Incentivizing knowledge institutions for entrepreneurship and society

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Abstract

Purpose – Going beyond the traditional approach of formal and informal institutions as antecedents of entrepreneurship (directly) and development (indirectly), this paper seeks to explore knowledge institutions as a necessary input for entrepreneurship and the development of societies.

Design/methodology/approach – Institutional economics lenses are utilized to observe other factors (e.g. the number of R&D staff and researchers from the public sector) that involve laws and socialization processes, which at the same time create knowledge useful for entrepreneurs and society. These ideas are tested through a sample of 281 observations from 17 autonomous communities and two autonomous cities in Spain. The information coming from the Global Entrepreneurship Monitor (GEM), Ministry of Economics, Industry, and Competitiveness, and INE (Instituto Nacional de Estadística), was analyzed through 3SLS, which is useful for a simultaneous equation strategy.

Findings – Knowledge institutions such as the number of R&D staff and researchers from the public sector are found positively associated with entrepreneurship, which is a factor directly and positively linked to economic development across Spanish regions.

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Originality/value – The findings help the operationalization of other institutions considered in institutional economics theory and its application to entrepreneurship research. Moreover, the results bring new insights into the knowledge spillover theory of entrepreneurship in the public sector, in which the institutional analysis is implicit.

Keywords Development, Entrepreneurship, Institutions, Knowledge, Society

Paper type Research paper

Introduction

Since its inception, entrepreneurship research has evolved from queries on the individual (psychological) and organizational (strategy) factors to contextual elements shaping decisions that involve risk and uncertainty (Audretsch, 2012; van Gelderen *et al.*, 2021). The evolution of the field has also considered a tireless task in search of the benefits of undertaking a new entrepreneurial project. Results have ranged from personal realization, firm growth and macroeconomic gains such as competitiveness and development (Landström, 2020). Additional research has brought together the two main questions "why" and "to whom" by simultaneously analyzing the antecedents and consequences of entrepreneurship (Bjørnskov and Foss, 2016; Urbano *et al.*, 2019). Thanks to this discussion, institutional factors have been put on the table as contemporaneous determinants of quantity and quality of entrepreneurship across regions and countries (Chowdhury *et al.*, 2019), which in turn spur economic development over time (Aparicio *et al.*, 2016; Bosma *et al.*, 2018).

The institutional approach is, certainly, not new. Veciana and Urbano (2008) have introduced a complete special issue devoted to understanding those elements *de facto* and *de jure* that condition individual decisions toward entrepreneurship. Afterward, Bruton *et al.* (2010) have created a thorough piece of research analyzing the evolution of the institutional theory and its connection with entrepreneurship research. Such an analysis has served to expand our knowledge about not only types (formal and informal; or normative, cultural-cognitive and regulative, etc.) but also levels of institutions (macro, meso and micro). Despite these efforts, a common vision persists on what institutions mean for economic activities (including entrepreneurship) and society. That is, North (1990, p. 3) has defined institutions as "rules of the game that shape human interaction . . ." Yet, little research has gone beyond this definition and conducted analyses around institutions as a system of incentives for, among other activities, entrepreneurship (Baumol, 1990). Urbano *et al.* (2019) and Zhai *et al.* (2019) find that formal institutions have been massively explored as compared to informal ones. While informal rules complement formal institutions (Scott, 1995; Williamson, 2000), this research attempts to continue the analysis of the latter by going beyond regulations, procedures and taxes as proxies of formal institutions.

Recently published articles have started exploring institutions as a conducive set of (public) decisions that foster entrepreneurial activity. Bennett (2019), Foss *et al.* (2019) and Mickiewikz *et al.* (2021) have studied pro-market institutions that incentivize individuals to take the risks involved in the entrepreneurial process, and hence, participate in the labor market. Although these institutions commonly come from public policies, private entities end up mobilizing required resources to turn new ideas into entrepreneurial projects. Audretsch *et al.* (2020) and Audretsch and Link (2019) have opened a new pathway to explore the role of governments in implementing policies and acting actively in processes of knowledge generation, which imply the utilization of resources and the coordination of partnerships that guarantee the transition from ideas to marketplaces. Their idea is rooted in the notion of the knowledge spillover theory of entrepreneurship (Acs *et al.*, 2009, 2013), in which entrepreneurs become the agents capable of identifying and translating ideas into society through practical and innovative solutions. Under this perspective, knowledge becomes a resource (Hughes *et al.*, 2021), which governments constantly feed. However, all the governmental efforts to acquire the funding that promotes research and development, as well as education also constitute a system of incentives that enables people to start new ventures. Peters and Besley (2008) have

explored knowledge institutions beyond the typical role of universities in the entrepreneurial process. Accordingly, Peters and Besley (2008) have suggested that other organizations (e.g. government and firms) can also participate in the process of knowledge creation through laws, decrees and budget (in the case of governments), as well as investments (in the case of firms). As little evidence exists in this regard, it has been claimed for further analysis about those formal factors in the public sector that incentive the inception of ideas (Peters and Besley, 2008), which are lately absorbed by entrepreneurs (Audretsch and Link, 2019).

Hence, this paper seeks to explore knowledge institutions as a necessary input for entrepreneurship and the development of societies. Institutional economics (North, 1990, 2005) is the main framework that sets the basis, upon which knowledge, as an institution, incentivizes entrepreneurship that is directly linked to economic development. Spanish regions serve as a laboratory to explore these ideas. Hence, we use an unbalanced panel data that comprise 281 observations from 17 autonomous communities and two autonomous cities (Ceuta and Melilla) over the 2004–2018 period. Our findings support the idea that knowledge institutions such as the number of staff involved in R&D and researchers from the public sector increase the level of entrepreneurial activity, which is a mechanism directly and positively linked to economic development.

Based on our findings, we bring a series of implications for theory and policy. First, our research helps a further comprehension of institutions beyond the traditional view of formal rules such as regulations, permits and procedures. We materialize North's (2005) ideas around knowledge as an institutional factor, which implies both laws to approve the budget for hiring public servants and socialization processes among R&D staff and researchers that result in new knowledge, hence, becoming a source of opportunities for the entrepreneurial identification. Second, Acs *et al.* (2009, 2013), for the private sector and Audretsch and Link (2019), for the public one, have approached these phenomena through the knowledge spillover theory of entrepreneurship. However, the institutional framework is still implicit in such analysis. We put together these two complementary (but disparate) perspectives by explicitly analyzing the existing intersection between them. And third, we close the story about economic development by contributing to Hausman's (2016) view of knowledge as a source of economic and social progress. We add to this literature the idea that governments are also important for knowledge generation, and that entrepreneurs transfer it to society, hence increasing the level of economic development. From a public policy angle, all this requires the creation and consolidation of think-tanks, entrepreneurial universities and industrial doctoral programs.

After this introduction, the paper continues as follows. First, a theoretical ground around institutions, knowledge, entrepreneurship and development is explained. Next, the methodology, including the data and modeling approach, is described. Afterward, results are analyzed, and so are the discussion and implications for theory and policy. Finally, conclusions, limitations and future research directions are highlighted.

Theory and hypotheses

Main theoretical foundations

The core idea within institutional economics (North, 1990) is that individual actions tend to be uncoordinated, hence uncertainty is created when those actions affect others' production and lifestyle. According to North (1990, 2005), institutions arise to mitigate such a problem by offering a set of written (i.e. formal) and unwritten (i.e. informal) rules, which become either incentives or barriers to performing a particular activity and spur the level of development. From here, literature has tried to further comprehend the formation, functioning and interaction of those that lately become incentives. Williamson (2000, p. 597), for example, has classified institutions into four levels, which range from those having slow change such as culture and customs to those changing rapidly, e.g. governance as well as resource allocation and employment.

A concern has existed to properly measure institutions, with a particular focus on formal and informal ones (cf. Voigt, 2013; Voigt, 2018). A bunch of projects has emerged to provide scholars and policymakers with the necessary tools for academic production and decision-making (see, for example, Djankov *et al.* (2002) for formal institutions; as well as Inglehart (1999) and Hofstede (2005) for informal factors). Implicit has been the treatment of knowledge as a stock of information common across society. Perhaps, we have interpreted Williamson's (2000) levels three and four as a (public and private) organizational resource that spurs efficiency and competitiveness (see the perspectives by Dyer and Singh (1998) and Teece *et al.* (1997)). Yet, North (2005, pp. 20–21) has considered other types of institutions that are still part of the macro environment, by explaining that:

> . . . the law merchant, patent laws, the institutional integration of distributed knowledge, the creation of a judicial system, have been important parts of efforts making markets more efficient in developed countries. And they are leading us into an unknown world of future uncertainties. When such institutional changes are applied to third world economies they frequently alter income distribution and produce political instability, sometimes leading to downstream consequences that are the very reverse of the intended objective.

These ideas have opened the possibility to explore and comprehend how entrepreneurs make decisions embedded in different environments (Baumol, 1990). Entrepreneurship research has grown thanks to this perspective, even though most of the literature has paid attention to the distinction between formal and informal institutions, affecting entrepreneurial activity, directly; and economic development, indirectly (Bruton *et al.*, 2010; Bjørnskov and Foss, 2016; Urbano *et al.*, 2019). While informal factors such as culture are the roots of any (entrepreneurial) society (Audretsch, 2007), formal institutions have played an important role in the entrepreneurial process and dynamics. Amorós *et al.* (2019a, b), Dau and Cazurra (2014), and McMullen *et al.* (2008) have discussed how the rapid change of formal institutions constitutes a policy mechanism that governments utilize to foster entrepreneurship. Governmental actions range from infrastructure, supportive policies and financial assistance for entrepreneurs (Amorós *et al.*, 2019a, b; McMullen *et al.*, 2008) to the creation and management of places such as universities and laboratories where people (i.e. researchers and academic staff) exchange ideas to create knowledge useful for entrepreneurs and society (Link, 2021).

Not precisely utilizing institutional economics, Acs *et al.* (2009, 2013) have considered knowledge as a contextual factor, which becomes a source of opportunities for people to work on entrepreneurial projects and bring benefits to society. This knowledge spillover theory of entrepreneurship has mostly relied on incumbent firms' capacity to create new knowledge. However, recent advances have extended this notion to the public sector. Although governments could be assumed as regulators affecting firm entry (Djankov *et al.*, 2002; van Stel *et al.*, 2007), this paper goes beyond the traditional vision and subscribes to the emerging trend, in which the public sector is an institution *a la* North (1990, 2005) that incentivizes knowledge (Audretsch and Link, 2019; Demircioglu and Chowdhury, 2021; Link, 2021).

When it comes to knowledge institutions, literature has explored the role of universities as entrepreneurial entities leveraging economic growth (Klofsten *et al.*, 2019). However, Peters and Besley (2008, p. 99) have explained that "[the] question should turn analysis away from the focus on the firm toward a better understanding of knowledge institutions, particularly universities but also research institutes, libraries, museums and galleries, as the primary ideas institutions." For Peters and Besley (2008, p. 101), these are central factors, that ". . . illustrate how the discussion of institutional design, especially for universities and other knowledge institutions, needs to acknowledge the emerging liberal political economy of commons-based peer production which arguably has always had a central role to play in the production of knowledge. . ." This analysis sets the basis for exploring knowledge institutions as antecedents of entrepreneurship.

Hypothesis development

Drawing on Audretsch and Link (2019), Link (2021) and Peters and Besley (2008), we are interested in understanding how knowledge is also part of the connection between institutions and entrepreneurship. Similar to the private sector, knowledge generation requires important endeavors in collecting funds to support this activity, but above all, to increase and maintain a solid group of people involved in R&D (Link and Wright, 2015). Key activities from local governments may consist of creating public organizations fully orchestrated by the public sector, which are devoted to the development of products, services and processes, oriented to bring solutions into the communities that are part of the same region (Del Rey and Lopez-Garcia, 2020). For example, Arenas *et al.* (2020) have explored a public organization in Colombia completely focused on innovation. An important conclusion from Arenas *et al.*'s (2020) study is the importance of investing in human capital as the main core of this organization. Likewise, Civera *et al.* (2021) show that the knowledge created thanks to the indirect investment in R&D incentives people in Spain to become entrepreneurs with high growth potential. In general, the creation of laboratories and R&D departments of public-owned firms constitutes a decision that is supported by laws and decrees. Although Audretsch and Link (2019) identify places and activities as a source of knowledge, literature is still scarce. Yet, the reasoning behind the decision of hiring qualified personnel involved in R&D thanks to laws and decrees motivates us to posit that:

H1. The number of public administration staff involved in R&D exerts a positive influence on entrepreneurship in Spain.

In line with the previous hypothesis, there is also a complementary activity that staff involved in knowledge generation constantly develops. While R&D activities entail the development of prototypes, these should be supported by theoretical analyses and advances. Thus, researchers devoted to exploring new theories, extant literature and results in other regions or countries become crucial to the creation of solid teams. Similar to R&D staff, researchers also create connections with industry and society through products such as academic articles, patents and so on (Aparicio *et al.*, 2022a; Olcay and Bulu, 2017; Wong *et al.*, 2007). Observing universities, this is clear as conducting research is part of their main activities (Culkin, 2016; Etzkowitz, 2017). Nonetheless, when observing public organizations, evidence of this idea remains scarce. Link and Scott (2021) provide evidence about the importance of having researchers in federal research laboratories, who create academic publications. These documents have two main functions. On the one hand, knowledge is disseminated to the rest of the academic community that builds prototypes or other innovative products upon that evidence. On the other hand, academic publications derived from research activities become the return to public-sector R&D (Link and Scott, 2021). Audretsch *et al.* (2019) also provide evidence about the role of innovation research centers in increasing a research team that produces academic articles. The key aspect here is the creation of knowledge that can be absorbed by entrepreneurs. Although the idea of knowledge spillover was focused on private companies (Acs *et al.*, 2009), Audretsch and Link (2019) expanded the analysis to the knowledge spillover theory of entrepreneurship in the public sector. In this regard, the origin of ideas that are transformed into products entrepreneurs commercialize comes from what researchers in public organizations such as research centers and universities perform. Therefore, a second hypothesis is suggested below.

H2. The number of researchers in public administration exerts a positive influence on entrepreneurship in Spain.

The previous literature has served to disentangle the influence knowledge as an institutional factor may have on the formation of new ventures in Spain. Audretsch and Keilbach (2008) have discussed that the knowledge paradox not only encourages entrepreneurial activity but also serves to improve the competitiveness and economic development of regions and countries

indirectly. Hausman (2016) has also suggested that knowledge and the way it is acquired explain development differences across regions and countries. In this regard, it seems knowledge is key for both entrepreneurship and economic development. To what extent does entrepreneurship become a mechanism between knowledge (as an institution) and development? There exist studies discussing the importance of institutions to spur entrepreneurship which, at the same time, is positively linked to growth and development in the long term (Aparicio *et al.*, 2016; Bosma *et al.*, 2018; Urbano *et al.*, 2020). In general, the relationship between entrepreneurship and economic development at the regional and country level has been widely documented (Audretsch and Keilbach, 2008; Erken *et al.*, 2018; Estrin *et al.*, 2022; Fernandes *et al.*, 2021; Liñán and Fernandez-Serrano, 2014). Even so, with the vast amount of evidence, the topic still draws the attention of different scholars in entrepreneurship, business, economics and management areas. Urbano *et al.* (2019) have found that most of the literature focuses on the national level. However, Kraus *et al.* (2021) have identified the need to continue exploring the effects that entrepreneurship may have on regional development. Particularly in Spain, González-Pernía and Peña-Legazkue (2015) and Gumbau Albert (2017) have provided empirical evidence on the importance of export-oriented and innovative entrepreneurship for higher regional development. Drawing on this evidence, one may assume that the effect of entrepreneurship on the Spanish economy is positive. Thus, we propose the following hypothesis:

H3. Entrepreneurship, influenced by knowledge institutions, has a positive effect on the economic development in the Spanish context.

Data and methods

Dataset

To assess the previous hypotheses, we have employed annual data of 17 autonomous communities and two autonomous cities (Ceuta and Melilla), comprising a sample of 281 observations for the 2004–2018 period. Our unbalanced panel dataset consisted of combining information from Global Entrepreneurship Monitor (GEM), Ministry of Economics, Industry, and Competitiveness, and INE (Instituto Nacional de Estadística). The GEM project is a complete dataset devoted to the exploration of entrepreneurial activity worldwide, its antecedents and its consequences (Bosma, 2013). Including more than 100 countries (both developed and developing), this dataset enables cross-national comparisons on the level of national entrepreneurial activity, as well as estimations of the role entrepreneurship plays in national economic growth. According to Acs *et al.* (2008), studies derived from GEM information have served to formulate and evaluate different public policies supporting innovation and entrepreneurship.

The existence of GEM national teams has enabled the collection of subnational data for some countries. This is the case in Spain, which counts with 26 teams covering all autonomous communities (Peña-Legazkue *et al.*, 2020). Since we have focused on the Spanish case, complementary data come from official sources such as the Ministry of Economics, Industry, and Competitiveness, as well as INE, which provide details about the economy, population and public sector across the autonomous communities and cities over the last 20 years.

Variables and methodology

As we have hypothesized, entrepreneurship and regional development may be recursively interplaying, thus, it is necessary to decompose this sort of entrepreneurial activity into the following effects.

$$Ln(E_{it}) = \alpha + \varphi Ln(KI_{it}) + \beta_j \sum_{J=1}^{9} Ln(X_{j,it}) + \mu_{it} \quad (1)$$

To measure entrepreneurship (*Eit*) in the first stage, we follow Aparicio *et al.* (2016) and Bosma *et al.* (2018), who measure entrepreneurial activity by considering the percentage of the adult population involved in the creation of a new venture that is between 0 and 42 months (TEA), which is representative for the autonomous community or city i (from 1 to 19) and year t. While there are other indicators within the GEM project, Bosma (2013) explains that traditional entrepreneurship is properly approached through TEA, which embraces all types of drivers and characteristics. In essence, TEA becomes the starting point to know the level of entrepreneurial activity across regions and countries. Regarding those independent variables associated with knowledge institutions (KI_{it-1}), Audretsch and Link (2019) and Link (2021) suggest that the number of staff involved in R&D and researchers represents the stock of rules (enabling enough budget for hiring the staff) and socialization processes (leading to innovation, ideas, etc.). Other scholars have had a similar approach by explaining entrepreneurial universities as other types of institutions (Culkin, 2016; Klofsten *et al.*, 2019). Although the available budget is an important component, what matters in this research stream is the activities that give the entrepreneurial characteristic to universities. Audretsch and Link (2019) and Link (2021) help us understand another angle of the same phenomenon. That is, academic and R&D staff working in the public sector exist thanks to institutional incentives (laws and decrees) that promote knowledge, which is ultimately absorbed by entrepreneurs in the marketplace.

In the case of control variables (X_{it-1}), we have drawn upon Arin *et al.* (2015) to consider unobservable characteristics related to economic (number of existing firms, public administration expenditure in R&D, unemployment rate and GDP per capita) and demographic variables (the percentage of population with tertiary education, number of self-employees in industry, construction and service and the total population). The parameter μ_{it} represents the error of Equation (1).

To study the spread of entrepreneurship and its effects on regional development in a second stage, we investigate how entrepreneurs stimulate economic development, by estimating Equation (2):

$$LnGDP_{it} = \theta + \gamma_1 Ln\widehat{E}_{it-1} + \gamma_2 LnR\&D_{it-1} + \gamma_3 LnK_{it-1} + \gamma_4 LnL_{it-1} + \gamma_5 LnGE_{it-1} + \omega_i + \lambda_t + \varepsilon_{it} \quad (2)$$

Here, the dependent variable in the second stage is GDP_{it}, which is the constant value of the gross domestic product by autonomous community or city i in the period t (2004–2018). The estimated variable ($\widehat{E}_{it-1}$) of Equation (1) is introduced in this stage, which means that the regional development is indirectly influenced by knowledge institutions. By following Aparicio *et al.* (2016), Audretsch and Keilbach (2008), Ferreira *et al.* (2017), González-Pernía and Peña-Legazkue (2015), traditional control variables in the augmented Cobb–Douglas production function are used. For instance, R&D expenditure (i.e. the governmental investment as a percentage of GDP), the stock of capital (invested by firms), the labor force (number of people actively participating in the labor market) and the government expenditure (as the constant value of the final consumption) are included. All data is converted into log form to make it smooth and easy to interpret (see Aparicio *et al.* (2016) and Wong *et al.* (2005) for further details). The main dependent and independent variables by autonomous communities and cities are shown in Appendix 1.

Given Equation (1) and Equation (2), a simultaneous modeling approach is used for the empirical purpose. For the estimation of these equations, a dynamic 3SLS is applied as it is more efficient than 2SLS as well as the traditional OLS approach. According to Zellner and Theil (1962), it is proved that the 3SLS allows the correlation between unobserved disturbances across various equations to be used in the analysis. This technique turns out to be more consistent and asymptotically normal. By considering certain conditions, 3SLS is

even asymptotically more efficient than single equation estimates. It combines multivariate regression and two-stage regression (Zellner and Theil, 1962). Given its advantages, we have opted for the 3SLS method to analyze empirically the influence of knowledge institutions on entrepreneurship and simultaneously the changes in regional development when entrepreneurs vary over space and time. The description of each variable is shown in Table 1.

Results

Main findings

Table 2 provides the means, standard deviations and pairwise correlation coefficients for all the variables we assess in both equations. On the one hand, it is possible to observe that the average level of entrepreneurial activity across Spanish autonomous communities and cities is 5.59%, which is consistent with the GEM 2017–2018 national report (Peña-Legazkue *et al.*, 2018). On the other hand, the correlation matrix shows potential associations between the variables used to capture knowledge institutions and entrepreneurship, which in turn is positively correlated with economic development, meeting our expectations. However, Table 2 also shows a high correlation between the three independent variables. Hence, we need to discard potential collinearity issues. A diagnostic test of multicollinearity was conducted through the variance inflation factors (VIFs) of all variables in the analyses for each model. After computing the test, we have found that variables are not problematic, since the obtained VIF was 3.07, a value substantially below 10, which is a suggested threshold (Hsieh *et al.*, 2003).

In Table 3, the results of the 3SLS regression with robust variance estimates are shown. Following Carree and Thurik (2008) and Carree *et al.* (2002, 2007) and Urbano *et al.* (2020), we have accounted for business cycle effects such as crisis (González-Pernía *et al.*, 2018) by including time-fixed effects. Thus, model 1 only estimates control variables in Equation (1) (education, number of firms, self-employees in industry, construction and service, as well as public administration expenditure in R&D, unemployment rate, GDP per capita and population). In addition to these controls, model 2 includes the first knowledge institution, which is the R&D staff in public administration. Model 3 replicates the same approach, but in this case, researchers in public administrations are considered a knowledge institution. Model 4 focuses on Equation (2) by independently estimating entrepreneurship, R&D expenditure, capital, labor force and government expenditure. Models 5 through 7 bring together Equation (1) and (2). For example, model 5 follows the same strategy as model 1. However, in this case, the entrepreneurship variable in Equation (2) was previously estimated in Equation (1) using only controls. Model 6 includes the first knowledge institutions (R&D staff in public administration), whereas model 7 considers the second knowledge institution (researchers in public administration). All the models are highly significant ($p < 001$), which means that the explanatory variables jointly explain the variance of entrepreneurial activity and economic development.

Concerning the suggested hypotheses, we have posited in hypothesis 1 that the number of public administration staff involved in R&D exerts a positive influence on entrepreneurship in Spain. Effectively, we found a positive effect of this knowledge institutions by observing that the number of people in the public administration working on R&D affected positively the total early-stage entrepreneurial activity in our sample ($\varphi = 0.123$, $p < 0.1$). Hence, we follow the statement presented by Link and Wright (2015), which suggests that endeavors in having a solid staff focused on R&D are translated into higher innovation and entrepreneurship. In fact, for each region in our sample, if the number of public administration staff involved in R&D increases by 1% through time, the level of entrepreneurship goes up by 0.123%, *ceteris paribus*. This result could indicate that public efforts in investing in R&D are important to engage more people in entrepreneurial activities.

Hypothesis 2 suggested that the number of researchers in public administration exerts a positive influence on entrepreneurship in Spain. The direction of this relationship was

Variables	Description	Source
Equation (1)		
Dependent variable		
TEA	Total early-stage entrepreneurial activity. Percentage of adults aged 18–64 setting up a business or owning–managing a young firm (up to 3.5 years old)	GEM 2004–2018
Independent variables		
Policy support		
R&D staff in Public Administration	Number of staff involved in R&D in public administration by autonomous community	Ministry of Economics, Industry and Competitiveness 2004–2018
Researchers in Public Administration	Number of researchers in public administration by autonomous community	Ministry of Economics, Industry and Competitiveness 2004–2018
Control variables		
Education	Percentage of population with tertiary education by autonomous community	INE 2004–2018
Firms	Number of firms within the autonomous community	INE 2004–2018
Self-employees in industry	Number of self-employed workers in the industry sector by autonomous community	INE 2004–2018
Self-employees in construction	Number of self-employed workers in the construction sector by autonomous community	INE 2004–2018
Self-employees in service	Number of self-employed workers in the service sector by autonomous community	INE 2004–2018
Public administration expenditure in R&D	Total expenditure of R&D by public administration in autonomous community (in thousand of Euros)	Ministry of Economics, Industry and Competitiveness 2004–2018
Unemployment rate	Unemployment rate by autonomous community	INE 2004–2018
GDP per capita	Total value of gross domestic product (GDP) per capita. Data in 2010 constant euros	INE 2004–2018
Population	Number of inhabitants by autonomous community	INE 2004–2018
Equation (2)		
Dependent variable		
GDP	Total value of gross domestic product (GDP) by autonomous community. Data in 2010 constant values	INE 2004–2018
Independent variables		
TEA	Total early-stage entrepreneurial activity. Percentage of adults aged 18–64 setting up a business or owning–managing a young firm (up to 3.5 years old)	GEM 2004–2018
R&D expenditure	Total expenditure of R&D as percentage of GDP approved by law. It includes firms and universities	Ministry of Economics, Industry and Competitiveness 2006–2014
Capital	Total gross capital formation by firms in autonomous community. Data in 2010 constant euros	INE 2004–2018
Labor force	Number of people with a job by autonomous community	INE 2004–2018
Government expenditure	Final government consumption. Data in 2010 constant euros	Ministry of Finance and Public Office (Ministerio de Hacienda y Función Pública) 2004–2018

Source(s): Authors' own creation

Table 1.
Variables description

Table 2.
Descriptive statistics and correlation matrix

	Variable	Mean	Std. dev.	1	2	3	4	5	6	7
1	GDP	5.6E+07	6.0E+07	1						
2	TEA	5.597	3.995	*0.132*	1					
3	R&D staff in Public Administration	2250.790	3592.564	*0.913*	0.079	1				
4	Researchers in Public Administration	1218.921	1866.649	*0.932*	0.084	0.991	1			
5	Education	31.230	7.107	*0.293*	−0.049	0.320	*0.295*	1		
6	Firms	171999.700	174904.900	*0.983*	*0.132*	0.851	*0.880*	*0.180*	1	
7	Self-employees in industry	977.313	1944.299	*0.493*	*0.118*	0.383	*0.453*	− 0.061	*0.523*	1
8	Self-employees in construction	2687.363	6045.740	*0.446*	*0.126*	0.410	*0.469*	−0.081	*0.465*	*0.928*
9	Self-employees in service	10373.950	18745.810	*0.682*	*0.117*	0.682	*0.727*	0.091	*0.674*	*0.855*
10	Public administration expenditure in R&D	137098.300	231125.800	*0.898*	0.074	0.994	*0.980*	*0.338*	*0.826*	*0.354*
11	Unemployment rate	16.753	7.611	−0.031	*−0.143*	0.033	0.007	*−0.276*	0.009	*−0.354*
12	GDP per capita	22253.270	4494.029	*0.399*	0.045	*0.447*	*0.446*	*0.781*	*0.275*	*0.177*
13	Population	2446.264	2401.790	*0.947*	*0.127*	*0.793*	*0.815*	*0.123*	*0.983*	*0.466*
14	R&D expenditure	0.958	0.521	*0.543*	0.057	*0.513*	*0.513*	*0.749*	*0.476*	*0.273*
15	Capital	12,600,000	13,000,000	*0.953*	*0.142*	*0.851*	*0.883*	*0.165*	*0.956*	*0.652*
16	Labor force	1032.431	1040.758	*0.981*	*0.137*	*0.865*	*0.893*	*0.183*	*0.994*	*0.570*
17	Government expenditure	9,479,519	8,762,550	*0.919*	*0.105*	*0.742*	*0.768*	*0.129*	*0.952*	*0.367*

	Variable	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
8	Self-employees in construction	1								
9	Self-employees in service	*0.916*	*1*							
10	Public administration expenditure in R&D	*0.374*	*0.653*	1						
11	Unemployment rate	*−0.360*	*−0.229*	0.023	1					
12	GDP per capita	*0.168*	*0.316*	*0.474*	*−0.478*	1				
13	Population	*0.415*	*0.612*	*0.763*	0.079	*0.166*	*1*			
14	R&D expenditure	*0.231*	*0.393*	*0.520*	*−0.347*	*0.721*	*0.430*	*1*		
15	Capital	*0.625*	*0.773*	*0.832*	*−0.149*	*0.327*	*0.925*	*0.493*	*1*	
16	Labor force	*0.524*	*0.721*	*0.839*	−0.034	*0.291*	*0.976*	*0.495*	*0.973*	*1*
17	Government expenditure	*0.300*	*0.512*	*0.718*	*0.176*	*0.148*	*0.971*	*0.408*	*0.871*	*0.935*

Note(s): Italic coefficients are significant at 10%
Source(s): Authors' own creation

Equation 1	(1) Ln TEA	(2) Ln TEA	(3) Ln TEA	(4) Ln TEA	(5) Ln TEA	(6) Ln TEA	(7) Ln TEA
Ln R&D staff in Public Administration ($t-1$)		0.114**				0.123*	
		(0.049)				(0.064)	
Ln Researchers in Public Administration ($t-1$)			0.102+				0.140**
			(0.062)				(0.070)
Ln Education ($t-1$)	−0.038***	−0.040***	−0.039***		−0.040***	−0.043***	−0.045***
	(0.012)	(0.011)	(0.011)		(0.007)	(0.008)	(0.008)
Ln number of firms ($t-1$)	−1.063***	−1.294***	−1.231***		−0.688*	−0.990**	−1.074***
	(0.374)	(0.358)	(0.360)		(0.380)	(0.406)	(0.401)
Ln Self-employees in industry ($t-1$)	−0.056	−0.060	−0.062		−0.061	−0.074+	−0.087*
	(0.045)	(0.045)	(0.044)		(0.046)	(0.046)	(0.046)
Ln Self-employees in construction ($t-1$)	0.089	0.109	0.077		−0.119**	−0.099*	−0.106**
	(0.082)	(0.082)	(0.080)		(0.052)	(0.053)	(0.053)
Ln Self-employees in service ($t-1$)	−0.160*	−0.180**	−0.139*		0.139*	0.115	0.129*
	(0.084)	(0.078)	(0.080)		(0.074)	(0.074)	(0.077)
Ln Public administration expenditure in R&D ($t-1$)	0.035	−0.026	−0.019		0.006	−0.054	−0.059
	(0.030)	(0.031)	(0.030)		(0.031)	(0.043)	(0.040)
Ln unemployment rate ($t-1$)	−0.157	−0.124	−0.113		−0.500***	−0.517***	−0.533***
	(0.162)	(0.168)	(0.174)		(0.080)	(0.079)	(0.079)
Ln GDP per capita ($t-1$)	1.449***	1.576***	1.512***		0.881***	1.050***	1.073***
	(0.490)	(0.473)	(0.489)		(0.333)	(0.340)	(0.332)
Ln population ($t-1$)	1.274***	1.443***	1.374***		0.859**	1.107***	1.181***
	(0.467)	(0.449)	(0.452)		(0.398)	(0.413)	(0.408)
Constant	−7.509**	−7.414**	−7.145*		−3.058	−2.938	−2.640
	(3.468)	(3.469)	(3.679)		(2.335)	(2.318)	(2.366)
R^2	0.418	0.428	0.429		0.277	0.289	0.297
Equation 2	Ln GDP	Ln GDP	Ln GDP	Ln GDP	Ln GDP	Ln GDP	Ln GDP
Ln TEA ($t-1$)				0.012**	0.013***	0.013***	0.013***
				(0.006)	(0.005)	(0.005)	(0.005)
Ln R&D expenditure ($t-1$)				−0.007	−0.008	−0.008	−0.006
				(0.020)	(0.019)	(0.019)	(0.019)
Ln capital ($t-1$)				0.072***	0.070***	0.070***	0.068***
				(0.014)	(0.011)	(0.011)	(0.011)
Ln labor force ($t-1$)				0.260***	0.252***	0.251***	0.237***
				(0.057)	(0.049)	(0.049)	(0.049)
Ln government expenditure ($t-1$)				0.119***	0.117***	0.117***	0.115***
				(0.029)	(0.026)	(0.026)	(0.025)
Constant				10.998***	11.068***	11.068***	11.183***
				(0.376)	(0.317)	(0.317)	(0.320)

(*continued*)

Table 3.
Main results

Equation 1	(1) Ln TEA	(2) Ln TEA	(3) Ln TEA	(4) Ln TEA	(5) Ln TEA	(6) Ln TEA	(7) Ln TEA
Observations	231	231	229	229	221	221	220
Regional fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2				0.925	0.931	0.959	0.912
AIC	111.741	110.053	108.998	−1089.256	−908.881	−910.522	−912.599
BIC	184.031	185.786	184.539	−972.509	−759.362	−757.605	−759.886

Note(s): *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, + $p = 0.1$. Standard errors in parentheses
Source(s): Authors' own creation

Table 3.

expected ($\varphi = 0.140$, $p < 0.05$). Based on our theoretical ground, it is possible to think that the number of researchers embraces different characteristics related to knowledge in each region in terms of the innovation process. According to Urbano *et al.* (2020), this type of intrapreneurial activity influenced by human capital tends to impact positively on firm growth. We find that for each region in our sample if researchers in public administration increased by 1% over time, the number of entrepreneurs increases by 0.140%, *ceteris paribus*. This might indicate that both public supports observed through the number of researchers and entrepreneurship are positively correlated. Extant literature emphasizes the importance of encouraging governments and universities to acquire an entrepreneurial mindset, so every strategic decision involving academic staff encompassing researchers, lecturers and practitioners yields the creation of social value (Wong *et al.*, 2007).

In hypothesis 3, we posited that entrepreneurship, influenced by knowledge institutions, has a positive effect on the economic development in Spain. After introducing the lag of entrepreneurial activity into Equation (2), as an endogenous factor, our results provide support for not rejecting hypothesis (3). Effectively, models 6 and 7 show that entrepreneurship, influenced by the two types of knowledge institutions, positively affected Spanish regional development ($\gamma_1 = 0.013$, $p < 0.01$ for both models). On the one hand, our findings are in line with the extant literature, which suggests that entrepreneurs, particularly those having close contact with R&D staff and researchers from the public sector, spur economic development (Acs *et al.*, 2009; Audretsch and Link, 2019; Link, 2021). And on the other, the dynamic results we have obtained are following other studies comparing local entrepreneurship in Spain (González-Pernía and Peña-Legazkue, 2015). Here it is important to consider that, perhaps, entrepreneurs are more adapted to the environment, thanks to the knowledge in terms of markets, procedures, products and so on, which is generated under the government budget (Link, 2021). What turns out interesting from our exercise is that the positive correlation between entrepreneurship and regional development might imply that a larger number of entrepreneurs may be located in prosperous regions, as Liñan *et al.* (2011) have found. In fact, Spanish regions grow 0.013% on average when the level of entrepreneurship increases by 1%, *ceteris paribus*.

Finally, the analysis of control variables suggests that regions with a large portion of highly educated people may incentivize individuals to look for a job to avoid the risks associated with entrepreneurship, which is consistent with Berril *et al.* (2020) and van Stel and van der Zwan (2020). In addition, overcrowded markets (i.e. highly populated regions and many incumbent firms) bring opportunities in terms of available niches, which can become potential customers with purchase capacity (i.e. high GDP per capita). Consistent with the existing literature (Carree *et al.*, 2002, 2007; Gries and Naudé, 2010; Hessels *et al.*, 2008;

Wennekers *et al.*, 2005, among others). However, these markets can also impose barriers for new entrepreneurs. Hence, the tough competition may bring extra costs entrepreneurs might not be willing to assume (Bailey and Thomas, 2017). This is revealed through the negative and statistically significant effect of the number of firms on entrepreneurship.

Robustness check

To verify whether our models remain invariant when additional changes take place, we have conducted a series of robustness tests. We sought, therefore, to validate the key assumptions that we maintained when instrumenting for the entrepreneurship choice. Firstly, Table 3 shows consistency across models, in which estimations for independent and control variables hold when the latter is solely considered (model 1 and model 4), and when the former is included in the rest of the models. It is important to clarify that models 1 through 4 are performed using traditional OLS. We observe that the results neither lose some significance nor change in magnitudes.

Secondly, by following Aparicio *et al.* (2016) work, we have performed our models not only through 3SLS but also relying on 2SLS. As we have discussed in section 3, 3SLS turns out to be more efficient than OLS and 2SLS, nonetheless, we wanted to obtain a reference estimation through the basic two-stage method. Based on the results that we obtained (see Appendix 2), we have observed that the magnitude holds for all variables, and the standard error is lower for those models estimated with 3SLS than 2SLS. Additionally, we have computed the Hausman test to validate whether variations in the estimations obtained through 2SLS and 3SLS exist. We have found that it is not possible to reject the null hypothesis about the non-systematic differences in coefficients of the 3SLS as compared to the 2SLS estimation. This Hausman test guarantees that our structural model, estimated through different methods, is well specified, basically because there are no higher differences concerning both sign and magnitude.

Thirdly, since entrepreneurship may be measured through different indicators (Iversen *et al.*, 2007), we changed our main dependent variable for Equation (1), which in turn is the main independent variable in Equation (2). Acs *et al.* (2008) have compared GEM data with World Bank information about newly registered firms. The authors have found that no systematic differences exist. Conducting a similar exercise, Margolis (2014) has shown that self-employment also represents individuals' decisions about entrepreneurship. Although having new ventures is an important approach, we have opted for replacing total early-stage entrepreneurial activity from GEM with self-employment as it follows the same micro-foundations (Bosma, 2013). In our particular case, we have considered the percentage of the population that is self-employed. Information was taken from the Work and Social Affairs Ministry (Ministerio de Trabajo y Asuntos Sociales) during the 2004–2018 period, across 17 autonomous communities and two autonomous cities. As it can be seen in Appendix 3, even though the number of researchers in public administration is not statistically significant, results hold for both knowledge institutions and entrepreneurship. The lack of significance might be due to the association between self-employment and necessity-driven entrepreneurship (Muñoz-Mora *et al.*, 2022; Puente *et al.*, 2019).

Based on the findings from the checks described above, we believe that our results and specification remain stable to various changes applied to the original specification. Therefore, we are confident that the knowledge institutions we studied had a robust positive effect on entrepreneurship, which, in turn, affects Spanish regional development.

Discussion and implications

Our findings shed light on knowledge institutions for entrepreneurship and society. First, public servants focused on R&D activities urge entrepreneurship thanks to the knowledge

they generate regularly. This result is aligned with the literature about innovation and entrepreneurship (Link and Scott, 2021; Link and Wright, 2015). However, in our case, knowledge comes through two main mechanisms, which are strongly associated with institutions. First, both communities and cities in Spain are autonomous when it comes to the definition of the public budget for all kinds of activities, including traditional consumption, R&D investment, acquisition of skilled personnel and ownership of firms. This budget is approved by law, which is directly related to the definition of an institution (North, 1990). The second mechanism is the socialization process among the staff working on R&D. It is well-known that innovative products and solutions are not created in isolation, hence teamwork is needed (Pinzón *et al.*, 2021). These endeavors result in new technologies, methodologies, goods and services, which need an engine that translates them to the market. A firm-government partnership may enable such a transition (Klein *et al.*, 2010). Yet, we are showing that entrepreneurs also absorb the remaining knowledge to bring social solutions.

Universities also play a key role in the partnership (Demircioglu and Audretsch, 2019). One of the main activities of higher education organizations is the constant work on theoretical and applied research. Audretsch and Belitski (2022) have suggested that universities are becoming entrepreneurial agents within the society as these organizations push the knowledge frontier thanks to research activities and include the society in their goal through (under)graduate programs. Our result for the number of researchers in the public sector goes in line with these ideas. This knowledge institution is also found an important element for entrepreneurship across Spanish regions. Similar to the staff involved in R&D, this factor also responds to the same mechanisms when it comes to the institutional analysis. Considering that most of the higher education organizations in Spain are public (Liñan *et al.*, 2011), universities are certainly the main location where researchers perform their tasks and socialize with others to build up a conversation around new ideas. Laboratories publicly funded are also an appropriate environment for people to work on academic research, which feeds the foundation of new knowledge that entrepreneurs identify as potential market projects.

If innovations, prototypes and ideas at large coming from the public sector overcome the valley of death thanks to entrepreneurs (Takata *et al.*, 2022), then society may obtain important benefits. Our results regarding the effect of entrepreneurship on regional development, effectively, indicate that having a certain number of people engaged in entrepreneurial activities is relevant for regional wealth in general. This can be explained in two ways. On the one hand, entrepreneurs bring new elements into Spanish regions and stimulate the opportunity identification through the existing knowledge in the environment. On the other hand, and as a possible consequence of the knowledge institutional setting, new entrepreneurs emerge to improve people's needs and problems ranging from products that are still not available in the market to deep social inclusion (Aparicio *et al.*, 2022b; Sulter *et al.*, 2019). Thus, the relevance of generating incentives that urge entrepreneurs should be a priority, especially because there is a huge movement of younger generations, with entrepreneurial and technological skills, interested in solving economic, environmental and humanitarian problems through entrepreneurship. Our results, then, are practical in nature. However, scholars and policymakers can also benefit from some theoretical and public policy implications originated in our research.

Implications for theory and literature

A first theoretical implication consists of going beyond the traditional interpretation of institutions such as laws, regulations, culture and norms. North (2005, p. 21) recognizes that the existing knowledge in a society is also an institution, which provides incentives for economic and social development. We bring up these ideas to operationalize possible factors representing knowledge institutions as explained in Peters and Besley (2008). In both cases,

R&D workers and researchers as staff of public administration are equipped with the necessary skills to expand knowledge and set the basis, upon which the society advances through better information, technology, health, etc. An example of this idea might consist of those efforts by the US government to enhance our understanding of the universe (Terjesen, 2016). The NASA, for instance, is a well-coordinated organization where skilled and qualified staff works constantly on solving complex problems, which lately is transferred to society through university programs.

Another way to create knowledge for the society consists of private initiatives that increase R&D as part of their strategies. Acs *et al.* (2009, 2013) have developed the knowledge spillover theory of entrepreneurship, in which entrepreneurs are the catalyst of economic development thanks to their ability to identify opportunities and turn them into new ventures. Audretsch and Link (2019) and Link (2021) have extended this notion to the public sector, which is also able to create necessary knowledge that ultimately entrepreneurs absorb. Putting together institutional economics (North, 2005) and the knowledge spillover theory of entrepreneurship in the public sector (Audretsch and Link, 2019) is precisely our second contribution to theory. It is undeniable the intersection between these frameworks, which implicitly have complemented each other. We explicitly suggest that the knowledge coming from public laws and subsequent investments is a source of inspiration for entrepreneurs, who contribute to economic development by bringing solutions to society.

Our third theoretical contribution is the role of entrepreneurs in the development process. Hausman (2016) has developed the scrabble theory of economic development, whose key element is the ability countries pose to create new knowledge helpful for the expansion of complex industries. Within this theory, foreigners play an important role to mobilize existing knowledge to other societies. Our results might complement this view in two ways. On the one hand, although it might take longer than Hausman's (2016) idea, knowledge may also be a result of public and private initiatives. Indeed, public-private partnerships are ideal to provide enough funding for different innovative projects. On the other hand, unlike foreigners, entrepreneurs can play a role in the mobilization of ideas into real projects that help the expansion of existing industries and the integration with new ones.

Implications for policy

As per public policies, entrepreneurship gained attention back in the 2000s when the European Union aimed at improving industrial competitiveness and economic development across the region (Smallbone, 2016). Since then, entrepreneurship has become an engine to tackle different economic and social problems (Bacq *et al.*, 2022). Governments have been interested in creating an appropriate environment where entrepreneurs make decisions with low risk and uncertainty (Arshed *et al.*, 2014). Setting up ecosystems has become the priority when it comes to the association of institutions with entrepreneurship, which is assumed a leverage spurring economic development (Stam, 2015). Yet, some concerns have been raised, especially if the intention is to replicate the Silicon Valley model (cf. Audretsch, 2021). Pahnke and Welter (2019) have suggested that other types of ecosystems are equally important to incentivizing the creation and growth of small businesses. In this case, the role of governments has consisted of providing sufficient infrastructure that supports entrepreneurial dynamics. We complement this idea by emphasizing the governments' role in not only the investment of infrastructure but also the staff and equipment they need to move forward research projects with theoretical and applied purposes.

Universities are primarily the vehicle to materialize these investments, especially because the basic infrastructure is already there. However, as part of the industrial policies under the ecosystems' notion, governments are seeking a transition toward entrepreneurial universities, where people can acquire skills and abilities related to entrepreneurship

(Audretsch and Belitski, 2022). The main goal is, therefore, to conceive universities as mechanisms that provide societies with an entrepreneurial mindset, increasing their entrepreneurial potential (Aparicio *et al.*, 2021). Thanks to our findings, we suggest that other organizations different from universities can also complement the achievement of this mission. Think tanks and knowledge hubs have seemed to be good policies to improve industrial competitiveness and economic development. Arenas *et al.* (2020) have explained the case of RutaN in Colombia, which is a public organization working on R&D projects. This organization counts on skilled staff and scholars, who serve to build up a direct bride between them and the university system. Therefore, the scholars-for-universities notion is discarded thanks to our results.

Overcoming this myth entails the creation and consolidation of industrial doctoral programs (Brush *et al.*, 2003; Pocek *et al.*, 2022), which tackle social problems from companies' needs. Certainly, a strong ecosystem requires the involvement of different stakeholders with social purposes (Spigel and Vinodrai, 2021). Incumbent companies are one of the key members to incentivizing and supporting people interested in becoming scientists and researchers. To achieve this, governments are called to play a role in this process and orchestrate people's intentions, business preferences and university programs. The more available funding the higher the possibilities to involve others in the knowledge generation, useful for entrepreneurship and development.

Conclusions

In this paper, unbalanced panel data (for the period 2004–2018) were utilized to explore knowledge institutions as a necessary input for entrepreneurship and the development of societies. In doing so, a simultaneous equation model to enhance the comprehension of the interplay between these variables was used. Conceptually, we have approached knowledge institutions through the theoretical framework of institutional economics (North, 1990, 2005), which has served to analyze the influence of the number of R&D staff and researchers from the public sector on entrepreneurship, which at the same time took account of regional development in terms of the GDP level.

Regarding the institutional determinants of entrepreneurship, we found strong positive effects from all knowledge proxies. Both laws for public budgeting and socialization processes were the analyzed mechanisms behind the relationship between R&D staff and entrepreneurship. The same analysis was applied to the association between researchers from the public sector and entrepreneurial activity across Spanish regions. However, in this case, universities have also played a role in the formation of structures where socialization, and hence, knowledge may emerge.

Concerning the effect of entrepreneurship on regional development and society, we found that, effectively, the fact of having a certain number of entrepreneurs is relevant for regional wealth in general. This could be interpreted in two ways. On the one hand, the entrepreneurs embedded in societies with complex knowledge bring new elements to the Spanish culture and stimulate the opportunity identification through social ties. On the other hand, and as a possible consequence, skilled entrepreneurs emerge to improve the economy and society at large. Thus, the relevance of generating incentives that urge public-private partnerships useful for entrepreneurs should be a priority.

Before highlighting potential future research directions, we wish to acknowledge three key limitations to our study. First, although we rely on the number of R&D staff and researchers as a key institutional component, we still have a huge aggregation of groups from the public sector, especially for those related to key innovative activities. Unfortunately, the data we are using were not as rich as one would prefer. In this regard, we are not able to distinguish public servants from universities, public-owned companies, or public

administration. However, similar to Aparicio *et al.* (2022a), we have assumed that the observed staff, despite different characteristics, share the public service feature, and hence, reflects scientific thinking and action. Secondly, our unit of analysis also suffers an important aggregation. Since we are using data only on the 17 autonomous communities and two autonomous cities, some details are escaping from our interpretation. For example, Andalucia, which is the biggest autonomous community, has slight differences among the towns that are part of it. Nevertheless, prior studies have provided important evidence about entrepreneurial activity at this aggregation level (Gumbau Albert, 2017; Liñán *et al.*, 2011). Thirdly, our study only examines total early-stage entrepreneurs based on the GEM project. Since Spain has low levels of necessity entrepreneurship, this is not an inconvenience that biases our result.

Our study highlights some promising directions for future research. The first one has to do with the limitations mentioned before. New studies could take advantage of updated data released by INE, which consider not a group of economies, but countries individually. Additionally, particular differences within Spain might be captured by conducting studies at the province level, rather than at the autonomous community level. From a policy perspective, future studies could examine whether budgeting regulations change the desired investment in public staff devoted to R&D and research and subsequently create knowledge that inspires entrepreneurs. We, therefore, suggest future research which further explores the relationship between knowledge institutions, entrepreneurship and development at the regional and national levels. Future research might also consider other types of entrepreneurs (e.g. innovative, technological, export-oriented) as developed countries such as Spain are characterized by having different typologies of productive entrepreneurship (Amorós *et al.*, 2019a; Dencker *et al.*, 2019; McMullen *et al.*, 2008). Other studies might focus on R&D staff and researchers from private universities as complimentary actors of public higher education organizations. While Spain is mainly characterized by the latter system, other countries such as the US or Latin America at large benefit from innovative endeavors in private universities. To this end, other techniques such as spatial econometrics might bring important insights into the debate.

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Appendix 1

Community/City	GDP[a]	TEA[b]	R&D staff in public administration[c]	Researchers in public administration[c]
Andalucía	1.43E+08	6.237	5,272.433	2709.327
Aragón	3.28E+07	5.184	1175.093	639.133
Principado de Asturias	2.17E+07	3.568	559.500	269.806
Illes Balears	2.69E+07	6.196	455.553	311.666
Canarias	4.04E+07	5.489	1166.953	670.773
Cantabria	1.24E+07	5.474	377.220	240.086
Castilla - León	5.34E+07	9.096	913.880	466.853
Castilla - La Mancha	3.71E+07	5.931	466.446	292.684
Catalunya	1.99E+08	6.988	8390.293	5092.660
Comunitat Valenciana	9.96E+07	5.324	2426.747	1444.807
Extremadura	1.75E+07	5.937	485.553	199.406
Galicia	5.52E+07	5.138	1440.677	758.500
Comunidad de Madrid	1.96E+08	6.312	13809.310	6798.933
Región de Murcia	2.74E+07	5.556	632.721	360.192
Comunidad Foral de Navarra	1.77E+07	4.967	341.957	244.757
País Vasco	6.35E+07	4.490	1028.720	598.16
La Rioja	7,748,945	5.092	238.980	128.973
Ceuta	1,538,724	3.870	1.300	0.700
Melilla	1,394,066	4.172	1.300	0.700

Note(s): [a]INE (Instituto Nacional de Estadística): https://www.ine.es
[b] GEM (Global Entrepreneurship Monitor): https://www.gemconsortium.org
[c] Ministry of Economics, Industry, and Competitiveness: https://datos.gob.es/es/
Source(s): Authors' own creation

Table A1. Descriptive statistics by autonomous community and city

Appendix 2

Equation (1)	(1) Ln TEA	(2) Ln TEA	(3) Ln TEA
Ln R&D staff in Public Administration ($t-1$)		0.122*	
		(0.065)	
Ln Researchers in Public Administration ($t-1$)			0.138*
			(0.072)
Ln Education ($t-1$)	−0.040***	−0.043***	−0.044***
	(0.008)	(0.008)	(0.008)
Ln number of firms ($t-1$)	−0.695*	−0.985**	−1.049**
	(0.389)	(0.416)	(0.412)
Ln Self-employees in industry ($t-1$)	−0.062	−0.074	−0.086*
	(0.047)	(0.047)	(0.047)
Ln Self-employees in construction ($t-1$)	−0.118**	−0.099*	−0.107**
	(0.054)	(0.054)	(0.054)
Ln Self-employees in service ($t-1$)	0.139*	0.115	0.132*
	(0.075)	(0.076)	(0.079)
Ln Public administration expenditure in R&D ($t-1$)	0.006	−0.054	−0.057
	(0.031)	(0.044)	(0.041)
Ln unemployment rate ($t-1$)	−0.501***	−0.517***	−0.530***
	(0.082)	(0.081)	(0.081)
Ln GDP per capita ($t-1$)	0.890***	1.045***	1.046***
	(0.340)	(0.348)	(0.341)
Ln population ($t-1$)	0.867**	1.102***	1.153***
	(0.408)	(0.424)	(0.419)
Constant	−3.110	−2.913	−2.499
	(2.390)	(2.378)	(2.427)
R^2	0.277	0.289	0.297
Equation (2)	Ln GDP	Ln GDP	Ln GDP
Ln TEA ($t-1$)	0.013**	0.013**	0.013**
	(0.005)	(0.005)	(0.005)
Ln R&D expenditure ($t-1$)	−0.008	−0.008	−0.005
	(0.020)	(0.020)	(0.020)
Ln capital ($t-1$)	0.070***	0.070***	0.068***
	(0.012)	(0.012)	(0.012)
Ln labor force ($t-1$)	0.251***	0.251***	0.239***
	(0.053)	(0.053)	(0.053)
Ln government expenditure ($t-1$)	0.117***	0.117***	0.115***
	(0.028)	(0.028)	(0.028)
Constant	11.068***	11.068***	11.181***
	(0.345)	(0.345)	(0.348)
Observations	221	221	220
Regional fixed-effects	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes
R^2	0.931	0.959	0.912

Table A2. Results using 2SLS

Note(s): *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parentheses
Source(s): Authors' own creation

Appendix 3

Equation (1)	(1) Ln self-employment	(2) Ln self-employment	(3) Ln self-employment
Ln R&D staff in Public Administration ($t-1$)		0.056***	
		(0.021)	
Ln Researchers in Public Administration ($t-1$)			0.025
			(0.025)
Ln Education ($t-1$)	0.010***	0.008***	0.009***
	(0.003)	(0.003)	(0.003)
Ln number of firms ($t-1$)	0.675***	0.528***	0.608***
	(0.124)	(0.133)	(0.135)
Ln Public administration expenditure in R&D ($t-1$)	0.021*	−0.008	0.009
	(0.011)	(0.015)	(0.014)
Ln unemployment rate ($t-1$)	−0.245***	−0.252***	−0.247***
	(0.027)	(0.027)	(0.027)
Ln GDP per capita ($t-1$)	−1.071***	−0.975***	−1.036***
	(0.107)	(0.111)	(0.113)
Ln population ($t-1$)	0.281**	0.405***	0.337**
	(0.129)	(0.135)	(0.137)
Constant	12.484***	12.410***	12.540***
	(0.751)	(0.740)	(0.783)
R^2	0.987	0.988	0.986
Equation (2)	**Ln GDP**	**Ln GDP**	**Ln GDP**
Ln self-employment ($t-1$)	0.085*	0.088**	0.068
	(0.045)	(0.045)	(0.045)
Ln R&D expenditure ($t-1$)	−0.007	−0.007	−0.007
	(0.015)	(0.015)	(0.014)
Ln capital ($t-1$)	0.067***	0.067***	0.066***
	(0.011)	(0.011)	(0.010)
Ln labor force ($t-1$)	0.226***	0.225***	0.223***
	(0.051)	(0.051)	(0.051)
Ln government expenditure ($t-1$)	0.119***	0.119***	0.118***
	(0.023)	(0.023)	(0.023)
Constant	10.554***	10.536***	10.727***
	(0.407)	(0.407)	(0.414)
Observations	238	238	236
Regional fixed-effects	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes
R^2	0.931	0.959	0.912

Note(s): *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parentheses
Source(s): Authors' own creation

Table A3. Results using self-employment as a proxy for entrepreneurship

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