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REGIONAL ENTREPRENEURSHIP CAPITAL, SPILLOVERS AND PRODUCTIVITY

José Luis Massón-Guerra

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DOCTORAL THESIS

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Dedication

To Teresa Amada, Luis Gerardo and José Luis.

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Regional Entrepreneurship Capital, Spillovers and Productivity

Introduction

Public intervention to foster entrepreneurship has been justified by the positive spillovers that regional entrepreneurship capital could have on firms' productivity. Acs et al. (2016) argues "that spatial externalities of various forms constitute serious market failures that require intervention" (p. 36). Those arguments are mainly based on the empirical literature generated around the Knowledge Spillover Theory of Entrepreneurship (KSTE). This theory suggests that entrepreneurship capital in a certain region has positive spillovers that increase the production of firms in the region (Audretsch and Keilbach 2005, 2007; Acs et al. 2009; Audretsch and Lehmann 2016). From this starting point, a growing amount of literature is estimating the effects of regional entrepreneurship capital on a region's production using aggregated data at the regional level (Audretsch and Keilbach 2004a,b,c, 2005, 2008; Mueller 2006, 2007; Bönte et al. 2008; Cravo et al. 2010; Stough et al. 2008; Chang et al. 2012; Hafer 2013; Laborda et al. 2011; Carree et al. 2014; Mendonça and Grimpe 2015). In practically all the cases, these studies report the positive and significant effects of regional entrepreneurship capital on regional production, which are interpreted as supporting the existence of positive spillovers on firms' productivity. This thesis deals with three gaps that the cited empirical literature has in order to measure such externalities.

Chapter 1 explicitly states the assumptions that one have to make in order to interpret the existing evidence as a support of the presence of positive spillovers of the regional entrepreneurship capital on the firms' productivity. A key assumption is the existence of constant returns to scale which is inconsistent with the fact that in practically all the empirical applications are decreasing returns to scale. This chapter shows how to deal with this inconsistences using aggregated data at the regional level. For doing that, it is necessary to include in the estimations the number of firms in the region. The idea is to estimate a representative production function of the firms in the region without imposing restrictions about the returns to scale on the production function. Given that it is expected a certain correlation between the number of firms in the region and the regional entrepreneurship capital, it is important to provide evidence when the number of firms is included in the estimations. Chapter 1 fills this gap providing evidence using a sample of 52 Spanish provinces (NUTS-3) over eleven years. Overall the results suggests that the previous literature could have overestimated the spillovers of regional entrepreneurship capital on firms' production.

A second gap in the literature is that those externalities have not been measured at the firm level. Data at the firm level has two important advantages. First, let us to provide evidence related with the kind of firms that benefit most from the spillovers. Second, the regional entrepreneurship capital could affect the regional aggregated production by at least two means: by affecting the number of firms in the region and/or by the spillovers in firm production. With aggregated data it is practically impossible to distinguish among them. This will not be the case when data at the firm level are used. Chapter 2 covers this gap providing evidence from a sample of 11,276 Spanish firms during the 2004–2012 period. The entrepreneurship capital is measured at the level of Autonomous Comunities (NUTS-2). Positive spillovers are estimated in between effects models, but such spillovers are only found in technological firms when within effects models have been estimated. Thus, the regional entrepreneurship capital spillovers are unclear when data at the firm level are used.

The third gap in the literature is the lack of evidence about the regional entrepreneurship capital spillovers on firms' production at the City level. For that purpose Chapter 3 takes advantage of the Ecuadorian census of establishments and uses data disaggregated at the firm level.

Furthermore, as far we know, this is the first study analyzing the spillovers of regional entrepreneurship capital in a Latin American country. A distinctive feature of those countries, in front of European countries the most analyzed ones, is the role of the informal economy. So we can provide first evidence related with the spillovers of the informal entrepreneurship capital. In general, the entrepreneurship capital accumulated in a city has positive spillovers over the production of the establishments. Those spillovers are higher in those cities where the entrepreneurship capital is mostly generating informal establishments.

In short, this is an empirical dissertation focused on measuring the regional entrepreneurship capital spillovers on firms' productivity. We would like to state explicitly that:

i) We do not exclude that the regional entrepreneurship capital could have other important implications on the regional economy. We just want to clarify that measuring those effects is not the purpose of this dissertation, nor of the previously cited literature. The most obvious implication of the regional entrepreneurship capital in the economy is that it an increase in the number of firms can reduce the unemployment and consequently the GDP of the region. In fact, most of our concerns related with using aggregated data at the region level is how to distinguish among those effects and the spillovers in the firms' productivity. This is why we propose the use of data at the firm level.

ii) We have tried to use methodological approaches as close as possible (except for the methodological innovation that we want to highlight) to the previous empirical literature. Consequently, we share most of their shortcomings, additionally to those related with the fact that, due to data restrictions, we cannot always reply exactly the measures used previously in the literature. This specially occurs with the measurement of the regional entrepreneurship capital.

iii) We do not develop new theory and therefore new policy implications. We just test theories and measure their importance. We expect that from all the evidence generated one can infer the most relevant theories and consequently the policy implications associated with these theories. In our case, the magnitude of the regional entrepreneurship capital spillovers on firms' productivity. Our results seems to suggest that this importance has been overestimated in previous studies, so the results relativize the importance of the public intervention. Further evidence referred to other periods of time and specific geographic regions, will help to understand the generalizability of our results.

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Entrepreneurship Capital and Regional Productivity Revisited(†) [Chapter 1]

(†) A short version of this chapter has been accepted for publication at the Revista de Economía Aplicada as a note. See Final Appendix

Entrepreneurship Capital and Regional Productivity Revisited [Chapter 1]

1. Introduction

Although there is general agreement regarding the idea that entrepreneurship contributes to economic growth, how such a contribution occurs, and how important it is, continue to be open questions in entrepreneurship research. One of the methodological approaches to entrepreneurship and growth is that proposed by Audretsch and Keilbach (2004a). This consists of considering entrepreneurship to be a productive input that, together with labour and capital, contributes to the output of the economy, but with one important difference: entrepreneurship is a public good from which everyone in the economy can benefit without hampering the effectiveness of the use of the input by others. This approach has been applied in different institutional contexts such as Germany (Audretsch and Keilbach, 2004a, 2004b, 2004c, 2005; Audretsch et al., 2008; Audretsch et al., 2006; Mueller, 2006, 2007), European regions (Bönte et al., 2008), Brazil (Cravo et al., 2010), the USA (Stough et al., 2008; Chang, 2011; Hafer, 2013) and the world (Laborda et al., 2011), among others. These studies provide evidence that regional entrepreneurship capital is positively related with regional production. The most commonly used indicators of entrepreneurship capital have been based on the number of firms (incumbent or new, in absolute or relative terms, or their respective growth rates over time).

The chapter's contributions to the cited literature are related with the recognition that a region's production is the aggregate of all the production activities of the firms in the region. In a simple model, we show that even if firms in different regions are equally productive, the number of firms in the region will be positively related with the region's production level when the firms' technology has decreasing returns to scale. Therefore, when the number of firms in the region is used as a proxy of entrepreneurship capital, the evidence of a positive contribution of number of firms to aggregate total factor productivity at the region level cannot be attributed to evidence that entrepreneurship capital contributes to total output produced. The reason is that when production takes place in firms each producing with decreasing returns to scale economies then number of firms will also be correlated with total regional production.

In other words, given two regions with the same total labor and tangible capital inputs, and with the same total output produced, the one producing with lower returns to scale will have more firms, and smaller average size per firm than the other producing with higher returns to scale. The hypothesis of entrepreneurship capital acting as a public good will only be supported if for the same volume of capital and labor inputs, controlling for differences in scale economies in production the region with higher number or firms produces more output than the region with lower number of firms.

So in order to determine which theoretical explanation is relevant, it is important to empirically distinguish between both effects. This has not been done before in the cited literature. In this sense, the main contribution of the chapter is to provide a methodological benchmark to help distinguish between these two effects. The proposal is therefore to estimate the regional differences in the firms' average production depending on the average use of private inputs and the total public inputs available at the regional level. This will provide estimations of the average total factor productivity of the firms in the region and can be applied with the usual data available in the literature. The only special requirement is to have information about the regional stock of firms.

Furthermore, the chapter argues that most of the entrepreneurship capital measures used previously by the literature are defined, or can be mathematically related with the stock of firms. For example, the firms' regional stock is the sum of such stock in the different economic sectors that it is composed of, or is the sum of the annual increases (or decreases). So it can be empirically tested whether those measures provide further information than the stock of firms. Throughout the text we provide some discussion of how to test that.

This chapter provides a first application of those developments in a data sample covering the 52 provinces into which Spain is administratively divided (NUTS 3 Eurostat) in the 2002-2012 period with information as close as possible to that used in the previously cited literature. Although studies have analyzed the economic impact of entrepreneurship capital in Spain (Salas-Fumás and Sánchez-Asín, 2008, 2010, 2013a, 2013b; Callejón, 2009; Callejón and Ortún, 2009), these use other methodological approaches and aggregate data referring to the Autonomous Communities (NUTS 2 Eurostat) into which provinces are grouped. As the effects of entrepreneurship capital seem to be stronger at the local level, smaller regional divisions are preferred when data is available.

The data is analyzed with and without our methodological contributions. In this case, there are major differences in the interpretation of the results and conclusions. Obviously we cannot make assertions regarding what will happen (or what would have happened) in other contexts, but a priori, future research cannot reject the idea that there may be decreasing returns to scale, which has to be corrected for. The chapter provides a simple methodological framework for making such corrections.

The chapter is organized as follows. First, the previous literature is summarized. Second a theoretical framework is developed to understand the interpretation of the evidence made in the previous empirical literature and discuss the methodological contributions proposed in this chapter. Third, the empirical approach is presented, which is summarized in the form of different hypotheses. Fourth, the sectorial decomposition is analyzed. After that, the data and variables used in testing the hypotheses are described. Finally, we present the results and discuss the chapter's implications.

2. Regional entrepreneurship capital and production: Literature review

Since Audretsch and Keilbach (2004a), several authors have suggested that entrepreneurship capital is a public input on a regional level. Their arguments are based on previous literature analyzing the influence of knowledge, measured in terms of human capital (Romer, 1986) or investments in research and development (Jones, 1995), on regional production. Knowledge could be generated in different institutions, such as universities, scientific parks or in-company research centres, among others. Acs et al., (2009) or Qian et al., (2013) among others argue in favour of the knowledge spillovers of entrepreneurship. Filters exist between knowledge and its commercialization. This knowledge is not always directly useful for production activities. Several papers (Delgado et al. 2010; Maskell and Malmberg 2007; Storper and Venables 2004; Gertler 2003) have analyzed different mechanisms people find to overcome such filters and find ways of using the knowledge to produce commercial goods and become entrepreneurs. The capacity of a region to generate such entrepreneurial activity, in short term entrepreneurship capital, will affect their production. From this starting point, a growing amount of literature is estimating the effects of regional entrepreneurship capital on a region's production.

The measurement and concept of entrepreneurship capital generates some discussion (Erikson, 2002; Audretsch, 2009; Bönte et al., 2008) as the measurement of whatever other kind of input. For example, the empirical applications work with different measures that go from the stock of firms in the region (Stough et al., 2008), to the entry rate of firms in key industries (Chang, 2011). Audretsch and Keilbach (2004a, 2004b, 2008) used the annual average of new firms per 1,000 workers created in a three year period. Mueller (2006, 2007) also uses this indicator along with the number of new firms created in one year. Sutter and Stough (2009) use the average number of technological and innovative firms created in the last five years; while Bönte et al., (2008), Salas-Fumás and Sánchez-Asín (2008, 2010, 2013a, 2013b) and Stough et al., (2008) use the self-employment rate on a regional level. All of those entrepreneurship capital measures are part of (and can therefore be related with) the number of firms in the region.

To estimate the impact of regional entrepreneurship capital on the production for region *i* and period *t*, $Y_{i,t}$, the usual method is to follow Solow (1956) by summarizing private inputs as capital ($K_{i,t}$) and labour ($L_{i,t}$) and summarizing public inputs as knowledge ($R_{i,t}$) and entrepreneurship capital ($E_{i,t}$). The output obtained as a combination of those private and public inputs is estimated in most cases by Cobb-Douglas (1928) functions:

$$\ln Y_{i,t} = \mu \ln R_{i,t} + \delta \ln E_{i,t} + \alpha \ln K_{i,t} + \beta \ln L_{i,t} + a_i + \varepsilon_{i,t} \quad [1]$$

Hence, the parameters to be estimated are the production elasticity with respect to capital (α), labour (β), entrepreneurship capital (δ) and knowledge (μ). Studies with panel data can control for the regional fixed effects (a_i), and $\varepsilon_{i,t}$ are the usual error terms, following independent and identical normal distributions. When it is assumed that production technologies present constant returns to scale for private inputs ($\beta = 1 - \alpha$) the production per employee ($y_{i,t} = Y_{i,t} / L_{i,t}$) will be:

$$\ln y_{i,t} = \ln Y_{i,t} - \ln L_{i,t} = \mu \ln R_{i,t} + \delta \ln E_{i,t} + \alpha \ln k_{i,t} + a_i + \varepsilon_{i,t} \qquad [2]$$

where $k_{i,t} = K_{i,t} / L_{i,t}$. The above production function has been estimated in several studies using one method [2] (Audretsch and Keilbach, 2004a) or another [1] (Audretsch and Keilbach, 2004b; Audretsch et al., 2008; Mueller, 2006, 2007; Bönte et al., 2008; Stough et al., 2008). In all the studies estimating Equation [1], with the exception of Audretsch and Keilbach (2004b), are decreasing returns to scale ($\beta + \alpha < 1$), although only Mueller (2006) reports a test of their significance. In their estimations, the elasticity of production with respect to knowledge (μ) and entrepreneurship capital (δ) are positive and statistically significant.

The theoretical arguments interpreting entrepreneurship capital as a public productive input suggest that their sectorial composition could be relevant. As much of the entrepreneurial activity is related with the newness of the knowledge applied, its impact on the regional production has to be higher when the entrepreneurship activity is concentrated in more knowledge intense economic sectors. To test this, Audretsch and Keilbach (2004a, 2004b, 2004c, 2008) classified entrepreneurship capital on the basis of the technological intensity of the sectors: high technology, ICT's, and other sectors. They have considered them as alternative measures of entrepreneurship capital. Although in all cases production elasticity with respect to entrepreneurship capital is positive and significant, the highest one is that associated with the less technological sectors, other sectors. Mueller (2006, 2007) finds that production elasticity with respect to knowledge generated in industry is greater than the elasticity with respect to knowledge generated in universities or public research centres. In terms of geographical location, the elasticity of production with respect to entrepreneurship capital in urban zones is higher than in rural ones (Audretsch and Keilbach, 2005).

Much of this literature provides isolated estimations of Equations [1] or [2]. They do not analyze the implications of the fact that regional production is the aggregation of the firms' production in the region on the interpretation of the elasticity of regional production with respect to entrepreneurship capital. Such problems with the interpretation of the parameters are detailed in the next section.

3. Aggregated data at the regional level and the firms' production functions

The reviewed literature can be considered a stream of a broader literature on the determinants of regional production (Solow, 1956; Romer, 1986) from which we would not like to depart. Regional production is the aggregation of firms' production in the region. But collecting information at the firm level would be extremely demanding in terms of data. So this literature makes some simplifying assumptions in order to use data on the aggregated level. We will argue that when research seeks to determine the role of entrepreneurship capital as a public good in the economy, as the literature reviewed in the previous section has done, such assumptions are not as innocuous as they might be for other research purposes.

Let us focus first on the implications of considering entrepreneurship capital as a public good in the production function of one firm. Define $Y_{j,i,t}$ as the production of firm *j* in region *i* during period *t*. Firm *j* can use a set of private inputs purchased on the market and a set of public goods available in region *i*. To reduce notation and be consistent with the reviewed literature consider only capital ($K_{j,i,t}$) and labour ($L_{j,i,t}$) as private inputs and knowledge ($R_{i,t}$) and entrepreneurship capital ($E_{i,t}$) as public goods at the regional level. The following function summarizes the relationship between the production and inputs used:

$$Y_{j,i,t} = TFP_{j,i,t} f\left(L_{j,i,t}, K_{j,i,t}\right) e^{v_{j,i,t}} = g\left(R_{i,t}, E_{i,t}\right) f\left(L_{j,i,t}, K_{j,i,t}\right) e^{a_{j,i}+v_{j,i,t}} \quad [3]$$

The parameter $a_{j,i}$ captures persistent differences in the total factor productivity ($TFP_{j,i,t} = g\left(R_{i,t}, E_{i,t}\right) e^{a_{j,i}}$) between firms and $v_{j,i,t}$ are independently distributed error terms. To be consistent with the previous literature we will assume that g and f are Cobb-Douglas functions, $g(R_{i,t}, E_{i,t}) = R_{i,t}^{\ \mu} E_{i,t}^{\delta}$ and $f\left(L_{j,i,t}, K_{j,i,t}\right) = L_{j,i,t}^{\alpha} K_{j,i,t}^{\beta}$. For most of our argumentations we will only require function f to be homogenous at degree θ. Remind that the Cobb-Douglas is a homogenous function of degree $\theta = \beta + \alpha$. If the entrepreneurship capital is a public good, it will be expected that $\partial g()/\partial E > 0$ or in terms of the Cobb-Douglas parameters' function $\delta > 0$.

As commented earlier, collecting information at the firm level would be extremely demanding. So the information that is usually available is the aggregation of the production, $Y_{i,t}$, labor, $L_{i,t}$, and capital $K_{i,t}$ of the $n_{i,t}$ firms operating in region *i* during period *t*. So in order to interpret the estimations made by the reviewed literature in terms of the parameters of Equation [3], further assumptions are needed. To analyze such assumptions, let us define $\bar{Y}_{i,t}$ as the average production in a certain region *i* and period *t*, $\bar{Y}_{i,t} = \sum_{j=1}^{n_{i,t}} Y_{j,i,t}/n_{i,t}$ and $\bar{y}_{j,i,t}$ as the ratio between the production of one firm and the average for the region, $\bar{y}_{j,i,t} = Y_{j,i,t}/\bar{Y}_{i,t}$. Likewise, we can define $\bar{K}_{i,t} = \sum_{j=1}^{n_{i,t}} K_{j,i,t}/n_{i,t}$, $\bar{L}_{i,t} = \sum_{j=1}^{n_{i,t}} L_{j,i,t}/n_{i,t}$, $\bar{k}_{j,i,t} = K_{j,i,t}/\bar{K}_{i,t}$ and $\bar{l}_{j,i,t} = L_{j,i,t}/\bar{L}_{i,t}$. Then we can relate the production and inputs used by one firm with the production and inputs used in the region in the following way: $Y_{j,i,t} = \bar{y}_{j,i,t}Y_{i,t}/n_{i,t}$, $L_{i,t,j} = \bar{l}_{j,i,t}L_{i,t}/n_{i,t}$ and $K_{j,i,t} = \bar{k}_{j,i,t}K_{i,t}/n_{i,t}$. Given that *f* is homogenous at degree θ and the definitions above, Equation [3] can be rewritten as:

$$Y_{j,i,t} = \bar{y}_{j,i,t}Y_{i,t}/n_{i,t} = n_{i,t}^{\theta} g(R_{i,t}, E_{i,t}) f(\bar{l}_{j,i,t}L_{i,t}, \bar{k}_{j,i,t}K_{i,t}) e^{a_{j,i}+v_{j,i,t}} \qquad [4]$$

Note that the aggregated data does not allow us to distinguish among firms. So assumptions have to be made about some parameters, more concretely: $a_{j,i} = a_i$ and $\bar{y}_{j,i,t} = \bar{l}_{j,i,t} = \bar{k}_{j,i,t} = 1$. The first assumption is that firm fixed effects are the same for all the firms in one region. The second assumption implies that all the firms in the region are of the same size in terms of outputs and inputs. This assumption is equivalent to assume that all the firms have the same production function, for example a Cobb-Douglas: $Y_{j,i,t} = R_{i,t}^{\mu} E_{i,t}^{\delta} K_{j,i,t}^{\alpha} L_{j,i,t}^{\beta}$, therefore:

$$Y_{i,t} = n_{i,t}Y_{j,i,t} = n_{i,t}^{1-\alpha-\beta} R_{i,t}^{\mu} E_{i,t}^{\delta} K_{j,i,t}^{\alpha} L_{j,i,t}^{\beta}$$

Obviously not all the firms in the region are of the same size, but if the distribution of firm sizes around the average is fairly constant over time, these effects will be captured by the regional fixed effect, a_i. Under these assumptions, using Cobb-Douglas functions in Equation [4] and taking logarithms, we obtain:

$$\ln \bar{Y}_{i,t} = \mu \ln R_{i,t} + \delta \ln E_{i,t} + \alpha \ln \bar{K}_{i,t} + \beta \ln \bar{L}_{i,t} + a_i + \varepsilon_{i,t} \qquad [5]$$

or what is exactly the same:

$$\ln Y_{i,t} = (1-\alpha-\beta) \ln n_{i,t} + \mu \ln R_{i,t} + \delta \ln E_{i,t} + \alpha \ln K_{i,t} + \beta \ln L_{i,t} + a_i + \varepsilon_{i,t} \qquad [6]$$

where $\varepsilon_{i,t} = \sum_{j=1}^{n_{i,t}} v_{j,i,t}/n_{i,t}$.

The reviewed literature has estimated Equation [1], which can be deduced from Equation [5 or 6] when a new assumption is introduced, $n_{i,t} = 1$. The region is considered to be a unit of production. This assumption could be understandable when there is no information about the number of firms in the regions analyzed, but not when most of the entrepreneurship capital measures used previously in the literature are based on the number of firms. Obviously, one could argue that this assumption is irrelevant because technologies usually present constant returns, $\theta = \beta + \alpha = 1$, but this is not the case in the studies analyzed.

For the sake of simplicity, let us assume that the entrepreneurship capital is measured by the number of firms, $E_{i,t} = n_{i,t}$. It is easy to check that Equation [1] and Equation [5 or 6] will provide the same estimation of all the parameters except for parameter δ. To differentiate between them, we will use δ_{CRS} to refer to the parameter estimated by Equation [1], and δ for that estimated by Equation [5 or 6], where $\delta_{CRS} = 1 - \alpha - \beta + \delta$. So those parameters will be equal when there are constant returns to scale. Note that if this is not the case, the production has decreasing returns to scale, and the regions only differ in the number of firms (the firms in all the regions are equally productive, $\mu = \delta = 0$, $a_i = a$, and are of the same average size, $\bar{K}_{i,t} = \bar{K}_t, \bar{L}_{i,t} = \bar{L}_t$) the effect of entrepreneurship capital estimated by Equation [1] will be positive, $\delta_{CRS} = 1 - \alpha - \beta > 0$.

In short, given two regions with an equal level of private inputs, ($K_{i,t}$, $L_{i,t}$), the region with a higher number of firms ($n_{i,t}$) could be more productive ($\delta_{CRS} > 0$) for two reasons. First, the firms are smaller (in terms of the private inputs used) and the production has decreasing returns to scale ($\theta = \alpha + \beta < 1$). Second, the number of firms is a proxy or a measure of a public good ($\delta > 0$).

The relationship between entrepreneurship capital and production ($\delta_{CRS} > 0$) has been interpreted in the reviewed literature in terms of its effect as a public good, neglecting the effect of returns to scale. Then, one could argue that the main empirical contribution of this literature is to suggest that, in terms of regional production, not only is the level of private inputs used at the regional level important, but the number of firms among which they are distributed is also relevant. Regions with a higher number of firms (smaller average firm size in terms of inputs) will be more productive. We genuinely believe that this is an important contribution, but evidence is needed to disentangle the causes: i) there are decreasing returns to scale ($\theta = \alpha + \beta < 1$) and/or ii) the number of firms affects the productivity of the firms in the region ($\delta > 0$).

Our proposal is to look in more depth at these two possible causes. A priori we do not know which is the case, and it could in fact vary among different entrepreneurship capital measures. The discussion above could be reformulated in terms of endogeneity, where the omitted variable is the stock of firms. In Equation [1], the error term ($(1-\alpha-\beta)\ln n_{i,t} + \varepsilon_{i,t}$) is expected to be correlated with the entrepreneurship capital measure, $\ln E_{i,t}$. The bias will depend on the importance of returns to scale and the correlation between the entrepreneurship capital measure and the number of firms. In fact, this is an empirical query and the discussion above suggests a methodological benchmark for addressing it. The solution is simply to introduce to the regressions the omitted variable, stock of firms (which is available in most of the studies reviewed in the section above), restricting its coefficient to $(1-\alpha-\beta)$. In other words, estimate Equation [6], or what is the same, Equation [5]. We will provide some evidence in this regard. The following section describes and discusses how we will proceed in more detail.

4. Proposals, hypotheses and limitations

Obviously, one alternative is to find a measure of entrepreneurship capital that is not related with the stock of firms. Then, the discussion in the section above is irrelevant. Our point is that it is very difficult to obtain measures of entrepreneurship capital that are not related with the number of firms in the region. Furthermore, this is not necessary in order to solve the problem. The problem is not measuring entrepreneurship capital, it is omitting a relevant variable from the estimations, the number of firms. In accordance with the discussion in the previous section, this is solved by estimating Equation [5], i.e. using the number of firms to compute the average production ($\bar{Y}_{i,t}$) and private inputs ($\bar{L}_{i,t}, \bar{K}_{i,t}$) used as variables in the cited equation:

$$\ln \bar{Y}_{i,t} = \mu \ln R_{i,t} + \delta \ln E_{i,t} + \alpha \ln \bar{K}_{i,t} + \beta \ln \bar{L}_{i,t} + a_i + \varepsilon_{i,t} \qquad [5]$$

This formulation enables us to decompose the effect of entrepreneurship capital on production estimated by Equation [1] (δ_{CRS}) into two components: i) the presence of decreasing returns to scale ($\theta = \alpha + \beta < 1$) and ii) the effect of entrepreneurship capital as a public good ($\delta > 0$).

In fact, a priori, we can not exclude the possibility of increasing returns to scale in production technologies ($\theta > 1$). In this case, previous methods (Equation [1]) will underestimate the effect of the entrepreneurship capital on the firms' productivity ($\delta_{CRS} = 1 - \alpha - \beta + \delta$). So our first proposal is to test a hypothesis that we expect to reject, the presence of constant returns to scale. In other words, that the coefficients estimated by Equation [1] and [5] will be the same ($\delta_{CRS} = \delta$).

Hypothesis 1: Technologies present constant returns to scale ($\beta + \alpha = 1$).

The rejection of this hypothesis will confirm the need to estimate Equation [5] in order to estimate the effect of entrepreneurship capital as a public good ($\delta > 0$).

Hypothesis 2: Firm production in a region is positively related with regional entrepreneurship capital ($\delta > 0$).

Obviously the interpretation of this parameter is made under the assumptions described in the previous section, which are related with the kind of data available. In the cited section, the size of the firms is exogenously determined, or more concretely, this is unrelated with the total factor productivity of the firm.

Some microeconomic literature has focused on the determinants of firm size (Rosen, 1982; Garicano, 2000; Ortín and Salas, 2002). Those theoretical models usually assume that firms maximize profits and behave in competitive markets; output and input prices are parametric. Then, to obtain a single interior solution, the production function must present decreasing returns to scale. Furthermore, those models assume that firms differ in their total factor productivity. In fact, the total factor productivity has been interpreted in this literature as the talent of the entrepreneur (or the manager when entrepreneurs are not in charge of the firm). When more talented entrepreneurs start and manage bigger firms, then the total factor productivity is positively correlated with firm's size. Leung et al., (2008) and Castany et al., (2005) provide evidence in this regard.

After controlling by the volume of inputs those regions with a lower number of firms will also be those with higher average firm size. In accordance with these models, the larger size of the firms is interpreted as a proxy of a higher average talent of firm managers. Consequently, a higher productivity of the firms is expected in those regions with a lower number of firms. This stream of literature predicts that the value of parameter δ will be negative. Note that $\delta < 0$ could be consistent with the evidence described in Section 2 ($\delta_{CRS} > 0$), as long as: $1-\alpha-\beta > -\delta > 0$. In fact both explanations, entrepreneurship capital as a public good and differences in entrepreneur's talent, are not exclusive. Disaggregate information at the firm level could help to distinguish between them. With regional aggregate data we can only estimate δ.

5. Sectorial entrepreneurship capital

The rejection of Hypothesis 2 can cast doubts on the economic importance of the role of regional entrepreneurship capital as a public good, but its rejection will not imply that the entrepreneurship capital of some concrete economic sectors is not economically relevant. Then, it is interesting to test whether the sectorial composition of the entrepreneurship capital will matter, as the theoretical arguments in Section 2 suggest.

Hypothesis 3: The decomposition of entrepreneurship capital into economic sectors is irrelevant for the regional firm's production.

To test Hypothesis 3 and for notational consistency, we define $E1_{i,t}$ as the $E_{i,t}$ logarithmic transformation, $E1_{i,t} = \ln E_{i,t}$. In fact, both can be interpreted as measures of entrepreneurship capital. Let us identify by $E_{i,t,s}$ the entrepreneurship capital of economic sector s. We can relate the entrepreneurship capital of the different economic sectors ($s = 1,\ldots,S$) with the entrepreneurship capital at the regional level by: $\sum_{s=1}^{S} E_{i,t,s} = E1_{i,t} \sum_{s=1}^{S} p_{i,t,s}$, where $p_{i,t,s} = E_{i,t,s} / E1_{i,t}$ is the proportion of entrepreneurship capital in sector s over the total in this region i. Then we define $b_{i,t} = \sum_{s=1}^{S} p_{i,t,s} - 1$ so $\sum_{s=1}^{S} E_{i,t,s} = (1+b_{i,t})\, E1_{i,t}$. For example, if the entrepreneurship capital is measured by the number of firms, $E1_{i,t} = n_{i,t} = \sum_{s=1}^{S} n_{i,t,s} = \sum_{s=1}^{S} E_{i,t,s}$, then $\sum_{s=1}^{S} p_{i,t,s} = 1$ and consequently $b_{i,t} = 0$, then the introduction of all this nomenclature does not make much sense. But, as argued in Section 2, entrepreneurship capital is usually introduced to equations in logarithmic terms (Cobb-Douglas functions). Then, $E1_{i,t} = \ln n_{i,t} = \ln(\sum_{s=1}^{S} n_{i,t,s})$. In the case that $E_{i,t,s} = \ln n_{i,t,s}$, $\sum_{s=1}^{S} p_{i,t,s} \neq 1$ so $b_{i,t} \neq 0$

and $\sum_{s=1}^{S} E_{i,t,s} \neq E1_{i,t}$. In these cases ($b_{i,t} \neq 0$), and to ensure that the sum of the sectorial entrepreneurship capital is equal to the aggregate one, we need to define: $E1_{i,t,s} = E_{i,t,s} / b_{i,t}$, so always $\sum_{s=1}^{S} E1_{i,t,s} = E1_{i,t}$ and $b1_{i,t} = \sum_{s=1}^{S} p1_{i,t,s} - 1 = 0$, where $p1_{i,t,s} = E1_{i,t,s} / E1_{i,t}$. Then, in order to test Hypothesis 3 we propose estimating:

$$\ln \bar{Y}_{i,t} = \mu \ln R_{i,t} + \delta_S E1_{i,t} + \sum_{s=1}^{S-1} (\delta_s - \delta_S) E1_{i,t,s} + \alpha \ln \bar{K}_{i,t} + \beta \ln \bar{L}_{i,t} + a_i + \varepsilon_{i,t} \qquad [7]$$

Therefore Equation [5] is a special case of the above equation, where $\delta_s = \delta_S$ for all sectors *s*. Hypothesis 3 implies testing for such restrictions. In fact, some previous papers (Audretsch and Keilbach, 2004a, 2004b, 2004c, 2008) have used the logarithm of sectorial measures of entrepreneurship capital. They consider these to be alternative measures of entrepreneurship capital. This implies the assumption that $b_{i,t}=0$ and only the entrepreneurship capital of one economic sector has an economic impact, $\delta_s > 0$, imposing for the remaining sectors $-s$, $\delta_{-s} = 0$.

Let us refer to $\bar{\delta}_s$ as the parameter estimated by Audretsch and Keilbach's (2004a, 2004b, 2004c, 2008) procedure, and δ_s the one estimated using Equation [7]. Let us assume that we are in a situation where the sectorial decomposition is irrelevant ($\delta_s = \delta_S$ for all *s*) and the weight of sector *s* is constant among regions and time, $p1_{i,t,s} = p1_s < 1$. It is easy to check that $\bar{\delta}_s = \delta_s / p_s$ given that $E1_{i,t,s} = p_s E1_{i,t}$. So in this case the estimated parameter $\bar{\delta}_s$ for sector *s* entrepreneurship capital will be higher than the one estimated for the aggregate entrepreneurship capital δ even when there are no real differences between the parameters ($\delta_s = \delta_S$ for all *s*). We will compare the estimations made by one and the other procedure.

Audretsch and Keilbach (2004a, 2004b, 2004c, 2008) classified entrepreneurship capital on the basis of the technological intensity of the sectors: high technology; ICT's; and the remaining sectors. For that purpose we can order the economic sectors from the most to the least technologically intensive (*s=1,2,3*). Their theoretical arguments suggest that $\delta_1 > \delta_2 > \delta_{S=3}$ as summarized in the following hypothesis:

Hypothesis 4: The effect of the regional entrepreneurship capital of one economic sector on firms' production is positively related with its technological base.

The interpretation of the parameters δ_s estimated by Equation [7] has similar problems to that detected in the section above related to the parameter δ in Equation [5]. Entrepreneurship capital has a scale effect, δ estimated in Equation [5], and a sectorial composition effect, δ_s estimated in Equation [7] by the introduction of $p1_{i,t,s}$. Previous literature (Audretsch and Keilbach, 2004a, 2004b, 2004c, 2008) assumes that the total factor productivity of firms, on average, does not differ among sectors. Baumol (1990) suggests that the emphasis on the development of economic activity in certain specific economic sectors could accelerate or reduce the economic growth of a certain region. So the aggregated total factor productivity of the region could depend on the weight of the different economic sectors. In this case, the sectorial composition is also expected to affect the total factor productivity. Disaggregate data at the sectorial level would allow us to distinguish between both explanations. Like the reviewed literature we do not have this disaggregation. Then, differences in δ_s could be explained because the entrepreneurship capital in some sectors is more productive, or due to differences in the total factor productivity of the firms between sectors.

6. Data and Variables

The purpose of the empirical exercise is to provide insights into the magnitude and implications of the problems highlighted in the previous sections. For this purpose we are going to provide estimations of Equation [7], where the dependent variable is the firms' average annual production in one region. Consequently, the private inputs used will also be the firms' averages for the region. Sure that the equations estimated are not fully capturing all of the economic relationships that affect these variables, and consequently for other possible sources of endogeneity already not considered in the reviewed literature. Given our comparative purpose, the current evidence and theoretical debate, it is difficult to figure out the nature of those relationships and then analyse other sources of endogeneity. We created panel data covering an eleven-year period from 2002 to 2012 (t = 1,...,11), for the 52 Spanish provinces (i = 1,...,52), a total of 572 observations. This could at least enable us to control for regional fixed effects, shocks that affect the regional firms' average production in all the years observed.

The output and inputs considered, and their measures, are as similar as possible to those used in the reviewed literature. As in many other countries, Spanish public and private institutions have made major efforts to provide internationally homogenous (i.e. EU-KLEMS project) measures of the labour and the physical capital used each year to obtain the regional output. We collected this information from different sources.

The regional aggregate output is measured by the *Gross Value Added* ($Y_{i,t}$).The Spanish National Statistics Institute (INE) generates periodically disaggregated information at the provincial level of the annual value of the production of goods and services minus intermediate consumption. Like all the other monetary variables, it will be expressed in constant million euros for the year 2000.

The BBVA Foundation and the Valencian Institute of Economic Research (BBVA-IVIE) is a well-known research institute that following the EU-KLEMS methods provides monetary values of the set of assets accumulated in each province, *Capital Stock* ($K_{i,t}$). This information has been widely used in studies related with the Spanish economy. *Labour* ($L_{i,t}$) is measured by the number of employees engaged in production activities in each province. It is derived from the Economically Active Population Survey (EAPS) which is periodically produced by the INE.

The stock of firms ($n_{i,t}$) is required to compute firms' average production and average private inputs. This information is available from the Central Business Register (DIRCE) database. This is the only variable with information disaggregated for the economic sectors defined according to the NACE 1999 classification. Based on the methodologies developed by the Organization for Economic Cooperation and Development (OECD) and EUROSTAT, the INE classifies the economic sectors in accordance with their technological intensity. They define technology sectors as the ones characterized by rapid knowledge renewal and that require a continuous and concerted effort to foster research and technological foundation. Somewhat consistent with previous classifications in the literature, we ultimately work with three sectors; very high tech service sectors (HT or s = 1), high and medium tech manufacturing sectors (MT or s = 2), and the remaining sectors (s = 3) which is the sector omitted from the regressions. Table 1 identifies the specific sectors in each category.

The number of firms ($n_{i,t}$) in one region can be considered a measure of the *Entrepreneurship Capital* ($E_{i,t}$) of this region. Unfortunately, we do not have data for the regional startups for each year; therefore, we cannot provide empirical evidence using the ratio of new firms per inhabitant as in Audretsch and Keilbach (2004a,b, 2008). Entrepreneurship capital has also been measured in previous literature as the entrepreneurs per inhabitant (Acs et al. 2012). The main conclusions are similar using this ratio or the number of entrepreneurs. For simplicity's sake we only present the results using the stock of firms ($n_{i,t}$) as the measure of entrepreneurship capital[1]By definition, the number of firms is the sum of all the flows accumulated over time. So the question is whether recent flows play a different role to older ones. For that purpose we define the rate of firms created in province *i* during the previous period *t* as: $\phi_{i,t} = n_{i,t}/n_{i,t-1} - 1 = (n_{i,t} - n_{i,t-1})/n_{i,t-1}$. In this case, $n_{i,t} = (1+\phi_{i,t})n_{i,t-1}$ and consequently, $\ln n_{i,t} = \ln(1+\phi_{i,t}) + \ln n_{i,t-1}$. In fact it is possible to introduce to Equation [7]:

$$\delta \ln E_{i,t} = \delta_F \ln(1+\phi_{i,t}) + \delta_T \ln n_{i,t-1} = \delta_F \ln n_{i,t} + (\delta_T - \delta_F)\ln n_{i,t-1}$$

and interpret Equation [7] as a special case that imposes $\delta_F = \delta_T$; the variation rate is not informative. This could be empirically tested, as $\delta_T = 0$, the stock does not add more information than that provided by the variation rates. In short, the number of firms is needed to estimate Equation [7]. In most cases it is used to define a measure of entrepreneurship capital. Then, the assumption that this measure provides additional information to that provided by the stock of firms can be empirically tested.

Following Bönte et al., (2008), *knowledge* ($R_{i,t}$) is measured by the number of patents filed each year based on the data available on a provincial level in the SPTO. We will not have access to other proxies at the regional level used before, such as, for example: the number of people employed in private companies or universities in areas related to R&D (Mueller, 2007) and the annual R&D costs (Griliches, 1998). Table 2 presents descriptive statistics of the variables.

7. Results

Table 3 provides estimations of Equation [7]. The columns differ in terms of the entrepreneurship capital measures used in the estimations, or in other words, the different restrictions imposed on the parameters of the equation. In Model 1 only considers the number of firms in the region,

[1] This and all the other estimations cited in the chapter but which do not appear in the text can be provided upon request to the authors.

providing estimations of δ. Model 2 also includes the last year's stock of firms providing estimations of δ_F and δ_T. Model 3 decomposes the current stock of firms into economic sectors providing estimations of δ_s.

Following the econometric literature on data panels; the group model, the fixed effects model and the random effects model have been estimated for all the equations. Results referred to hypotheses are maintained. For expositional simplicity we only provide the estimations of the fixed effects model because, the Breush and Pagan (1979) and Hausman (1978) tests indicate that this is the most appropriate method for modelling the non-observable heterogeneity among provinces in the sample analyzed[2]. The error terms of all the estimated equations are robust to heteroskedasticity and clustered by provinces.

Table 3 shows estimations of the elasticity of production with respect to knowledge (μ) between 0.098 and 0.012, positive and statistically significant at 1%. The elasticity of production with respect to capital (α) takes values between 0.1804 and 0.2170 and the elasticity with respect to labour (β) between 0.1875 and 0.2126, all these parameters being statistically significant at the 1% level. These values indicate that the production technology presents decreasing returns to scale ($\alpha + \beta < 1$), as expected, Hypothesis 1 is rejected at the usual levels of significance[3].

Model 1 presents the estimation of Equation [7] without any decomposition of the entrepreneurship capital. In concordance with the presence of decreasing returns to scale, the estimations of the elasticity of production with respect to entrepreneurship capital using Equation [1], as was usual in previous empirical studies, ($\delta_{CRS} = 1 - \alpha - \beta + \delta = 0.3357$) is higher than the one estimated by Equation [7], ($\delta = -0.2347$). We do not present the estimation of Equation [1] because it only differs from Equation [7] in the value of the cited parameter, which in both estimations is statistically significant at the 1% level. According to the results above, and consistent with the previous literature, those regions with (on average) smaller firms (measured in terms of inputs) are more productive. After controlling for the level of private inputs, those regions with 1% more firms, produce, on average, 0.3357% more. But, the main explanation for those effects is the existence of decreasing returns to scale ($1 - \alpha - \beta = 0.5704$). In fact, according to Equation [7], the productivity of the average firm decreases by a percentage of 0.2347% for

[2] This and all the other estimations cited in the chapter but which do not appear in the text can be provided upon request to the authors.

[3] The null hypothesis that $\beta + \alpha = 1$ is rejected at the 1% level in all equations.

each 1% increase in the number of firms in the province. So Hypothesis 2 is not supported by the data. Note that the traditional methods (Equation [1]) would lead to the opposite conclusion.

Adding to Model 1 the stock of firms lagged one year (in logarithmic terms), we obtain Model 2. In this case we lose the 52 observations for 2002. The coefficient associated to this lagged variable is 0.0496, positive but not statistically significant at the usual levels. So in our case the flow of firms does not provide new statistically significant information ($\delta_T - \delta_F =$ 0.0496). The effect estimated for the flow of firms in the previous year (–0.2605=δ_F) is even more negative than the one associated with the stock of firms (–0.2109=δ_T).

Model 3 in Table 3 provides estimations of Equation [7] including the sectorial decomposition of the stock of firms. The coefficients associated with the stock of firms in the two technological sectors considered are positive and statistically significant at the usual levels of significance. So Hypothesis 3 (the sectorial decomposition is irrelevant) is rejected in this case[4].

Furthermore, the estimated elasticity of production with respect to the number of firms in very high tech services sectors (δ_1 = –0.1625) is higher than the one associated with high and medium tech manufacturing firms (δ_2 = –0.4019) and other sectors (δ_3 = –0.5207). Although not provided in the table, all those elasticities remain negative and statistically significant at 1%. In fact, the differences in the parameters are all statistically significant at the 5% level. So the data supports Hypothesis 4.

Table 4 estimates the elasticity of production with respect to the number of firms in very high tech services sectors using similar econometric procedures to the previous literature (Audretsch and Keilbach, 2004a, 2004b, 2004c, 2008). The results are consistent with those obtained previously in the literature. As opposed to Model 3 in Table 3, the elasticity of production with respect to the number of firms in very high tech services sectors will now be positive and lower than that estimated for the general number of firms.

[4] The null hypothesis that $\delta_1 = \delta_2 = \delta_3$ is rejected in all cases at 1% of significance.

8. Conclusion and discussion

After controlling for the level of inputs used, in those regions with a higher number of firms, the average size of those firms will be smaller (in terms of the inputs used). From a theoretical point of view, these regions can be more productive for at least two reasons, because there are decreasing returns to scale or due to the fact that the number of regional entrepreneurs produces positive externalities. We argue that previous literature on entrepreneurship capital has not properly distinguished between both effects, so the previous evidence has only been interpreted in terms of positive externalities.

The chapter presents a methodology to help to distinguish between both effects. The methodology is simple: for each region, the regressions use the firms' average output and private inputs. It can be applied with data aggregated at the regional level and only requires information about the number of firms in the region. This is a starting point for analyzing the sources of differences in productivity between regions as detected previously by the entrepreneurship capital literature.

Note that the methodology proposed is not about the measure of the entrepreneurship capital used, it is about the kind of equations estimated. The methodology suggests that the number of firms has to be used in order to control for the existence of returns to scale, but it does not claim to be the best measure of entrepreneurship capital. Even if there is a measure of entrepreneurship capital that is not related with the number of firms, then the suggested methodology will provide similar estimations of the elasticity of production with respect to entrepreneurship capital to those of traditional ones.

A second order methodological contribution is to suggest that most of the measures of entrepreneurship capital used in the literature can be formally related with the number of firms. So we can make explicit the assumptions that make one measurement different from the other and test it empirically. In particular, we demonstrate the procedure with sectorial measures of entrepreneurship capital and with the variation rate in the number of firms. But it could be applied to other measures.

We provide evidence related with all these aspects in a data sample of Spanish provinces in the 2002-2012 period. In accordance with the estimations presented, production technologies present decreasing returns to scale in the use of private inputs; labour and capital. This seems to be the norm, and not the exception in the literature reviewed. In this chapter, this is the main explanation for the estimated positive relationship between the stock of firms and production at the regional level.

According to our estimations, the total factor productivity of firms is lower in those regions with a higher stock of firms. Unfortunately we cannot check exactly what would have happened in past studies if we had made such corrections. It is even difficult to reproduce the exact measures of entrepreneurship capital that were used before. Instead of the stock of firms, we employed the variation rate in the number of firms and the stock of firms in different economic sectors. The above conclusion is robust to all these alternative measures. In fact, only the division of the stock of firms into economic sectors is statistically significant.

The evidence provided cannot be understood as evidence against the knowledge spillover theory of entrepreneurship (Acs et al., 2009). This is merely a preliminary warning that the role of entrepreneurship capital as a public good in regional economies may be overestimated when we do not correct for decreasing returns to scale. In fact, the evidence concerning the sectorial decomposition of the stock of firms seems consistent with the prediction of the cited theory. In regions where proportionally more firms are related with technological sectors, the average total factor productivity of the firms in the region increases.

The methodology proposed does not address other relevant issues concerning the reviewed entrepreneurship capital literature, such as the measurement of inputs or reverse causality problems. As discussed in the theoretical sections, without information that has been disaggregated at the firm level, it is difficult to distinguish between the effect of public goods or the existence of correlations between the size of firms and their total factor productivity. Our conjecture is that the latter is the most plausible explanation for the negative relationship between the stock of firms and production after controlling for returns to scale. Large firms have higher total factor productivity levels as some theoretical models (Rosen, 1982; Garicano, 2000; Ortín and Salas, 2002) and empirical evidence (Leung et al., 2008; Castany et al., 2005) suggest.

There is therefore a need for further evidence with information disaggregated at the firm level to distinguish between both explanations. Furthermore, regional information disaggregating outputs and inputs at the sectorial level will be valuable for distinguishing between the effects of sectorial entrepreneurship capital and the effects of differences in the total factor productivity among economic sectors. The proposed methodology can easily be adapted to this kind of information. Indeed, it can be extended to the consideration of new theoretical or empirical relationships that have not been explored in this study. Theoretical developments can improve our understanding of the relationships between the different inputs and outputs measured. In future empirical studies, it would be useful to control for such sources of endogeneity.

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Table 1. Technological Sectors - INE

NACE	Sectors		
72	Scientific research and development	Very high tech services sectors [HT]	*s=1*
	721 Research and experimental development on natural sciences and engineering		*s=1*
	722 Research and experimental development on social sciences and humanities		*s=1*
59	Motion picture, video & TV programme production, sound recording & music publishing		*s=1*
60	Programming and broadcasting activities		*s=1*
61	Telecommunications		*s=1*
62	Computer programming, consultancy and related activities		*s=1*
63	Information service activities		*s=1*
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	High & medium tech manufacturing sectors [MT]	*s=2*
26	Manufacture of computer, electronic and optical products		*s=2*
	303 Manufacture of air and spacecraft and related machinery		*s=2*
20	Manufacture of chemicals and chemical products		*s=2*
25	Manufacture of fabricated metal products, except machinery and equipment		*s=2*
27	Manufacture of electrical equipment		*s=2*
29	Manufacture of motor vehicles, trailers and semi-trailers		*s=2*
30	Manufacture of other transport equipment		*s=2*
	325 Manufacture of medical and dental instruments and supplies		*s=2*
	Remaining sectors	Other sectors	*s=3*

Source: INE [http://www.ine.es/daco/daco43/notaiat.pdf]

Table 2. Descriptive Variables

Variable		Average	Standard Deviation
$\ln Y_{i,t}$		15.9535	0.9620
$\ln K_{i,t}$		17.1079	0.9935
$\ln L_{i,t}$		12.2875	0.9709
$\ln R_{i,t}$		3.1233	1.4702
$\ln n_{i,t}$		10.4960	0.9936
$p_{i,t,1}$	[HT]	0.0131	0.0049
$p_{i,t,2}$	[MT]	0.0108	0.0046
$p_{i,t,3}$		0.9760	0.0078
Observations		572	

Table 3. Impact of Entrepreneurship Capital on Production

Dependent Variable: ln $\overline{Y}_{i,t}$

Independent Variables	*Coefficient*	Model 1		*Coefficient*	Model 2		*Coefficient*	Model 3	
Constant		6.0725 [0.000]	***		6.0972 [0.000]	***		8.0188 [0.000]	***
ln $\overline{K}_{i,t}$	α	0.2170 [0.000]	***		0.1822 [0.000]	***		0.1804 [0.000]	***
ln $\overline{L}_{i,t}$	β	0.2126 [0.000]	***		0.1860 [0.000]	***		0.1875 [0.000]	***
ln$R_{i,t}$	μ	0.0103 [0.007]	***		0.0120 [0.003]	***		0.0098 [0.008]	***
ln$E_{i,t}$	δ	-0.2347 [0.000]	***	δ_F	-0.2605 [0.000]	***	δ_3	-0.5207 [0.000]	***
ln$E_{i,t-1}$				δ_T - δ_F	0.0496 [0.430]				
$E1_{i,t,1}$ [HT]							δ_1 - δ_3	0.3582 [0.000]	***
$E1_{i,t,2}$ [MT]							δ_2 - δ_3	0.1188 [0.019]	**
Observations		572.0000			520.0000			572.0000	
Groups:		52.0000			52.0000			52.0000	
R-squared within		0.3436			0.3073			0.3981	
R-squared		0.1442			0.1493			0.1427	
R-squared overall		0.1446			0.1495			0.1422	

*: Significant at the 0.10 level. **: Significant at the 0.05 level. ***: Significant at the 0.01 level. Standard errors are in brackets. Regional fixed effects estimations.

Table 4. Impact of High Technological Entrepreneurship Capital on Production

Dependent Variable: ln $Y_{i,t}$

Independent Variables	*Coefficient*	Model 1	
Constant		8.5685 [0.000]	***
ln$K_{i,t}$	α	0.1981 [0.000]	***
ln$L_{i,t}$	β	0.2554 [0.000]	***
ln$R_{i,t}$	μ	0.0106 [0.004]	***
$E1_{i,t,1}$ [HT]	δ_1	0.1349 [0.000]	***
Observations		572.0000	
Groups: Provinces		52.0000	
R-squared within		0.7600	
R-squared between		0.9853	
R-squared overall		0.9835	

*: Significant at the 0.10 level. **: Significant at the 0.05 level. ***: Significant at the 0.01 level. Standard errors are in brackets. Regional fixed effects estimations.

Appendix.

Table A.1. Number of firms by province and firm size

	Number of firms	
	Mean over years	***Standard Deviation***
Alava	20.747,0910	928,7867
Albacete	25.903,0000	1.672,4648
Alicante	129.322,8200	9.742,3576
Almeria	40.740,1820	3.339,7839
Asturias	69.429,0000	2.495,9637
Avila	10.894,8180	529,1153
Badajoz	38.614,0910	2.185,5507
Barcelona	446.137,8200	23.567,3510
Burgos	24.634,6360	1.201,5965
Caceres	24.915,0910	1.681,5950
Cadiz	60.047,0000	3.023,4469
Cantabria	37.881,7270	1.914,0257
Castellon	39.740,3640	2.703,1652
Ceuta	3.663,9091	62,9038
Ciudad Real	30.521,4550	1.731,1113
Cordova	46.716,0910	2.518,1718
Coruna	79.842,1820	3.922,1760
Cuenca	13.853,0910	780,2130
Girona	53.007,2730	5.190,8535
Granada	56.589,2730	4.005,9918
Guadalajara	12.268,9090	1.559,9707
Guipuzcoa	58.322,7270	2.959,4098
Huelva	25.424,6360	1.459,8271
Huesca	16.041,5450	838,7669
Balearic Is.	87.298,2730	4.684,1157
Jaen	34.947,3640	1.641,7038
La Rioja	22.426,3640	1.136,1248
Las Palmas	68.874,0000	4.237,9413
Leon	32.382,8180	1.167,6203
Lleida	34.493,0000	2.467,3645
Lugo	23.982,2730	934,2235
Madrid	482.953,4500	35.165,9080
Malaga	106.690,0000	8.327,3874
Melilla	3.683,5455	85,7734
Murcia	89.650,3640	6.925,2530
Navarra	41.522,9090	1.523,0878
Ourense	22.830,3640	620,9752
Palencia	10.706,5450	268,9332
Pontevedra	66.071,8180	3.676,2084
Salamanca	22.751,0000	861,8835
Segovia	11.133,9090	610,3754
Seville	110.561,0900	7.978,8579
Soria	5.876,8182	143,2179
Tarragona	53.375,5450	3.799,8152
Tenerife	63.088,1820	3.733,2914
Teruel	9.131,0909	418,2252
Toledo	43.201,7270	3.760,8704
Valencia	174.680,5500	10.505,2220
Valladolid	33.771,4550	1.904,5800
Vizcaya	83.581,2730	3.714,1327
Zamora	12.055,8180	321,9298
Zaragoza	64.566,6360	2.376,1499
Total	61.183,5940	87.943,5000

Table A.1. Number of firms by province and firm size (cont.)

	Number of firms	
	Mean over years	***Standard Deviation***
0 Employees	32.159,5600	48.945,8200
1-9 Employees	25.681,1500	33.968,0200
10-99 Employees	3.104,1120	4.749,6240
100-499 Employees	205,7168	425,9461
>500 Employees	33,0594	99,6303
Total	61.183,5940	87.943,5000

Table A.2. Impact of Entrepreneurship Capital on Production

Equation [1]: Dependent Variable: $\ln Y_{i,t}$

Independent Variables	*Coefficient*	Model 1	Model 2	Model 3
Constant		4,5947 ***	6,0940 ***	13,1106 ***
		[0,238]	[0,273]	[0,769]
$\ln K_{i,t}$	α	0,1404 ***	0,2158 ***	0,0774 **
		[0,021]	[0,016]	[0,041]
$\ln L_{i,t}$	β	0,6175 ***	0,2103 ***	0,0081
		[0,062]	[0,033]	[0,035]
$\ln R_{i,t}$	μ	0,0839 ***	0,0103 ***	0,0086 **
		[0,009]	[0,004]	[0,003]
$\ln E_{i,t}$	δ	0,1055 **	0,3383 ***	0,1254 ***
		[0,060]	[0,049]	[0,048]
Regional Effects		No	Yes	Yes
Temporal Effects		No	No	Yes
Observations		572.0000	572.0000	572.0000
Groups:			52.0000	52.0000
R-squared		0.9841	0.7451	0.8142

*: Significant at the 0.10 level. **: Significant at the 0.05 level. ***: Significant at the 0.01 level. Standard errors are in brackets.

Regional Entrepreneurship Capital and Firm Production (††)
[Chapter 2]

(††) This chapter has been accepted for publication at the Small Business Economics Journal (See Final Appendix)

Regional Entrepreneurship Capital and Firm Production [Chapter 2]

1. Introduction

The Knowledge Spillover Theory of Entrepreneurship (KSTE) suggests that entrepreneurship capital in a certain region has positive spillovers that increase the production of firms in the region (Audretsch and Keilbach 2005, 2007; Acs et al. 2009; Audretsch and Lehmann 2016). From this starting point, a growing amount of literature is estimating the effects of regional entrepreneurship capital on a region's production using aggregated data at the regional level (Audretsch and Keilbach 2004a,b,c, 2005, 2008; Mueller 2006, 2007; Bönte et al. 2008; Cravo et al. 2010; Stough et al. 2008; Chang et al. 2012; Hafer 2013; Laborda et al. 2011; Carree et al. 2014; Mendonça and Grimpe 2015). In practically all the cases, these studies report the positive and significant effects of regional entrepreneurship capital on regional production, which are interpreted as supporting the existence of positive spillovers.

The measurement and concept of entrepreneurship capital has been discussed, unlike the measurements of other kinds of inputs (Erikson 2002; Audretsch and Keilbach 2004a; Bönte et al. 2008). The empirical applications work with different measures that range from the stock of new firms in the region (Audretsch and Keilbach 2004a,b,c, 2005, 2008) to the entry rate of firms in key industries (Chang et al. 2012). Most of the entrepreneurship capital measures used[5] are part of (and can therefore be related to) the number of firms in the region (Henrekson and Sanandaji 2014).

This chapter argues that the regional entrepreneurship capital could affect the regional aggregated production by at least two means: by affecting the number of firms in the region and/or by affecting the spillovers in firm production. The next section of this chapter discusses why using data aggregated at the regional level makes it very difficult to distinguish between these two effects. Therefore, data need to be gathered at the firm level to properly test whether entrepreneurship capital has positive spillovers on a regional level that increase the production of firms in this region, as suggested by the Knowledge Spillover Theory of Entrepreneurship and other theoretical arguments such as the increase of competition suggested by Geroski (1989) or Roberts and Tybout (1996).

Acs et al. (2016) argues “that spatial externalities of various forms constitute serious market failures that require intervention” (p. 36). Thus, it is important to properly measure the existence and amount of such externalities to justify government intervention and the quantity of resources devoted to such an intervention. Therefore, we have collected information about the entrepreneurship capital in Spanish Autonomous Communities (NUTS 2 in accordance with Eurostat) from INE[6]. From the Spanish Technological Innovation Panel[7], we construct an unbalanced data panel of 11,276 Spanish firms during the 2004–12 period with information about the production obtained, the capital and the labour used by each firm. As far as we know, this chapter is the first to have used data at the firm level to provide evidence for the effect of spillovers of regional entrepreneurship capital on existent firms’ production. In addition to a more proper measure of the regional entrepreneurship capital spillovers, data at the firm level have many other advantages over data aggregated at the regional level. For example, the data allowed us to work

[5] Other authors have used the annual average of new firms per 1,000 workers created in a three-year period, such as Audretsch and Keilbach (2004a,b, 2008). Mueller (2006, 2007) uses this indicator in addition to the number of new firms created in one year. Sutter and Stough (2009) use the average number of technological and innovative firms created in the last five years, while Bönte et al. (2008), Salas-Fumás and Sánchez-Asín (2013a,b) and Stough et al. (2008) use the self-employment rate on a regional level. Erken et. al (2016) use the business ownership rate (number of business owners per workforce) corrected for the level of economic development (GDP per capita) to evaluate the relation between entrepreneurship and total factor productivity.

[6] [http://www.ine.es/]

[7] [http://icono.fecyt.es/PITEC/Paginas/por_que.aspx]

with an exponentially higher number of observations and to analyse which kind of firms benefits the most from regional entrepreneurship capital.

The chapter is organized as follows. In Section 2, the previous literature methods are summarized and their limitations discussed. Section 3 discusses the methodological approach used in this chapter and states the hypotheses. In Section 4, we present the data. Section 5 presents the estimations of firms' production functions. Section 6 concludes the chapter by discussing its implications.

2. A main shortcoming of the previous literature

Most of the literature cited in the introduction has estimated the impact of regional entrepreneurship capital on the production for region *i* at period *t*, $Y_{i,t}$. The usual method is to act in accordance with that used by Solow (1956). The regional output is obtained as a combination of the sum of inputs purchased by the firms of the region and other regional inputs. Cobb-Douglas (1928) functions are usually estimated, and the inputs considered are labour ($L_{i,t}$), (physical) capital ($K_{i,t}$), regional knowledge ($R_{i,t}$) and regional entrepreneurship capital ($E_{i,t}$):

$$\ln Y_{i,t} = \beta \ln L_{i,t} + \alpha \ln K_{i,t} + \mu \ln R_{i,t} + \delta \ln E_{i,t} + \varepsilon_{i,t}, \qquad [1]$$

where $\varepsilon_{i,t}$ captures the usual error terms. According to the study, the error terms may include time and/or regional fixed effects. Usually, except for specific cases (see Carre et al. 2014), regional cross effects are not considered. Hence, the main parameters estimated are production elasticity with respect to labour (β), capital (α), regional knowledge (μ) and regional entrepreneurship capital (δ). The estimations of the elasticity of production with respect to regional knowledge and regional entrepreneurship capital are usually positive and statistically significant.

The literature has interpreted the positive relationship between regional entrepreneurship capital and regional production as evidence of the regional entrepreneurship capital spillovers on firms' production. This interpretation is not free of assumptions. To make such assumptions explicit, we will formalize our arguments. This formalization is based on the previous analyses of the limitations related to the use of regional aggregated production functions (see Fisher 1969, 2005 for further details).

In each period, a set of inhabitants of the region decide to be (or continue to be) entrepreneurs, thus determining the number of firms in the region, $n_{i,t}$. These firms will contract for a set of inputs to produce outputs in accordance with the production function described by the following equation:

$$Y_{j,i,t} = L_{j,i,t}^{(1-\gamma-s)}(K_{j,i,t}/L_{j,i,t})^{\alpha} R_{i,t}^{\mu} E_{i,t}^{\delta} S_{i,t}^{s}, \qquad [2]$$

where $L_{j,i,t}$ is the size of each firm measured in terms of employment, the stock of capital per employee is $k_{i,t} = K_{j,i,t}/L_{j,i,t}$, $S_{i,t}$ is the average size of the firms in the region, and γ,α, μ, δ and *s* are parameters. By definition, the outputs and certain inputs at the regional level are the aggregate of those used by the $n_{i,t}$ firms (*j*=1,..., $n_{i,t}$) in region i in period *t*: $Y_{i,t} = \sum_{j=1}^{n_{i,t}} Y_{j,i,t}$, $K_{i,t} = \sum_{j=1}^{n_{i,t}} K_{j,i,t}$, and $L_{i,t} = \sum_{j=1}^{n_{i,t}} L_{j,i,t}$. If all the firms in the region have the same size ($S_{i,t} = L_{j,i,t}$), it is easy to show that the regional production is

$$Y_{i,t} = n_{i,t} Y_{i,j,t} = n_{i,t}^{\gamma+s} L_{i,t}^{(1-\gamma-s)} k_{i,t}^{\alpha} S_{i,t}^{s} R_{i,t}^{\mu} E_{i,t}^{\delta} = n_{i,t}^{\gamma} L_{i,t}^{1-\gamma} k_{i,t}^{\alpha} R_{i,t}^{\mu} E_{i,t}^{\delta}, \qquad [3]$$

where $\gamma = 1 - \alpha - \beta$ measures the returns to scale at the regional aggregated level, while the returns to scale at the firm level are $\gamma + s$. Those returns differ when the average size of the firms in the region has spillovers on the production of the firms in this region, $s \neq 0$.

It is easy to verify that in those particular cases, when the regional aggregated level returns to scale are constant ($\gamma = 1 - \alpha - \beta = 0$) or $s = -\gamma$, the regional production is $Y_{i,t} = n_{i,t} Y_{i,j,t}$ $= L_{i,t} k_{i,t}^{\alpha} R_{i,t}^{\mu} E_{i,t}^{\delta} = L_{i,t}^{\beta} K_{i,t}^{\alpha} R_{i,t}^{\mu} E_{i,t}^{\delta}$. Taking logarithms and adding error terms, this equation is equal to Equation 1, which is the one used in the literature. In short, these are the main assumptions (implicitly) made by the previous literature.

In practically all of the studies revised (with the exception of Audretsch and Keilbach 2004b), the parameters estimated by Equation [1] show decreasing returns to scale ($\gamma = 1 - \alpha - \beta > 0$), although only Mueller (2006) reports a test of their significance. Thus, it is difficult to accept the assumption that, at the regional aggregated level, returns to scale are constant.

Therefore, the alternative is to assume that the average size of the firms $S_{i,t}$ is a regional input with an elasticity equal to $s = -\gamma = -(1-\alpha-\beta)$. The problem with aggregated data at the regional level is that we cannot provide evidence about the value of s. When $\gamma + s > 0$, the previous literature has omitted a relevant variable, the number of firms in the region. This finding is important, because it appears reasonable to expect that the measures of entrepreneurship capital used ($E_{i,t}$) are positively correlated with the number of firms in the region, $n_{i,t}$. As previously discussed in the introduction, most of the measures of entrepreneurship capital used previously in the literature are based on the number of firms. Thus, it is expected that the number of firms is positively related to the entrepreneurship capital in the region. In this case, the literature is overestimating the real spillovers of entrepreneurship capital on firms' production.

For illustrative purposes, let us assume that the correlation between entrepreneurship capital and the number of firms is one, and specifically that $E_{i,t}$ = $n_{i,t}$. Let us call $\hat{\delta}$ the estimated coefficient of the entrepreneurship capital using Equation [1]. In accordance with Equation [3], $\hat{\delta}$= $\delta + \gamma + s$; therefore, the bias will depend on the presence of returns to scale γ and on the spillovers of the regional average size of the firms on the production of the firms in the region, s. In fact, we cannot exclude the possibility that the entrepreneurship capital does not affect the production at the firm level (δ=0), although there is evidence showing a positive effect on the production aggregated at the regional level ($\hat{\delta}$>0 since $\gamma + s > 0$). This finding is an important shortcoming of the previous literature, since it casts doubt on their main interpretation of the evidence generated, that the regional entrepreneurship capital has positive spillovers on the production of the firms in the region. This bias disappears using data at the firm level to estimate Equation [2].

Data at the firm level also enables us to address new issues other than those in the cited literature. Some of the papers revised seek to identify the kind of entrepreneurship capital that generates more spillovers. For example, Audretsch and Keilbach (2004a,b,c, 2008) classified entrepreneurship capital on the basis of the technological intensity of the sectors: high technology, ICTs, and other sectors. The researchers find that other sectors that are less technological generate more spillovers. In terms of geographical location, urban zones generate higher spillovers than rural ones (Audretsch and Keilbach 2005). Data at the firm level allows us to extend those analyses and estimate the elasticities of production with respect to entrepreneurship capital for different groups of firms. Consequently, we can identify the groups of firms that benefit the most from entrepreneurship capital spillovers (i.e., which receive more externalities). The KSTE justifies those spillovers by the role of entrepreneurship capital in the diffusion of knowledge. The evidence can therefore be interpreted in terms of the differences in the absorptive capacity of knowledge between firms.

3. The methodological approach

We use the number of firms per inhabitant in the region as the measure of regional entrepreneurship capital[8], $E_{i,t} = \frac{n_{i,t}}{P_{i,t}}$. Implicitly, we assume that the number of firms in the region ($n_{i,t}$) is determined by the population of the region ($P_{i,t}$) and the entrepreneurship capital in the region ($E_{i,t}$). The focus of our analyses, and that of the previous literature, is not to quantify the effects of entrepreneurship capital on regional GDP via the increases in the number of firms, ($Y_{i,t} = \sum_{j=1}^{n_{i,t}} Y_{j,i,t}$); instead, it is to measure the spillovers of regional entrepreneurship capital on firms' production. In other words, the focus is to test whether $Y_{j,i,t}$ depends on $E_{i,t}$. The previous section has noted the problems in disentangling both effects using data aggregated at the regional level. Thus, we use data at the firm level to estimate the firms' production function (Equation [2] in logarithmic terms), which is defined in the section above:

$$\ln Y_{j,i,t} = \beta \ln L_{j,i,t} + \alpha \ln K_{j,i,t} + \mu \ln R_{i,t} + \delta \ln E_{i,t} + s \ln S_{i,t} + \varepsilon_{j,i,t}. \quad [4]$$

Given the purpose of this chapter, in accordance with the previous literature measuring only the entrepreneurship capital spillovers in the firms of the same region, we do not consider cross-border effects. Apart from the inclusion of entrepreneurship capital (and the average size of the firms in the region), these kinds of equations have been extensively estimated in other contexts (see Syverson 2011 for further discussion of their limitations). The following discussion is focused on the proposed measure of entrepreneurship capital: $E_{i,t} = \frac{n_{i,t}}{P_{i,t}}$.

Obviously, we will not argue that everyone in the population has the same probability of being an entrepreneur nor that all types of entrepreneurs provoke the same spillovers. For example, the persistence of the decision of being an entrepreneur is well documented (for a recent discussion,

[8] Normalizing $P_{i,0} = 1$ and assuming that the population of the region remains constant along time, and $P_{i,t} = 1$, we obtain the case analysed in the previous section in which the entrepreneurship capital in the region is equal to the number of firms, $E_{i,t} = n_{i,t}$.

see Fritsch and Wyrwich 2014). Consequently, the probability of being an entrepreneur is higher for those who were entrepreneurs the previous year (persistent entrepreneurs) than for the remainder of the population (entrant entrepreneurs). Certain authors claim (Congregado et al. 2012) that, among the persistent entrepreneurs, there will be a relatively higher presence of entrepreneurs who play the risk-bearing arbitrageur role, emphasized by the writings of Knight (1921), Say (1803) and Kirzner (1979), than the role of innovative entrepreneurs, highlighted by Schumpeter (1950).

In accordance with the KSTE, innovative entrepreneurs will cause relatively more spillovers and appear to be more present among the entrant entrepreneurs. Therefore, Audretsch and Keilbach (2004a,b, 2008) use the annual average of new firms per 1,000 inhabitants created in a three-year period as the measure of entrepreneurship capital. This ratio can be related with the probability of an inhabitant of the region creating a new firm. Unfortunately, we do not have data regarding the regional startups for each year; therefore, we cannot provide empirical evidence analysing the differences among both measures. Previous evidence suggests that those measures are highly correlated (Fritsch and Wyrwich 2014). This finding is consistent with recent theoretical approaches (Van den Steen 2010; Gutiérrez and Ortín-Ángel 2016) arguing that, in any case, an important role of entrepreneurs is to establish a use of productive factors that otherwise would not exist.

Nevertheless, we can test whether the entrepreneurship capital in a region affects the production ($\delta > 0$) of those firms located in the region.

Hypothesis 1: The production of firms in a region is positively related to regional entrepreneurship capital.

As previously noted, certain authors use the average of the entrepreneurship capital during certain time periods because, as is argued, the entrepreneurship capital is a latent variable. To focus our argument, let us assume that the measure used is related to the entrepreneurship capital in the following manner: $m_{i,t} = \frac{n_{i,t}}{P_{i,t}} = E_{i,0} \prod_1^t e^{\theta \Delta_{i,t} + (1-\theta) v_{i,t}}$. The error measurements are captured by $v_{i,t}$, where *t* is independent random variables with a mean equal to zero. The relative importance of the measurement errors with respect to the annual variation in entrepreneurship capital $\Delta_{i,t}$ is measured by the parameter $\theta \in [0,1]$. When θ=1, $m_{i,t}$ is the most accurate measure of the entrepreneurship capital, and when θ= 0, the most accurate measure is the average (of logarithms) of $m_{i,t}$ during the period analysed. Other approaches use time series techniques. For an example[9], refer to Congregado et al. (2012).

Our approach utilizes the fact that we have an unbalanced data panel referring to 11,276 firms (*j*) distributed throughout 18 regions (*i*) with an average of 7.9 observed years per firm (*t*); thus, there are ultimately 89,370 observations. We can estimate the elasticity of production with respect to the measure of entrepreneurship using the fixed effects (or within) model (δ^w). Furthermore, disaggregated data at the firm level enable us to estimate the between effects model (and the correspondent elasticity δ^b) with 11,276 observations instead of the 18 observations that would be used for data aggregated at the regional level.

Assuming that entrepreneurship capital is related to the production of the firms in accordance with Equation [2], and the annual variation in entrepreneurship capital $\Delta_{i,t}$ is cyclical ($\sum_{t=1}^{T} \ln m_{i,t} / T = \ln E_{i,0}$, where T is the number of periods observed), we expect that $\delta^w = \delta^b \theta$. Therefore, the elasticities estimated will be the same when θ=1 and differ otherwise (according to the estimations of Congregado et al. 2012, the value of this parameter for Spain is approximately 0.28 for the 1987 to 2008 period). In this last case ($\theta < 1$), we cannot exclude other sources of differences in those parameters, such as the omission of time invariant variables correlated with the entrepreneurship capital or that Equation [2] is not the underlying production function.

As discussed in the section above, data at the firm level also allow us to identify those firms that benefit more from entrepreneurship capital spillovers. In accordance with the KSTE, entrepreneurship is a facilitator of knowledge dissemination. Consequently, it is expected that entrepreneurship capital spillovers will be higher in those firms with lower current levels of knowledge and in firms with a higher capacity to learn, or absorptive capacities (Cohen and Levinthal 1990; Qian and Acs 2013). As a proxy of these two concepts, we use the size of the firm and its technological intensity. The technological intensity has been related to firms' higher absorptive capacities from the outset (Cohen and Levinthal 1990). Furthermore, we postulate that small firms have fewer resources; therefore, on average, we expect that they have accumulated

[9] According to Congregado et al. (2012) terminology, $E_{i,0}$ is the non-stationary natural rate component, and $\Delta_{i,t}$ is the stationary cyclical component.

lower levels of knowledge and thus have more to learn. In short, we propose the following hypothesis:

Hypothesis 2: The benefits from entrepreneurship capital spillovers decrease with the size of the firm and increase with its technological intensity.

As in much of the literature on firms' productivity (Syverson 2011 for a summary), Equation [1] and [2] are interpreted in terms of how the production is organized, without considering that there is a process of input accumulation that occurs nearly simultaneously. Audretsch and Keilbach (2004a,c, 2008) argue that estimations based only on Equation [1] could suffer from an endogeneity problem[10], which arises when the measure of entrepreneurship capital is correlated with the production function error. Although this correlation is expected to be lower when using data at the firm level (Equation [4]), in accordance with Audretsch and Keilbach (2004a,c, 2008), we provide simultaneous estimations of the consequences of entrepreneurship capital on firms' production, Equation [4], and the determinants of the stock of entrepreneurship capital, Equation [5]:

$$\ln E_{i,t} = \sum_{z} \pi_z Z_{z,i,t-1} + v_{i,t}, \qquad [5]$$

where Z_z are the z possible determinants of entrepreneurship capital, π_z are the parameters to be estimated and $v_{i,t}$ are the usual error terms. The estimator of the relationship between firms' production and entrepreneurship capital that provides the simultaneous equation estimation is a full information instrumental variable (Hausman 1978) in that it considers the possible correlation between error terms and regressors and between the error terms of the two equations.

To consider the persistence of the regional levels of entrepreneurship, we will introduce the entrepreneurship capital of the last year as an independent variable in Equation [5]. Although the persistence is important, the decision of being an entrepreneur may evolve over time due to changes in their financial situation, economic perspectives, regional government policies and other personal situations.

[10] The next considerations regarding entrepreneurship capital can be extended to the remainder of inputs in Equation [2]. As the focus of the chapter is based on the entrepreneurship capital, we omit such analyses.

Therefore, we have collected information concerning wealth, the aggregated value added and the population density, as well as the economic perspectives of the region and the annual increase in the aggregated value added. The existing evidence (see Koellinger and Thurik 2012 for a discussion) is ambiguous about the relationship between the previous general economic conditions of the inhabitants of a region and the current entrepreneurship capital of the region.

An analysis of each regional government policy is beyond our research purpose. One of the main instruments for such policies is tax. We have collected information about the tax pressure in each region. Consistent with the evidence available (for further discussion see Gentry and Hubbard 2004), we expect a positive relationship between the previous tax pressure and the current entrepreneurship capital.

Finally, one of the most dramatic changes in the personal situation is to become unemployed. We include information about the regional unemployment rates. Consistent with the existing evidence (for a more detailed discussion see Fairlie 2013), we expect that entrepreneurship capital will increase in those regions with previously higher unemployment rates.

4. Data

The firms' data used in this study originate from the Spanish Technological Innovation Panel (PITEC) and refer to the 2004-2012 period. This is an unbalanced data panel (each year some firms join and others leave the panel). We use the information corresponding to the firms' research activity and location of headquarters to allocate the firms to a specific Spanish region (further details about the allocation process are provided in Appendix 1). Those R&D activities are expected to play a key role in the diffusion/absorption of knowledge. On average, we have 7.9 observations per firm and 11,276 firms; therefore, we use a total of 89,370 observations. Next, we define the variables collected at the *firm level*. All monetary variables are expressed in 2000 constant Euros. Table 1 presents the descriptive statistics of the variables.

Region (i): this variable indicates the Spanish Autonomous Community where the firm is located. *Output* ($Y_{j,i,t}$): measures the firm's annual production. This variable was defined by the sales volume of each firm in real terms. *Labour* ($L_{j,i,t}$) is measured by the number of employees engaged in production activities. In Appendix 2, we explain the procedure to obtain the stock of capital ($K_{j,i,t}$) of a firm. *Private Knowledge* ($Z_{j,i,t}$) is measured by the investment in R&D activities.

The firms can be classified in different categories in accordance with their technological intensity and size. Based on the methodologies developed by the Organization for Economic Cooperation and Development (OECD) and EUROSTAT, the Spanish National Statistics Institute (INE) classifies economic sectors in accordance with their technological intensity: very high tech service sectors (HT), high and medium tech manufacturing sectors (MT), and other sectors. The INE defines technology sectors as those characterized by rapid knowledge renewal and that require a continuous and concerted effort to foster research and technological foundation (see Table 2).

In accordance with the EUROSTAT classification of enterprises, firms can be classified into three categories according to the number of employees: small (1-49 employees), medium (50-249 employees) and large firms. Table 3 shows the distribution of firms by technological intensity and size categories. Therefore, a maximum of nine categories can be used in the analyses. For simplicity purposes, in this chapter, we present the analyses that best summarize the results. We use two dummies, one for size (50 or more employees) and another for technological intensity (includes HT and MT firms)[11]. The category omitted in the analyses is firms with less than 50 employees and of low technological intensity.

For *each region*, in our case Autonomous Community (i= 1,…,18), we have collected the following aggregated information.

Regional Knowledge ($R_{i,t}$) is measured by the number of patents filed each year based on the Spanish Patents and Trademarks Office (Bönte et al. 2008). Unfortunately, we do not have access to data to estimate other proxies used in previous studies, for example, the total number of people employed in private companies or universities in areas related to R&D (Mueller 2007) or the annual regional costs of R&D (Griliches 1998).

The information on the stock of firms ($n_{i,t}$) in each region is available in the Central Business Register (DIRCE) database. The *entrepreneurship capital* is measured by the ratio between the stock of firms and the regional population[12] obtained from the INE, $E_{i,t} = n_{i,t}/P_{i,t}$. The average

[11] All the analyses that are cited but not provided in the text are available on request from the authors.
[12] There is also information available about the economically active population. The estimations presented in the next section have been replicated using the ratio between the stock of the firms and the economically

size of firms in the region is measured by the ratio between the regional labour force obtained from the INE and the stock of firms, $S_{i,t} = L_{i,t}/n_{i,t}$. Table 4 presents a summary of those variables.

Regarding Equation [5], the independent variables are the aggregated value added for each region ($Y_{i,t-1}$), the population density (number of inhabitants per square kilometre; $DEN_{i,t-1}$), the annual growth of the regional output ($g_{i,t} = \ln[Y_{i,t}/Y_{i,t-1}]$), the tax pressure (ratio between taxes and GDP; $TAX_{i,t-1}$) and the regional unemployment ($UNEM_{i,t-1}$). We have measured such determinants using information from the INE. In the estimations, these variables have been included one period lagged; therefore, we also collect regional data for 2003.

5. Results

Regarding Hypothesis 1, Table 5 shows different estimations of Equation [2] using the between and the within effects models, in this last case providing the clustered (by firm) robust variance estimators. Breush and Pagan's (1979) and Hausman's (1978) tests indicate that the fixed effects model is the most appropriate for modelling the non-observable heterogeneity among firms. The difference between the first and second pairs of columns is the inclusion of the variables measured at the regional level (in the best of cases, the increase in the explanatory power of the model, R^2, is 0.0024). The last two columns show the joint estimation with Equation [5].

The elasticity of production with respect to labour (β) takes values of between 0.7382 and 0.8914, the elasticity with respect to capital (α) takes values of between 0.1680 and 0.2198, and the elasticity of production with respect to private knowledge (ρ) takes values of between 0.0051 and 0.0067. All of those parameters are statistically significant at the 1% level. The null hypothesis of the constant returns to scale is rejected in both models. In short, the elasticities of production with respect to the inputs purchased by the firms are very stable among the different models estimated.

active population as the measure of entrepreneurship capital. The conclusions are very similar but, in this case, the models have a lower explanatory capacity, R square, than those of the estimations presented in the text.

This finding does not apply to the parameters associated with regional inputs (last four columns in Table 5). The coefficients associated with the regional entrepreneurship capital and knowledge are statistically significant only in the between effects model. Thus, Hypothesis 1 is only supported in the between effects model. The coefficients associated with the entrepreneurship capital are always positive and, in the between models, take the values 1.0313 and 1.0338, while in the within models, take the values 0.2362 and 0.4019, which are 22 and 39 percent of those estimated in the between models (θ between 0.22 and 0.39), respectively. The coefficients associated with regional knowledge are positive and statistically significant at the 10% level in the between effects model, while they are negative and statistically insignificant in the within effects model. The coefficients related to the average size of firms in the region are positive in all cases, but not statistically significant; therefore, we cannot reject that $s = 0$. The average size of the firms in the region has no spillover on firms' productivity.

Regarding the determinants of the entrepreneurship capital (Equation [5]), we find evidence of their persistence and their positive correlation with the personal wealth of the inhabitants of the region, the regional output growth, the tax pressure and the unemployment ratio.

Regarding Hypothesis 2, Table 6 shows the estimations of the above models allowing for differences in the elasticities of production with respect to the entrepreneurship capital depending on the size and the technological intensity of the firm. Hypothesis 2 is supported in the within effects model and partially supported in the between effects model. The spillovers decrease with the size of the firm (statistically significant in both models) and increase with the technology intensity (only statistically significant in the within effects model). It is important to note that the elasticities of production with respect to the entrepreneurship capital for technological firms with less than 50 employees are very similar using the between effects model (approximately 1.46) and the within effects model (1.3057 and 1.4624; all of these values are statistically significant). This finding does not apply to the other types of firms. The values of the remaining parameters are consistent with the previous estimations in Table 5.

6. Conclusions

Spatial externalities have been considered a main argument for justifying the existence of policies stimulating entrepreneurship among the population (Acs et al. 2016). This chapter uses data at the firm level to test whether the regional entrepreneurship capital has positive spillovers on the production of the firms in the region. Previous evidence is based on aggregated data at the regional level. The theoretical discussion in this chapter suggests that those studies may be overestimating the spillovers, particularly when the production functions present decreasing returns to scale, and the regional average size of the firms has no spillovers on the production of the firms of the region. Our evidence suggests that both features are present in the production functions estimated (at least in the within effects model); therefore, it is important to provide evidence at the firm level to confirm the presence of regional entrepreneurship capital spillovers. It is important to note that we do not provide evidence for the sources of the entrepreneurship capital spillovers (for such kind of evidence see Carree et al. 2014). Therefore, we cannot guarantee that the source of those spillovers is the KSTE argument, and we cannot reject the possibility of other sources of positive (or negative) spillovers being present at the same time.

For the overall sample of firms, we find that the regional entrepreneurship capital has positive spillovers on the production of the firms in the region; these are statistically significant in the between effects but not in the within effects model. Consequently, one could argue that we do not find clear support for such spillovers; however, those results could have different interpretations. In accordance with Congregado et al. (2012), the ratio of the stock of firms and the population is a measure of the latent variable, entrepreneurship capital. The annual variation in the measure is an imperfect indicator of the annual variation in the latent variable. According to Congregado et al. (2012) and our estimations, approximately 20-35% of the variation in the measure is related to a variation in the latent variable. Another interpretation is that we have omitted time invariant variables correlated with entrepreneurship capital. If this is the case, it appears that those variables are particularly relevant for non-technological firms. It is important to note that, for technological firms, the elasticities estimated are positive, statistically significant and with similar values in both models (between and within effects). We also find that, if there is a benefit, small firms benefit more from the regional entrepreneurship capital spillovers.

In short, we only detect generally extended positive spillovers in between effects models, while in the within effects models, significant positive spillovers are only found for technological firms. Our results need to be confirmed in other contexts: different geographical areas, different definitions of region and different periods of time. The evidence presented opens interesting theoretical and empirical questions among which are the omitted time invariant variables correlated with the regional entrepreneurship capital and the production of the firms in the region.

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Table 1. Descriptive variables.

Information on the firm level	**Mean**	**Standard Deviation**
$\ln Y_{i,i,t}$	15.5697	2.1288
$\ln K_{i,i,t}$	14.3528	2.4080
$\ln L_{i,i,t}$	4.1255	1.7025
$\ln Z_{i,i,t}$	6.082	5.3774
Observations: 89,370		
Number of Firms: 11,276		

Information on the region		
$\ln Y_{i,t}$	17.0336	1.1507
$\ln R_{i,t}$	4.6072	1.2440
$\ln DEN_{i,t}$	4.8166	1.2580
$UNEMP_{i,t}$	0.4208	0.0405
$q_{Yi,t}$	0.0104	0.0260
$TAX_{i,t}$	0.1009	0.0542
Observations: 162		
Number of Regions: 18		

Table 2. Categories of technological sectors: INE.

NACE	**Sectors**	*Category=c*
72	Scientific research and development	Very high tech services sectors [HT]
	721 Research and experimental development on natural sciences and engineering	
	722 Research and experimental development on social sciences and humanities	
59	Motion picture, video & TV programme production, sound recording & music publishing	
60	Programming and broadcasting activities	
61	Telecommunications	
62	Computer programming, consultancy and related activities	
63	Information service activities	
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	High & medium tech [MT]
26	Manufacture of computer, electronic and optical products	
	303 Manufacture of air and spacecraft and related machinery	
20	Manufacture of chemicals and chemical products	
25	Manufacture of fabricated metal products, except machinery and equipment	
27	Manufacture of electrical equipment	
29	Manufacture of motor vehicles, trailers and semi-trailers	
30	Manufacture of other transport equipment	
	325 Manufacture of medical and dental instruments and supplies	
	Other Sectors	Low tech [LT]

Source: [http://www.ine.es/daco/daco43/notaiat.pdf]

Table 3. Distribution of firms by technological intensity and size categories.

Firm Size	*Number of Workers*	Low Tech *[LT]*	*Medium Tech [MT]*	*High Tech [HT]*	*Total*
Small	[1-49]	3,606	184	1,046	4,836
Medium	[50-249]	2,431	160	837	3,428
Large	[>=250]	2,277	356	379	3,012
Total		8,314	700	2,262	11,276

Table 4. Regional entrepreneurship capital.

	Means	
	$\ln(E_{it})$	$\ln s_{it}$
Andalusia	-2.7950	1.7819
Aragon	-2.6590	1.8276
Asturias	-2.7122	1.7660
Balearic Is.	-2.4707	1.6784
Canary Is.	-2.7215	1.8151
Cantabria	-2.6964	1.8384
Castilla La Mancha	-2.7335	1.7988
Castilla y Leon	-2.7043	1.8042
Catalonia	-2.4866	1.6891
Ceuta	-2.9949	1.8967
Extremadura	-2.8085	1.7853
Galicia	-2.6335	1.7521
La Rioja	-2.6112	1.7878
Madrid	-2.5267	1.7637
Murcia	-2.7353	1.8379
Navarra	-2.6750	1.8777
Basque Country	-2.5635	1.7570
Valencia	-2.6305	1.7528
Total	-2.5901	1.7542

Table 5. Test of Hypothesis 1.

		Equation [4]: Dependent Variable: $\ln Y_{j,i,t}$.					
Model		**Between**	**Within**	**Between**	**Within**	**Between**	**Within**
Independent Variable	*Coef.*						
Constant		8.8670 ***	10.0661 ***	10.7188 ***	10.6614 ***	10.7166 ***	11.0099 ***
		[0.088]	[0.219]	[0.461]	[0.490]	[0.461]	[0.549]
$\ln L_{j,i,t}$	β	0.8914 ***	0.7387 ***	0.8793 ***	0.7384 ***	0.8793 ***	0.7382 ***
		[0.007]	[0.016]	[0.007]	[0.016]	[0.007]	[0.016]
$\ln K_{j,i,t}$	α	0.2148 ***	0.1684 ***	0.2198 ***	0.1682 ***	0.2198 ***	0.1680 ***
		[0.005]	[0.016]	[0.005]	[0.016]	[0.005]	[0.016]
$\ln Z_{j,i,t}$	ρ	0.0067 ***	0.0053 ***	0.0051 ***	0.0053 ***	0.0051 ***	0.0053 ***
		[0.002]	[0.001]	[0.002]	[0.001]	[0.002]	[0.001]
$\ln R_{i,t}$	μ			0.0247 *	-0.0173	0.0248 *	-0.0201
				[0.013]	[0.019]	[0.013]	[0.019]
$\ln E_{i,t}$	δ			1.0338 ***	0.2362	1.0313 ***	0.4019 *
				[0.132]	[0.197]	[0.132]	[0.227]
$\ln s_{i,t}$	γ			0.3752	0.0693	0.3726	0.1275
				[0.263]	[0.151]	[0.263]	[0.154]
Temporal Effects		Yes	Yes	Yes	Yes	Yes	Yes
R^2		0.8170	0.3241	0.8194	0.3241	0.8194	0.3241
		Equation [5] Dependent Variable: $\ln E_{i,t}$					
Constant						-0.0699 ***	-8.8545 ***
						[0.004]	[0.133]
$\ln E_{i,t-1}$	π_1					0.9812 ***	0.3369 ***
						[0.001]	[0.004]
$\ln Y_{j,i,t-1}$	π_2					0.0049 ***	0.5518 ***
						[0.000]	[0.006]
$g_{Y\,i,t}$	π_3					0.7434 ***	0.3240 ***
						[0.016]	[0.007]
$\ln DEN_{i,t-1}$	π_4					-0.0021 ***	-0.3869 ***
						[0.000]	[0.004]
$TAX_{i,t-1}$	π_5					0.0631 ***	0.1150 ***
						[0.002]	[0.004]
$UNEMP_{i,t-1}$	π_6					0.0648 ***	0.0519 ***
						[0.002]	[0.007]
Observations	89,370						
Groups	11,276						

*: Significant at the 0.10 level. **: Significant at the 0.05 level. ***: Significant at the 0.01 level. Robust standard errors are in brackets.

Table 6. Test of Hypothesis 2.

		Equation [4] Dependent Variable: $\ln Y_{j,i,t}$.			
Model		Between	Within	Between	Within
Independent Variable	*Coefficient*				
Constant		11.3732 ***	10.6246 ***	11.3580 ***	11.0201 ***
		[0.532]	[0.488]	[0.532]	[0.546]
$\ln L_{j,i,t}$	β	0.8358 ***	0.7379 ***	0.8358 ***	0.7377 ***
		[0.009]	[0.016]	[0.009]	[0.016]
$\ln K_{j,i,t}$	α	0.2156 ***	0.1643 ***	0.2155 ***	0.1638 ***
		[0.005]	[0.016]	[0.005]	[0.016]
$\ln Z_{j,i,t}$	ρ	0.0024	0.0052 ***	0.0024	0.0052 ***
		[0.002]	[0.001]	[0.002]	[0.001]
$\ln R_{i,t}$	μ	0.0243 *	-0.0162	0.0245 *	-0.0196
		[0.013]	[0.019]	[0.013]	[0.019]
$\ln s_{i,t}$	γ	0.5297 **	0.0852	0.5235 **	0.1540
		[0.259]	[0.150]	[0.259]	[0.154]
$\ln E_{i,t}$	δ	1.3861 ***	0.3706	1.3764 ***	0.6115 **
		[0.172]	[0.226]	[0.172]	[0.264]
$Big_{j,i,t}$	α_{Big}	-1.0298 **		-1.0150 **	
		[0.442]		[0.442]	
$Tech_{j,i,t}$	α_{Tech}	0.5652		0.5726	
		[0.493]		[0.493]	
$\ln E_{i,t} * Big_{j,i,t}$	δ_{Big}	-0.4747 ***	-0.6957 ***	-0.4690 ***	-0.7679 ***
		[0.170]	[0.142]	[0.170]	[0.145]
$\ln E_{i,t} * Tech_{j,i,t}$	δ_{Tech}	0.0831	0.9351 ***	0.0860	0.8919 ***
		[0.190]	[0.148]	[0.190]	[0.149]
Temporal Effects		Yes	Yes	Yes	Yes
R^2		0.8258	0.3251	0.8258	0.3251
		Equation [5] Dependent Variable: $\ln E_{i,t}$			
Constant				-0.0751 ***	-8.3585 ***
				[0.004]	[0.132]
$\ln E_{i,t-1}$	π_3			0.9787 ***	0.3158 ***
				[0.001]	[0.004]
$\ln Y_{j,i,t-1}$	π_1			0.0048 ***	0.5206 ***
				[0.000]	[0.006]
$g_{Y\,i,t}$	π_2			0.7383 ***	0.3105 ***
				[0.016]	[0.007]
$\ln DEN_{i,t-1}$	π_4			-0.0021 ***	-0.3621 ***
				[0.000]	[0.003]
$TAX_{i,t-1}$	π_6			0.0633 ***	0.1063 ***
				[0.002]	[0.003]
$UNEMP_{i,t-1}$	π_5			0.0647 ***	0.0506 ***
				[0.002]	[0.007]
Observations	89,370				
Groups	11,276				

*: Significant at the 0.10 level. **: Significant at the 0.05 level. ***: Significant at the 0.01 level. Robust standard errors are in brackets.

Appendix 1. Firm location.

The firms are allocated to Autonomous Communities (*Comunidades Autónomas* - CCAAs) on the basis of where they perform their research activities. Specifically, for each firm, there is information available to calculate the percentage of the following expenditures: Total Expenditure on Innovation, Total Internal Personnel in R&D Activities and Total Internal Expenditure on R&D located in each of the 18 CCAA's. 8,012 firms make 100% of each of the expenditures in the same Autonomous Community. The first column (Location of R&D Activities) in Table A.1. shows their distribution among CCAAs.

The remaining 4,826 firms were allocated to a CCAA if:

i) The same Autonomous Community concentrates 100% of the expenditure on which we have information (1 or 2 types of expenditure).
ii) This Autonomous Community is the one with the highest expenditure level at least in two of the three types of expenditures considered.

After this process, 1,020 firms cannot be allocated to a specific CCAA. The second column (Location of most R&D Activities) in Table A.1 shows the distribution of the firms finally allocated after this process.

The PITEC database also contains information about where the headquarters of the firm are located. The problem is that they only recognize three Autonomous Communities: Madrid, Catalonia and Andalusia. To those Autonomous Communities, 4,848 firms are allocated, while 5,719 firms are allocated to the other CCAAs without identifying which. Furthermore, there are 1,465 missing values. The third column in Table A.1 summarizes the distribution of firms according to information about their headquarters. We use this information to check the robustness of the classification based on where the firms perform their research activities. We only find 590 divergences; therefore, we do not include such firms in the analyses. The last column (final firm location) in Table A.1 summarizes the distribution of firms among CCAA in the sample finally used in this chapter.

Table A.1. Sample and firms' regional distribution.

REGION	*ALL R&D ACTIVITIES LOCATION*	*MOST of R&D ACTIVITIES LOCATION*	*HEADQUARTER LOCATION*	*FINAL FIRM LOCATION*
Andalusia	509	883	761	818
Aragon	287	356		348
Asturias	158	197		191
Balearic, Is.	55	88		87
Canary Is.	66	125		121
Cantabria	93	123		119
Castilla La Mancha	130	201		183
Castilla y Leon	314	422		404
Catalonia	2,139	3,045	2,726	2,884
Ceuta	1	3		3
Extremadura	68	87		79
Galicia	426	547		537
La Rioja	89	123		118
Madrid	1,108	2,384	2,167	2,241
Murcia	201	264		256
Navarra	328	415		406
Basque Country	1,077	1,322		1,263
Valencia	963	1,244		1,218
Firms localized	**8,012**	**11,818**	**4,848**	**11,276**
Firms not localized	4,826	1,020	7,184	1,562
PITEC Number of Firms	**12,838**	**12,838**	**12,838**	**12,838**

Appendix 2. Firms' stock of capital.

The PITEC provides information about the annual investment on the physical capital of each firm, $I_{j,t}$. In accordance with (Goya and Vayá 2011; Barge-Gil and López 2013, Ortega-Argilés et al. 2011), we use the perpetual inventory method to estimate the stock of capital of firm *j* in period *t*: $K_{j,t} = (1 - d) K_{j,t-1} + I_{j,t}$ being $K_{j,0} = I_{j,0} / d$.

The depreciation rate adopted was $d = 0.1$. Given that the investments are highly affected by economic fluctuations, in accordance with Ferreira et al. (2013), we use the average of all of the sample years' investments instead of $I_{j,0}$. The basic results of this chapter are insensitive to this decision.

Entrepreneurship Capital Spillovers at the City Level [Chapter 3]

Entrepreneurship Capital Spillovers at the City Level [Chapter 3]

1. Introduction

The Knowledge Spillover Theory of Entrepreneurship (KSTE) suggests that entrepreneurship capital in a certain region has positive spillovers that increase establishments' production in the region (Audretsch and Keilbach 2005; 2007; Acs et al. 2009; Audretsch and Lehmann 2016). From this starting point, a growing amount of literature is estimating the effects of regional entrepreneurship capital on a region's production using aggregated data at the regional level (Audretsch and Keilbach 2004a, 2004b, 2004c, 2005; 2008; Mueller 2006, 2007; Bönte et al. 2008; Cravo et al. 2010; Stough et al. 2008; Chang 2011; Hafer 2013; Laborda et al. 2011; Mendonça and Grimpe 2015). These studies report the positive and significant effects of regional entrepreneurship capital on regional production, which are interpreted as supporting the existence of positive spillovers. There are three main differences between this chapter and this previous empirical literature. First, the entrepreneurship capital is measured at the city level. Second, we measure the spillovers using firm data. Third, we can split the entrepreneurship capital between formal and informal one.

As far we know, most of the studies have been used regions at the level of NUTS 3 with or even more aggregated (NUTS 2). For that purpose, we present evidence related with 222 cities (old NUTS 5 or new LAU2) in Ecuador. From the National Economic Census (Censo Nacional

Económico, CENEC)[13] conducted by the National Institute of Statistics and Censuses of Ecuador (Instituto Nacional de Estadísticas y Censos del Ecuador, INEC) we have collected information at the establishment level, so the production functions can be estimated with information about 445.490 establishments referred to the year 2010.

Furthermore, some of the papers revised seek to identify the kind of entrepreneurship capital that generates more spillovers. For example, Audretsch and Keilbach (2004a,b,c, 2008) classified entrepreneurship capital on the basis of the technological intensity of the sectors: high technology, ICTs, and other sectors. They find that less technological sectors, other sectors, generate more spillovers. Data at the establishment level allows us to extend those analyses by identifying the establishments that benefit the most from entrepreneurship capital spillovers (i.e., which receive more externalities).

As far we know, this is the first study analyzing the spillovers of regional entrepreneurship capital in a Latin American country. A distinctive feature of those countries from European ones, the most analyzed ones, it is the role of the informal economy. Ecuadorian official data considers informal entrepreneurs to those that are not registered in the *Servicio de Rentas Internas*[14] and have less than 100 employees. According to this criteria,[15] the informal economy represents the 34.96% of the establishments in the economy and 21,13% of the employment in 2010. The data available let us to identify those establishments that fulfills the requirements to be considered as part of the informal economy. Therefore, we can differentiate the entrepreneurship capital of the cities between formal and informal one.

The chapter is organized as follows. In Section 2, we summarize the previous literature methods, discuss their limitations and state the hypotheses. Section 3 presents the data. Section 4 presents the estimations of firms' production functions. Section 5 concludes the chapter and discusses its implications.

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13 [http://www.ecuadorencifras.gob.ec/censo-nacional-economico].
14 [http://www.sri.gob.ec].
15 [http://www.ecuadorencifras.gob.ec//documentos/web-inec/EMPLEO/2015/Junio-2015/Metogologia_Informalidad/notatecnica.pdf].

2. Related literature

Most of the literature cited in the introduction (Audretsch and Keilbach 2004a, 2004b, 2004c, 2005; 2008; Mueller 2006, 2007) has estimated the impact of regional entrepreneurship capital on the production for a given region. In those studies, the regions go from countries (Cravo et al. 2010; Stough et al. 2008; Chang 2011; Hafer 2013; Laborda et al. 2011; Mendonça and Grimpe 2015) to regions equivalent to NUTS-3 accordingly with Eurostat classification (Salas-Fumás and Sánchez-Asín 2008, 2010a, 2010b, 2013). As far we know, there is no studies based at the city level.

The measurement and concept of entrepreneurship capital has been discussed, unlike the measurements of other kinds of inputs (Erikson 2002; Audretsch and Keilbach 2004a; Bönte et al. 2008). The empirical applications usually work with different measures of regional population densities, for example the stock of establishments per inhabitant (Acs et al., 2012) or the ratio of startups per inhabitant (Audretsch and Keilbach, 2004a,b, 2008). Two regions with the same population density can have very different realities. For example, one of them can be configured by a very large city that concentrates almost all the population, while in the other the population can be dispersed in many medium size cities.

Distinguish between these two situations seems important when the local proximity is essential for accessing complementary inputs (Saxenian, 1994). “The value of any individual’s or firm’s capabilities is therefore conditional on the existence of partners in a network. Firms and workers place a greater value on locations within clusters that contain complementary workers and firms than on those outside of clusters” (Audretsch et. al 2006a, pp 173). These network externalities are at the heart of the KSTE theory. Audretsch et. al (2006a) suggest that the firms’ capabilities are conditional on the geographic proximity of complementary firms. One would expect that such networks will be more important in regions with large cities than in other regions with the same population density. So a more proper test of the KSTE theory can be made when the geographical distribution of the population is more detailed.

A second feature of the KSTE literature is that the data about production and inputs is collected at the region level. Chapter 2 of this dissertation extensively analyses the limitations of this approach, and the advantages of using data at the establishment level in order to estimate the spillovers of the regional entrepreneurship capital and distinguish it from the simple increase in the regional GDP due to the fact that there are more establishments in the region. Following this discussion, we purpose to estimate the following equation already proposed in Chapter 2:

$$\ln Y_{j,i} = \beta \ln L_{j,i} + \alpha \ln K_{j,i} + \phi \ln I_{j,i} + \mu \ln R_i + \delta \ln E_i + s \ln S_i + \varepsilon_{j,i} \qquad [1]$$

This is the estimation of a Cobb-Douglas (1928) function where the establishment j output ($Y_{j,i}$) is obtained as a combination of the sum of inputs purchased by the establishments of the region i and other regional inputs, while $\varepsilon_{j,i}$ captures the usual error term which will include regional fixed effects. The inputs considered are labour ($L_{j,i}$), (physical) capital ($K_{j,i}$), intermediate goods ($I_{j,i}$), private knowledge ($I_{j,i}$), regional knowledge (R_i), regional entrepreneurship capital (E_i) and the average size of the establishments in the region (S_i). The parameters to be estimated are production elasticity with respect to labour (β), capital (α), intermediate goods (ϕ), private knowledge (ρ), regional knowledge (μ), regional entrepreneurship capital (δ) and average size of the establishments in the region (s). In fact, the parameter s measures the difference between the returns to scale measured with data at the establishment level and the returns to scale using data at the regional aggregated level (see further details in Chapter 2).

Apart from the inclusion of entrepreneurship capital (and the average size of the establishments in the region), these kinds of equations have been extensively estimated in other contexts (see Syverson 2011 for further discussion of their limitations) finding positive elasticities of production with respect to labour and capital (physical capital and intermediate goods). This is also the case of the estimations of the elasticity of production with respect to regional knowledge and regional entrepreneurship capital, which are usually positive and statistically significant. In this sense, we can reproduce these analyses and test the following hyphotesis:

Hypothesis 1: The production of establishments in a region is positively related to regional entrepreneurship capital.

According to the KSTE, "the context in which decision-making is derived can influence one's determination to become an entrepreneur. In particular, a context that is rich in knowledge generates entrepreneurial opportunities from those ideas. By commercializing ideas that evolved from an incumbent organization via the creation of a new firm, the entrepreneur (human capital) not only serves as a conduit for the spillover of knowledge, but also for the ensuing innovative activity and enhanced economic performance through resource allocation" (Acs et. al 2013, p.

757). The reason is that knowledge created endogenously results in knowledge spillovers, which allow entrepreneurs to identify and exploit opportunities (Acs et. al 2009). Based on these arguments, we expect a certain complementarity among this two factors.

Hypothesis 2: The effect of the regional entrepreneurship capital and regional knowledge are complementary.

Some of the papers revised seek to identify the kind of entrepreneurship capital that generates more spillovers. For example, Audretsch and Keilbach (2004a,b,c, 2008) classified entrepreneurship capital on the basis of the technological intensity of the sectors: high technology, ICTs, and other sectors. The researchers find that other sectors that are less technological generate more spillovers (Audretsch and Keilbach, 2008).

Furthermore, the data available offers us the possibility to distinguish between the amount of formal and informal entrepreneurship capital. We would like to test whether the informal entrepreneurship capital has a different role or importance than the formal one, the analysed in previous studies. For example, one could argue that a great number of the formal establishments have been previously an informal one. In this case, informal establishments seems a more proper measure of the entrepreneurial dynamism of the region. As a tentative hypothesis we postulate that the spillovers of the informal entrepreneurship capital are higher than those associated with the formal one. The following hypothesis summarizes the expected differences in the magnitude of the spillovers depending on different types of entrepreneurship capital.

Hypothesis 3: The effect of the regional entrepreneurship capital is higher when this is accumulated in a) less technological sectors and b) informal firms

Data at the establishment level allows us to extend those analyses and estimate the elasticities of production with respect to entrepreneurship capital for different groups of establishments. Consequently, we can identify the groups of establishments that benefit the most from entrepreneurship capital spillovers (i.e., which receive more externalities). The evidence can therefore be interpreted in terms of the differences in intensity of knowledge between establishments. In accordance with the KSTE, entrepreneurship is a facilitator of knowledge dissemination. Consequently, it is expected that entrepreneurship capital spillovers will be higher in those establishments with lower current levels of knowledge and in establishments with a higher capacity to learn. As a proxy of these concepts, we use the size of the establishment, its technological intensity and the informality of the establishment. In short, we propose the following hypothesis:

Hypothesis 4: The benefits from entrepreneurship capital spillovers: (a) increase with the size of the establishment, (b) increase with its technological intensity, (c) increase with the level of informality.

3. Data

The establishments' data used in this study originate from the Censo Nacional Económico (CENEC). This is a census of the establishments in Ecuador when the data was collected, between September and November of 2010. There are included all (visible) establishments where an economic activity is carried out under a single direction, and physically separated from a home. We excluded public and government establishments (10.310), minning and oil extraction establishments (87). The census do not consider establishments that has a head office at the same city, even that, we have identified and omitted some cases where this is the case (55.278). We end up with 445.490 establishments.

Next, we define the variables collected at the *establishment level*.

Region (i): this variable indicates the city where the establishment is located. Due the lack of establishments, we omit two cities, El Piedrero y Las Golondrinas, so we work with 222 cities, see Appendix 1 for further details. *Output* ($Y_{j,i}$): measures the establishment's annual production. This variable was defined by the sales volume of each establishment in real terms. In our case there is no information available to compute the added value of each firm. *Labour* ($L_{j,i}$) is measured by the number of employees engaged in production activities. *Capital* ($K_{j,i}$) is measured by the fixed assets of the establishment. *Intermediate Goods* ($I_{j,i}$) is measured by the current assets of the establishment. *Private Knowledge* ($Z_{j,i}$) is measured by the investment in R&D activities and training.

The establishments can be classified in different categories in accordance with their knowledge base and their formal character. Based on the methodologies developed by the Organization for

Economic Cooperation and Development (OECD) and EUROSTAT, the Spanish National Statistics Institute (INE) identifies the knowledge based economic sectors. As in previous chapters, we use the classification of the Spanish National Statistics Institute (INE) for identifying the technological sectors in the case of Ecuador, see Table 1 for further details. The dummy variable $D_{Tech\ j,i}$ takes value 1 when the firm belongs to a technological sector.

Accordingly with the *Instituto Ecuatoriano de Estadísticas y Censos*[16] an establishment is considered formal when it is included in the *Registro Único de Contribuyentes* in *Servicio de Rentas Internas*. and it has less than 100 workers. For each establishment we have information about these two items, so it is possible to classify it as formal or informal one. The dummy variable $D_{Informal\ j,i}$ takes value 1 when the firm belongs to the informal economy.

For *each region*, in our case cities (*i*= 1,…,222), we have collected the following aggregated information.

Regional Knowledge (R_i) is measured by the investment in R&D activities and training in the cities by public and government establishments[17]. Following Acs et al. (2012), the *entrepreneurship capital* is measured by the ratio between the stock of establishments and the city population obtained from the *Censo de Población y Vivienda* (CPV)[18], $E_i = n_i/P_i$. In Appendix 2, we reproduce all the analyses using the average of last three years Start-Ups per inhabitant ratio in each city following Audretsch and Keilbach (2004a,b, 2008). The main conclusions does not depend on the measure of entrepreneurship capital used. Considering only the knowledge based establishments, we can compute the *Knowledge based Entrepreneurship Capital* (KE_i) and its relative importance over the regional entrepreneurship capital (KE_i/E_i). In a similar way it can be defined the relative importance of the informal entrepreneurship capital (IE_i/E_i). The average size of establishments in the region is measured by the ratio between the city labour force and the stock of establishments, $S_i = L_i/n_i$. Due that are two cities extremely large, we are going to create a dummy variable for identifying firms in Guayaquil and Quito, $D_{BigCities\ j,i}$. Table 2 presents the descriptive statistics. The correlations between the different variables at the regional level are in Table 3a and at the firm level in Table 3b.

[16] [http://www.ecuadorencifras.gob.ec/institucional/home].
[17] We use information related to the 10.310 establishments not included in the sample.
[18] [http://www.ecuadorencifras.gob.ec/censo-de-poblacion-y-vivienda, 2010].

4. Results

Table 4 shows different estimations of Equation [1]. The difference between columns are the additional variables included. In the best case, the increase in the explanatory power of the model, R^2, is 0.0192. As an indicator of the collinearity magnitude we use the variance inflator factor (VIF) and in all the cases the values are below 10, the usual maximum acceptable level.

Model (1) is the basic model. The elasticity of production with respect to labour (β) takes a value of 0.7352, the elasticity with respect to capital (α) takes a value of 0.1663, the elasticity with respect to current capital (ϕ) takes a value of 0.2195, the elasticity of production with respect to private knowledge (ρ) takes a value of 0.0577, and the establishments in Guayaquil and Quito are, on average, more productive (approximately a 18,72% more). All these coefficients are statistically significant at the 1% level.

In model (2) we add the basic variables related with the KTSE theory, entrepreneurship capital, the size of the establishment and the regional knowledge. The coefficient associated with the regional entrepreneurship capital is 0.0564, positive and statistically significant at the 1% level, supporting Hypothesis 1. We also find that the elasticity of production with respect the size of the firm is 0.1346 and statistically significant at the 1%, while the elasticity with respect to the cities' knowledge takes a value of 0.0055 which is statistically insignificant at the usual levels. The multiplicative variable between entrepreneurship and the cities' knowledge is 0,0023, positive and statistically significant at the 5%. This supports Hypothesis 2, regional entrepreneurship capital and knowledge are complementary.

Model (3) provides the tests of Hypothesis 3. In this model we include two variables to measure the impact of externalities generated by knowledge sectors and informal sectors on firm's production. The coefficient associated with the ratio between technological and total establishments is -0.0400, negative and stastitically significant at the 1% level. The value of elasticity with respect to the ratio between informal and total establishments is 0.0401, positive and statistically significant at the 1%. This supports Hypothesis 3. The entrepreneurship capital spillovers are higher when the entrepreneurship capital is accumulated in less technological and informal establishments.

Regarding Hypothesis 4, model (4) shows the estimations of the above models allowing for differences in the elasticities of production with respect to the entrepreneurship capital depending on the size, the technological intensity and the formalization of the establishments. Large, more technological and informal establishments benefit more from the spillovers of the regional entrepreneurship capital. All the effects are statistically significant at the 1% level. These results support Hypothesis 4, except for the case of the firms' size.

5. Conclusions

This chapter reproduces at the city level and with data aggregated at the establishment level, two pieces of evidence detected in previous analyses made for larger regions and using data aggregated at the regional level. First, the regional entrepreneurship capital has positive spillovers over the production of the firms. Second, the spillovers decrease when the regional entrepreneurship capital is accumulated in technological sectors.

Those results gives support to the generality of the existence of regional entrepreneurship capital spillovers, mostly when this evidence come from a Latin American country, an institutional environment scarcely analyzed until now. This environment is characterized by the relative importance of the informal economy and let us to provide evidence that the analyzed spillovers increase when the regional entrepreneurship capital is accumulated in informal sectors. Further evidence is needed to confirm those results in other contexts and theory to explain it.

The use of data at the establishment level let us also to analyse new issues as which are the type of firms more benefited from the entrepreneurship capital spillovers. The evidence can be interpreted in terms of the differences in the capacity to learn, or absorptive capacities (Cohen and Levinthal 1990; Qian and Acs 2013) of establishments. Accordingly with our analyses, we detect that technological, large and informal establishments, are the most benefited from such spillovers, so it could be argued that have higher capacity to learn, or absorptive capacities.

The research is not free of limitations. This is a cross-section data, so it is difficult to deal with endogeneity and causality problems. The data comes from a concrete country and institutional setting so we can not guarantee its generality. The data do not let us to analyse how these spillovers are produced and consequently the sources of such spillovers. Further evidence could help to overcome these limitations.

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Table 1. Categories of technological sectors – INEC.

CIIU	**High Tech**
J58	Actividades de publicación.
J59	Actividades de producción de películas, vídeos y programas de TV, grabación de sonido y edición de música.
J60	Actividades de programación y transmisión.
J61	Telecomunicaciones.
J62	Programación informática, consultoría de informática y actividades conexas.
J63	Actividades de servicios de información.
M69	Actividades jurídicas y de contabilidad.
M70	Actividades de oficinas principales; actividades de consultoría de gestión.
M71	Actividades de arquitectura e ingeniería; ensayos y análisis técnicos.
M72	Investigación científica y desarrollo.
M73	Publicidad y estudios de mercado.
M74	Otras actividades profesionales, científicas y técnicas.
P85	Enseñanza.
R91	Actividades de bibliotecas, archivos, museos y otras actividades culturales.

Notes: CIIU2.P, CENEC.
Source: National Institute of Statistics and Censuses, INEC, 2010.

Table 2. Descriptive statistics.

Establishments	***Mean***	***Standard Deviation***
$\ln Y_{j,i}$	9.2404	1.6141
$\ln I_{j,i}$	5.6803	2.4177
$\ln K_{j,i}$	7.3621	1.8953
$\ln L_{j,i}$	0.4981	0.6668
$\ln Z_{j,i}$	0.0255	0.4556
$D_{Inform\ j,i}$	0.3496	0.4769
$D_{Tech\ j,i}$	0.0831	0.2760
$D_{BigCities\ j,i}$	0.3703	0.4829

Observations: 445,490

Cities	***Mean***	***Standard Deviation***
$\ln E_i$	-3.8823	0.6208
$\ln S_i$	0.7085	0.2300
$\ln R_i$	4.2586	4.8352
$\ln(IE_i/E_i)$	-1.0718	0.4498
$\ln(KE_i/E_i)$	-2.7284	0.4271

Observations: 222

Table 3.a. Correlation Matrix (Regional variables).

	$\ln E_i$		$\ln s_i$		$\ln R_i$		$\ln(IE_i/E_i)$
$\ln s_i$	-0.0986 [0.143]						
$\ln R_i$	0.1528 [0.023]	**	0.2200 [0.001]	***			
$\ln(IE_i/E_i)$	-0.1758 [0.009]	***	0.0698 [0.300]		-0.1305 [0.052]	**	
$\ln(KE_i/E_i)$	0.1531 [0.023]	**	-0.0004 [0.996]		0.1248 [0.063]	**	-0.0551 [0.414]

Observations: 222
*: Significant at the 0.10 level. **: Significant at the 0.05 level. ***: Significant at the 0.01 level. p-value are in brackets.

Table 3.b. Correlation Matrix (Firm variables).

	$\ln Y_{j,i}$	$\ln K_{j,i}$	$\ln I_{j,i}$	$\ln L_{j,i}$	$\ln Z_{j,i}$	$\ln R_i$	$\ln s_i$	$\ln E_i$	$\ln(IE_i/E_i)$	$\ln(KE_i/E_i)$	$D_{Inform\ j,i}$	$D_{Tech\ j,i}$
$\ln K_{j,i}$	0.4067 ***											
	[0.000]											
$\ln I_{j,i}$	0.4275 ***	0.2325 ***										
	[0.000]	[0.000]										
$\ln L_{j,i}$	0.4484 ***	0.4291 ***	0.1677 ***									
	[0.000]	[0.000]	[0.000]									
$\ln Z_{j,i}$	0.0803 ***	0.0889 ***	0.0300 ***	0.1183 ***								
	[0.000]	[0.000]	[0.000]	[0.000]								
$\ln R_i$	0.0749 ***	0.0565 ***	0.0315 ***	0.0516 ***	0.0210							
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]							
$\ln s_i$	0.1051 ***	0.0827 ***	0.0227 ***	0.0989 ***	0.0144 ***	0.6307 ***						
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]						
$\ln E_i$	0.0414 ***	0.0361 ***	0.0263 ***	0.0054 ***	0.0143 ***	0.4415 ***	0.2392 ***					
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]					
$\ln(IE_i/E_i)$	-0.0068 ***	-0.0537 ***	-0.0379 ***	0.0361 ***	-0.0174 ***	-0.2454 ***	0.1159 ***	-0.4541 ***				
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				
$\ln(KE_i/E_i)$	0.0402 ***	0.0586 ***	0.0292 ***	0.0021	0.0265 ***	0.5236 ***	0.3216 ***	0.4739 ***	-0.4850 ***			
	[0.000]	[0.000]	[0.000]	[0.163]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]			
$D_{Inform\ j,i}$	-0.0202 ***	0.1492 ***	-0.1799 ***	0.0893 ***	0.0511 ***	0.0333 ***	0.0193 ***	0.0302 ***	-0.0334 ***	0.0617 ***		
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]		
$D_{Tech\ j,i}$	-0.3147 ***	-0.3341 ***	-0.2281 ***	-0.1967 ***	-0.0375 ***	-0.0667 ***	0.0154 ***	-0.1063 ***	0.2112 ***	-0.1246 ***	-0.0901 ***	
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	
$D_{BigCities\ j,i}$	0.0990 ***	0.0587 ***	0.0346 ***	0.0701 ***	0.0163 ***	0.6545 ***	0.8043 ***	0.1809 ***	0.0572 ***	0.3364 ***	0.0218 ***	0.0014
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.344]

Note: $D_{BigCities\ j,i} = D_{Guayaquil\ j,i} + D_{Quito\ j,i}$
Observations: 445,490
*: Significant at the 0.10 level. **: Significant at the 0.05 level. ***: Significant at the 0.01 level. p-value are in brackets.

Table 4. Test of Hypothesis (General Entrepreneurship Capital).

		Equation [1] Dependent Variable: $\ln Y_{j,i}$							
Model		**(1)**		**(2)**		**(3)**		**(4)**	
Independent Variable	*Coefficient*								
Constant		6.3339	***	6.4398	***	6.4140	***	6.2617	***
		[0.009]		[0.036]		[0.050]		[0.055]	
$\ln K_{j,i}$	α	0.1663	***	0.1656	***	0.1662	***	0.1377	***
		[0.001]		[0.001]		[0.001]		[0.001]	
$\ln I_{j,i}$	ϕ	0.2195	***	0.2196	***	0.2197	***	0.2004	***
		[0.001]		[0.001]		[0.001]		[0.001]	
$\ln L_{j,i}$	β	0.7352	***	0.7346	***	0.7332	***	1.8278	***
		[0.003]		[0.003]		[0.003]		[0.031]	
$\ln Z_{j,i}$	ρ	0.0577	***	0.0576	***	0.0581	***	0.0594	***
		[0.004]		[0.004]		[0.004]		[0.004]	
$\ln R_i$	μ			0.0055		0.0145	***	0.0137	***
				[0.003]		[0.004]		[0.004]	
$\ln S_i$	s			0.1346	***	0.1084	***	0.1872	***
				[0.015]		[0.015]		[0.015]	
$\ln E_i$	δ			0.0564	***	0.0643	***	-0.1371	***
				[0.009]		[0.009]		[0.011]	
$\ln E_i * \ln R_i$	δ_{RD*E}			0.0023	**	0.0046	***	0.0045	***
				[0.001]		[0.001]		[0.001]	
$\ln(KE_i/E_i)$	δ_{KE}					-0.0400	***	-0.0594	***
						[0.011]		[0.011]	
$\ln(IE_i/E_i)$	δ_{IE}					0.0401	***	0.1584	***
						[0.008]		[0.008]	
$\ln E_i * \ln L_i$	δ_S							0.3289	***
								[0.009]	
$D_{Tech\ j,i}$	d_T							0.2522	***
								[0.071]	
$\ln E_i * D_{Tech\ j,i}$	δ_T							0.1264	***
								[0.021]	
$D_{Inform\ j,i}$	d_I							-0.1539	***
								[0.040]	
$\ln E_i * D_{Inform\ j,i}$	δ_I							0.0958	***
								[0.011]	
$D_{BigCities\ j,i}$	d_B	0.1827	***	0.1424	***	0.1433	***	0.1293	***
		[0.007]		[0.007]		[0.007]		[0.007]	
Observations	445.490								
R^2		0.3632		0.3632		0.3633		0.3821	

*: Significant at the 0.10 level. **: Significant at the 0.05 level. ***: Significant at the 0.01 level. Robust standard errors are in brackets.

Appendix 1. Information about the cities

Table A.1. Cities, province and entrepreneurship capital [ln(*E*)=ln(*n/POP*)]

Id	*Province*	*City*	ln*(E)*
1	Azuay	Cuenca	-3.0182
2	Azuay	Girón	-3.2274
3	Azuay	Gualaceo	-3.1349
4	Azuay	Nabon	-4.3457
5	Azuay	Paute	-3.3003
6	Azuay	Pucara	-4.7157
7	Azuay	San Fernando	-3.1218
8	Azuay	Santa Isabel	-3.4550
9	Azuay	Sigsig	-3.7435
10	Azuay	Oña	-3.3012
11	Azuay	Chordeleg	-3.2250
12	Azuay	El Pan	-4.2806
13	Azuay	Sevilla De Oro	-4.7490
14	Azuay	Guachapala	-3.5803
15	Azuay	Camilo Ponce	-3.9874
16	Bolivar	Guaranda	-3.8114
17	Bolivar	Chillanes	-4.3755
18	Bolivar	Chimbo	-4.2240
19	Bolivar	Echeandia	-3.6464
20	Bolivar	San Miguel	-4.3490
21	Bolivar	Caluma	-3.4211
22	Bolivar	Las Naves	-4.2488
23	Cañar	Azogues	-3.2371
24	Cañar	Biblian	-3.7072
25	Cañar	Cañar	-3.7844
26	Cañar	La Troncal	-3.1182
27	Cañar	El Tambo	-3.1801
28	Cañar	Deleg	-3.8958
29	Cañar	Suscal	-3.2023
30	Carchi	Tulcán	-3.3345
31	Carchi	Bolívar	-4.6015
32	Carchi	Espejo	-3.8908
33	Carchi	Mira	-4.3386
34	Carchi	Montufar	-3.7071
35	Carchi	San Pedro De Huaca	-4.1684
36	Cotopaxi	Latacunga	-3.3709
37	Cotopaxi	La Mana	-3.7007
38	Cotopaxi	Pangua	-4.9668
39	Cotopaxi	Pujilí	-4.7728
40	Cotopaxi	Salcedo	-3.7241
41	Cotopaxi	Saquisilí	-3.9030
42	Cotopaxi	Sigchos	-4.8723
43	Chimborazo	Riobamba	-2.9972
44	Chimborazo	Alausí	-4.4344
45	Chimborazo	Colta	-4.9580
46	Chimborazo	Chambo	-3.2051
47	Chimborazo	Chunchi	-3.5055
48	Chimborazo	Guamote	-4.7724
49	Chimborazo	Guano	-4.4569
50	Chimborazo	Pallatanga	-3.8205
51	Chimborazo	Penipe	-4.4849
52	Chimborazo	Cumandá	-3.3983
53	El Oro	Machala	-3.2025
54	El Oro	Arenillas	-3.6597
55	El Oro	Atahualpa	-4.2524
56	El Oro	Balsas	-3.2806
57	El Oro	Chilla	-3.5981
58	El Oro	El Guabo	-3.8224
59	El Oro	Huaquillas	-2.9761
60	El Oro	Marcabeli	-3.2374
61	El Oro	Pasaje	-3.5044
62	El Oro	Piñas	-3.4440
63	El Oro	Portovelo	-3.3809
64	El Oro	Santa Rosa	-3.4548
65	El Oro	Zaruma	-3.8113
66	El Oro	Las Lajas	-3.8600
67	Esmeraldas	Esmeraldas	-3.6238
76	Guayas	Alfredo Baquerizo	-4.2588
77	Guayas	Balao	-4.1895
78	Guayas	Balzar	-3.8835
79	Guayas	Colimes	-4.4375
80	Guayas	Daule	-4.1358
81	Guayas	Durán	-3.6091
82	Guayas	El Empalme	-3.9694
83	Guayas	El Triunfo	-3.5248
84	Guayas	Milagro	-3.5965
85	Guayas	Naranjal	-3.9144
86	Guayas	Naranjito	-3.6139
87	Guayas	Palestina	-3.7234
88	Guayas	Pedro Carbo	-3.7683
89	Guayas	Samborondón	-4.1514
90	Guayas	Santa Lucía	-4.4758
91	Guayas	Salitre (Urbina Jado)	-4.7452
92	Guayas	San Jacinto De Yaguachi	-4.1990
93	Guayas	Playas	-3.4257
94	Guayas	Simón Bolívar	-5.1219
95	Guayas	Marcelino Maridueña	-3.7255
96	Guayas	Lomas De Sargentillo	-3.6470
97	Guayas	Nobol	-3.9352
98	Guayas	General Antonio	-3.2861
99	Guayas	Isidro Ayora	-4.2000
100	Imbabura	Ibarra	-3.0627
101	Imbabura	Antonio Ante	-3.4760
102	Imbabura	Cotacachi	-3.8629
103	Imbabura	Otavalo	-3.4349
104	Imbabura	Pimampiro	-3.9815
105	Imbabura	San Miguel De Urcuqui	-4.4834
106	Loja	Loja	-2.9886
107	Loja	Calvas	-3.2246
108	Loja	Catamayo	-2.9686
109	Loja	Celica	-3.7304
110	Loja	Chaguarpamba	-3.7827
111	Loja	Espindola	-4.5024
112	Loja	Gonzanama	-4.1083
113	Loja	Macará	-2.9946
114	Loja	Paltas	-3.6822
115	Loja	Puyango	-3.4925
116	Loja	Saraguro	-4.0516
117	Loja	Sozoranga	-4.8071
118	Loja	Zapotillo	-4.0477
119	Loja	Pindal	-3.6531
120	Loja	Quilanga	-4.1123
121	Loja	Olmedo	-4.7067
122	Los Ríos	Babahoyo	-3.7529
123	Los Ríos	Baba	-4.7656
124	Los Ríos	Montalvo	-3.6824
125	Los Ríos	Puebloviejo	-4.3265
126	Los Ríos	Quevedo	-3.5309
127	Los Ríos	Urdaneta	-4.0615
128	Los Ríos	Ventanas	-3.8093
129	Los Ríos	Vinces	-4.2740
130	Los Ríos	Palenque	-4.7662
131	Los Ríos	Buena Fe	-3.7507
132	Los Ríos	Valencia	-4.3744
133	Los Ríos	Mocache	-4.4757
134	Los Ríos	Quinsaloma	-3.9926
135	Manabí	Portoviejo	-3.6503
136	Manabí	Bolívar	-4.2415
137	Manabí	Chone	-4.2709
138	Manabí	El Carmen	-3.9565
139	Manabí	Flavio Alfaro	-4.6013
140	Manabí	Jipijapa	-3.8725
141	Manabí	Junín	-4.6674
142	Manabí	Manta	-3.3349

68	Esmeraldas	Eloy Alfaro	-4.5666
69	Esmeraldas	Muisne	-4.4853
70	Esmeraldas	Quinindé	-4.2170
71	Esmeraldas	San Lorenzo	-4.6048
72	Esmeraldas	Atacames	-3.5365
73	Esmeraldas	Rioverde	-4.7916
74	Esmeraldas	La Concordia	-3.4795
75	Guayas	Guayaquil	-3.4033

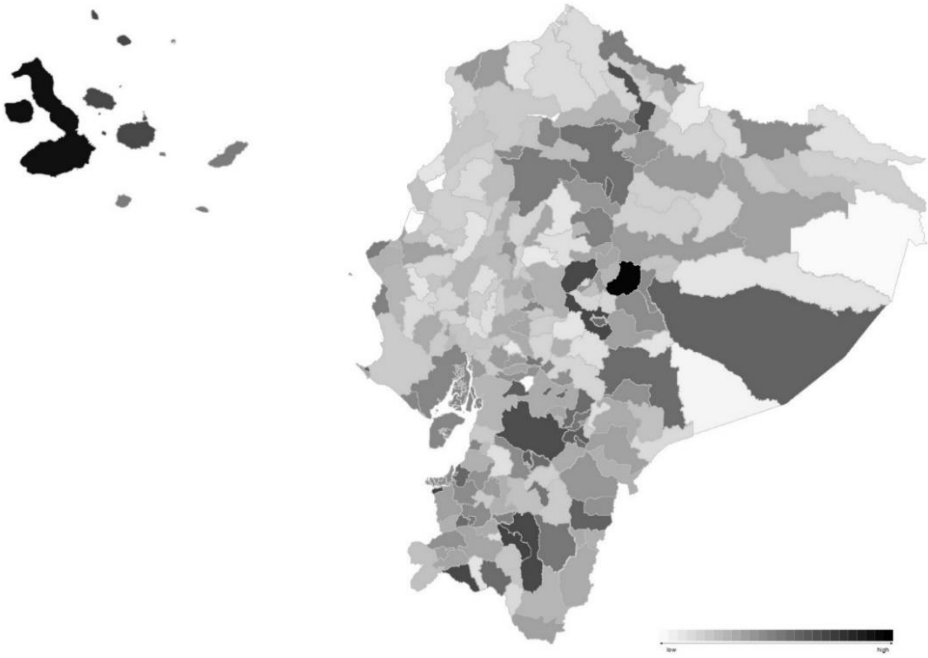
143	Manabí	Montecristi	-3.8606
144	Manabí	Pajan	-4.5094
145	Manabí	Pichincha	-4.7837
146	Manabí	Rocafuerte	-4.0082
147	Manabí	Santa Ana	-4.3944
148	Manabí	Sucre	-3.9951
149	Manabí	Tosagua	-4.2462
150	Manabí	24 De Mayo	-4.7975

Id	***Province***	***City***	**ln(*E*)**
151	Manabí	Pedernales	-4.0930
152	Manabí	Olmedo	-4.1257
153	Manabí	Puerto López	-3.3819
154	Manabí	Jama	-4.8894
155	Manabí	Jaramijó	-3.8741
156	Manabí	San Vicente	-4.0784
157	Morona Santiago	Morona	-3.2226
158	Morona Santiago	Gualaquiza	-3.5479
159	Morona Santiago	Limón Indanza	-3.6370
160	Morona Santiago	Palora	-3.4600
161	Morona Santiago	Santiago	-3.7759
162	Morona Santiago	Sucua	-3.4913
163	Morona Santiago	Huamboya	-4.8243
164	Morona Santiago	San Juan Bosco	-3.8049
165	Morona Santiago	Taisha	-5.7617
166	Morona Santiago	Logroño	-4.0471
167	Morona Santiago	Pablo Sexto	-3.6581
168	Morona Santiago	Tiwintza	-4.5222
169	Napo	Tena	-3.6142
170	Napo	Archidona	-4.2906
171	Napo	El Chaco	-3.6023
172	Napo	Quijos	-4.3054
173	Napo	Carlos Julio	-4.1120
174	Pastaza	Pastaza	-3.1517
175	Pastaza	Mera	-3.4514
176	Pastaza	Santa Clara	-4.1716
177	Pastaza	Arajuno	-4.9280
178	Pichincha	Quito	-3.2507
179	Pichincha	Cayambe	-3.5461
180	Pichincha	Mejia	-3.5635
181	Pichincha	Pedro Moncayo	-4.0691
182	Pichincha	Rumiñahui	-3.1552
183	Pichincha	San Miguel De Los	-3.9781
184	Pichincha	Pedro Vicente	-3.4054
185	Pichincha	Puerto Quito	-4.1634
186	Tungurahua	Ambato	-2.9979

Id	***Province***	***City***	**ln(*E*)**
187	Tungurahua	Baños De Agua Santa	-2.6995
188	Tungurahua	Cevallos	-3.5957
189	Tungurahua	Mocha	-3.5743
190	Tungurahua	Patate	-3.8790
191	Tungurahua	Quero	-4.0310
192	Tungurahua	San Pedro De Pelileo	-3.6050
193	Tungurahua	Santiago De Pillaro	-3.7227
194	Tungurahua	Tisaleo	-4.5442
195	Zamora Chinchipe	Zamora	-3.3073
196	Zamora Chinchipe	Chinchipe	-3.6458
197	Zamora Chinchipe	Nangaritza	-3.7935
198	Zamora Chinchipe	Yacuambi	-4.2057
199	Zamora Chinchipe	Yantzaza	-3.1566
200	Zamora Chinchipe	El Pangui	-3.5205
201	Zamora Chinchipe	Centinela Del Condor	-3.7394
202	Zamora Chinchipe	Palanda	-3.8984
203	Zamora Chinchipe	Paquisha	-3.8624
204	Galápagos	San Cristobal	-3.0085
205	Galápagos	Isabela	-2.7377
206	Galápagos	Santa Cruz	-3.3390
207	Sucumbíos	Lago Agrio	-3.4654
208	Sucumbíos	Gonzalo Pizarro	-4.4744
209	Sucumbíos	Putumayo	-4.6529
210	Sucumbíos	Shushufindi	-4.0753
211	Sucumbíos	Sucumbios	-4.9931
212	Sucumbíos	Cascales	-4.5444
213	Sucumbíos	Cuyabeno	-4.2978
214	Orellana	Orellana	-3.6484
215	Orellana	Aguarico	-6.4067
216	Orellana	La Joya De Los Sachas	-4.2598
217	Orellana	Loreto	-4.3841
218	Sto. Dom. de los Tsáchilas	Santo Domingo	-3.3384
219	Santa Elena	Santa Elena	-4.2294
220	Santa Elena	La Libertad	-3.1690
221	Santa Elena	Salinas	-3.6982
222	Manabí*	Manga Del Cura	-2.9518

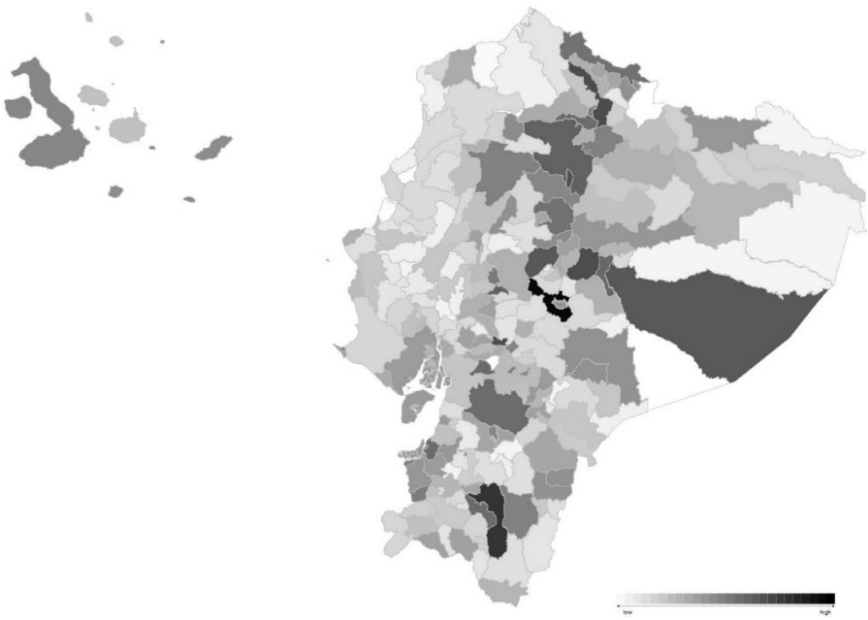
Note: (*) Recently incorporated to the province of Manabí.
Source: National Institute of Statistics and Censuses, INEC, 2010.

Graph A.1. Entrepreneurship Capital Density



Note: Obserbvations: 445.490 (Entrepreneurial density = *n/POB*)
Source: Own elaboration, using CENEC data.

Graph A.2. Technological Entrepreneurship Capital Density



Note: Observations: 21.728 (Technological entrepreneurial density = n_{Tech}/POB)
Source: Own elaboration, with CENEC data.

Appendix 2. Entrepreneurship capital measured by cities' Start Ups.

In the table below, the entrepreneurship capital is measured by the average of the three last years ratio between the start ups per inhabitant of each city.

Table A.2. Test of Hypothesis (General Entrepreneurship Capital: Start-Ups).

		Equation [1] Dependent Variable: $\ln Y_{j,i}$							
Model		**(1)**		**(2)**		**(3)**		**(4)**	
Independent Variable	*Coefficient*								
Constant		6.3339 [0.009]	***	6.5635 [0.051]	***	6.5561 [0.061]	***	5.9834 [0.071]	***
$\ln K_{j,i}$	α	0.1663 [0.001]	***	0.1654 [0.001]	***	0.1660 [0.001]	***	0.1375 [0.001]	***
$\ln I_{j,i}$	ϕ	0.2195 [0.001]	***	0.2195 [0.001]	***	0.2196 [0.001]	***	0.2002 [0.001]	***
$\ln L_{j,i}$	β	0.7352 [0.003]	***	0.7348 [0.003]	***	0.7335 [0.003]	***	2.6223 [0.048]	***
$\ln Z_{j,i}$	ρ	0.0577 [0.004]	***	0.0576 [0.004]	***	0.0581 [0.004]	***	0.0584 [0.004]	***
$\ln R_i$	μ			0.0061 [0.005]		0.0245 [0.006]	***	0.0228 [0.006]	***
$\ln S_i$	s			0.1421 [0.015]	***	0.1151 [0.015]	***	0.1950 [0.015]	***
$\ln E_i$	δ			0.0598 [0.009]	***	0.0695 [0.009]	***	-0.1346 [0.011]	***
$\ln E_i * \ln R_i$	δ_{RD*E}			0.0015 [0.001]		0.0047 [0.001]	***	0.0045 [0.001]	***
$\ln(KE_i/E_i)$	δ_{KE}					-0.0461 [0.011]	***	-0.0701 [0.011]	***
$\ln(IE_i/E_i)$	δ_{IE}					0.0478 [0.008]	***	0.1670 [0.008]	***
$\ln E_i * \ln L_i$	δ_S							0.3565 [0.009]	***
$D_{Tech\ j,i}$	d_T							0.6003 [0.113]	***
$\ln E_i * D_{Tech\ j,i}$	δ_T							0.1452 [0.021]	***
$D_{Inform\ j,i}$	d_I							-0.0541 [0.062]	
$\ln E_i * D_{Inform\ j,i}$	δ_I							0.0795 [0.011]	***
$D_{BigCities\ j,i}$	d_B	0.1827 [0.004]	***	0.1356 [0.007]	***	0.1333 [0.007]	***	0.1198 [0.007]	***
Observations	445,490								
R^2		0.3629		0.3632		0.3633		0.3825	

*: Significant at the 0.10 level. **: Significant at the 0.05 level. ***: Significant at the 0.01 level. Robust standard errors are in brackets.

Concluding Remarks

This Ph.D. Dissertation has analysed some methodological concerns about the existing empirical evidence around the Knowledge Spillover Theory of Entrepreneurship (KSTE) (Acs et al., 2009). The results seems to be a preliminary warning that the role of entrepreneurship capital as a public good in regional economies may be overestimated by the current literature, and consequently the profits associated with a public intervention. More concretely, using data panel of Spanish provinces and Autonomous Communities, different measures of entrepreneurship capital and measuring the spillovers at the firm and regional level we find that:

i) There is no clear evidence that temporal changes in the entrepreneurship capital of one region are positively correlated with changes in the productivity of the firms in the region.
ii) There is clear evidence that the firms in those regions with higher entrepreneurship capital are more productive.

This last evidence is also confirmed for the case of Ecuador. Obviously, it is needed further evidence using the methodological innovations proposed in this Ph.D. Dissertation for confirming the generality of these results. In the case of confirmation, these results opens and interesting theoretical debate. At least, there are two interpretations of those results. The first one is that cross-section data sets omit time invariant variables correlated with entrepreneurship capital. Then, the relationship between the regional entrepreneurship capital and firms' productivity is an spurious one. An alternative interpretation is that the empirical evidence uses measures of a latent variable, entrepreneurship capital. The annual variation in the measure is an imperfect indicator of the annual variation in the latent variable. In short, the variations in the measures of entrepreneurship capital among the periods of time analysed is a random one. Given the implication of one or another type of interpretations, it is key to generate further empirical evidence in order to distinguish among them.

A methodological contribution of this Ph.D. Dissertation to the literature is the measure of the regional entrepreneurship capital spillovers on firms' productivity using data at the firm level. This kind of data let us to open a new research question in the literature, which kind of firms benefit the most from those spillovers. The evidence is generated using databases from Spain and Ecuador, with different regional sizes (Autonomous Communities and cities) and different measures of entrepreneurship capital. The results suggests that the informal firms and those in technological sectors benefit more from those spillovers. Related with the size of the firms, in Ecuador and Spain we obtain different results. While in Ecuador, big firms benefit more from the spillovers, in Spain are the smaller ones. Theoretical work it is needed to understand such differences in the absorptive capacity of the firms and empirical evidence to confirm the generality of these results and analyse other sources of differences.

The Ph.D. Dissertation also provides insights about the heterogeneity of the regional entrepreneurship capital and its implications on the spillovers in firms' production. The main contribution of this Ph.D. Dissertation in this debate is to provide evidence about a new source of heterogeneity, the level of informality of the entrepreneurs. We find that in those Ecuadorian cities with a relatively high weight of informal establishments, the spillovers are higher. The thesis also analyse another source of heterogeneity, the technological intensity of the entrepreneurship capital. As previous evidence (Audretsch y Keilbach, 2005; 2008), the results are unclear, while in Spain reinforces the spillovers, in Ecuador reduces it. New evidence is needed to analyse other sources of heterogeneity and confirm the generality of the current results. Further theoretical work will help to make sense of all these results.

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