regions

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Summary

Many rural regions are characterised by low technology-intensive activities. Their predominant focus is often on primary, agri-food, and natural resources and services sectors, and there is a competitive gap with respect to urban regions. The objective of this article is to determine the contribution of the innovation system to regional development, distinguishing between rural and urban regions. Qualitative comparative analysis (QCA) was used to study 256 EU NUTS 2 regions. The analysis helped identify 'recipes' of drivers of regional competitiveness in rural and urban regions. These innovation recipes consist of varying combinations of private and public R&D expenditure, the presence or absence of top-ranked universities and the percentage of SMEs that collaborate in innovation activities. In rural regions, excellence in higher education combined with strong public and private R&D offers an important recipe for regional competitiveness. Alternative pathways include the presence of business collaboration as a driver of competitiveness.

Key words: regional innovation, regional competitiveness, innovative pathways, Qualitative Comparative Analysis (fsQCA)

1 Introduction

Many rural regions are characterised by low technology-intensive sectors with a focus on primary, agri-food and natural resources sectors. Competitively, they often lag behind urban regions. These differences beg the question of what role the innovation system plays in regional development. This paper focuses on a key element of regional competitiveness, namely the ability of regions to produce, absorb and disseminate knowledge (Cooke et al. 2011; Pike et al. 2016; Akpinar et al. 2017). It also examines the availability of knowledge-intensive infrastructures and services (Huggins and Johnston 2010). The present study assesses the relevance of knowledge-related variables, testing their influence on regional competitiveness in rural and urban regions.

Research on regional innovation and competitiveness has been conducted from different theoretical and methodological perspectives, such as triple helix, clusters and innovation systems, to name but a few (Jiao et al. 2017; Ericson et al. 2018; Kveton and Horak 2018). Some scholars insist on the potential differences between rural and urban regions (Harpa 2017; Aryal et al. 2018). Rural regions face problems in the form of lack of accessibility, lower levels of agglomeration and limited access to knowledge centres (Doloreux and Dionne 2008). Rural firms are also less likely to be growth oriented, which may be attributed to owners' social characteristics or an aversion to the risks associated with adopting innovations (Knickel et al.

2009). Aryal et al (2018) stressed that rural and urban businesses differ in their innovative nature, suggesting that urban firms squeeze more out of their resources than rural firms. Nevertheless, those authors suggest that the innovation creation enhanced by universities may be an advantage in rural contexts. Jakobsen and Lorentzen (2015) demonstrated that collaboration in innovation activities is especially important amongst small and medium-sized enterprises (SMEs) in rural regions. In such regions, SMEs take a more active part in creating linkages than firms in urban areas. This is especially true in sectors such as agri-food, where spill-over effects of new technologies are more critical (Bayona-Saez et al. 2017, Heisei and Fuglie 2018).

In this paper, qualitative comparative analysis (QCA) is used to identify the 'recipes' of conditions that are necessary or sufficient to characterise a region as competitive. In the analysis, a distinction is made between predominantly rural, predominantly urban and intermediate regions. Regional competitiveness is the outcome of interest that the analysis seeks to explain. The recipes consist of the presence or absence of certain innovative characteristics (or conditions) that the theory suggests may be linked to regional competitiveness. These conditions are (i) percentage of firms that collaborate in innovation activities; (ii) presence of excellent universities, indicated by the presence of top-ranked universities; (iii) public spending on R&D; and (iv) private business spending on R&D. In the coming pages, a review of the possible links between such characteristics and the outcome of regional competitiveness is presented (Section 2). Next, Section 3 describes the QCA methodology and its application to the evaluation of the links between innovation characteristics and competitiveness. Section 4 presents the main findings and distinguishes between the results for the rural and urban subsets. Finally, Section 5 offers the conclusions and limitations of the study.

2 Background

2.1 Urban-Rural Differentiation

Innovation processes are largely related to the regional context where firms operate (Audretsch 2003; Kalantaridis and Bika 2006; Garcia-Alvarez-Coque et al. 2013 and 2015; Breitenecker et al. 2016). Some authors have noted that the mediating effect of the knowledge structure can help explain the varying effect of some forms of innovation on business performance in different types of regions (Zhou et al. 2019). The business environment in rural regions has weaknesses due to the quality of schools and transportation networks. Other infrastructure-related issues also hamper access to modern support services and the use of advanced technologies. Hiring qualified workers in rural areas is hindered by limited access to public services (Webber et al. 2009). Limited accessibility can impede innovation if there is a low presence of non-local networks (Atterton 2007). As explained below, however, a collective orientation in rural areas could help build bonds. Firms in rural economies do not enjoy some of the advantages that industries in urban areas possess. Examples include direct access to urban markets, the ability to build economies of scale and an assured supply of resources. Capital markets are also affected by a lack of proximity to metropolitan areas because transaction costs for venture capital access are higher (Henderson 2002). However, Chi and Marcouiller (2009)

report that natural amenities (landscapes, open space, climate, forests, etc.) are important resources that help generate employment and drive economic activity. Despite rural regions' handicaps, no single innovation pattern can ensure that urban and rural regions will be competitive or non-competitive.

2.2 The Role of Business Collaboration

Studies have highlighted the key role of inter-firm collaboration in generating regional competitive advantages (Chesbrough 2006; Ystrom and Aspenberg 2017). Collaborative networks help organisations access various types of knowledge that are crucial for business and regional competitiveness (Bjerke and Johansson 2015; Miozzo et al. 2016). The intensity of inter-business collaboration depends largely on certain local characteristics such as culture, historical experience, and the rural or urban nature of the region (Mackinnon et al. 2009; Martin and Boschma 2010).

Dense urban areas are depicted as environments that are conducive to promoting innovation processes. Rural regions, in contrast, usually lack specialised suppliers of knowledge-intensive services, financial institutions and research centres. This institutional weakness is usually defined as 'organisational thinness' (Jakobsen and Lorentzen 2015). However, Shearmur (2017) and Meili and Shearmur (2019) have argued that the role of rural contexts should not be underestimated.

Often, companies located in rural settings have a remarkable sense of belonging to their surroundings. This sense of belonging has two favourable consequences for collaboration. First, stable values, together with this sense of belonging, can be a positive element of agricultural and rural systems. Second, this feeling of belonging creates possibilities for interactions within the region, assuming that companies can find suitable partners (Martin and Sunley 2006). In the face of resource constraints, individuals act as agents in creating and sourcing external input for the benefit of their projects (Scott et al. 2019). Jakobsen and Lorentzen (2015) add that innovative rural firms must establish networks and links with partners outside their region. Camarero (2009) and Camarero and Sampedro (2019) have shown that the sustainability of territories is the result of not only economic growth and material conditions but also social interactions.

Highly competitive companies in rural regions tend to counteract their lack of internal resources through the use of social networks (Grillitsch and Nilsson 2015; Shearmur and Doloreux 2016). Access to the Internet, the possibility of exchanging information remotely, the search for strategic partners and other such factors can help overcome barriers to collaboration in rural environments (Meili and Shearmur 2019). Recent research has highlighted the importance of innovation networks in the agri-food sector, which, by extension, could be applied to rural areas (Tóth and Rizzo 2020).

Research on the number and density of collaborative networks has shown that an excess of connections can actually be detrimental to business performance because of the management difficulties involved in operating with a large number of external agents and extensive knowledge (Katila and Ahuja 2002; Mors 2010). The study by Laursen and Salter (2006)

suggests the existence of an inverted U-shaped relationship between business performance and the number of external collaborators.

Therefore, the contribution of business collaboration to regional competitiveness is hypothesised to be positive. However, this influence may be affected by the local context in rural and urban regions. Whilst organisational thickness in predominantly urban regions is expected to boost regional competitiveness, the collective orientation found in predominantly rural regions can hinder competition and rivalry, which are characteristics of urbanised contexts.

Proposition 1. Regions with high levels of business collaboration are highly competitive.

Proposition 2. Collaboration is a key driver of regional competitiveness, but this role is affected by the characteristics of rural and urban regions.

2.3 Universities and Regional Development

Universities have added the mission of promoting regional development to their traditional functions of education and research (Breznitz and Feldman 2012; Loi and Di Guardo 2015). The contribution of universities to regional competitiveness does not occur automatically. Instead, it requires the transfer of knowledge, which in turn is related to factors such as the level of business collaboration in the region and private and public investment in R&D. Therefore, synergies between the presence of top universities and other knowledge-related characteristics are important.

In addition, the contribution of universities to regional development largely depends on the socioeconomic characteristics of the region (Cowan and Zinovyeva 2013). García Álvarez-Coque et al. (2019) suggest that the impact of highly ranked universities on regional competitiveness varies according to the regional context. Therefore, the analysis in this study is differentiated according to whether the region is rural or urban. Salomaa (2019) notes that case studies of universities based in rural regions tend to highlight the importance of business leadership and personal commitment amongst actors (Foss and Gibson 2015; Lindeman 2015; Ferreira et al. 2019).

Proposition 3. Regions with excellent universities are highly competitive.

Proposition 4. Presence of excellent universities is a key driver of regional competitiveness, but it is more important in rural regions that lack other innovation characteristics.

2.4 Public and Private R&D

Most studies indicate the positive impact of R&D spending on regional growth and productivity. The potential difference in the effect of public versus private R&D spending on regional competitiveness has been shown by Pichová (2015) and Kveton and Horak (2018), amongst others. The literature provides a detailed discussion of the complementarity or substitutability of public and private R&D spending (David et al. 2000; Mas-Verdu et al. 2016).

However, recent research (Marino et al. 2016; Choi and Le 2017) has also pointed out the absence of the substitutive effects of private and public investment in R&D. Moreover, research has shown that private spending on R&D can be strengthened by supporting public actions. The public sector can provide the right infrastructure to support research and innovation. This infrastructure includes knowledge transfer offices, public research centres and higher education institutions to train highly qualified human capital talent. The role of public spending in R&D may be more important in rural regions, where the absence of large companies means that private R&D spending is lower.

Proposition 5. High R&D spending is present in highly competitive regions.

Proposition 6. The comparative influence of private and public R&D spending may vary depending on the rural versus urban nature of the region.

3 Method: Fuzzy-Set Qualitative Comparative Analysis (fsQCA)

Fuzzy-set qualitative comparative analysis (fsQCA) was applied for the analysis in this study. This technique can be used to evaluate how the membership of different cases (regions) to different fuzzy sets is consistent with a given outcome of interest.

The qualitative comparative analysis (QCA) method developed by Ragin (2008) has the advantage of showing a selection of alternative 'recipes' of attributes that can lead to a given outcome of interest. This approach proves useful for policy analysis. Furthermore, fsQCA is a suitable methodology for regional analysis (Garcia-Alvarez-Coque et al. 2017; Nieto-Aleman et al., 2019; Alama-Sabater et al. 2019).

The current study uses fsQCA to explore how combinations (recipes) of the presence or absence of specific innovation attributes are linked to the outcome of regional competitiveness. According to Ragin (2008) and Schneider and Wagemann (2012), a fsQCA study follows a series of steps.

(i) First, the raw data are transformed into sets indicating whether each characteristic is present or absent in a given region. This step is called calibration. In this study, to calibrate the conditions and the outcome from the raw data to a set, the direct method proposed by Ragin (2008) was used. This method establishes three thresholds: fully inside the set, fully outside the set and the cross-over point (neither inside nor outside).

(ii) Second, analysis of necessary conditions for the outcome must be performed.

(iii) Third, recipes that are considered sufficient for the outcome are analysed. Prior to this step, the 'truth table' must be created. This table summarises all logically possible combinations of characteristics (presence or absence of attributes). The size of the truth table is 2^k, where k is the number of individual conditions. In this study, for example, five attributes were considered. Therefore, 32 possible recipes were explored. In fsQCA, an algorithm is used to reduce the truth table. The most relevant

recipes with acceptable levels of consistency are thus selected. The idea behind considering all logically possible recipes lies in not discarding combinations of conditions that might complement one another.

3.1. Data and Calibration

The regional unit for the QCA was the Nomenclature of Territorial Units for Statistics level 2 (NUTS 2) for European regions. Specifically, 256 regions were analysed. From these regions, 82 were classified (in the calibration process) as predominantly urban, 119 were classified as predominantly rural, and 55 were classified as intermediate regions.

Table 1 summarises the description of the outcome, the causal conditions and the data source. Table 1 also shows the main descriptive statistics for the raw data.

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INSERT Table 1

Table 1. Description (outcome/conditions), data source and descriptive statistics for the raw data

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In this study, four models were specified. Model a contained the five causal conditions for regional competitiveness for the 256 analysed regions. Models b, c and d contained four conditions (public investment in R&D, private investment in R&D, collaborative regions and top-ranked universities). These models corresponded to the analysis of predominantly urban regions, predominantly rural regions and intermediate regions, respectively.

Ragin (2000, p.7) defined a fuzzy set as a 'fine-grained, continuous measure that has been carefully calibrated using substantive and theoretical knowledge relevant to set membership'. However, in cases where there is insufficient theoretical knowledge, Greckhamer et al. (2018) proposed the use of the properties of the study's sample.

Following Ragin (2008), the method used to calibrate the raw data into sets was the direct method. This method consists of establishing three thresholds: one for full membership, one for full non-membership and one for the cross-over point (neither membership nor non-membership). This point is best clarified with the help of an example. Take an imaginary example with the *public investment in R&D* condition. Suppose there are three regions: A, B and C. Public investment in R&D in these three regions is as follows: 5.0%, 2.2% and 1.5% of GDP, respectively. The direct method is used to calibrate the raw data to sets. At this point, a region is considered to have a high level of R&D investment if the region invests more than 3% in R&D. A region is considered to have a low level of R&D investment if it invests less than 1%. Regions with an R&D spend of 2% are at the cross-over point. Therefore, the transformation of A, B and C to a set will be as follows: A = 1, meaning that A is fully inside the set of regions with high levels of R&D investment; B = 0.65, meaning that it is more in than out; and C = 0.18, meaning that it is mostly (but not fully) outside the set.

In this study, the following specific thresholds were used: the 75^{th} percentile and 25^{th} percentile

were used as cut-offs to determine the full presence or full absence of the innovative characteristics of public investment in R&D, private investment in R&D and collaborative regions; the median was used to establish the point of maximum ambiguity, or cross-over point (Misangyi and Acharya 2014). These thresholds were also applied to the outcome of regional competitiveness. The condition *top-ranked universities (500)* was calculated as the number of top 500 universities in the region per million inhabitants. To establish the presence of excellent universities, the thresholds were the 75th, 50th and 25th percentiles.

To measure the degree of rurality, the EUROSTAT methodology was followed. This methodology provides a spatial delimitation of regions based on population density (EUROSTAT, 2018). EUROSTAT categorises NUTS 3 areas as predominantly rural (PR; more than 50% of population living in rural communities), intermediate (IR; rural population accounts for 20%–50%) and predominantly urban (PU; rural population of less than 20%). To combine the data with the Regional Innovation Scoreboard data, the NUTS 2 data were obtained using a similar method of aggregation of NUTS 3 regions to the method proposed by Mas-Verdu et al. (2016). Specifically, to calibrate degree of rurality, the percentages of PR, PU and IR of each region were first calculated. For example, if a NUTS 2 (FR21) region had four NUTS 3 regions where three were rural, zero were urban and one was intermediate, the percentage would be 75% rural and 25% intermediate. Second, the following fuzzy values were assigned to the NUTS 2 regions:

- more than 80% rural = 1;
- more than 60% rural = 0.8;
- more than 80% urban = 0.0;
- more than 60% urban = 0.2;
- if rurality was higher than 30% and lower than 60% and the intermediate percentage was higher than 40% and lower than 80%, then the fuzzy value was 0.6;
- if the urban percentage was higher than 30% and lower than 60% and the intermediate percentage was higher than 40% and lower than 80%, then the fuzzy value was 0.4;
- if 50% of the region was rural, then the fuzzy value was 0.7;
- if 50% of the region was urban, then the fuzzy value was 0.3;
- if the intermediate percentage was higher than 75%, then the fuzzy value was 0.49.
- Finally, ambiguous situations (e.g. IR = 0, PR = 50%, PU = 50%; IR = 33%, PU = 33%, PR = 33%; IR = 50%; PU = 25%; PR = 25%) were calibrated as 0.49. The value 0.49 was used instead of 0.5 because values of 0.5 are not interpretable and are automatically dropped by the truth table generation process. Map 1 shows the results of the calibration.

Public investment in R&D, private investment in R&D and collaborative regions are expected to be ingredients of recipes (configurations) that lead to high levels of regional competitiveness. The same is expected of regions with excellent universities. However, these effects may be influenced by whether the region is rural or urban, as explained in Section 2. This factor may specifically affect the contribution of collaborative regions, which may be more important in regions that lack a supply of knowledge, R&D investment and top-ranked universities.

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INSERT Map 1

Map 1. Predominantly rural, predominantly urban and intermediate regions

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After building the truth table with all logically possible combinations of conditions, optimisation was performed using the R software QCA package developed by Medzihorsky et al. (2018). *Necessary conditions* are conditions that are required for the outcome to occur. However, necessary conditions may not be enough by themselves. By contrast, *sufficient recipes* tend to lead to the outcome in most cases. Consistency scores were measured by calculating the proportion of cases for which the condition leads to the outcome with respect to the total number of cases where that condition is present. The coverage score reflects the proportion of cases where the outcome is represented by a particular configuration of attributes.

4 Findings and Discussion

According to the European Regional Competitiveness Index (Annoni et al. 2017), 34 predominantly rural regions were above the 50th percentile of regional competitiveness. This number corresponds to only 13% of the total subset of predominantly rural regions. However, this percentage is not negligible. Naturally, there were also competitive regions of the other two types. There were 57 competitive predominantly urban regions and 29 competitive intermediate regions. There was also a substantial percentage of non-competitive regions in both subsets (30% and 46% in predominantly rural and predominantly urban regions, respectively). Therefore, it is not immediately obvious that being a rural, urban or intermediate region determines whether the region is non-competitive.

4.1 Necessary Conditions

The 'presence' or 'absence' of rurality in the recipes for high regional competitiveness is considered a necessary condition if the consistency score is above the threshold of 0.9. The *absence* of rurality (~rural region) is not a necessary condition for a region to be competitive, nor is the *presence* of rurality necessary to be non-competitive. In fact, none of the specific innovation conditions considered in this study is necessary for regional competitiveness (Table 2).

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INSERT Table 2

Table 2. Analysis of necessary conditions

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4.2 Sufficient Recipes

Tables 3 and 4 show the results of the analysis of sufficiency for models a, b, c and d. As per the notation used by Fiss (2011), black circles '●' indicate the presence of antecedent conditions, white circles '⭘' indicate the absence or negation of antecedent conditions, big circles indicate core conditions (present in the parsimonious and intermediate solutions), small circles indicate peripheral conditions (only present in the intermediate solution), and blank cells indicate conditions that are irrelevant to the outcome.

Five sufficient recipes had consistency scores above the threshold for Model a in Table 3. Business collaboration in innovation activities appears in four of these recipes, which supports Proposition 1.

The remaining recipe consists of what is termed here as the 'magic triangle': *public investment in R&D* and *private investment in R&D* and *top-ranked universities*. This formula is consistent with a robust R&D system and excellent higher education, thus supporting Propositions 3 and 5. This recipe is a specific solution in 9.6% of regional cases. It accounts for potential synergies between innovation conditions that are often neglected in empirical analyses. However, this 'magic' recipe is not feasible in all situations. For example, it cannot occur if resources are not available for research. Business collaboration in innovation activities offers an interesting alternative. The recipe (*rural region* and *collaborative regions*) suggests that business collaboration is important in rural areas, which are normally less likely to attract private R&D (Garcia-Alvarez-Coque et al. 2015; Hagedoorn 2002). This finding supports Proposition 2.

A separate application of fsQCA for each regional subset (predominantly urban, predominantly rural and intermediate) was also carried out. Table 4 summarises the paths to regional competitiveness for the three regional subsets.

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INSERT Table 3

Table 3. Analysis of sufficient recipes for the whole regional set (Model a for all 256 regions)

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INSERT Table 3

Table 4. Analysis of sufficient recipes for the three regional subsets (Models b, c and d)

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The results for Model b in Table 4 indicate that for predominantly urban regions, it is sufficient to have private investment in R&D or collaborative regions for the outcome to occur. For predominantly rural regions (Model c), sufficient configurations also include collaborative

regions or the expected ‘magic’ recipe of public investment in R&D and private investment in R&D and top-ranked universities (Map 2). Two implications can be derived from these models. First, whilst private investment in R&D is relevant in predominantly urban regions, public investment in R&D is a crucial type of R&D spending in predominantly rural and intermediate regions. Thus, these results support the distinction posited in Proposition 6.

Second, the condition of *collaborative regions* seems sufficient for regional competitiveness in the predominantly rural and predominantly urban regions (Models b and c). This finding validates Proposition 1. The condition of *collaborative regions* is crucial in 57% of competitive rural regions and 15% of competitive urban regions (see ‘Unique coverage’ in Table 4). These findings emphasise the fact that promoting business collaboration in innovation activities, which may be with intra- or extra-regional partners, is a key ingredient in a large number of competitive regions (see Map 2b). Not only does collaboration between companies and other actors contribute to innovation activities and territorial development (Porter 2000; Audretsch and Keilbach 2006; Pike et al. 2016), but also ‘regions do matter for collaboration in innovation between companies’ (Jakobsen and Lorentzen 2015).

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INSERT Map 2

Map 2. Regional recipes for competitiveness

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For intermediate regions (Model d), the condition *collaborative regions* is also present in sufficient recipes. Notably, however, business collaboration alone is not sufficient in intermediate regions; instead, it must be combined with other conditions such as public investment in R&D or top-ranked universities. This finding suggests that the effectiveness of business collaboration may be moderated by the socioeconomic context, which may support Proposition 2. Further reflection is needed to explain the crucial role of business collaboration in the predominantly rural and predominantly urban areas and to understand why this role is not sufficient per se in intermediate regions. In urban regions, agglomeration aids information flows and the dissemination of knowledge amongst innovative companies. In rural regions, organisational thinness can catalyse businesses to become involved in creating ties with different types of actors (Jakobsen and Lorentzen 2015). According to this hypothesis, firms in rural regions tend to establish a high degree of bonding social capital, a sense of belonging and a collective focus (Putnam 2000). In intermediate regions, higher numbers of contacts and greater information exchange with respect to predominantly rural regions can result in higher innovation performance. However, the excess competition in more populated areas may introduce the risk of opportunism amongst cooperating firms (Wu 2014). This argument is in line with previous studies that suggest that the association between the intensity of firms’

cooperation and innovative outcomes may have an inverted U-shaped relationship (Laursen and Salter 2006; Haans et al. 2016; Jiao et al. 2016). In more densely populated areas, business competition could neutralise some of the advantages of cooperation. However, in these regions, universities and research institutes generate synergies, which could strengthen the linkages between cooperation and innovation performance. Here the advantages of urban regions with a consolidated knowledge and innovation system (KIS) can overcome the risk of opportunistic behaviour.

The effectiveness of business collaboration is summarised visually in Figure 1. The graph illustrates how the effectiveness of collaboration may be moderated in intermediate regions more than in predominantly rural regions. The advantages of the knowledge and innovation system (KIS) are strengthened as economies of agglomeration develop in urban regions, as reflected by the positive slope in Figure 1. As regions become more urbanised, the regional collective orientation weakens, leading to the negative curve observed in the figure.

The benefits of consolidated knowledge and innovation systems and organisational thickness increase as the degree of urbanisation grows (positive slope). However, the potential for collective orientation in rural areas diminishes as competition, opportunism and fragmentation begin to act in more dense and complex regions. Consequently, in some intermediate regions, opportunistic behaviour is not counteracted by the synergies and lower transaction costs enjoyed in predominantly urban areas. Accordingly, the advantages of organisational thickness and collective orientation are not sufficient. In these regions, the ties for a collective orientation are not strong enough. This combined model could help explain why collaboration in intermediate regions must be coupled with other factors such as public R&D spending or excellent universities to form part of a sufficient recipe for regional competitiveness.

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INSERT Figure 1

Figure 1. Illustrating innovation collaboration's effect and underlying factors

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5 Conclusions

Various conclusions can be derived from this study. These conclusions may be helpful in the proposal of actions for regional development policies. First, merely characterising a region as urban, intermediate or rural does not in itself indicate its level of competitiveness. The results of the analysis indicate that there is no single model to determine that urban and rural regions are either competitive or non-competitive simply by virtue of their degree of rurality. In all contexts, territorial innovation policies arise from a varying mix of business collaboration, university excellence, and public and private R&D.

Second, this research emphasises the synergies between R&D activities and the education system. The analysis shows five possible ways (recipes) to achieve regional competitiveness,

each with considerable territorial coverage. One of the recipes consists of a 'magic triangle' formed of excellence in higher education and substantial private and public R&D investment. Thus, excellence in higher education combined with strong public and private investment in R&D enhances regional competitiveness. This is especially true in rural regions. In such regions, SMEs are more specialised in low technology-intensive industries such as agriculture, natural resources and service-based activities. In such cases, there are greater knowledge spill-overs, lower levels of agglomeration and a lack of accessibility. These factors undermine the functioning of the innovation system in these regions.

Third, business collaboration appears in four of the recipes for regional competitiveness, always in combination with other attributes. The role of business collaboration may be undermined in cases where opportunism and fragmentation increase. This is the case in some intermediate regions, where the advanced innovation systems that are present in predominantly urban regions are not fully developed.

Finally, the analysis suggests several roadmaps for innovation strategies. These roadmaps depend on the territorial context. For instance, private R&D investment appears to be crucial in predominantly urban regions. This finding suggests that policies should be oriented to support investment in R&D by private companies. This support can be offered by transferring financial resources through either direct subsidies or tax incentives or by enacting legislation to protect industrial property rights (patents, etc.). In predominantly rural regions, public R&D spending, excellence in higher education and business collaboration should be combined to achieve regional competitiveness. Here, public policies must promote a strong infrastructure to support research and innovation. This infrastructure should include knowledge transfer offices, public research centres and higher education institutions to train highly qualified human capital talent.

In both types of regions, collaboration matters. It is especially important in predominantly rural regions that specialise in agriculture, natural resources and services with difficulties to attract private R&D investment. In intermediate regions, collaboration must be complemented with other ingredients such as public R&D or excellent universities. In summary, innovation policies require careful assessment of the practical feasibility of each strategy in each individual context.

This research is not without limitations. Cultural variables can affect regional development in rural and urban regions, influencing the link between collaboration and development. Besides the rural and urban differentiation, explicit structural variables such as accessibility or business concentration in larger or smaller firms could also be considered more explicitly. Future studies should also investigate local contexts at the NUTS 3 level or even lower levels of regional classification, depending on data availability.

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Table 1. Description (outcome/conditions), data source and descriptive statistics for the raw data

Type	Description	Source	Descriptive statistics		
			Max	**Min**	**Mean (SD)**
Outcome	***Regional competitiveness***. Means that a region belongs to the competitive set.	European Regional Competitiveness Index (Annoni et al. 2017)	1.21	-1.5	0.00 (0.64)
Causal condition	***Rural region***. Means that the region is included in the rural set.	EUROSTAT, 2018	--	--	--
Causal condition	***Public investment in R&D***. Means that the region has high levels of public investment in R&D.	The Regional Innovation Scoreboard (European Commission 2018)	1.00	0.01	0.22 (0.12)
Causal condition	***Private investment in R&D.*** Means that the region has high levels of private investment in R&D.	The Regional Innovation Scoreboard (European Commission 2018)	0.99	0.02	0.36 (0.18)
Causal condition	***Collaborative regions***. Means that the region is in the set of highly collaborative regions.	The Regional Innovation Scoreboard (European Commission 2018)	0.88	0	0.36 (0.23)
Causal condition	***Top-ranked universities (500***). Means that the region has a high proportion of Top 500 SCIMAGO Institutions Ranking Universities, relative to the population.	SCIMAGO, 2019	2.98	0	0.48 (0.61)

Table 2. Analysis of necessary conditions for regional competitiveness

	Model a Full data set		**Model b** Predominantly urban regions		**Model c** Predominantly rural regions		**Model d** Intermediate regions	
Conditions	*Cons.*	*Cov.*	*Cons.*	*Cov.*	*Cons.*	*Cov.*	*Cons.*	*Cov.*
Public investment in R&D	0.685	0.708	0.731	0.862	0.619	0.586	0.699	0.647
~ Public investment in R&D	0.409	0.414	0.340	0.623	0.494	0.323	0.414	0.401
Private investment in R&D	0.760	0.779	0.805	0.902	0.725	0.644	0.722	0.802
~ Private investment in R&D	0.351	0.358	0.267	0.533	0.434	0.297	0.392	0.323
Collaborative region	*0.815*	0.830	*0.838*	0.867	*0.819*	0.779	0.754	0.848
~ Collaborative region	0.296	0.303	0.208	0.486	0.388	0.253	0.330	0.270
Top-ranked universities	0.664	0.712	0.760	0.817	0.504	0.580	0.730	0.693
~ *Top-ranked universities*	0.410	0.401	0.289	0.623	0.595	0.346	0.355	0.336
Rural region	0.508	0.493	--	--	--	--	--	--
~ Rural region	0.623	0.674	--	--	--	--	--	--

NOTE: '~' means that the condition is absent; the indicator of consistency for necessity is Cons. > 0.9 (Schneider et al., 2010). Model a contains all regions (256) and the causal condition *rural region*.

Table 3. Analysis of sufficient recipes for the whole regional set (Model a for all 256 regions)

	Solution for Model a of all regions (256)				
	1	**2**	**3**	**4**	**5**
Public investment in R&D		●			●
Private investment in R&D			●		●
Collaborative regions	●	●	●	●	
Top-ranked universities				●	●
Rural region	●				
Consistency	0.84	0.90	0.87	0.90	0.92
Raw coverage	0.44	0.56	0.62	0.54	0.44
Unique coverage	0.03	0.01	0.03	0.02	0.10
Overall solution consistency		**0.84**			
Overall solution coverage		**0.89**			

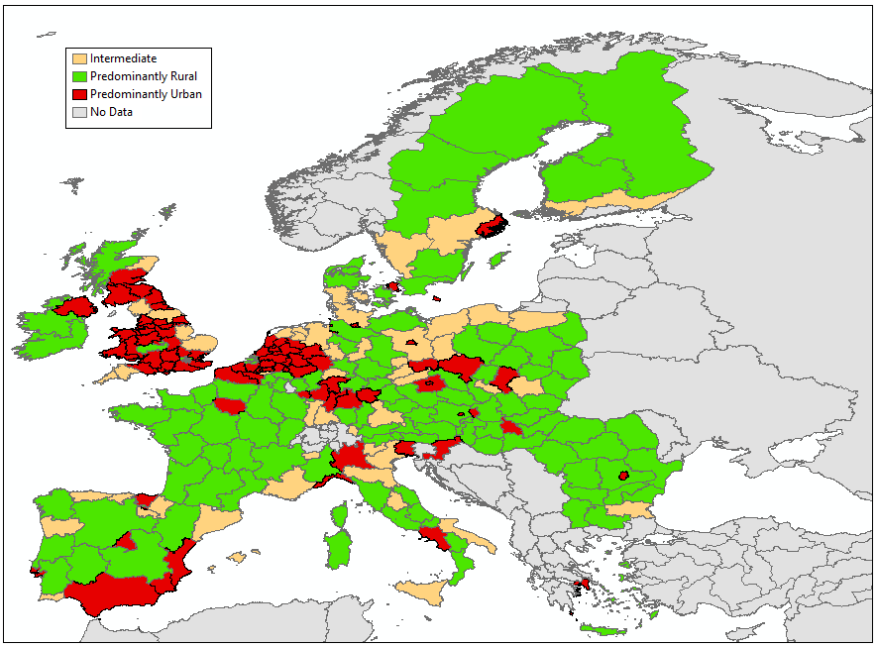
Note: Frequency cut-off = 1; Consistency cut-off = 0.829; Direct expectation (1, 1, 1, 1, -). As per the notation used by Fiss (2011), black circles '●' indicate the presence of antecedent conditions, white circles '○' indicate the absence or negation of antecedent conditions, big circles indicate core conditions, small circles indicate peripheral conditions, and blank cells indicate irrelevant conditions. Analysis of the absence of the outcome (~RC) was performed but is not reported here. Results are available on request.

Table 4. Analysis of sufficient recipes for the three regional subsets (Models b, c and d)

	Model b. Predominantly urban regions (82)		Model c. Predominantly rural regions (119)		Model d. Intermediate regions (55)	
	1	**2**	**3**	**4**	**5**	**6**
Public investment in R&D				●		●
Private investment in R&D	●			●		•
Collaborative regions		●	●		●	●
Top-ranked universities				●	●	
Consistency	0.90	0.87	0.78	0.87	0.97	0.92
Raw coverage	0.80	0.84	0.82	0.35	0.57	0.41
Unique coverage	0.12	0.16	0.57	0.10	0.22	0.06
Overall solution consistency	**0.85**		**0.78**		**0.96**	
Overall solution coverage	**0.96**		**0.91**		**0.63**	

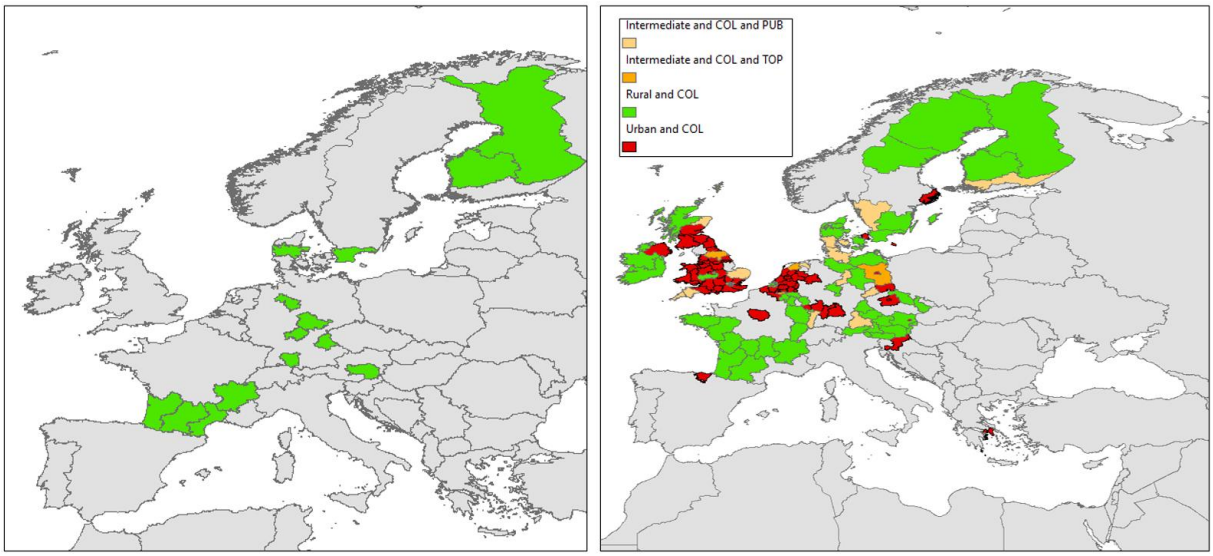
Note: Model b: Frequency cut-off = 1; Consistency cut-off = 0.803; Direct expectation (1, 1, 1, 1). Model c: Frequency cut-off = 3; Consistency cut-off = 0.753; Direct expectation (1, 1, 1, 1). Model d: Frequency cut-off = 1; Consistency cut-off = 0.900; Direct expectation (1, 1, 1, 1). As per the notation used by Fiss (2011), black circles '●' indicate the presence of antecedent conditions, white circles '⭘' indicate the absence or negation of antecedent conditions, big circles indicate core conditions, small circles indicate peripheral conditions, and blank cells indicate irrelevant conditions. Analysis of the absence of the outcome (~RC) was performed but is not reported here. Results are available on request.

Map 1. Predominantly rural, predominantly urban and intermediate regions



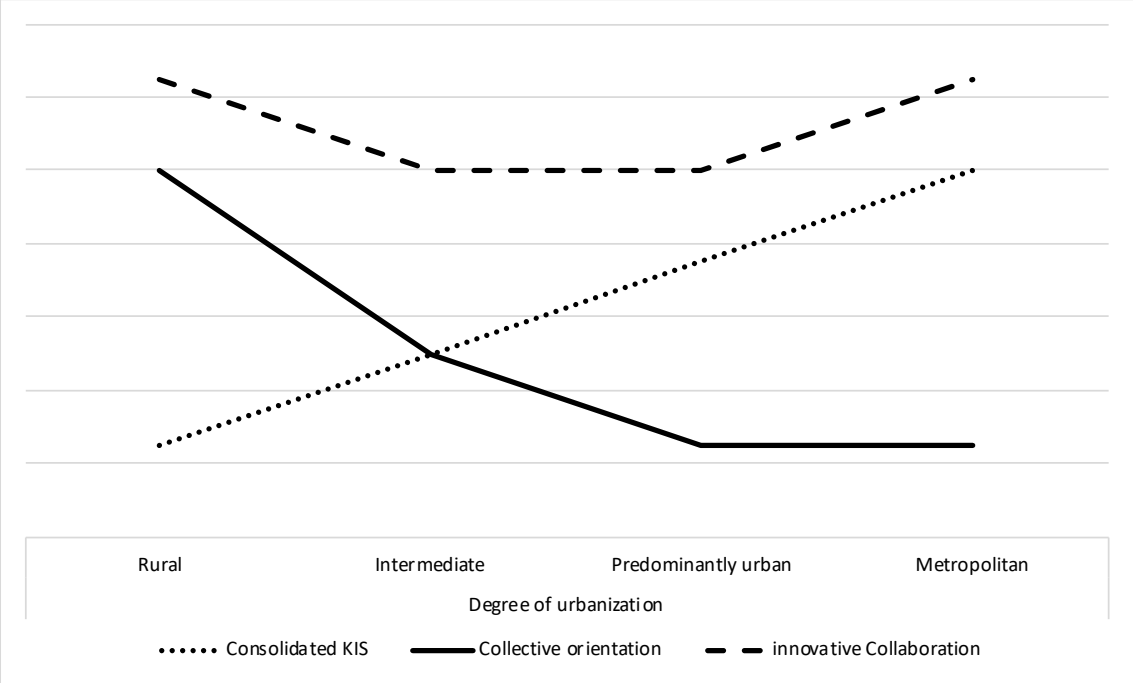
Source: Compiled by the authors for NUTS 2 regions based on Eurostat classifications at the NUTS 3 level. Green = predominantly rural; red = predominantly urban; yellow = intermediate.

Map 2. Regional recipes for competitiveness



Map 2a (Left). Rural regions with business collaboration AND public R&D spending AND universities ranked in the top 500. **Map 2b** (Right). Regions with presence of business collaboration in complementary recipes leading to competitiveness within the predominantly urban, predominantly rural and intermediate regional subsets. Source: Compiled by the authors based on fsQCA results.

Figure 1. Illustrating innovation collaboration's effect and underlying factors



Source: Compiled by the authors. Note: KIS = knowledge and innovation system.