This is a pre-print of an article published in Socio-Economic Planning Sciences. The final authenticated version is available online at: https://doi.org/10.1016/j.seps.2020.100900

Horváth, K.; **Berbegal-Mirabent, J.** (2020). The role of universities on the consolidation of knowledge-based sectors: A spatial econometric analysis of KIBS formation rates in Spanish regions. *Socio-Economic Planning Sciences*. DOI: 10.1016/j.seps.2020.100900.

The role of universities on the consolidation of knowledge-based sectors: A spatial econometric analysis of KIBS formation rates in Spanish regions

Krisztina Horváth*
Regional Innovation and Entrepreneurship Research Center (RIERC),
Faculty of Business and Economics, University of Pécs
Pécs, Rákóczi út 80. 7622-Hungary
E-mail: horvath.krisztina@ktk.pte.hu

Jasmina Berbegal-Mirabent
Department of Economy and Business Organization, Universitat Internacional de Catalunya (UIC)
C. Immaculada, 22. 08017. Barcelona, Spain
E-mail: jberbegal@uic.es

Abstract
This study evaluates how features related to the regional configuration of universities—i.e., the number of universities in a region and the proportion of public universities—influence the regional formation rate of knowledge-intensive business service (KIBS) firms. Using a sample of 47 Spanish regions (provinces) during 2009-2013, the results of the spatial econometric panel analysis give support to the argument that regions with a greater concentration of universities and with higher proportion of public universities attract more new KIBS firms. However, the findings also indicate a substitution effect between these university-based variables and the region's industry specialization. Thus, new KIBS businesses tend to locate in regions where they expect either stronger knowledge inputs from universities or higher demand from potential industrial customers. We also reveal the presence of interregional spillover effects. The paper offers insights on how territories may attract more knowledge-based businesses by encouraging the development of the local higher education system.

Keywords: knowledge-intensive business service (KIBS), university, public university, territorial servitization, spatial econometrics, Spain

* Corresponding author

The role of universities on the consolidation of knowledge-based sectors: A spatial econometric analysis of KIBS formation rates in Spanish regions

1. Introduction

Governments have increasingly devoted considerable resources to finance science, either through tax policy or direct investments. The recent trend of facilitating socio-economic progress via the creation and/or development of knowledge-based economies has resulted in reforms and investments in research and development (R&D) infrastructures, including universities and research centers (Izsak et al., 2013; Cruz-Castro and Sanz-Menéndez, 2016). Additionally, the growing awareness of the importance of universities as key pillars for the consolidation of knowledge-based economies has led European governing bodies to adopt specific policies within the EU 2020 strategic plan aimed at stimulating knowledge creation and diffusion, as well as scientific productivity among universities (European Commission, 2015).

In parallel, over the last decade economies have witnessed a drastic change in their industry configuration, and knowledge-intensive business service (KIBS) firms—such as management consultancy or research and development (R&D) services—have become one of the key engines for the consolidation of knowledge-based economies (European Commission, 2012). For instance, KIBS businesses can contribute to regional development (e.g., economic and employment) through the creation and transfer of knowledge to regional partners such as manufacturing firms, a concept recently referred to as territorial servitization (Lafuente et al., 2017; 2019). However, the weight of KIBS firms across territories is heterogeneous and conditioned by several factors, such as agglomeration economies, the quality of the entrepreneurial environment or the density of potential clients (Meliciani and Savona, 2015; Lafuente et al., 2017; Horváth and Rabetino, 2019).

The role of universities on regional development invites to research their potential contribution to the creation of KIBS firms at territorial level (Bonaccorsi et al., 2014; Calcagnini et al., 2016; Valero and Van Reenen, 2019). Universities might be strongly connected to the knowledge creation and diffusion processes that KIBS perform as both sources (e.g., by providing students as future employees, business idea incubators or accelerators) and recipients of knowledge (e.g., as clients or via informal connections) (Pinto et al., 2015; Agasisti et al., 2019). Nevertheless, universities' capacity to facilitate KIBS formation rates in a focal territory may not be homogeneous in terms of knowledge diffusion metrics. Additionally, knowledge spillovers that occur between territories may influence the level of knowledge available within an area (Acs et al., 2009).

Therefore, our study seeks to obtain a better grasp of how features related to the regional configuration of universities influence the regional formation rate of KIBS firms. More specifically, we test the effect of universities' concentration and ownership status—two measures potentially perceived important in the location decision of new KIBS businesses—on KIBS formation rates in 47

Spanish provinces during 2009-2013. Besides, our study analyzes whether (and how) the region's industry specialization conditions the impact of these university-linked factors.

Following the debate on the importance of efficiency of public universities from a policy perspective (e.g., Agasisti and Pérez-Esparrells, 2010; Lafuente and Berbegal-Mirabent, 2019), this research aims at investigating the extent to which universities are shaping the creation of new KIBS businesses within and between territories. To account for knowledge spillover processes between neighboring territories, we employ spatial econometric models—i.e., spatial Durbin panel models—that quantify the intraregional and interregional (spillover) effects of the analyzed variables. The analysis of the role of higher education institutions on the formation of knowledge-intensive businesses has been largely sidelined in prior work (Fischer et al., 2018). Yet, the use of spatial econometrics model together with the analysis of direct/indirect effects constitutes a novelty in the field, becoming one of the first studies that evaluate the relationship between universities and KIBS formation rates employing this technique. Accordingly, this work contributes to the existing literature both from a theoretical (i.e., how universities stimulate KIBS business creation at regional level) and a methodological (i.e. using spatial econometrics) angle.

The results of the spatial econometric models highlight the positive effect of universities on regional KIBS formation processes. More specifically, we find both an increased role of concentration of universities and public universities in attracting KIBS businesses to the territory. However, we also observe that these effects only prevail in areas with a relatively low industry specialization, which results in lower KIBS formation rates in territories with both high number of universities (high proportion of public universities) and high industry specialization. In line with Horváth and Rabetino (2019), this result shows that market demand and related regional characteristics can have an important modifying effect on the location decisions of KIBS businesses.

The remainder of the paper is structured as follows. Section 2 provides the theory that reveals the role of universities on regional KIBS formation processes. For hypotheses development, two university-linked drivers and the potentially moderating effect of industry specialization are considered. As a framework of our empirical analyses, data, variables and estimation strategy are provided in Section 3. Results are presented in Section 4, while Section 5 gives space to concluding remarks.

2. Background theory and hypotheses development

2.1. Growing in universities' backyard: A fertile ground for new KIBS businesses

Increasingly, regional development relies on territories' capacity to innovate and transfer knowledge to local businesses (Boschma, 2005; Crespo et al., 2014), and KIBS firms play a decisive role in this process (e.g., Lafuente et al., 2010; European Commission, 2012; Corrocher and Cusmano, 2014; Gebauer and Binz, 2019). Based on Miles et al. (1995, p. 18) who first coined the term, KIBS businesses are business-to-business (B2B) service providers that deal with *"…economic activities*

which are intended to result in the creation, accumulation or dissemination of knowledge". Beyond knowledge diffusion as their main value-added, KIBS businesses may contribute to the territory's performance via own, internal innovations and as mediators of external innovations too (Muller and Zenker, 2001; Shearmur, 2012). A significant part of KIBS businesses' knowledge lies in their employees, and therefore, the quality of their human resources is essential (Tether and Hipp, 2002). Basically, two stages of business-employee interactions determine this quality: employee selection—e.g., initial quality of knowledge inputs such as qualification, skills, and experience—and after-integration employee development. As we see in Pinto et al. (2015), over time, KIBS businesses gain the human capital and relevant expertise required to their operations, and they develop greater independence from external knowledge sources such as science and technology parks. But, when it comes to businesses facing different liabilities—e.g., liability of newness and smallness, and resource constraints (Aldrich and Auster, 1986; Hudson et al., 2001)—tapping external knowledge sources for high-quality human capital and knowledge may be of utmost relevance (Koch and Stahlecker, 2006; Johnston and Huggins, 2018). In this sense, universities may serve as important fertilizers to KIBS businesses and provide them with strategic advantages, especially in their early stages of development.

Besides their traditional core functions (i.e., education and research), the growing importance of knowledge and innovation as key pillars of development and growth has led universities to become decisive actors of territorial economic development (e.g., Etzkowitz, 2003; Shore and McLauchlan, 2012; Degl'Innocenti et al., 2019). A relevant task within this so-called "third mission" is knowledge transfer from universities to businesses. According to Laredo (2007), these interactions take place mainly via future employees' knowledge and skills; but also research contracts and intermediary roles such as internships or consultancy activities. Pinto et al. (2015, p. 1880) added to this list informal relationships, defined as *"all types of engagement not supported by a formal contract or agreement"*, with an even superior relevance. For instance, informal relationships can be established in conferences, workshops, or via unofficial discussion of research results and business ideas. Businesses—including the KIBS sector—may absorb and convert this knowledge to wealth-creating processes such as new product development, advanced service provision or increased competitiveness (Agasisti et al., 2019).

Therefore, universities have turned into one of the most important engines for regional economic development as well as for business consolidation (e.g., Harris, 2001; Hegde, 2005). For instance, Ponds et al. (2010) detected in the Netherlands a positive effect of universities' research and development (R&D) on regional innovation, while Moutinho et al. (2015) provided evidence that higher university R&D employment in Europe has the potential to reduce unemployment and increase gross-value added figures. From this viewpoint, Spain—the focus of our study—constitutes a special case since universities proved themselves as relevant external R&D partners for innovative businesses (Segarra-Blasco and Arauzo-Carod, 2008; Fernández-López et al., 2019).

A traditionally central factor deemed to determine universities' knowledge diffusion capacity is geographic or spatial proximity (e.g., Siegel et al., 2003; Abramovsky et al., 2007). Although it ceased to be a pre-requisite for university-led knowledge spillover to take place (e.g., Feldman, 1994; Raspe and Van Oort, 2011; Varga and Sebestyén, 2017), scientific evidence shows that it still remained a decisive characteristic of university-business relationships (e.g., Crescenzi et al., 2017; Drejer and Østergaard, 2017). For instance, Bresnahan et al. (2001) revealed that important elements of universities' "knowledge toolkit" such as provision of skilled human capital, managerial and entrepreneurial skills, are key factors in the formation of regional entrepreneurial and innovation clusters (e.g., Silicon Valley). Besides, Fernandes and Ferreira (2013) found a positive relationship between geographic proximity, KIBS businesses' cooperation with universities and their number of innovations.

After a general insight into universities' knowledge generation capacity for new KIBS businesses, in Section 2, hypotheses development follows. In the first subsections (Sections 2.2.1 and 2.2.2), we explore universities' ability to foster regional KIBS formation and articulate the hypotheses for two potential drivers of this process. Then, in Section 2.2.3 we investigate the potential impact of regions' industry specialization that possibly moderates universities' effect on the location choices of new KIBS businesses.

2.2. Hypotheses development

2.2.1. Concentration of universities to steer regional KIBS business formation

Businesses' choice to locate close to universities might be conditioned by both their differing need for university knowledge and the quality of this knowledge. First of all, not all businesses require university knowledge to the same extent. For instance, some influencing factors that determine the need for university knowledge are *industry characteristics* (Anselin et al., 2000), *cost of internal knowledge production, acquisition from a larger geographic distance* (Harhoff, 2000; Fischer et al., 2018) as well as *growth ambition of businesses* (Segarra-Blasco and Arauzo-Carod, 2008). Based on the industry characteristics, cost sensitivity and growth—or at least survival—ambitions of new KIBS firms (see Section 2.1 before), they are likely to have a greater need for university knowledge, and thus, a solid reason to locate close to universities. This intuition is supported by Baptista et al. (2011) who showed for the specific case of Portugal that establishing a new university in Portuguese municipalities enhanced the level of business entry in knowledge-based sectors.

Second, a link can be developed between the need for geographic proximity and the accessibility—i.e., the codified vs. tacit nature (Foray and Lundvall, 1998)—of knowledge. Audretsch et al. (2005) found that both the *knowledge output* (research or human capital) and the *knowledge orientation* (natural science and social science) of universities may condition the location of businesses. Particularly, they observed that in Germany, new knowledge-based businesses from highly innovative industries tend to locate further from universities with better quality research in the field of

natural sciences and closer to universities with better quality social sciences research. The effect was the opposite in terms of human capital: firms chose to locate closer to universities with more students in the field of natural sciences, while more potential future employees in social sciences did not evoke this effect. In Spain, Acosta et al. (2011) partially confirmed these results. The authors found a positive significant relationship only between the number of graduates in science and technology and the location of new high-technology businesses. Besides, their results revealed a potential need for the *match of specialization*. In Italy (Calcagnini et al., 2016) and in Brazil (Fischer et al., 2018) findings partially overlapped with those observed in the previous countries.

Finally, the third stream of studies highlights the role of the quality of knowledge on the location decision of businesses. The *presence of universities in a territory* itself may reflect a good-quality local infrastructure that can positively influence the location decision of knowledge-based service firms (Lafuente et al., 2010). Woodward et al. (2006) found a significant relationship between *university R&D expenditures* and the number of newly created high-technology plants by county, and Kirchhoff et al. (2007) reported similar results in the US. Based on the findings by Agasisti et al. (2019), co-location with more *efficient and better performing* universities might be a logical choice—as far as businesses are able to perceive it—too as they may have a higher capacity to foster intraregional economic development.

Because businesses tend to lack comprehensive information about the qualities of a given university and especially the qualities of all the universities in an area, perceptions constitute an essential link in establishing university-business relationships. For instance, in their case study Johnston and Huggins (2018) found that in the UK small firms tend to engage in collaborative relationships with universities based on their perceived credibility. However, their judgment is mostly shaped by the credibility of an academic individual (e.g., their achievements, recommendations, and knowledge field) and not of an organization as a whole. Besides, although the authors list several individual traits whose complex assessment would reduce the risk of coupling with the wrong university, most study firms confine themselves to the evaluation of only some of these characteristics.

Nevertheless, as opposed to collaboration decisions made by existing businesses in a territory, when it comes to preceding business location decisions a broader context analysis seems to take place to gauge the territory's knowledge potential. As Alcácer and Chung (2007) suggested—among others—businesses choose to locate in areas that may provide them the most knowledge gains. Given the limited capacity and/or willingness to measure these gains (e.g., efficiency or performance of universities), a good proxy in business decisions could be the spatial concentration of universities. Concentration likely indicates high-quality university knowledge available in the area, due to the presence of competitors that provoke development efforts in the co-locating universities (Porter, 1994).

Empirical evidence supports this argument. For instance, Audretsch et al. (2005) revealed that the higher the number of universities in a territory, the closer a new knowledge-based business is located

to the closest university. For innovative start-ups in general, Calcagnini et al. (2016) confirmed these results. Valero and Van Reenen (2019) added that a high number of universities is associated with greater regional economic development. Agasisti (2009) and Agasisti et al. (2019) came to the same result, and—supporting the previously assumed beneficial role of co-location with competitors—explained this phenomenon by the higher level of competition among universities that may lead to increased university performance, and trigger economic development. Therefore, taking as a basis the results of the aforementioned studies, we propose the following hypothesis:

Hypothesis 1. A higher concentration of universities contributes to a greater KIBS business formation rate in the same region.

2.2.2. Public vs. private universities – Is there a difference in regional knowledge generation?

As suggested in the previous section (Section 2.2.1), universities possess different capacities to disseminate knowledge, and thus, they may have a diverse impact on regional KIBS business formation rates. A common distinction originating in the organization theory and made between universities is their public / private status (e.g., Denis et al., 2015). Similar to most European countries, Spanish public universities are state-owned and receive most of their funding from public taxes (Lafuente and Berbegal-Mirabent, 2019). Their financing model implies that although they ask for a tuition fee from their students, the partial coverage of educational costs by the state can make knowledge accessible to a relatively wide range of inhabitants (e.g., even in less developed areas) (Escardíbul et al., 2017). Besides, the use of public money comes with a responsibility to invest this amount efficiently and contribute to the region's development.

The efficient utilization and justification of public funding can be examined via the comparison between the efficiency and performance of public vs. private universities. Most evidence comes from the USA. For instance, Hegde (2005) found that public universities tend to adapt to private sector demand less efficiently, and their patents and research target local innovation needs to a less extent as compared to private universities. Also, in their analysis of more than 7,000 US colleges and universities, Guironnet and Peypoch (2018) found that in terms of education efficiency, public universities perform better while private universities excel at research efficiency. Public universities' excellence in educational efficiency might be traced back to a more rigorous initial quality filter of students, while higher research efficiency in private universities—consistently with the findings by Hegde (2005)—manifests in a higher rate and quality of publications.

Nevertheless, as for the private-public context of universities, results are sensitive to country-specific characteristics, and therefore, it is important to analyze the knowledge spillover capability of public and private universities in the national environment, which is the actual focus of this study. For Spain, Caldera and Debande (2010) found that public universities have a higher R&D income, higher number of R&D contracts but private universities issue more licenses. Analyzing a more extended set of knowledge outputs, Casani et al. (2014) found that on average public universities outperform

private ones in several aspects associated with the quantity and quality of produced knowledge: for instance, in the number of staff with PhDs, research productivity, percentage of papers published in first quartile (Q1) in Web of Science, and in engagement in innovation. In terms of efficiency, de la Torre et al. (2017) found that the greater flexibility of private universities seem to help them make a better adjustment between inputs and outputs than public ones. However, this result is no longer valid after the economic crisis. Data from the period 2013-2014 revealed that public universities have caught up with private ones although having their inputs substantially reduced.

However, against the higher state expectations towards public universities, evidence shows the limited capacity of Spanish public universities to excel at each of their three hypothetical missions (Berbegal-Mirabent et al., 2019). As Sánchez-Barrioluengo (2014) found, while research and knowledge transfer activities develop in synergy, teaching is less compatible with these activities. But, in Spain, on average, public universities seem to outperform private ones in terms of the quality of graduates and research—i.e., knowledge outputs with the most impact on territorial development—and thus, they may have a more pronounced positive effect on intraregional development and on KIBS formation rates at territorial level. Keep in mind that in Spain the territorial landscape is dominated by peripheral regions. In these geographies public universities can be of great relevance to less developed businesses, as they can provide them cost advantages due to their proximity and more affordable service offerings. Innovative businesses can also benefit from their presence as a compensation of missing complementary services (e.g., professional KIBS for technological KIBS businesses) (Pinto et al., 2015). Consequently, in the context of our study, we hypothesize that:

Hypothesis 2. A higher proportion of public universities contributes to a greater KIBS business formation rate in the same region.

2.2.3. The moderating role of the region's industry specialization

In addition to potential knowledge gains from universities, market demand likely constitutes an important location factor for KIBS businesses. Besides, beyond a pure trade relationship, KIBS' existing knowledge stock can develop with accumulated experience on customized and time-changing problem solving for their business clients (Tether and Hipp, 2002; Scarbrough et al., 2004). More specifically, a business segment that has proved to be one of the most important clients of KIBS businesses is the industry sector, and more specifically, the manufacturing industry (den Hertog, 2000; Vendrell-Herrero et al., 2017; Bustinza et al., 2019). For instance, Bienkowska (2015) documents that a remarkable share of jobs in the manufacturing industry in Europe (40%) is related to high value added services. In addition, over the last few decades, manufacturers' demand for knowledge-intensive services has increased due to various emerging and valuable forms of cooperation such as outsourcing (e.g., Hätönen and Eriksson, 2009) and combined product-service offerings, that is, business servitization (e.g., Vendrell-Herrero et al., 2017; Bustinza et al., 2019).

By interacting with customers, KIBS firms face the challenge of both dealing with unprecedented cases that require additional knowledge and managing frequent interactions in an efficient way (Garicano and Wu, 2012). Therefore, and similar to accessing university-based advantages, building (tacit) knowledge through interactions with clients likely requires geographic proximity, in particular, at the beginning of their lifecycle and establishing their client base (Koch and Stahlecker, 2006). For KIBS businesses, proximity to clients has been identified as a crucial location factor by several scientific studies (e.g., Keeble and Nachum, 2002; Meliciani and Savona, 2015). In this regard, there is a growing stream in the academic literature that is gaining momentum investigating the characteristics and territorial effects of the interactions between KIBS and manufacturing sector, recently referred to as "territorial servitization" (Lafuente et al., 2017). Among others, this research line suggests that territories with a consolidated manufacturing base will likely have greater KIBS formation rates (e.g., Lafuente et al., 2017; Gomes et al., 2019).

Notwithstanding, this also implies that a pure mass of manufacturers does not automatically induce the spread of new KIBS businesses in a territory. Instead, the scientific literature points to the relevance of a favorable entrepreneurial environment that can serve as a seedbed for elevated KIBS formation. As Acs et al. (2014) describe, the relevance of a healthy, developed entrepreneurial environment—or "entrepreneurial ecosystem" (p. 490)—lies in its high-quality business actors and institutional background that may serve as a catalyst to new business success through its self-reinforcing processes. In terms of interaction with manufacturers, the findings by Horváth and Rabetino (2019) demonstrate two regional development paths for KIBS businesses. First, they reveal that a healthy entrepreneurial ecosystem (e.g., via the provision of developed digital infrastructure and high-quality human capital) per se is able to stimulate KIBS formation in a territory. Second, they find that increased manufacturing specialization only spurs KIBS formation if the region accommodates a healthy entrepreneurial ecosystem. Some ecosystem elements that have proved to be relevant for elevated KIBS formation are the size, dynamism (e.g., generation of spin-off companies) and cooperation willingness (e.g., need for external R&D efforts) of their local client base (Koch and Stahlecker, 2006; Bellandi and Santini, 2019). Similarly, Wyrwich (2019) showed that the recognition of new, large-scale business opportunities in a territory can also contribute to an increased start-up rate of its KIBS businesses.

Based on the KIBS generation competence of the industry sector—that mostly incorporates manufacturing businesses—, we hypothesize that it strengthens the positive effect of universities—both in terms of concentration of universities and the proportion of public universities—on KIBS formation in the region. Accordingly, we conjecture that:

Hypothesis 3. The region's industry specialization moderates the positive relationship between concentration of universities and KIBS business formation rate in the same region.

Hypothesis 4. The region's industry specialization moderates the positive relationship between the proportion of public universities and KIBS business formation rate in the same region.

3. Data, variables and method

3.1. Data and variable description

The data used in this study comes from multiple sources: the Statistical Office of the European Communities (Eurostat), the European Tertiary Education Register (ETER) database and the Spanish Statistical Office (INE)). In this paper the unit of analysis is the region, and the final sample includes 47 NUTS-3 level Spanish regions (provinces). Because of data availability issues and the importance of common borders in our spatial models, we analyze 47 out of the available 59 NUTS-3 Spanish regions (see more in Section 3.2). The excluded territories include islands (regions in the Balearic Islands and Canary Islands) and the territories of Ceuta and Melilla regions which are located in Africa.[1] The dataset includes information for the period 2009-2013.

Dependent variable. The dependent variable is the KIBS business formation rate (KIBS_fr), which is computed from data available in the Eurostat regional database. Similar to Tödtling and Wanzenböck (2003) and Fritsch and Falck (2007), this variable is measured as the number of newly created KIBS firms per 1000 workers in the region. An advantage of this variable is that a higher (lower) density of new KIBS firms can be explained by reasons other than simple variations in the territory's active population. As start-ups' location decision may depend on specific attributes of the firm (Audretsch and Lehmann, 2004), the composition of knowledge-intensive service businesses should be presented. In our analysis, due to data availability issues, we included three broader categories of KIBS businesses: information and communication (NACE: category J), professional, scientific and technical activities (NACE: category M), and administrative and support service activities (NACE: category N).

Independent variables. The two independent variables of the study are related to the characteristics of the regional university system and were obtained from the ETER database. The first variable is the number of universities (NumberUniv) which is a proxy for the concentration of universities and approximates the overall quality of knowledge provided by universities in the region. More specifically, it is measured by the number of universities that operate in the focal region either via their main establishment or campuses located outside the university's home region. As mentioned before, the number of universities as a measure of the presence of higher education institutions or as a proxy of positive agglomeration externalities has been used in prior studies (Audretsch et al., 2005; D'Este and Iammarino, 2010; Calcagnini et al., 2016).

The second variable is the proportion of public universities (PropPublic) that aims to differentiate the potential role of public and private universities on KIBS business formation rates in a territory. The differential role of public and private universities has been analyzed in many studies, for instance,

[1] The excluded regions by NUTS-3 codes and names are: ES630 Ceuta, ES640 Melilla, ES531 Eivissa y Formentera, ES532 Mallorca, ES533 Menorca, ES703 El Hierro, ES704 Fuerteventura, ES705 Gran Canaria, ES706 La Gomera, ES707 La Palma, ES708 Lanzarote and ES709 Tenerife.

by Caldera and Debande (2010), and Guironnet and Peypoch (2018). Yet, different from these studies where the unit of analysis is the university, our approach based on the study of regions gives space to a complex, more systemic type of analysis.

Moderator variable. In addition, we employ a moderator variable that accounts for the region's industry specialization (IndSpec) and it is measured by the proportion of industrial businesses among all the businesses in the territory. Industrial businesses include manufacturing sectors (NACE: category C) as important clients of KIBS businesses (Arnold et al., 2016; Lafuente et al., 2017), and additionally, they include businesses operating in the field of mining and quarrying (NACE: category B); electricity, gas, steam and air conditioning supply (NACE: category D); and water supply, sewerage, waste management and remediation activities (NACE: category E). The data to this variable was downloaded from the Eurostat regional database.

Control variables. We include two commonly used control variables in our study: gross domestic product (GDP) per capita and population density. GDP per capita (GDP_pc) is an indicator of regional economic development (e.g., Fisman and Khanna, 2004) that has been employed in various analyses on territorial servitization (e.g., Lafuente et al., 2017; Horváth and Rabetino, 2019). In this study, GDP per capita is expressed in constant euro at 2011 prices, and it is retrieved from the Spanish Statistical Office (INE). We also include population density (PopDens), retrieving the data from the Eurostat regional database and measured in inhabitants per square km. Similar to Meliciani and Savona (2015), population density is considered as a proxy for urbanization externalities. Table 1 presents the descriptive statistics and correlation between the selected variables.

Table 1. Descriptive statistics and correlation matrix

Variable name	Mean	SD	1	2	3	4	5
1 KIBS_fr	1.9504	0.5655	1				
2 NumberUniv	1.9830	2.6083	0.6619	1			
3 PropPublic	0.8186	0.2634	–0.2965	–0.4446	1		
4 IndSpec	0.0821	0.0185	–0.3944	–0.2409	0.0838	1	
5 GDP_pc	21209.81	4479.22	0.3252	0.3634	–0.2920	0.0402	1
6 PopDens	120.43	167.32	0.7702	0.7993	–0.3381	–0.3048	0.4135

Note: Sample size = 235 observations. Except for correlation coefficients below |0.09| that are non-significant, all values in the correlation matrix represent correlations significant at the 1% level.

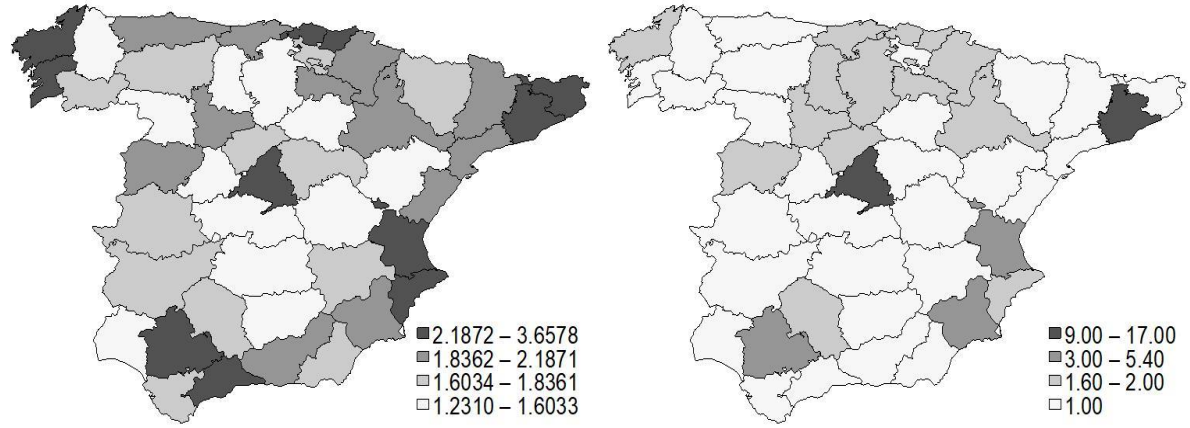
Figure 1 depicts the geographic distribution of the main (dependent, independent and moderator) study variables using average values between 2009 and 2013. In terms of KIBS formation rate, a few outstanding nodes can be identified in the country. As expected, Madrid (3.66) and Barcelona (3.65) are on top of the ranking, while high rates of new KIBS businesses can be observed in Málaga (3.13), Valencia (2.66), Girona (2.62), Alicante (2.41), La Coruña (2.37), Sevilla (2.30), Guipúzcoa (2.26), Pontevedra (2.24), and in Vizcaya (2.19) too. The lowest rates can be found mainly in the inner regions. Looking at our two independent variables, Madrid and Barcelona again report the highest numbers, that is, 17 and 9 universities, respectively; however, Valencia (5.4 universities), Sevilla (3.6

universities) and Murcia (3 universities) still belong to the best-performing regions. 28 regions are home of only one university. Also, an extreme distribution characterizes the proportion of public universities across Spain. In 30 regions, only public universities (mostly one university in the region) can be found, while Madrid (0.41), Valencia (0.37) and Ávila (0) host the least proportion of public universities.

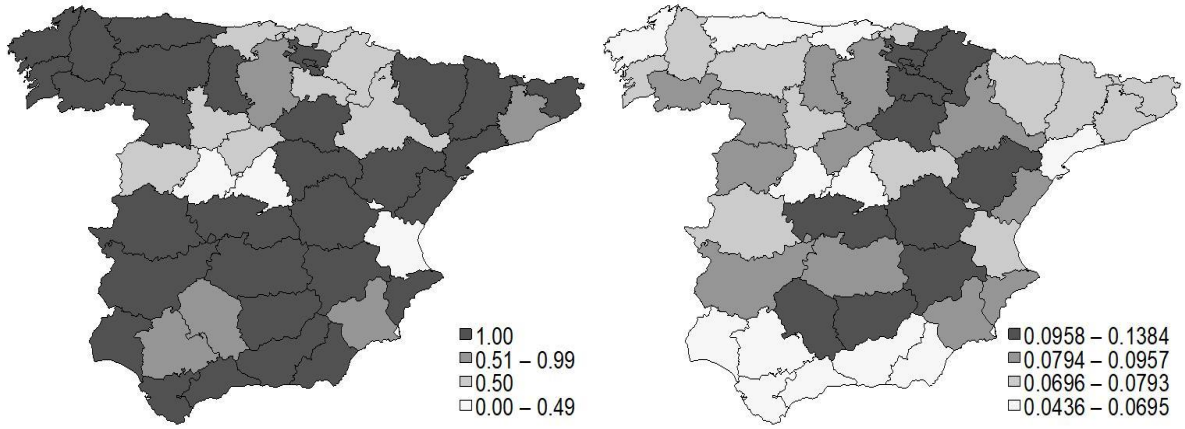
While some regions abundant in universities clearly excel at KIBS business generation (e.g., Madrid and Valencia), regions with a high proportion of public universities such as La Coruña and Pontevedra also have the capacity to form a relatively high number of new KIBS businesses. Interestingly, however, none of these regions have a high industry specialization. For instance, Madrid, Barcelona and Valencia belong to the less industrialized territories. Nevertheless, some successful KIBS-generating northern regions (e.g., Guipúzcoa and Navarra) demonstrate an opposite tendency: while they have a high regional industry specialization, they relatively underperform in terms of the number of universities and the rate of public universities in the region. We seek to reveal the reasons in our proposed empirical analyses described in Section 3.2.

Figure 1. Distribution map of the main study variables (average between 2009-2013)

(a) Number of new KIBS businesses per 1000 workers (b) Number of universities



(c) Proportion of public universities (d) Industry specialization



3.2. Method

Looking at the distribution of the dependent variable presented in Figure 1, a geographic pattern can be observed among regions with high (and low) capacity to facilitate the creation of KIBS firms. For instance, we can see that Madrid, excelling at the generation of new KIBS businesses, is surrounded by provinces with much less capacity to create or attract these firms. Therefore, it seems quite likely that different characteristics of neighboring provinces influence each other's capacity to contribute to KIBS formation too. This suggests the presence of spillover effects between regions, and therefore, we employ spatial econometric methods. More specifically, in this study we use spatial Durbin (SDM) fixed-effect panel model that quantifies three types of effects on regional KIBS formation rates: 1) intraregional effects, that is, effect of the independent, moderator and control variables (e.g., GDP_pc_{rt}), 2) effect of the dependent variable from neighboring regions ($W\_KIBS\_fr_{rt}$), and 3) spillover effects from neighboring regions (e.g., $W\_GDP\_pc_{rt}$). As indicated, effects from neighboring regions are defined by a spatial weight matrix (W). Also, the model assumes that spillover effects do not come exclusively from the direct neighbors but the effect of the neighboring region's neighbors is also observable (global spatial spillover) (LeSage and Pace, 2009).

In a spatial econometric framework, the effect of neighboring regions on a focal region is determined by the pattern that interregional spatial processes mainly follow. Two main patterns have been identified based on spatial proximity between regions: contiguity- and distance-based (e.g., Meliciani and Savona, 2015; Varga and Sebestyén, 2017). For instance, a contiguity-based connection might be observed between two regions with common borders (queen contiguity). An example to distance-based connection is the inverse distance approach, in which case interregional effects show a decreasing rate with respect to the distance between the two analyzed regions.

Universities' extraregional effects have been in the interest of several studies in the scientific literature. Looking at the contributions, however, it seems that there is neither a rule nor a consensus how far and at what intensity these impacts can spread in space. For instance, in the USA, Anselin et al. (2000) reported a maximum 75-mile-range of effect (121 km) from the central of the region, while Woodward et al. (2006) detected that university R&D expenditures can positively influence new venture creation up to a distance of 145 miles (233 km). In Brazil, Fischer et al. (2018) revealed that most university effects are restricted to a city level, however, microregions can also profit from a higher share of university students. In case of Italy, there is evidence for no spatial dependence between territories (Calcagnini et al., 2016), whereas Agasisti et al. (2019) suggested that under specific conditions—in their case, reaching a certain university efficiency level—university knowledge can spill over from one labor market area (LMA) to another.

As for the mechanism of these effects, in the Netherlands, Ponds et al. (2010) found that a network-based positive spatial dependence exists between university R&D and regional-level innovation. They also found that in some cases, a distance-based spatial dependence can explain the

innovation level of territories. In the same vein, Bonaccorsi et al. (2014) questioned how far university spillovers may reach in order to give birth to new knowledge-intensive businesses. Using Italian provinces as the units of analysis, they found that universities' spillover effects decay with increased geographic distance.

After all, and based on the characteristics of the applied methodology, in this study we run the following two spatial models. Equation (1) is the baseline model and equation (2) is the full model that incorporates interaction terms between university-based variables (number of universities and proportion of public universities) and the region's industry specialization:

Equation (1):

$$\begin{aligned}\text{KIBS\_fr}_{rt} &= \rho\text{W\_KIBS\_fr}_{rt} + \beta_1\text{NumberUniv}_{rt} + \beta_2\text{PropPublic}_{rt} + \beta_3\text{IndSpec}_{rt} + \beta_4\text{Controls}_{rt} \\ &+\theta_1\text{W\_NumberUniv}_{rt} + \theta_2\text{W\_PropPublic}_{rt} + \theta_3\text{W\_IndSpec}_{rt} + \theta_4\text{W\_Controls}_{rt} + \mu_r + \lambda_t + \varepsilon_{rt}\end{aligned}$$

Equation (2):

$$\begin{aligned}\text{KIBS\_fr}_{rt} &= \rho\text{W\_KIBS\_fr}_{rt} + \beta_1\text{NumberUniv}_{rt} + \beta_2\text{PropPublic}_{rt} + \beta_3\text{IndSpec}_{rt} \\ &+\beta_{41}\text{NumberUniv}_{rt}\times\text{IndSpec}_{rt} + \beta_{42}\text{PropPublic}_{rt}\times\text{IndSpec}_{rt} + \beta_5\text{Controls}_{rt} \\ &+\theta_1\text{W\_NumberUniv}_{rt} + \theta_2\text{W\_PropPublic}_{rt} + \theta_3\text{W\_IndSpec}_{rt} + \theta_{41}\text{W\_NumberUniv}_{rt}\times\text{IndSpec}_{rt} \\ &+\theta_{42}\text{W\_PropPublic}_{rt}\times\text{IndSpec}_{rt} + \theta_5\text{W\_Controls}_{rt} + \mu_r + \lambda_t + \varepsilon_{rt}\end{aligned}$$

In equations (1) and (2), KIBS formation rate (KIBS_fr_{rt}) is the dependent variable, *r* denotes the region and *t* the year of observation. W_KIBS_fr_{rt} indicates the spatially lagged dependent variable, that is, the number of new KIBS businesses per 1000 workers in neighboring regions. The number of universities (NumberUniv_{rt}) and the proportion of public universities (PropPublic_{rt}) are the main explanatory variables, and the region's industry specialization (IndSpec_{rt}) is the moderator variable. Controls_{rt} include GDP per capita (GDP_pc_{rt}) and population density (PopDens_{rt}). Similar to the case of the dependent variable, the term "W" identifies the spatially lagged forms of the independent, moderator and control variables. The terms β and θ are regression parameters for the aforementioned variables in local and neighboring regional settings, respectively. μ_r refers to region-specific fixed effects, λ_t indicates time-specific fixed effects, and ε_{rt} is the error term.

As opposed to a non-spatial model, regression coefficients in the spatial Durbin model cannot be interpreted as marginal effects of a change in each explanatory variable. Thus, to determine the sign and magnitude of these impacts, we follow the recommendation by Lesage and Pace (2009) and Elhorst (2014) and estimate the direct effects (i.e., the effect of a region on its own KIBS formation rate) and indirect effects (i.e., the effect of a region on its neighboring regions' KIBS formation, spillovers) for SDM. More specifically, we use the matrix of partial derivatives of KIBS formation rates with respect to the specific explanatory variable. Direct effects are calculated as the average of

main diagonal elements (own-partial derivatives, e.g., ∂ KIBS_fr$_r$/ ∂ NumberUniv$_r$), while the average of the off-diagonal elements (cross-partial derivatives, e.g., ∂ KIBS_fr$_j$/ ∂ NumberUniv$_r$, where *j* identifies the adjacent region) provides the spillover or indirect effects (LeSage and Pace, 2009).

Also, note that to verify the selected spatial model, we test its soundness over three models: an ordinary least squares (OLS) model, a spatial autoregressive model (SAR), and a spatial error model (SEM). As a first step of spatial diagnostics, we test whether a spatial or a non-spatial model better fits the data. For this purpose, as described in Elhorst (2014) and Anselin and Rey (2014), we use Lagrange Multiplier (LM) and robust Lagrange Multiplier tests. If the LM tests point to spatial dependence among neighboring territories, we estimate the proposed spatial Durbin model. As a second step, we still need to confirm that SDM is better than choosing one of the reduced spatial models (SAR or SEM) (Elhorst, 2014). As both SAR and SEM are models nested in SDM, a common factor analysis can guide our choice. If H_0: $\theta = 0$ is supported, simplification to SAR, while if H_0: $\theta + \rho\beta = 0$ is supported, simplification to SEM is the right decision (Anselin, 1988). These hypotheses are tested by Wald tests (Elhorst, 2014). Finally, we also conduct a likelihood ratio (LR) test to identify which type of fixed effect models—time or time-space—should be employed in our study models (Elhorst, 2014).

4. Results

Following the methodological plan described in Section 3.2, we first tested the existence of spatial dependence among neighboring regions. For this purpose, four spatial weight matrices were considered, namely, queen contiguity, binary distance, inverse distance and squared inverse distance matrices. Based on the results of the LM and robust LM tests (Table 2), the only spatial effect was observed with the queen contiguity (QUEEN) weight matrix, whereas we found no evidence of distant-based spatial dependence among neighboring regions in Spain. These results indicate that there is no common spatial pattern in terms of how far in space spillover effects can reach, but instead spillover processes can take place between any NUTS-3 regions that share common borders. In case of university-business relationships, Johnston and Huggins (2018) reported similar findings. The results of the Wald test indicate the dominance of the spatial Durbin model over both the SAR and SEM models. Thus, we apply SDM in our analysis. The significant LR test supports the extension of SDM from time fixed effects to a time- and space-specific fixed effects specification.

After running the spatial models suggested by the diagnostic tests, the SDM results in Table 2 point to universities' capacity, as potential knowledge users or providers, to influence KIBS formation rates in a territory. In Model 1, regional beta coefficients indicate that the increased presence of universities in the region may contribute to a higher rate of new KIBS businesses per 1000 workers in the same region. This confirms our first hypothesis (**H1**) which states that a higher concentration of universities is associated with a greater rate of new KIBS businesses in the region. We also find evidence to more lively KIBS formation processes in regions where the proportion of public

universities is higher as compared to private universities. Therefore, we confirm our second hypothesis (**H2**). These findings correspond with our complementary analysis in which regional level effects are clearly separated from the effects coming from the surrounding territories (direct effects).

Nevertheless, when we look at the results in Model 2, it turns out that universities' positive effect on regional KIBS formation—both in terms of the number of universities and the proportion of public universities in the territory—is not homogeneous across space but conditioned by the level of the region's industry specialization. Based on our theoretical underpinning, it is reasonable to think that territories with both a higher industry specialization and more universities (higher proportion of public universities) would contribute to enhanced KIBS business creation rates. However, as indicated in Model 2, this is not the case: a substitution effect exists between the industrial specialization and the given university-based characteristics of a region. To better gauge and interpret these effects, we estimated and plotted the marginal effects of university-based variables in regions with low and high industry specialization using pooled OLS models (Figures 2 and 3).

Figure 2 illustrates the moderating role of industry specialization on the effect of concentration of universities—measured by the number of universities in a region—on regional KIBS formation rate. On the one hand, and against our expectations, regions with various universities only experience a more pronounced KIBS formation rate if they have a low industry specialization. On the other hand, however, regions more specialized in industrial activities, even if their university landscape is scarcer, have the capacity to attract new KIBS businesses. Consequently, we cannot give support to our third hypothesis (**H3**).

A logical explanation to this phenomenon is that these locations are chosen by new KIBS businesses for different reasons. First, regions with a strong university base, even if they have a relatively low industry share, may be able to channel valuable resources such as competitive knowledge and innovative thinking to new KIBS businesses. This can compensate for a less extensive local industrial client base as it can make knowledge-based services attractive at extraregional level or even in an international context. Some regions' capacity to facilitate interaction with clients at a spatially less bounded level is evidenced by Keeble and Nachum (2002) who found that global activity of KIBS businesses may be more intense in territories characterized by collective learning and networking opportunities.

Second, regions with high industry specialization—as described in Section 2.2.3—may provide twofold advantages to new KIBS businesses: a critical mass of potential customers and experiential learning via interactions with customers. Nevertheless, based on the results of Model 1, the non-significant, unclear effect of industry specialization raises awareness to the heterogeneity and different capacity of these areas to contribute to regional KIBS formation.

Table 2. Spatial Durbin model: Regression results

(Dependent variable: KIBS formation rate, number of regions: 47, time period: 2009–2013, N=235)

	Model 1: Baseline model				Model 2: Full model			
	Coefficient (Std. error)	Direct effect	Indirect Effect	Total effect	Coefficient (Std. error)	Direct effect	Indirect effect	Total effect
NumberUniv (ln)	0.8865**	1.0912**	3.1916	4.2829*	1.4450***	1.5799***	3.4166	4.9966**
	(0.3858)	(0.4360)	(2.2572)	(2.5098)	(0.4951)	(0.5117)	(2.2975)	(2.5080)
PropPublic	1.2507**	1.5815***	5.1155	6.6970*	3.0407***	3.3780***	9.0966*	12.4746**
	(0.5230)	(0.5902)	(3.2033)	(3.5495)	(0.9237)	(0.9207)	(4.7185)	(5.0833)
IndSpec	0.0104	0.0203	0.1326	0.1529	0.2328***	0.2419***	0.3102	0.5521
	(0.0568)	(0.0557)	(0.1093)	(0.1145)	(0.0701)	(0.0799)	(0.3919)	(0.4507)
NumberUniv (ln) × IndSpec					–0.0843**	–0.0712*	0.1916	0.1204
					(0.0389)	(0.0387)	(0.1983)	(0.2411)
PropPublic × IndSpec					–0.2280***	–0.2232***	–0.1525	–0.3757
					(0.0650)	(0.0729)	(0.3367)	(0.3879)
GDP_pc (ln)	0.0424	0.0677	0.4176*	0.4853*	0.0898	0.1315	0.6323**	0.7738**
	(0.0690)	(0.0737)	(0.2455)	(0.2811)	(0.0731)	(0.0826)	(0.2735)	(0.3265)
PopDens (ln)	–0.1818	–0.3226	–2.5775	–2.9001	–0.0051	–0.2469	–2.9780	–3.2049
	(0.7858)	(0.7588)	(2.1464)	(2.1645)	(0.7209)	(0.6993)	(2.0085)	(2.1400)
W_KIBS_fr (Spatial rho)	0.3909***				0.3716***			
	(0.0924)				(0.0918)			

Table 2. Continued.

	Model 1: Baseline model				Model 2: Full model			
	Coefficient (Std. error)	Direct effect	Indirect Effect	Total effect	Coefficient (Std. error)	Direct effect	Indirect effect	Total effect
W_NumberUniv (ln)	1.6239				1.5083			
	(1.3754)				(1.5106)			
W_PropPublic	2.7089				4.8262*			
	(1.9254)				(2.9907)			
W_IndSpec	0.0762				0.0649			
	(0.0812)				(0.2224)			
W_NumberUniv (ln) × IndSpec					0.1884*			
					(0.1055)			
W_PropPublic × IndSpec					0.0341			
					(0.1972)			
W_GDP_pc (ln)	0.2492*				0.3928***			
	(0.1470)				(0.1285)			
W_PopDens (ln)	–1.5667				–1.7360			
	(1.4223)				(1.3155)			
Time dummies	Yes				Yes			
Diagnostic statistics								
R2 (within)	0.0778				0.0952			
Log (pseudo) likelihood value	270.0140				278.5652			
Wald test (chi2)	72.64***				58.02***			
Spatial diagnostics								
LM error (QUEEN)	31.71***				30.73***			
Robust LM error (QUEEN)	20.61***				13.70***			
LM lag (QUEEN)	22.17***				17.59***			
Robust LM lag (QUEEN)	11.07***				0.56			
Wald test: SDM / SAR	11.18*				17.28**			
Wald test: SDM / SEM	11.68*				16.94**			

Note: Time dummies are included in the model specification (2013 is the omitted time category). Robust standard errors adjusted by heteroskedasticity are presented in brackets. "W_" indicates the spatially lagged variables, calculated with row-standardized QUEEN weight matrix. *, **, *** indicate significance at the 10%, 5% and 1% levels, respectively.

Figure 2. The moderating role of industry specialization on the effect of number of universities on regional KIBS formation rate

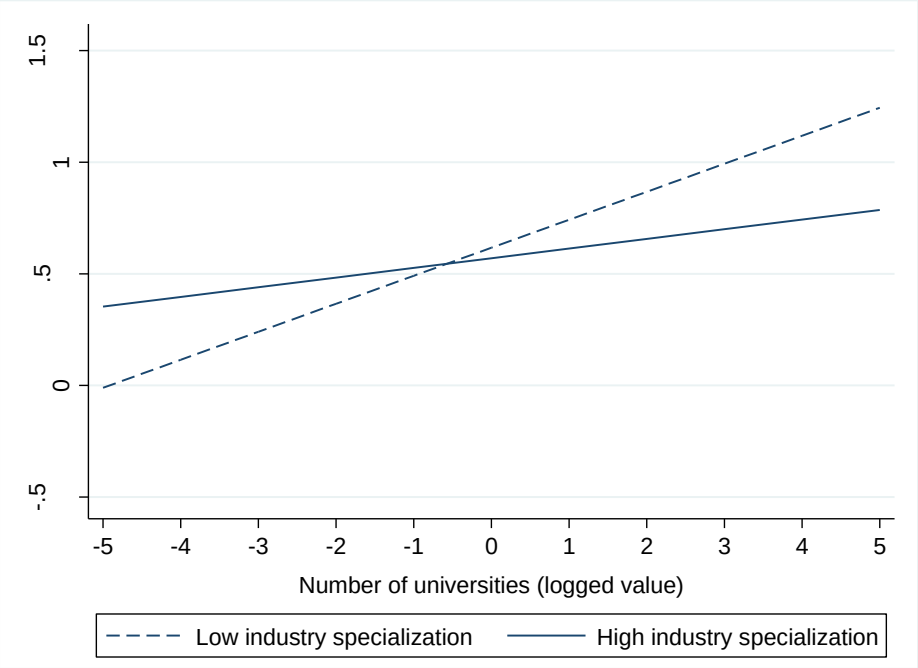
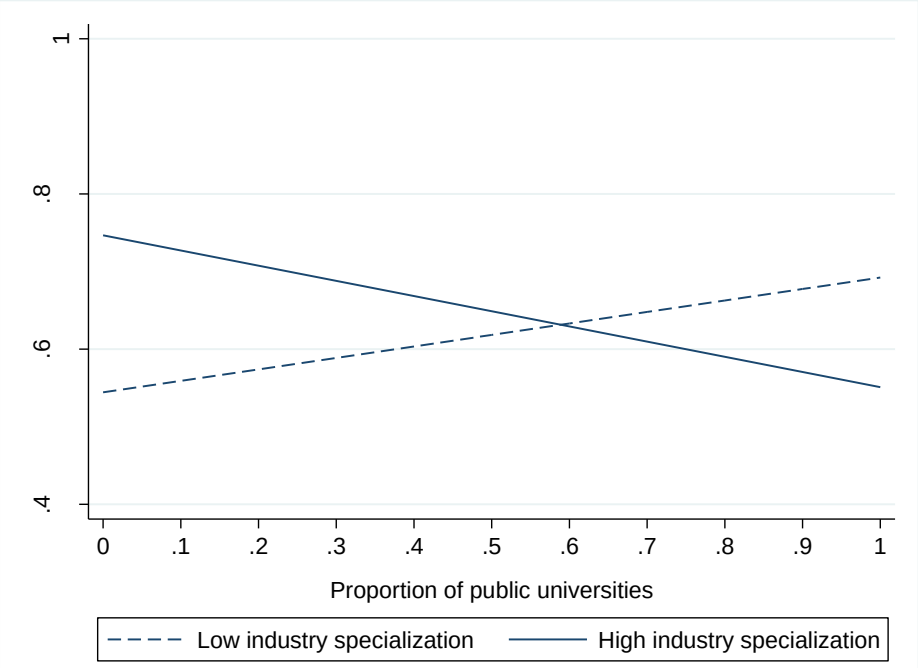


Figure 3 depicts the outcome of the moderating role of industry specialization on the effect of proportion of public universities. In this case, we can also observe that regions with a more dominant public university segment can have a more pronounced KIBS formation rate, even if the territory lacks the potentially inviting industrial businesses. This indicates that public universities may be able to compensate for some regional economic disadvantages—in our case, the lack of a consolidated industry base—in territories. Therefore, our fourth hypothesis (**H4**) is also rejected.

However, one can see that the effect of public universities exceeds regional boundaries. While public universities have the potential to facilitate KIBS formation in a territory, neighboring regions turn out to have a more pronounced, though less significant ($p<10\%$), positive effect. This result indicates that although regions may benefit from the presence of public universities, the density of new KIBS businesses may be higher in neighboring territories that have a more favorable entrepreneurial environment (e.g., Madrid and Valencia), and are able to offer more economic benefits to new KIBS businesses. Nevertheless, the regional combination of higher industry specialization and a university landscape characterized by more private universities can also encourage a more intense formation of KIBS businesses in the area. As we previously mentioned, for instance, Guipúzcoa and Navarra regions in the Basque Country constitute a positive example, where the density of new KIBS businesses is one of the highest in Spain.

Figure 3. The moderating role of industry specialization on the effect of proportion of public universities on regional KIBS formation rate



Finally, our findings also reveal a positive development shift (in terms of GDP per capita), as knowledge spillovers take place from economically developed regions to less developed regions. This phenomenon might be nurtured by regional measures that trigger economic development in less developed regions (e.g., more favorable tax environment), while businesses can still locate close enough to profit from the advantages of more developed neighboring regions. Based on Lafuente et al. (2010), non-economic location factors can also overwrite the profit-oriented thinking of businesses by offering a desirable personal choice for the business founder, in terms of, for instance, quality of life or nice childhood memories from the place where the founder was raised. Our result is thus in line with Gallego and Maroto (2015) and Horváth and Rabetino (2019) who found that KIBS formation is more intense in less developed regions than in already developed territories.

5. Discussion and implications of the results

Supported by previous studies (e.g., Audretsch et al., 2005; Agasisti et al., 2019), our results confirm that regions with diverse university system configurations have different capacity to contribute to regional KIBS formation rates. More specifically, we found that a higher concentration of universities can lead to a superior KIBS formation rate in the same region. Also, and supporting the need for public interventions, we uncover that a greater weight of public universities in the region can positively impact KIBS formation rates. Nevertheless, and more importantly, we conclude that these university-led constructive forces are conditioned by the region's industry specialization. In a regional environment with lower industry share, characterized by either—though with differing knowledge

support potential and retaining power—a developed university system or stronger public university presence, universities can take the lead in KIBS business creation. In highly industrialized regions, however, where (public) universities' weight is lower, connecting with industry businesses may constitute the main incentive to KIBS business formation processes.

Our results offer various insights for the scientific community, both in terms of the impact of universities embedded in regions with different level of industry activity and the application of an analytical approach that can better quantify the actual regional and extraregional effects. First, it turns out that the concentration and proportion of public universities may play a crucial role in regional knowledge generation, and more specifically, in KIBS business formation. These findings—recognizing the role of the extent of the local customer base—highlight that regions with more universities may serve as entrepreneurial and knowledge hubs and can compensate for a lower share of potential industry clients in the area. Similarly, regions which are potentially less attractive for KIBS businesses in terms of the degree of industrialization in the area, may overcome the shortage of local industry demand with increased public university presence. Second, and especially in terms of justifying the benefits of public universities on regional development, the use of a spatial model separating intraregional and extraregional effects may be important for future empirical analyses.

A number of relevant policy implications can be drawn from our results. It should be noted that both the characteristics of new KIBS businesses and the environment should be taken into account when designing future policies for regional development. Based on the findings of this study, and considering the substitution role of regions' university system and industry specialization, regional policy makers should target most of their resources to create places of excellence for new KIBS businesses with different location considerations. First, to attract new KIBS businesses to less industrialized areas, a differentiation should be made due to quality differences between regions with more universities (e.g., Madrid, Barcelona) and regions in which public universities dominate the university landscape (e.g., Sevilla, Málaga, Alicante). In the first case, regions abundant in universities are likely to follow a natural development path within the country, as new KIBS businesses can enjoy the nurture of an extensive and high-quality knowledge and entrepreneurial community. Therefore, these leading regions should facilitate that their new KIBS businesses can also adapt to international standards and gain a competitive edge in international markets.

In the second type of regions, where public universities are more dominant in the university system, policy makers can provide support to public universities by several means. For instance, public universities should design more competitive and transformative programs (e.g., degree programs, incubators for new KIBS businesses) that adjust to the knowledge demand of existing and potentially unexploited economic strengths of the area. However, as Pinto et al. (2015) suggest, because of their public funding, public universities may offer services cheaper than KIBS businesses, and this way crowd them out of the market. Therefore, to avoid this unwanted substitution effect, it is also important that universities exclusively focus on contributing to develop a consolidated stock of

new KIBS businesses in the territory. Besides, governmental policy could encourage interregional knowledge transfers from high-quality universities located in more developed regions to improve the services of public universities in less developed areas.

Second, in regions with a solid industry base, but with less universities / relatively more private universities, KIBS-industry interactions should be encouraged by public incentives to motivate industry businesses to innovate and acquire knowledge from KIBS businesses. In this role, it may be important to dissolve the potential bottlenecks in the system such as low networking propensity of local industry businesses and high entry barriers for new KIBS businesses (Koch and Stahlecker, 2006). Wyrwich (2019) suggests that developing the local industry sector should be sufficient to foster the market-led emergence of KIBS businesses. Nevertheless, universities can take an active role in this process by matching the demand of the industry sector to the supply of new KIBS firms (e.g., related and competitive services), and thus, the government should compensate universities for their increased third mission contributions. A successful regional transformation story is the case of the Basque Country that managed to move from an old industrial region to the road of economic renewal (Morgan, 2016).

6. Concluding remarks

Universities are invoked as relevant knowledge conduits with the capacity to contribute to the consolidation of knowledge-based economies. In this sense, we sought the answer to the economically crucial question of how universities can contribute to the formation of new knowledge-intensive business service firms at a regional level. In this regard, the original contribution of our study stems from being the first in shedding light on the potentially moderating role of a region's industry specialization on this process. To analyze regions' KIBS generation capacity linked to universities and their industry share, we used a sample of Spanish provinces for a five-year-period. We employed two variables related to the regional concentration and composition—i.e., in terms of their public or private status—of universities, and the region's industry specialization that we measured by the proportion of industry businesses in the region. To accurately quantify the intraregional impact of these variables and to separate effects that spill over to neighboring regions, we employed spatial econometric regression models.

Our study is not exempt from limitations. First, we use regional level data that limit the depth of analysis in terms of the study phenomenon. Second, against the focus of our study, it should be noted that a high level of KIBS business formation does not necessarily signal healthy development processes in a region. Due to data availability reasons, we do not analyze the weight of university-based characteristics in the location decisions of KIBS businesses with different value added for the region. Therefore, a differentiation between innovative vs. non-innovative, and exporting vs. non-exporting KIBS businesses could be made. This separation might be especially important, as territories do not benefit from KIBS businesses with different innovation/export potential to the same extent.

Third, the innovative and competitive nature of incumbent KIBS businesses as well as the networking characteristics and growth aspirations of the local industry sector may influence regional KIBS formation rates too (Koch and Stahlecker, 2006; Szerb et al., 2019). These are potentially relevant aspects that should be addressed in future studies. Finally, instead of provinces, the analysis of cities or labor market areas could provide us a more reliable picture on the scope of interregional spillover effects.

Funding: This work was funded by the Hungarian government through the project titled "Sustainable, intelligent and inclusive regional and city models" [grant number: EFOP-3.6.2-16-2017-00017]. The project was supported by the European Union and co-financed by the European Social Fund.

References

Abramovsky, L., Harrison, R., Simpson, H. (2007). University research and the location of business R&D. *The Economic Journal*, 117(519), 114-141.

Acosta, M., Coronado, D., Flores, E. (2011). University spillovers and new business location in high-technology sectors: Spanish evidence. *Small Business Economics*, 36(3), 365-376.

Acs, Z., Braunerhjelm, P., Audretsch, D. B., Carlsson, B. (2009). The knowledge spillover theory of entrepreneurship. *Small Business Economics*, 32(1), 15-30.

Acs, Z. J., Autio, E., Szerb, L. (2014). National Systems of Entrepreneurship: Measurement issues and policy implications. *Research Policy*, 43(3), 476-494.

Agasisti, T. (2009). Market forces and competition in university systems: theoretical reflections and empirical evidence from Italy. *International Review of Applied Economics*, 23(4), 463-483.

Agasisti, T., Pérez-Esparrells, C. (2010). Comparing efficiency in a cross-country perspective: the case of Italian and Spanish state universities. *Higher Education*, 59(1), 85-103.

Agasisti, T., Barra, C., Zotti, R. (2019). Research, knowledge transfer, and innovation: The effect of Italian universities' efficiency on local economic development 2006− 2012. *Journal of Regional Science*, 59(5), 819-849.

Alcácer, J., Chung, W. (2007). Location strategies and knowledge spillovers. *Management Science*, 53(5), 760-776.

Aldrich, H., Auster, E. R. (1986). Even dwarfs started small: Liabilities of age and size and their strategic implications. *Research in Organizational Behavior*, 8, 165-198.

Anselin, L. (1988). *Spatial econometrics: methods and models*. Kluwer Academic, Boston.

Anselin, L., Varga, A., Acs, Z. (2000). Geographical spillovers and university research: A spatial econometric perspective. *Growth and Change*, 31(4), 501-515.

Anselin, L., Rey, S. J. (2014). *Modern Spatial Econometrics in Practice: A Guide to GeoDa, GeoDaSpace and PySAL*. GeoDa Press LLC, Chicago, IL.

Arnold, J. M., Javorcik, B., Lipscomb, M., Mattoo, A. (2016). Services reform and manufacturing performance: Evidence from India. *The Economic Journal*, 126(590), 1-39.

Audretsch, D. B., Lehmann, E. E. (2004). Mansfield's missing link: the impact of knowledge spillovers on firm growth. *Journal of Technology Transfer*, 30(1), 207-210.

Audretsch, D. B., Lehmann, E. E., Warning, S. (2005). University spillovers and new firm location. *Research Policy*, 34(7), 1113-1122.

Baptista, R., Lima, F., Mendonça, J. (2011). Establishment of higher education institutions and new firm entry. *Research Policy*, 40(5), 751-760.

Bellandi, M., Santini, E. (2019). Territorial servitization and new local productive configurations: the case of the textile industrial district of Prato. *Regional Studies*, 53(3), 356-365.

Berbegal-Mirabent, J., Gil-Doménech, D., de la Torre, R. (2019). Dealing with heterogeneity: an analysis of spanish universities. *TEC Empresarial*, 13(3), 58-77.

Bienkowska, E. (2015). *Reindustrialization of Europe: Industry 4.0 – Innovation, growth and jobs, Forum Europe conference* [Speech]. Retrieved from European Commission, https://ec.europa.eu/commission/commissioners/2014-2019/bienkowska/announcements/reindustrialisation-europe-industry-40-innovation-growth-and-jobs-forum-europe-conference_en (18/08/2017)

Bonaccorsi, A., Colombo, M. G., Guerini, M., Rossi-Lamastra, C. (2014). The impact of local and external university knowledge on the creation of knowledge-intensive firms: Evidence from the Italian case. *Small Business Economics*, 43(2), 261-287.

Boschma, R. (2005). Proximity and innovation: a critical assessment. *Regional Studies*, 39(1), 61-74.

Bresnahan, T., Gambardella, A., Saxenian, A. (2001). 'Old economy' inputs for 'new economy' outcomes: Cluster formation in the new Silicon Valleys. *Industrial and Corporate Change*, 10(4), 835-860.

Bustinza, O. F., Lafuente, E., Rabetino, R., Vaillant, Y., Vendrell-Herrero, F. (2019). Make-or-buy configurational approaches in product-service ecosystems and performance. *Journal of Business Research*, 104, 393-401.

Calcagnini, G., Favaretto, I., Giombini, G., Perugini, F., Rombaldoni, R. (2016). The role of universities in the location of innovative start-ups. *Journal of Technology Transfer*, 41(4), 670-693.

Caldera, A., Debande, O. (2010). Performance of Spanish universities in technology transfer: An empirical analysis. *Research Policy*, 39(9), 1160-1173.

Casani, F., De Filippo, D., García-Zorita, C., Sanz-Casado, E. (2014). Public versus private universities: Assessment of research performance; case study of the Spanish university system. *Research Evaluation*, 23(1), 48-61.

Corrocher, N., Cusmano, L. (2014). The 'KIBS engine' of regional innovation systems: Empirical evidence from European regions. *Regional Studies*, 48(7), 1212-1226.

Crescenzi, R., Filippetti, A., Iammarino, S. (2017). Academic inventors: collaboration and proximity with industry. *The Journal of Technology Transfer*, 42(4), 730-762.

Crespo, J., Suire, R., Vicente, J. (2014). Lock-in or lock-out? How structural properties of knowledge networks affect regional resilience. *Journal of Economic Geography*, 14(1), 199-219.

Cruz-Castro, L., Sanz-Menéndez, L. (2016). The effects of the economic crisis on public research: Spanish budgetary policies and research organizations. *Technological Forecasting and Social Change*, 113, 157-167.

de la Torre, E. M., Gómez-Sancho, J. M., Pérez-Esparrells, C. (2017). Comparing university performance by legal status: a Malmquist-type index approach for the case of the Spanish higher education system. *Tertiary Education and Management*, 23(3), 206-221.

Degl'Innocenti, M., Matousek, R., Tzeremes, N. G. (2019). The interconnections of academic research and universities' "third mission": Evidence from the UK. *Research Policy*, 48(9), 103793.

Den Hertog, P. (2000). Knowledge-intensive business services as co-producers of inno-vation. *International Journal of Innovation Management*, 4(4), 491-528.

Denis, J. L., Ferlie, E., Van Gestel, N. (2015). Understanding hybridity in public organizations. *Public Administration*, 93(2), 273-289.

D'Este, P., Iammarino, S. (2010). The spatial profile of university-business research partnerships. *Papers in Regional Science*, 89(2), 335-350.

Drejer, I., Østergaard, C. R. (2017). Exploring determinants of firms' collaboration with specific universities: employee-driven relations and geographical proximity. *Regional Studies*, 51(8), 1192-1205.

Elhorst, J. P. (2014). Matlab Software for Spatial Panels. *International Regional Science Review*, 37(3), 389-405.

Escardíbul, J. O., Pérez-Esparrells, C., de la Torre, E. M., Sequera, S. M. (2017). Tuition fees in Spanish public universities: A regional convergence analysis. *Estudios sobre Educación*, 32, 197-221.

Etzkowitz, H. (2003). Research groups as 'quasi-firms': the invention of the entrepreneurial university. *Research Policy*, 32(1), 109-121.

European Commission (2012). *Knowledge-Intensive (Business) Services in Europe*. Publications Office of the European Union, Luxembourg.

European Commission (2015). *Annual report on the ERC activities and achievements in 2014*. Publications Office of the European Union, Luxembourg.

Feldman, M. P. (1994). The university and economic development: the case of Johns Hopkins University and Baltimore. *Economic Development Quarterly*, 8(1), 67-76.

Fernandes, C. I., Ferreira, J. J. (2013). Knowledge spillovers: cooperation between universities and KIBS. *R&D Management*, 43(5), 461-472.

Fernández-López, S., Calvo, N., Rodeiro-Pazos, D. (2019). The funnel model of firms' R&D cooperation with universities. *Science and Public Policy*, 46(1), 45-54.

Fischer, B. B., Schaeffer, P. R., Silveira, J. P. (2018). Universities' gravitational effects on the location of knowledge-intensive investments in Brazil. *Science and Public Policy*, 45(5), 692-707.

Fisman, R., Khanna, T. (2004). Facilitating development: The role of business groups. *World Development*, 32(4), 609-628.

Foray, D., Lundvall, B. Ä. (1998). The knowledge-based economy: from the economics of knowledge to the learning economy. In: Neef, D., Siesfeld, G. A., Cefola, J. (Eds.), *The Economic Impact of Knowledge*, 115-121. Butterworth Heinemann, Boston.

Fritsch, M., Falck, O. (2007). New business formation by industry over space and time: a multidimensional analysis. *Regional Studies*, 41(2), 157-172.

Gallego, J., Maroto, A. (2015). The specialization in knowledge-intensive business services (KIBS) across Europe: permanent co-localization to debate. *Regional Studies*, 49(4), 644-664.

Garicano, L., Wu, Y. (2012). Knowledge, communication, and organizational capabilities. *Organization Science*, 23(5), 1382-1397.

Gebauer, H., Binz, C. (2019). Regional benefits of servitization processes: evidence from the wind-to-energy industry. *Regional Studies*, 53(3), 366-375.

Gomes, E., Bustinza, O.F., Tarba, S., Khan, Z., Ahammad, M. (2019). Antecedents and implications of territorial servitization. *Regional Studies*, 53(3), 410-423.

Guironnet, J. P., Peypoch, N. (2018). The geographical efficiency of education and research: The ranking of US universities. *Socio-Economic Planning Sciences*, 62, 44-55.

Harhoff, D. (2000). R&D spillovers, technological proximity, and productivity growth-Evidence from German panel data. *Schmalenbach Business Review*, 52, 238-260.

Harris, R. G. (2001). The knowledge-based economy: intellectual origins and new economic perspectives. *International Journal of Management Reviews*, 3(1), 21-40.

Hätönen, J., Eriksson, T. (2009). 30+ years of research and practice of outsourcing–Exploring the past and anticipating the future. *Journal of International Management*, 15(2), 142-155.

Hegde, D. (2005). Public and private universities: unequal sources of regional innovation?. *Economic Development Quarterly*, 19(4), 373-386.

Horváth, K., Rabetino, R. (2019). Knowledge-intensive territorial servitization: regional driving forces and the role of the entrepreneurial ecosystem. *Regional Studies*, 53(3), 330-340.

Hudson, M. A., Smart, A., Bourne, M. (2001). Theory and practice in SME performance measurement systems. *International Journal of Operations & Production Management*, 21(8), 1096-1115.

Izsak, K., Markianidou, P., Lukach, R., Wastyn, A. (2013). *The impact of the crisis on research and innovation policies*. Study for the European Commission DG Research by Technopolis Group Belgium and Idea Consult.

Johnston, A., Huggins, R. (2018). Partner selection and university-industry linkages: Assessing small firms' initial perceptions of the credibility of their partners. *Technovation*, 78, 15-26.

Keeble, D., Nachum, L. (2002). Why do business service firms cluster? Small consultancies, clustering and decentralization in London and southern England. *Transactions of The Institute of British Geographers*, 27(1), 67-90.

Kirchhoff, B. A., Newbert, S. L., Hasan, I., Armington, C. (2007). The influence of university R & D expenditures on new business formations and employment growth. *Entrepreneurship Theory and Practice*, 31(4), 543-559.

Koch, A., Stahlecker, T. (2006). Regional innovation systems and the foundation of knowledge intensive business services. A comparative study in Bremen, Munich, and Stuttgart, Germany. *European Planning Studies*, 14(2), 123-146.

Lafuente, E., Vaillant, Y., Serarols, C. (2010). Location decisions of knowledge-based entrepreneurs: Why some Catalan KISAs choose to be rural? *Technovation*, 30(11), 590-600.

Lafuente, E., Vaillant, Y., Vendrell-Herrero, F. (2017). Territorial servitization: Exploring the virtuous circle connecting knowledge-intensive services and new manufacturing businesses. *International Journal of Production Economics*, 192, 19-28.

Lafuente, E., Berbegal-Mirabent, J. (2019). Assessing the productivity of technology transfer offices: an analysis of the relevance of aspiration performance and portfolio complexity. *The Journal of Technology Transfer*, 44(3), 778-801.

Lafuente, E., Vaillant, Y., Vendrell-Herrero, F. (2019). Territorial servitization and the manufacturing renaissance in knowledge-based economies. *Regional Studies*, 53(3), 313-319.

Laredo, P. (2007). Revisiting the third mission of universities: toward a renewed categorization of university activities? *Higher Education Policy*, 20(4), 441-456.

LeSage, J. P., Pace, R. K. (2009). *Introduction to Spatial Econometrics*. CRC Press, Taylor & Francis Group, Boca Raton, FL.

Meliciani, V., Savona, M. (2015). The determinants of regional specialisation in business services: agglomeration economies, vertical linkages and innovation. *Journal of Economic Geography*, 15(2), 387-416.

Miles, I., Kastrinos, N., Bilderbeek, R., Den Hertog, P., Flanagan, K., Huntink, W., Bouman, M. (1995). *Knowledge-intensive business services: users, carriers and sources of innovation*. Report. Brussels, (European Commission), 117.

Morgan, K. (2016). Collective entrepreneurship: The Basque model of innovation. *European Planning Studies*, 24(8), 1544-1560.

Moutinho, R., Au-Yong-Oliveira, M., Coelho, A., Manso, J. P. (2015). Beyond the "Innovation's Black-Box": Translating R&D outlays into employment and economic growth. *Socio-Economic Planning Sciences*, 50, 45-58.

Muller, E., Zenker, A. (2001). Business services as actors of knowledge transformation: the role of KIBS in regional and national innovation systems. *Research Policy*, 30(9), 1501-1516.

Pinto, H., Fernandez-Esquinas, M., Uyarra, E. (2015). Universities and knowledge-intensive business services (KIBS) as sources of knowledge for innovative firms in peripheral regions. *Regional Studies*, 49(11), 1873-1891.

Ponds, R., Oort, F. V., Frenken, K. (2010). Innovation, spillovers and university–industry collaboration: an extended knowledge production function approach. *Journal of Economic Geography*, 10(2), 231-255.

Porter, M. E. (1994). The role of location in competition. *Journal of the Economics of Business*, 1(1), 35-40.

Raspe, O., Van Oort, F. G. (2011). Firm heterogeneity, productivity and spatially bounded knowledge externalities. *Socio-Economic Planning Sciences*, 45(1), 38-47.

Sánchez-Barrioluengo, M. (2014). Articulating the 'three-missions' in Spanish universities. *Research Policy*, 43(10), 1760-1773.

Scarbrough, H., Swan, J., Laurent, S., Bresnen, M., Edelman, L., Newell, S. (2004). Project-based learning and the role of learning boundaries. *Organization Studies*, 25(9), 1579-1600.

Segarra-Blasco, A., Arauzo-Carod, J. M. (2008). Sources of innovation and industry–university interaction: Evidence from Spanish firms. *Research Policy*, 37(8), 1283-1295.

Shearmur, R. (2012). The geography of intrametropolitan KIBS innovation: Distinguishing agglomeration economies from innovation dynamics. *Urban Studies*, 49(11), 2331-2356.

Shore, C., McLauchlan, L. (2012). 'Third mission' activities, commercialisation and academic entrepreneurs. *Social Anthropology*, 20(3), 267-286.

Siegel, D. S., Westhead, P., Wright, M. (2003). Assessing the impact of university science parks on research productivity: exploratory firm-level evidence from the United Kingdom. *International Journal of Industrial Organization*, 21(9), 1357-1369.

Szerb, L., Lafuente, E., Horváth, K., Páger, B. (2019). The relevance of quantity and quality entrepreneurship for regional performance: The moderating role of the entrepreneurial ecosystem. *Regional Studies*, 53(9), 1308-1320.

Tether, B.S., Hipp, C. (2002). Knowledge intensive, technical and other services: patterns of competitiveness and innovation compared. *Technology Analysis & Strategic Management*, 14(2), 163-182.

Tödtling, F., Wanzenböck, H. (2003). Regional differences in structural characteristics of start-ups. *Entrepreneurship & Regional Development*, 15(4), 351-370.

Valero, A., Van Reenen, J. (2019). The economic impact of universities: Evidence from across the globe. *Economics of Education Review*, 68, 53-67.

Varga, A., Sebestyén, T. (2017). Does EU Framework Program participation affect regional innovation? The differentiating role of economic development. *International Regional Science Review*, 40(4), 405-439.

Vendrell-Herrero, F., Bustinza, O. F., Parry, G., Georgantzis, N. (2017). Servitization, digitization and supply chain interdependency. *Industrial Marketing Management*, 60, 69-81.

Woodward, D., Figueiredo, O., Guimaraes, P. (2006). Beyond the Silicon Valley: University R&D and high-technology location. *Journal of Urban Economics*, 60(1), 15-32.

Wyrwich, M. (2019). New KIBS on the bloc: the role of local manufacturing for start-up activity in knowledge-intensive business services. *Regional Studies*, 53(3), 320-329.