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The Regional Determinants of Innovation in a Developing Economy: Canton-Level Evidence from Ecuador

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Research Article

Keywords: regional innovation, urban agglomeration, cooperatives, developing countries

Posted Date: April 1st, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9181206/v1

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Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at Review of Regional Research on October 28th, 2026. See the published version at https://doi.org/10.1007/s10037-026-00299-7.

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Abstract

This paper examines whether cantonal context in Ecuador shapes firms' decisions to invest in innovation activities. Using cross-classified multilevel logistic models that simultaneously account for sectoral and territorial effects, the analysis isolates the net contribution of geography while controlling for firm-level characteristics. The results indicate that location remains a significant determinant of innovation investment: the cantonal environment explains 10.29% of the residual variance in manufacturing and 7.50% in services. Among the territorial factors considered, local financial depth, the share of the population with higher education, and the presence of cooperatives emerge as robust predictors of firms' propensity to innovate. By contrast, urban agglomeration and aggregate business R&D effort do not reach statistical significance. These findings suggest that, in a developing economy such as Ecuador, innovation depends less on simple density effects than on territorially embedded capabilities associated with finance, human capital, local institutional coordination, and collective learning dynamics, which more broadly shape firm behavior.

Keywords: regional innovation; urban agglomeration; cooperatives; developing countries.

JEL Classification: O31, R11, O18, O16, O54

1. Introduction

Despite the clear territorial embeddedness of innovation activities, empirical evidence consistently shows that firm-level characteristics and sectoral specialization are the predominant determinants of innovative behaviour, systematically outweighing the explanatory power of the geographical environment (Sternberg and Arndt 2001; Rodríguez-Gulías et al. 2016; López-Bazo and Motellón 2017; Bruna and Fernández-Sastre 2021). In this sense, empirical studies continue to examine the extent to which spatial differences reflect genuinely contextual effects or, alternatively, a mere compositional effect arising from the uneven location of innovative firms across territories. A central methodological risk in this debate is the ecological fallacy, that is, attributing causality to territory on the basis of aggregate correlations that actually stem from firm-level heterogeneity (Beugelsdijk 2007).

Disentangling spatial effects is especially relevant in developing economies, where sharp subnational asymmetries and the adaptive nature of technological change require a

rigorous identification of the impact of the geographical environment. In such contexts, regional innovation systems are still at an emerging stage, and the productive structure channels its efforts mainly towards adaptive and incremental forms of innovation (Chaminade et al. 2009). Because this technological profile depends critically on the transmission of tacit knowledge and face-to-face interaction, firms become highly sensitive to the conditions of their immediate environment (Fitjar and Rodríguez-Pose 2015). Consequently, the territory in which firms operate becomes a structural boundary that may either catalyse or stifle modernization efforts.

This paper analyses the extent to which Ecuadorian firms' decision to invest in innovation activities is conditioned by the canton in which they operate. This focus is particularly relevant in the Ecuadorian case, a country characterized by profound territorial heterogeneity, where productive activity and scarce technological resources have historically been concentrated in a few major urban poles, such as Quito, Guayaquil, and Cuenca. Taken together, these three cantons accounted for 5,095,691 inhabitants, that is, 35.18% of Ecuador's population in 2010.

To address this issue, we estimate cross-classified multilevel logistic models that acknowledge that firms are simultaneously exposed to the dynamics of their cantonal geographical environment and to sector-specific characteristics. This methodology makes it possible to isolate the net territorial effect after controlling for firm-level variables, thereby determining whether the residual variance across regions remains statistically significant. First, the paper quantifies the geographical component through the Intraclass Correlation Coefficient (ICC), both for the full sample and separately for manufacturing and services. Second, it evaluates whether a set of regional characteristics related to financial development, human capital endowments, economic development, urban agglomeration, the presence of cooperatives, and the aggregate R&D effort of the local business sector can explain such heterogeneity and, consequently, reduce the variance captured by the ICC.

This paper makes several contributions to the multilevel empirical literature on the geography of innovation (Sternberg and Arndt 2001; Srholec 2011; Rodríguez-Gulías et al. 2016; López-Bazo and Motellón 2017; Bruna and Fernández-Sastre 2021). First, it moves from aggregated regional scales to a micro-territorial resolution at the cantonal level, the

spatial unit where territorial frictions and opportunities materialize most clearly. Second, it implements cross-classified multilevel models that isolate the genuine territorial effect from the bias introduced by local sectoral specialization and firm-specific characteristics. Third, it contrasts the dynamics of manufacturing and services, since the territorial environment may condition innovation propensities in both sectors through markedly different spatial mechanisms (Corrocher and Cusmano 2014). Finally, it assesses the extent to which different cantonal characteristics stimulate firm innovation in the context of a developing country, thus providing evidence on the territorial mechanisms that matter where spatial, institutional, and productive asymmetries are especially pronounced.

The results reveal that, once firms' internal characteristics are controlled for, 10.29% of the variance in the decision to invest in innovation in manufacturing is strictly attributable to geographical location, while in services this figure amounts to 7.50%. The analysis of territorial determinants shows that the factors contributing to the probability of investing in innovation activities are the share of firms receiving bank credit, the share of the population with higher education, and the number of cooperatives relative to the population. Gross Value Added per capita, in turn, emerges as a relevant predictor only for manufacturing. By contrast, population density and total business R&D expenditure relative to Gross Value Added do not show statistical significance. Overall, these findings indicate that geography plays a crucial role in innovation, especially in countries such as Ecuador, and that the most robust local transmission mechanisms operate through the availability of finance, human talent, and the presence of cooperativism, rather than through knowledge spillovers or mechanisms purely associated with urban agglomeration.

2. Literature Review

Knowledge generates externalities, but its spatial diffusion is not uniform. Since a significant share of technological learning is tacit in nature, its transmission depends on frequent interaction (Storper and Venables 2004). Consequently, geographical proximity facilitates access to new ideas and better practices (Jaffe et al. 1993). Factors such as human capital, knowledge, and local institutions shared by firms within the same region may systematically affect their decision to invest in innovation activities.

Several studies have attempted to identify which regional characteristics shape firms' innovation behaviour. One group has focused on knowledge externalities associated with the technological and human capital resources available in regions (Feldman and Audretsch 1999; Raspe and Van Oort 2008). Within these resources, the literature has paid particular attention to regional R&D effort and the availability of skilled workers (Corsi and Prencipe 2016; Powers and McDougall 2005). The underlying argument is that regional R&D may itself function as an input into firms' innovation activities; firms may therefore benefit both from the outcomes of regional R&D effort and from the presence of highly qualified workers (Powers and McDougall 2005; Corsi and Prencipe 2016; Rodríguez-Gulías et al. 2016).

Several studies have documented a positive relationship between regional R&D effort and firm innovation (Love and Roper 2001; López-Bazo and Motellón 2017), as well as between the concentration of skilled workers and the probability of introducing innovations (Czarnitzki and Hottenrott 2011; Bellmann et al. 2013). However, there is also contrasting evidence suggesting that the significance of these associations depends on the underlying spatial context (Rodríguez-Gulías et al. 2016; Chen et al. 2022).

Another stream of research has focused on the relationship between urban agglomeration and innovation. Agglomeration economies, such as the provision of specialized inputs, the depth of labour markets, and knowledge externalities, are seen as major catalysts of technological change (Duranton and Puga 2001; Rosenthal and Strange 2004). The link between urban agglomeration and innovation lies in the localized nature of knowledge externalities, which tend to be stronger in environments where multiple firms are located in close physical proximity. Carlino et al. (2007) and Lee and Rodríguez-Pose (2013) show that firms located in denser areas display higher rates of product and process innovation. Chen et al. (2022), analysing 25 developing Asian economies, find that firms located in larger cities are more likely to introduce product and process innovations and to undertake R&D projects. Nevertheless, the empirical evidence is not unequivocal: López-Bazo and Motellón (2017), for Spanish firms, do not find a statistically significant relationship between regional population density and the propensity to innovate.

Closely related to agglomeration dynamics, the regional level of economic development, commonly approximated by Gross Value Added per capita (GVApc),

constitutes another crucial contextual determinant. The economic prosperity of a territory significantly alters the expected returns to innovation investment (Schmookler 1966; Capello 2015). Regions with higher GVApc host more sophisticated local markets and greater purchasing power, which reduces the risk associated with the introduction of new products. They also tend to provide better complementary public goods and a more robust institutional ecosystem, which together mitigate the costs and uncertainty inherent in technological change. Srholec (2011), for developing countries, consistently finds a positive and significant association between territorial income per capita and firms' propensity to innovate. By contrast, López-Bazo and Motellón (2017) do not find a significant association between regional economic development and innovation propensity in Spain.

The literature also emphasizes that the local financial system constitutes another indispensable geographical determinant (Alessandrini et al. 2010; Lee and Brown 2017). Innovation is characterized by high uncertainty and a strong reliance on intangible assets, which are difficult to liquidate (Hall 2002). These features generate severe information asymmetries between firms and lenders, often leading to credit rationing. In this context, proximity to a well-developed local financial ecosystem becomes crucial. Financial institutions embedded in the territory are better able to mitigate these frictions through long-term relationships and a deeper knowledge of regional productive dynamics (Alessandrini et al. 2010). Benfratello et al. (2008), in the European context, show that a greater expansion and density of the local banking system significantly increases the probability that firms introduce innovations. For emerging and developing economies, Ayyagari et al. (2011), Gorodnichenko and Schnitzer (2013), and Bruna and Fernández-Sastre (2021) show that access to finance in the immediate geographical environment relaxes structural liquidity constraints and operates as one of the most robust predictors of why some firms can sustain investments in technology and R&D.

A regional factor that has received far less attention is the presence of cooperatives. Yet this feature may be especially relevant in developing countries, where weak markets and institutional fragmentation increase the value of organizational arrangements capable of generating trust, coordinating actors, and sustaining collective learning. Cooperatives are not only an alternative business form but also a social infrastructure that produces social capital

and favours knowledge circulation (Saz-Gil et al. 2021). Their contribution stems from their ties with other cooperatives, firms, and organizations in the territory. The literature suggests that a greater presence of cooperatives strengthens social capital by densifying networks with local suppliers and customers, consolidating shared norms and mechanisms of opportunism control that facilitate coordination, and thereby favouring endogenous development (Birchall 2011; Bauer et al. 2012). For this reason, in territories with a stronger cooperative presence, one may expect not only a greater availability of cooperative relationships, but also a stronger collective capacity to identify, assimilate, transform, and exploit external knowledge, which may translate into a higher propensity for firms to innovate. Nevertheless, this relationship is not necessarily univocal: the literature also warns that social capital may have adverse effects when excessive pressure towards cohesion and conformity promotes the homogenization of actors, reduces diversity of views, and ultimately limits innovation (Beltrán Tapia 2012; Saz-Gil et al. 2021).

Finally, the geographical component of innovation and the factors influencing it may differ between manufacturing and services. For example, empirical research shows that the impact of population density on innovation propensity displays marked asymmetries between manufacturing and services (Shearmur and Doloreux 2009; Corrocher and Cusmano 2014). On the one hand, innovation in services, especially in knowledge-intensive services, shows a strong dependence on demographic and urban concentration (Asheim and Gertler 2005). On the other hand, manufacturing innovation responds more strongly to the availability of infrastructure and territorial specialization than to mere population concentration. As a result, manufacturing tends to locate in peripheral areas or connected industrial zones in order to avoid high land costs and congestion in dense urban cores (McCann and Simonen 2005).

3. Methodology

3.1 Data and Variables

The study mainly uses data from the 2010 National Economic Census (CENEC), conducted by the National Institute of Statistics and Censuses (INEC). Some regional variables are additionally constructed using the 2010 Population and Housing Census and the 2010 Regional National Accounts produced by the Central Bank of Ecuador. All variables refer to 2010. CENEC provides exhaustive information at the firm level and constitutes the

basis for building a detailed map of Ecuador's productive structure. After excluding firms outside manufacturing and services and dropping observations with missing values, the final database consists of 465,112 firms, belonging to 24 two-digit ISIC manufacturing sectors and 54 two-digit ISIC service sectors, distributed across the 221 cantons that Ecuador had in 2010. Model estimation is carried out for the full sample and for the manufacturing and service subsamples separately.

The choice of the canton as the spatial unit is particularly relevant because cantons can be understood as local urban-territorial systems. They are the scale at which many of the conditions affecting economic activity are governed: land use, local regulation, urban services, connectivity, proximate labour markets, and urban-rural linkages. For this reason, they capture reasonably well firms' immediate operating environment, even though they do not always coincide exactly with the functional city or metropolitan area.

The dependent variable, `Innov`, is dichotomous and takes the value 1 if the firm invested in research and development (R&D) or in technological training during 2010, and 0 otherwise. These two expenditure items were aggregated into a single indicator because the same multilevel models estimated separately for R&D and technological training produced virtually identical results. In other words, both investment decisions display the same spatial pattern and respond similarly to internal and contextual determinants in our specifications.

Figure 1 presents three maps showing the percentage of firms investing in innovation activities at the cantonal level. The first map displays the spatial distribution for both sectors together, while the next two differentiate the incidence for the manufacturing and service subsamples, providing preliminary evidence of spatial and sectoral heterogeneity.

Fig. 1. Distribution of innovation-active firms by sector: manufacturing, services, and total

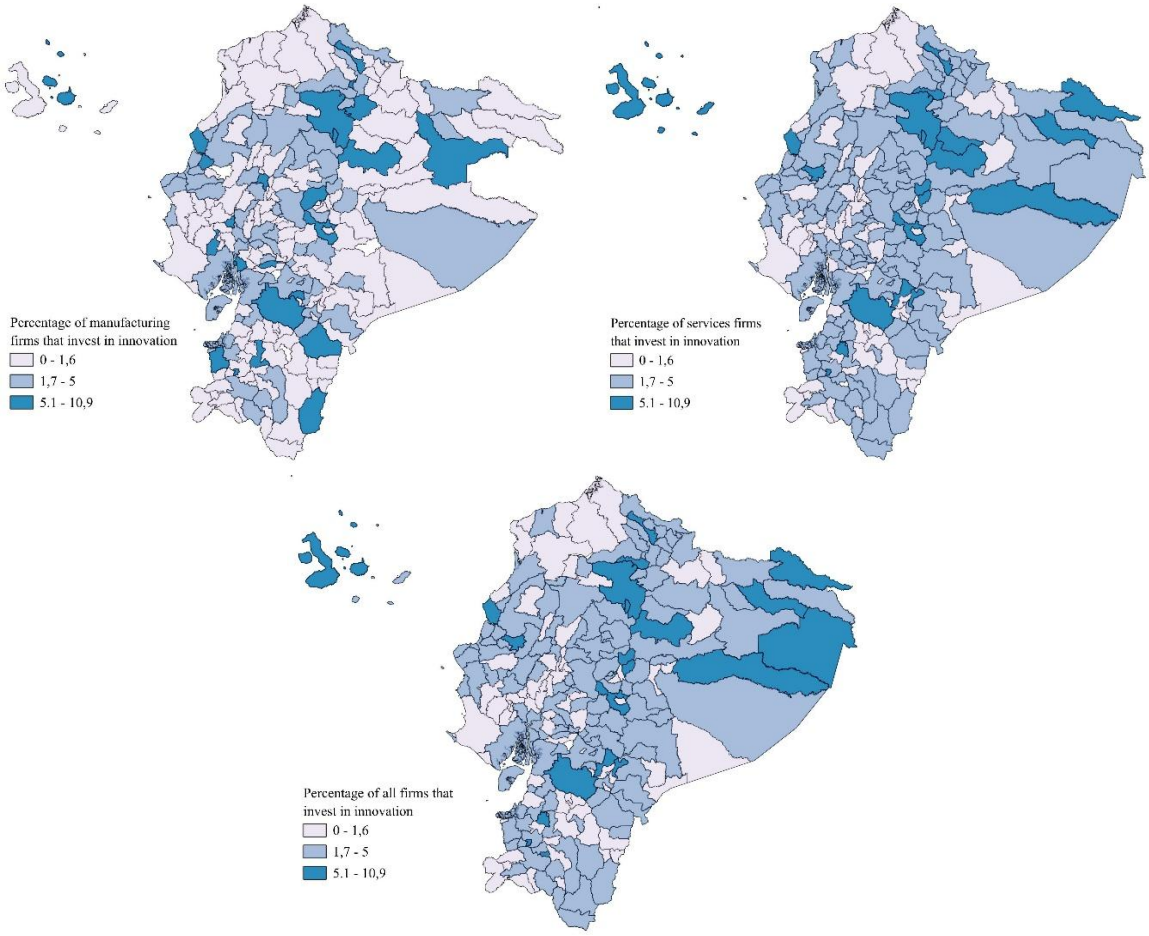


Figure 1 reveals marked spatial heterogeneity in the share of firms investing in innovation activities at the cantonal level. The observed distribution is far from uniform and suggests that firm innovation in Ecuador is organized through a fragmented geography, with territorial clusters of greater intensity separated by broad areas of low incidence. Although the country's main urban cantons—Quito, Guayaquil, and Cuenca—show high percentages of firms investing in innovation, the map suggests that such investment is not confined exclusively to these major centres. On the contrary, non-metropolitan cantons with relatively high levels can also be identified, indicating that firms' propensity to innovate responds to territorial conditions that are more complex than mere urban hierarchy. This heterogeneity remains when distinguishing between manufacturing and services, although with relevant sectoral nuances. In manufacturing, the spatial pattern appears more concentrated in a limited set of cantons and displays sharper territorial contrasts, suggesting a stronger anchoring of

innovation in specific local conditions. In services, by contrast, the distribution appears somewhat more widespread and less concentrated in a few focal points, although it remains clearly uneven across cantons.

To isolate the genuine effect of territory on the decision to invest in innovation, we control for firm-level heterogeneity through the following variables: `ln_Size`, measured as the natural logarithm of the number of employees; `ln_Age`, measured as the natural logarithm of the number of years the firm has been operating; `Web`, which takes the value 1 if the firm has a website and 0 otherwise; and `Finan`, which equals 1 if the firm received external financing during the previous year and 0 otherwise.

Regarding geographical-level variables, we include a set of cantonal variables closely aligned with the literature on the geography of innovation (Srholec 2011; Rodríguez-Gulías et al. 2016; López-Bazo and Motellón 2017). To approximate knowledge externalities derived from technological and human capital resources, we include `BERD` and `Graduates`. `BERD` represents total business R&D expenditure relative to cantonal Gross Value Added, while `Graduates` measures the percentage of the population holding a university degree. To capture urbanization externalities and the level of economic development, we include the natural logarithm of population density, `ln_Density`, and Gross Value Added per capita. The quality of the local financial system is proxied by the percentage of firms receiving financing in the canton, `Fin_cant`. Finally, we include `Cooperatives`, defined as the number of cooperatives in the canton relative to its total population. This variable approximates the density of cooperativism at the cantonal scale as an institutional feature of the territory potentially associated with greater capacities for coordination, cooperation, and collective learning. To facilitate coefficient comparability and avoid distortions arising from differences in measurement units, all regional variables are standardized with respect to the national mean and standard deviation. Table 1 describes all variables used in the study and reports descriptive statistics.

Table 1. Descriptive statistics of the variables

Variables	Description	Mean	Std. dev.	Min	Max
Dependent variable					
Innov	Dummy variable equal to 1 if the firm invests in R&D or training; 0 otherwise.	0.043	0.204	0	1

Independent variables: firm level					
ln_Size	Natural logarithm of firms' number of employees	0.594	0.803	0	9.104
ln_Age	Natural logarithm of firms' age	1.579	1.087	0	6.917
Web	Dummy variable equal to 1 if the firm has a website, and 0 otherwise.	0.036	0.187	0	1
Finan	Dummy variable equal to 1 if the firm received financing in the past year; 0 otherwise.	0.210	0.407	0	1
Independent variables: regional level					
BERD	Business spending on research and development as a share of gross value added at cantonal level.	5.779	49.810	0	695.898
Graduates	Percentage of the total population with tertiary education attainment (bachelor's degree or higher) at canton level.	3.548	2.490	0.820	14.733
ln_Density	Natural logarithm of population density (population per km²) at canton level.	3.722	1.403	- 0.865	8.253
GVApc	Gross value added per capita cantonal	4281.20	14196.78	749.03	187144.67
Fin_cant	Percentage of firms with access to financing at cantonal level.	21.014	3.968	1.754	53.226
Cooperatives	Share of cooperatives to total population at cantonal level	6.58×10^{-5}	7.69×10^{-5}	0	4.55×10^{-4}

Descriptive statistics refer to the full sample, and all variables are measured in 2010.

3.2 Method

Given the binary nature of the dependent variable, the empirical approach is based on multilevel logit models with random intercepts. The modelling strategy follows a three-step procedure.

Step 1: Empty models and selection of the multilevel structure

The first step consists of estimating empty models, that is, models without explanatory covariates, in order to assess the presence of spatial intraclass correlation. Two alternative multilevel structures are compared: a hierarchical model and a cross-classified model.

In the empty hierarchical model, firms `i` are assumed to be strictly nested within cantons `c`, and neither firm-level nor sectoral heterogeneity is controlled for:

$$logit\ (Innov_{ic}) = \beta_0 + u_c + \varepsilon_{ic}, \qquad u_c \sim N(0, \sigma_u^2)\ \ \varepsilon_{ic} \sim Logistic(0, \sigma_\varepsilon^2)$$

where β_0 is the global intercept, u_c is the random component capturing residual variation across cantons, and ε_{ic} is the individual error term. Although the level-1 variance ε_{ic} is not directly estimated in logit models because the dependent variable is binary, it is assumed to take a constant value:

$$\sigma_\varepsilon^2 = \frac{\pi^2}{3} \approx 3{,}29$$

Under this specification, the ICC is calculated as follows (Rabe-Hesketh and Skrondal 2012):

$$ICC_c = {\sigma_c^2}\Big/{(\sigma_c^2 + 3.29)}$$

This coefficient represents the proportion of total variance in the probability of investing in innovation activities that is attributable to inter-cantonal differences. Higher ICC values indicate that geographical location, understood as a shared contextual environment, significantly influences the probability of investing in innovation activities.

The empty cross-classified model relaxes the assumption of strict nesting within cantons by recognizing that firms simultaneously belong to a canton and a sector. Two independent random intercepts are therefore incorporated (`$u_c$` and `$v_s$`):

$$logit\ (Innov_{ics}) = \beta_0 + u_c + v_s + \varepsilon_{ic}, \qquad u_c \sim N(0, \sigma_u^2) \quad v_s \sim N(0, \sigma_s^2)$$

The choice between these two specifications is based on the AIC and BIC information criteria, which penalize parametric complexity (Akaike 1974; Schwarz 1978). In this empirical application, the cross-classified structure performed better according to both criteria (see Table 2 in Section 4), and all subsequent steps are therefore conducted using the cross-classified models only.

From the empty cross-classified models, both a cantonal ICC and a sectoral ICC can be computed:

$$ICC_c = {\sigma_c^2}\Big/{(\sigma_c^2 + \sigma_s^2 + 3.29)}$$

$$ICC_s = {\sigma_s^2}\Big/{(\sigma_c^2 + \sigma_s^2 + 3.29)}$$

Step 2: Spatial persistence conditional on firm composition

Once the cross-classified structure has been validated, a vector of firm-level characteristics, X', described in Table 1, is introduced in order to assess whether the cantonal effect persists after controlling for firm composition:

$$logit\ (Innov_{ics}) = \beta_0 + \boldsymbol{X'}_{ics}\beta + u_c + v_s + \varepsilon_{ic}$$

The change observed between the empty-model ICC and the conditional ICC allows us to analytically distinguish compositional effects from contextual effects.

Step 3: Cantonal covariates and explained spatial heterogeneity

The final step incorporates a vector of contextual variables, Z', described in Table 1, in order to identify which territorial attributes are associated with the investment decision and to what extent they reduce residual geographical variance:

$$logit\ (Innov_{ics}) = \beta_0 + X'_{ics}\beta + \boldsymbol{Z'}_c\gamma + u_c + v_s + \varepsilon_{ic}$$

In this specification, the vector of coefficients γ captures the variation in the log-odds of investing associated with cantonal attributes, conditional on both firm characteristics and cross-classified heterogeneity.

The entire econometric strategy is replicated separately for the manufacturing and service subsamples. This allows the coefficient vectors to differ structurally across sectors and prevents the average ICC from masking sector-specific spatial patterns.

4. Results

Table 2 reports the results of the empty models, both hierarchical and cross-classified, which show that the decision to invest in innovation activities goes beyond the purely idiosyncratic sphere and displays systematic heterogeneity across cantons. In the three samples analysed, likelihood-ratio tests confirm the strong statistical significance of the multilevel structure. As noted above, the AIC and BIC criteria systematically favour the cross-classified specification over the hierarchical one. The cross-classified model captures sectoral heterogeneity as a random disturbance. Therefore, from this point onward, only the results from the cross-classified models are presented.

Table 2. Null models

Innov	(1) Hierarchical: total	(2) Crossed: total	(3) Hierarchical: Manufacture	(4) Crossed: Manufacture	(5) Hierarchical: Services	(6) Crossed: Services
Cantonal ICC	8.50 %	6.81 %	14.11 %	10.55 %	8.10 %	6.51 %
Sectoral ICC		21.19 %		19.48 %		20.87 %
LR test	4660.30***	29848.89***	547.86***	1337.19***	4087.40***	28437.58***
AIC	161970.60	136601.70	17148.80	16361.47	144813.60	120295.30
BIC	161992.70	136634.80	17166.27	16387.67	144835.40	120328.10
Observations	465112	465112	45867	45867	419245	419245
Groups	221	221	221	221	221	221

*** p < 0.01; ** p < 0.05; * p < 0.1.

For the full sample, the empty cross-classified model reveals a cantonal ICC of 6.81% and a sectoral ICC of 21.19%. This pattern highlights two structural dimensions. First, the decision to invest in innovation is strongly stratified by each sector's technological regime. Second, it reveals a marked geographical component whose magnitude is considerably high. This ordering of explanatory relevance, where firm-level characteristics outweigh sectoral dynamics and the latter exceed the influence of the regional environment, is a consistent finding in previous studies (Rodríguez-Gulías et al. 2016; López-Bazo and Motellón 2017; Bruna and Fernández-Sastre 2021).

The empty cross-classified models estimated separately for manufacturing and services reveal that the geographical component is not homogeneous: it is much stronger in manufacturing (ICCc = 10.55%) than in services (6.51%). This divergence suggests that manufacturing innovation has a deeper territorial anchoring, since its productive and technological processes depend more heavily on tangible location economies, such as physical infrastructure, logistical connectivity, proximity to input suppliers, and access to localized labour markets with specific technical skills. By contrast, services rely on more intangible knowledge bases and thus display greater flexibility in overcoming spatial frictions and partially decoupling from the limitations of their immediate physical environment. This empirical pattern introduces an important nuance with respect to the evidence from developed countries, where services often display stronger spatial dependence due to their need for urban agglomeration (Asheim and Gertler 2005; Corrocher and Cusmano 2014).

However, the inferences drawn from ICCs based on empty models remain preliminary and cannot be considered conclusive. Since these specifications do not yet include firms' internal characteristics, the cantonal ICC is exposed to a spatial composition bias. In other words, the variance attributed to the geographical environment may actually be capturing the asymmetric agglomeration of firms with intrinsically more innovative profiles in certain territories. To isolate the genuine territorial effect, it is therefore necessary to purge this firm-level heterogeneity. Table 3 addresses this issue by presenting the results of the cross-classified multilevel models once internal firm characteristics are introduced.

Table 3. Multilevel Logit Models with Firm Characteristics (Odds Ratios)

Innov	(1) Total firms	(2) Manufacture	(3) Services
ln_Size	1.978*** (0.017)	2.485*** (0.063)	1.908*** (0.018)
ln_Age	1.092*** (0.009)	1.114*** (0.028)	1.089*** (0.009)
Web	2.540*** (0.075)	2.172*** (0.203)	2.554*** (0.079)
Finan	2.224*** (0.040)	1.862*** (0.095)	2.277*** (0.044)
Constant	0.018*** (0.002)	0.011*** (0.002)	0.021*** (0.002)
Random effects			
Canton	0.330 (0.044)	0.406 (0.099)	0.313 (0.043)
Sectors	0.527 (0.091)	0.253 (0.091)	0.566 (0.116)
Firms	3.289	3.289	3.289
Total	4.147	3.949	4.169
Cantonal ICC	7.96 %	10.29 %	7.50 %
Sectoral ICC	12.70 %	6.41 %	13.59 %
LR test	17493.58***	496.72***	16961.56***
Observations	465112	45867	419245
Groups	221	221	221

*** p < 0.01; ** p < 0.05; * p < 0.1. Standard errors in parentheses.

Across all samples, the results show that microeconomic heterogeneity is a fundamental determinant of innovative behaviour (Beugelsdijk 2007; Srholec 2011). More specifically, firm size, age, the adoption of digital tools, and access to finance significantly increase the probability of investing in innovation activities. The positive effect of firm size is in line with studies showing that economies of scale and greater resource slack are crucial for absorbing the fixed costs and risks inherent in innovation processes (Ayyagari et al. 2011). The positive relationship between age and innovation suggests that accumulated experience, organizational capabilities, and learning routines strengthen a firm's ability to undertake technological modernization. In this respect, Cucculelli (2018) shows that, once CEO tenure and product tenure are controlled for, the relationship between firm age and product innovation becomes positive, indicating that business maturity can become an asset for innovative renewal. Likewise, the adoption of digital tools, proxied by the existence of a corporate website, operates as an indicator of firms' absorptive capacity, facilitating their connection to external information networks and new market opportunities (Crespi and Zúñiga 2012). Finally, the significance of access to finance underlines the crucial importance of overcoming the severe liquidity constraints that characterize productive structures in developing economies, providing the support needed to materialize and sustain technological upgrading projects (Gorodnichenko and Schnitzer 2013).

A revealing result concerns the behaviour of unexplained variance once these firm-level characteristics are introduced. Rather than declining, the cantonal ICC in the cross-classified model increases in the full sample, reaching 7.96%, and in services, reaching 7.50%, while remaining stable in manufacturing at 10.29%. This phenomenon, documented in multilevel models, reflects a spatial composition effect: once the sample is homogenized and firms with similar internal capacities are compared, pure territorial inequality emerges more clearly. In other words, the inclusion of level-1 covariates removes the noise generated by the agglomeration of larger or more mature firms in certain cantons, thereby revealing that the geographical environment exerts an even stronger structural influence on otherwise comparable firms.

In comparative terms, the magnitude of this spatial dependence, ranging between 7% and 10%, lies at the upper end of the evidence reported for developed economies, where the

regional ICC is usually considerably lower or even marginal once microeconomic composition is taken into account (; Rodríguez-Gulías et al. 2016; López-Bazo and Motellón 2017). This confirms that, in developing economies such as Ecuador, territorial asymmetries impose much more powerful frictions and opportunities for technological change.

Table 4 incorporates the level-2 covariates and disentangles the contextual mechanisms underlying this geographical effect.

Table 4. Multilevel Logit Models with Firm and Regional Characteristics (Odds Ratios)

Innov	(1) Total firms	(2) Manufacture	(3) Services
ln_Size	1.977***	2.478***	1.908***
	(0.017)	(0.062)	(0.018)
ln_Age	1.092***	1.117***	1.089***
	(0.009)	(0.028)	(0.009)
Web	2.534***	2.170***	2.546***
	(0.074)	(0.201)	(0.080)
Finan	2.221***	1.848***	2.273***
	(0.040)	(0.094)	(0.044)
BERD	1.016	1.019	1.017
	(0.036)	(0.041)	(0.035)
Graduates	1.187***	1.135*	1.187***
	(0.051)	(0.077)	(0.050)
ln_Density	1.005	1.099	0.995
	(0.039)	(0.078)	(0.038)
GVApc	1.099	1.279**	1.048
	(0.064)	(0.130)	(0.067)
Fin_cant	1.160***	1.353***	1.153***
	(0.053)	(0.132)	(0.052)
Cooperatives	1.101**	1.198**	1.096**
	(0.049)	(0.100)	(0.048)
Constant	0.017***	0.010***	0.020***
	(0.002)	(0.002)	(0.003)
Random effects			
Canton	0.236	0.278	0.222
	(0.035)	(0.082)	(0.034)
Sectors	0.526	0.252	0.565
	(0.091)	(0.091)	(0.116)
Firms	3.289	3.289	3.289
Total	4.051	3.820	4.077
Cantonal ICC	5.82 %	7.27 %	5.45 %
Sectoral ICC	12.98 %	6.60 %	13.86 %
LR test	14551.95***	240.47***	14268.75***
Observations	465112	45867	419245
Groups	221	221	221

*** p < 0.01; ** p < 0.05; * p < 0.1. Standard errors in parentheses. The regional variables are globally mean-centered and standardized using the standard deviation of regional data, considering a single observation per region.

Three factors emerge as robust and transversal determinants across all estimations. First, the percentage of the population holding a university degree displays a positive and statistically significant association in the full sample as well as in manufacturing and services, indicating that a stronger territorial endowment of human capital systematically increases the probability that firms invest in innovation activities. Second, average cantonal financing is the strongest predictor among all those included in the model: its effect is positive and highly significant in the three cases, and reaches its greatest magnitude in manufacturing. The robustness of this finding is supported by previous research in the same national context. In particular, Bruna and Fernández-Sastre (2021), using provinces as the geographical unit of analysis, also find a positive and statistically significant effect of regional loan volume, measured as the share of loans over GVA. Their results similarly show that greater territorial financial depth substantially increases the probability that firms invest in innovation activities. Third, the share of cooperatives at the cantonal level is also positive and significant in all estimations, in line with studies suggesting that a denser cooperative fabric is associated with territorial contexts that are more conducive to economic coordination, knowledge circulation, and collective learning (Birchall 2011; Bauer et al. 2012; Saz-Gil et al. 2021).

The inclusion of these factors sharply reduces the cantonal ICC, explaining approximately between 27% and 29% of the territorial variance across the three models, reducing the ICC to 5.82% in the full sample, 7.27% in manufacturing, and 5.45% in services. This attenuation shows that a substantial share of the "geography effect" in Ecuador actually reflects observable inequalities in skills, financial frictions, and the presence of cooperatives.

The statistical irrelevance of population density invites a reconsideration of the role of agglomeration economies in a developing-country context such as Ecuador. Although a greater concentration of innovative firms is empirically observed in urban cantons, our results show that this spatial advantage does not primarily stem from classic Marshallian externalities or interactive learning generated by mere physical proximity. Rather, what is often mistaken for a pure agglomeration effect appears to reflect other structural determinants

that tend to cluster geographically in urban areas, such as more educated labour markets, greater access to finance, and higher levels of economic activity. In line with our findings, López-Bazo and Motellón (2017) also found no positive relationship between regional population density and firms' propensity to innovate in Spain.

The non-significance of `BERD` indicates that the mere territorial concentration of R&D expenditure is not, by itself, sufficient to induce a higher propensity to innovate. In the context of a developing economy, this result can be interpreted as reflecting regional innovation systems that are still emerging, in which inter-actor linkages, institutional density, and, above all, firms' absorptive capacities remain insufficient to transform available knowledge into effective spillovers. In other words, proximity to local R&D efforts does not automatically generate exploitable externalities when firms do not possess the capacities needed to identify, assimilate, and exploit external knowledge. This interpretation is consistent with literature emphasizing that, in low- and middle-income countries, learning and absorption are preconditions for external knowledge to become innovation, as well as with recent evidence showing that technological spillovers in emerging economies depend critically on pre-existing local capacities (Garcia et al. 2024).

Finally, the effect of economic activity, proxied by GVA per capita, reveals a marked sectoral dichotomy. Its effect is positive and significant only for manufacturing firms, while remaining irrelevant for services. This asymmetry is consistent with the intrinsic nature of their innovation processes. Manufacturing innovation is generally more intensive in tangible capital and requires consolidated productive environments offering solvent demand, robust infrastructure, and physical supplier networks. By contrast, service firms, particularly knowledge-intensive ones, have more flexible cost structures and business models that allow them to profit from intangible innovations even in territories with lower aggregate wealth, provided that talent and connectivity are available.

5. Conclusions

This paper examined the extent to which Ecuadorian firms' decision to invest in innovation activities is conditioned by the cantonal geographical environment, once firm-level characteristics and sectoral membership are taken into account. By means of cross-classified multilevel logistic models, the results show that geography matters. Even after

comparing firms that are equivalent in size, age, digital adoption, and access to finance, the canton retains substantial explanatory power: the residual cantonal ICC reaches 10.29% in manufacturing and 7.50% in services. This indicates that a non-negligible share of innovation propensity is shaped by contextual territorial factors rather than by firms' internal attributes alone. In a country such as Ecuador, marked by sharp subnational asymmetries, the territory in which firms operate remains a structural condition that expands or constrains the possibilities for productive modernization.

The comparative analysis across sectors further shows that this territorial effect does not operate uniformly. Manufacturing exhibits deeper spatial anchoring than services, suggesting that its innovation decisions depend more strongly on the availability of infrastructure and on more tangible forms of local productive articulation. By contrast, services display a lower degree of territorial dependence, which is consistent with their greater organizational flexibility and the more dematerialized character of part of their innovation processes. This result introduces an important nuance into the study of the geography of innovation in developing economies: rather than mechanically reproducing the patterns observed in advanced countries, sectoral spatial dependence appears to be mediated by the productive structure, the quality of the local environment, and the still incomplete character of regional innovation systems.

Once cantonal covariates are introduced, the paper identifies the territorial mechanisms underpinning this geographical effect. Three factors emerge as robust and transversal determinants in the three estimated models: the financial depth of the local environment, the endowment of human capital, and the presence of cooperatives. The percentage of firms with access to financing in the canton is the strongest predictor, confirming that the easing of liquidity constraints remains a central condition for firms to undertake technological modernization efforts. Added to this is the positive effect of the share of the population with higher education, which highlights the importance of local talent as a basis for the absorption, adaptation, and implementation of knowledge. Finally, the density of cooperativism is also positively associated with the decision to innovate, suggesting that the presence of cooperatives may be capturing greater institutional thickness and better

capacities for coordination, collective learning, and local knowledge circulation. Together, these dimensions reduce between 27% and 30% of the territorial variance initially observed, indicating that a substantial share of the geographical component is driven by observable inequalities in capabilities, financing, and local institutional embeddedness.

One of the most relevant findings of the study is precisely what does not turn out to be significant. Neither population density nor aggregate cantonal R&D effort is related to the probability of investing in innovation. The statistical irrelevance of population density challenges the view that urban agglomeration automatically generates innovation externalities. In the Ecuadorian case, the spatial concentration of innovative firms in the main urban centres appears to be explained less by physical proximity itself than by the simultaneous concentration of strategic resources such as finance, human capital, and higher levels of economic development. Similarly, the non-significance of `BERD` suggests that the mere territorial concentration of business R&D expenditure is insufficient to generate effective spillovers for the rest of the productive structure. This finding is consistent with the idea that, in developing economies, regional innovation systems are still emerging and exhibit limited absorptive capacities. In such a context, proximity to local R&D poles does not automatically translate into stronger innovation decisions if firms and the local environment lack the capacities required to identify, assimilate, and exploit external knowledge.

The behaviour of GVA per capita introduces an additional sectoral distinction. Its positive and significant effect only in manufacturing suggests that the level of local economic development remains especially relevant where innovation requires more tangible investments, stronger production linkages, and more robust demand conditions. In services, by contrast, innovation appears to depend less on the aggregate size or wealth of the local economy and more on the availability of talent, finance, and relational structures capable of sustaining learning and adaptation processes. This asymmetry reinforces the need to avoid uniform readings of territory and to recognize that the spatial mechanisms fostering innovation differ depending on the technological and organizational basis of each sector.

The policy implications of these findings are clear. First, innovation policies in countries such as Ecuador should not rely exclusively on spatially blind strategies or on an

excessive confidence that urban concentration or increases in aggregate R&D expenditure will, by themselves, generate dynamic innovation ecosystems. The findings suggest that territorial priorities should focus on strengthening the mechanisms that actually mediate innovation: expanding access to productive finance, consolidating the training and retention of skilled human capital, and reinforcing local institutional infrastructures that favour economic cooperation and collective learning, including networks associated with cooperativism. Second, policy design must recognize sectoral heterogeneity. For manufacturing, improving the innovation environment also entails raising the level of local economic development, strengthening productive infrastructure, and reducing the territorial disadvantages faced by peripheral cantons. For services, by contrast, policy efforts should focus on talent, connectivity, and institutional articulation mechanisms capable of sustaining innovations that are less dependent on physical assets.

Finally, the results should be interpreted in light of some limitations. The cross-sectional nature of the database prevents the establishment of strict causal relationships and does not allow us to model explicitly the endogeneity of firm location. It is plausible that firms with stronger innovation capabilities tend to locate in cantons that already concentrate better financial, educational, or institutional conditions. Likewise, the fact that the analysis relies on data from 2010 calls for caution in extrapolating the findings to the present, given that the past decade, and particularly the post-pandemic period, has transformed the spatial organization of many economic activities, especially in services. Even so, the paper provides robust evidence on a central point: in a developing economy such as Ecuador, territory is not merely a passive container of firms, but a structure that substantially conditions the probability of innovating. Understanding which local attributes turn that structure into a platform for learning, or into a barrier to modernization, therefore remains a core task for both research and productive development policy.

Data Availability Statement

The data used in this study come primarily from the 2010 National Economic Census (CENEC) conducted by the National Institute of Statistics and Censuses of Ecuador (INEC), as well as from the 2010 Population and Housing Census and the 2010 Regional National Accounts of the Central Bank of Ecuador. All data sources used in the study are publicly

available. The replication materials used for the analyses are available from the corresponding author upon reasonable request.

References

Akaike H (1974) A new look at the statistical model identification. IEEE Transactions on Automatic Control 19(6):716–723. https://doi.org/10.1109/TAC.1974.1100705.

Alessandrini P, Presbitero AF, Zazzaro A (2010) Bank size or distance: What hampers innovation adoption by SMEs? Journal of Economic Geography 10(6):845–881. https://doi.org/10.1093/jeg/lbp055.

Asheim BT, Gertler MS (2005) The geography of innovation: Regional innovation systems. In: Fagerberg J, Mowery DC, Nelson RR (eds) The Oxford handbook of innovation. Oxford University Press, Oxford, pp 291–317. https://doi.org/10.1093/oxfordhb/9780199286805.003.0011.

Ayyagari M, Demirgüç-Kunt A, Maksimovic V (2011) Small vs. young firms across the world: Contribution to employment, job creation, and growth. World Bank Policy Research Working Paper 5631. https://hdl.handle.net/10986/3397.

Bauer CM, Guzmán C, Santos FJ (2012) Social capital as a distinctive feature of social economy firms. International Entrepreneurship and Management Journal 8:437–448. https://doi.org/10.1007/s11365-012-0230-7.

Bellmann L, Crimmann A, Evers K, Hujer R (2013) Regional determinants of establishments' innovation activities: A multi-level approach. IZA Discussion Paper 7572. https://ssrn.com/abstract=2318753.

Beltrán Tapia FJ (2012) Commons, social capital, and the emergence of agricultural cooperatives in early twentieth-century Spain. European Review of Economic History 16(4):511–528. https://doi.org/10.1093/ereh/hes014.

Benfratello L, Schiantarelli F, Sembenelli A (2008) Banks and innovation: Microeconometric evidence on Italian firms. Journal of Financial Economics 90(2):197–217. https://doi.org/10.1016/j.jfineco.2008.01.00.

Beugelsdijk S (2007) The regional environment and a firm's innovative performance: A plea for a multilevel interactionist approach. Economic Geography 83(2):181–199. https://doi.org/10.1111/j.1944-8287.2007.tb00342.x.

Birchall J (2011) People-centred businesses: Co-operatives, mutuals and the idea of membership. Palgrave Macmillan, London. https://doi.org/10.1057/9780230295292.

Bruna F, Fernández-Sastre J (2021) Regional characteristics and the decision to innovate in a developing country: A multilevel analysis of Ecuadorian firms. Papers in Regional Science 100(6):1337–1354. https://doi.org/10.1111/pirs.12632.

Capello R (2015) Regional economics. 2nd edn. Routledge, London.

Carlino GA, Chatterjee S, Hunt RM (2007) Urban density and the rate of invention. Journal of Urban Economics 61(3):389–419. https://doi.org/10.1016/j.jue.2006.08.003.

Chaminade C, Lundvall BÅ, Vang-Lauridsen J, Joseph KJ (2009) Designing innovation policies for development: Towards a systemic experimentation-based approach. In: Lundvall BÅ, Joseph KJ, Chaminade C, Vang J (eds) Handbook of innovation systems and developing countries. Edward Elgar, Cheltenham, pp 360–379. https://doi.org/10.4337/9781849803427.00022.

Chen Y, Hasan I, Jiang L (2022) Urban agglomeration and firm innovation: Evidence from Asia. World Bank Economic Review 36 (2): 533–558. https://doi.org/10.1093/wber/lhab022.

Corrocher N, Cusmano L (2014) The "KIBS engine" of regional innovation systems: Empirical evidence from European regions. Regional Studies 48(7):1212–1226. https://doi.org/10.1080/00343404.2012.731045.

Corsi C, Prencipe, A (2016). Improving innovation in university spin-offs: The fostering role of university and region. Journal of Technology Management & Innovation, 11(2), 13–21. https://doi.org/10.4067/S0718-27242016000200002.

Crespi G, Zuñiga P (2012) Innovation and productivity: Evidence from six Latin American countries. World Development 40(2):273–290. https://doi.org/10.1016/j.worlddev.2011.07.010.

Cucculelli M (2018) Firm age and the probability of product innovation: Do CEO tenure and product tenure matter? Journal of Evolutionary Economics 28:153–179. https://doi.org/10.1007/s00191-017-0542-4.

Czarnitzki D, Hottenrott H (2011) R&D investment and financing constraints of small and medium-sized firms. Small Business Economics 36(1):65–83. https://doi.org/10.1007/s11187-009-9189-3.

Duranton G, Puga D (2001) Nursery cities: Urban diversity, process innovation, and the life cycle of products. American Economic Review 91(5):1454–1477. https://doi.org/10.1257/aer.91.5.1454.

Feldman MP, Audretsch DB (1999) Innovation in cities: Science-based diversity, specialization and localized competition. European Economic Review 43(2):409–429. https://doi.org/10.1016/S0014-2921(98)00047-6.

Fitjar RD, Rodríguez-Pose A (2015) Networking, context and firm-level innovation: Cooperation through the regional filter in Norway. Geoforum 63:25–35. https://doi.org/10.1016/j.geoforum.2015.05.010.

Garcia R, Araujo V, Mascarini S, Santos EG, Costa A, Ferreira S (2024) Unveiling the role of different types of local absorptive capacity: The effects of inward FDI spillovers on regional innovation. Papers in Regional Science 103(5):100044. https://doi.org/10.1016/j.pirs.2024.100044.

Gorodnichenko Y, Schnitzer M (2013) Financial constraints and innovation: Why poor countries don't catch up. Journal of the European Economic Association11(5):1115–1152. https://doi.org/10.1111/jeea.12033.

Hall BH (2002) The financing of research and development. Oxford Review of Economic Policy 18(1):35–51. https://doi.org/10.1093/oxrep/18.1.35.

Jaffe AB, Trajtenberg M, Henderson R (1993) Geographic localization of knowledge spillovers as evidenced by patent citations. Quarterly Journal of Economics 108(3):577–598. https://doi.org/10.2307/2118401.

Lee N, Brown R (2017) Innovation, SMEs and the liability of distance: The demand and supply of bank funding in UK peripheral regions. Journal of Economic Geography 17(1):233–260. https://doi.org/10.1093/jeg/lbw011.

Lee N, Rodríguez-Pose A (2013) Innovation and spatial inequality in Europe and USA. Journal of Economic Geography 13(1):1–22. https://doi.org/10.1093/jeg/lbs022.

López-Bazo E, Motellón E (2017) Innovation, heterogeneous firms and the region: Evidence from Spain. Regional Studies 52(5):673–687. https://doi.org/10.1080/00343404.2017.1331296.

Love JH, Roper S (2001) Location and network effects on innovation success: Evidence for UK, German and Irish manufacturing plants. Research Policy 30(4):643–661. https://doi.org/10.1016/S0048-7333(00)00098-6.

McCann P, Simonen J (2005) Innovation, knowledge spillovers and local labour markets. Papers in Regional Science 84(3):465–485. https://doi.org/10.1111/j.1435-5957.2005.00036.x.

Powers JB, McDougall PP (2005) University start-up formation and technology licensing with firms that go public: A resource-based view of academic entrepreneurship. Journal of Business Venturing 20(3):291–311. https://doi.org/10.1016/j.jbusvent.2003.12.008.

Rabe-Hesketh S, Skrondal A (2012) Multilevel and longitudinal modeling using Stata. 3rd edn. Stata Press, College Station.

Raspe O, Van Oort F (2008) Firm growth and localized knowledge externalities. The Journal of Regional Analysis and Policy 38(2):100–116. https://doi.org/10.22004/AG.ECON.132349.

Rodríguez-Gulías MJ, Rodeiro-Pazos D, Fernández-López S (2016) The regional effect on the innovative performance of university spin-offs: A multilevel approach. Journal of the Knowledge Economy 7:869–889. https://doi.org/10.1007/s13132-015-0287-y.

Rosenthal SS, Strange WC (2004) Evidence on the nature and sources of agglomeration economies. In: Henderson JV, Thisse JF (eds) Handbook of regional and urban economics. Vol 4. Elsevier, Amsterdam, pp 2119–2171. https://doi.org/10.1016/S1574-0080(04)80006-3.

Saz-Gil I, Bretos I, Díaz-Foncea M (2021) Cooperatives and social capital: A narrative literature review and directions for future research. Sustainability 13(2):534. https://doi.org/10.3390/su13020534.

Schmookler J (1966) Invention and economic growth. Harvard University Press, Cambridge

Schwarz G (1978) Estimating the dimension of a model. The Annals of Statistics 6(2):461–464. https://doi.org/10.1214/aos/1176344136.

Shearmur R, Doloreux D (2009) Place, space and innovation: Do KIBS and manufacturing firms interact differently? Environment and Planning A 41(7):1641–1656. https://doi.org/10.1080/13662710902728001.

Srholec M (2011) A multilevel analysis of innovation in developing countries. Industrial and Corporate Change 20(6):1539–1569. https://doi.org/10.1093/icc/dtr024.

Sternberg R, Arndt O (2001) The firm or the region: What determines the innovation behavior of European firms? Economic Geography 77(4):364–382. https://doi.org/10.1111/j.1944-8287.2001.tb00170.x.

Storper M, Venables AJ (2004) Buzz: Face-to-face contact and the urban economy. Journal of Economic Geography 4(4):351–370. https://doi.org/10.1093/jnlecg/lbh027.