Intangible capital and business productivity

Paz Rico & Bernardí Cabrer-Borrás

Published online: 10 Dec 2019.

Submit your article to this journal ↗

Article views: 688

View related articles ↗

View Crossmark data ↗

Citing articles: 1 View citing articles ↗

Routledge
Taylor & Francis Group

Intangible capital and business productivity

Paz Rico 🆔 and Bernardí Cabrer-Borrás

Department Economic Analysis, University of ValSencia, Valencia, Spain

ABSTRACT

The importance of intangible capital as a driver of productivity growth is recognised at both macroeconomic and microeconomic levels. However, in general, there is a lack of strong empirical evidence in the relevant literature on the connection between micro and macro approaches. This study integrates both perspectives to analyse how internal and external intangible capital influence the productivity of companies and, therefore, economic growth. A model is estimated in which the total factor productivity of companies is explained through their internal and external intangible capital. To this end, regional characteristics are considered in terms of technological endowment, human capital, and entrepreneurial capital. In addition, other agglomeration economies such as regional specialisation and regional productive diversity are also considered. In the empirical application, a panel of companies from the seventeen Spanish regions over the period 2006–2015 is used. The findings suggest that there is a positive effect of intangible capital on companies' productivity and evidence of a spillover effect as a result of local intensities of intangibles.

1. Introduction

The importance of intangible capital as a driver of productivity growth is recognised both at a macroeconomic level (Corrado, Hulten, & Sichel, 2009; Corrado, Haskel, Jona-Lasinio, & Iommi, 2012; Goodridge, Haskel, & Wallis, 2017) and a microeconomic level (Piekkola, 2014; Marrocu, Paci, & Pontis, 2012; Riley & Robinson, 2011). At a macroeconomic level, there is consensus in the economic literature on a strong relationship between regional economic development and the level of knowledge and innovation, concluding that regions with higher levels of technological development and innovation show greater growth.

At the company level, intangible capital is an important determinant of innovation and is a source of future economic growth. According to Marrocu et al. (2012), the competitiveness and success of companies in industrialised countries are increasingly based on intangible capital that includes, among other things, innovation in new

---

processes and products, improvement in the skills of employees, and the building of a strong company reputation. Therefore, intangible assets are fundamental for improving the productivity of companies and, consequently, for the development of local economies.

In the macroeconomic or regional approach, several types of intangible capital, such as human, technological, and entrepreneurial capital, are considered for the effect they have on economic development. These effects are generally interpreted as externalities that positively influence the agglomeration of economic activities and economic results at a local level (Marrocu et al., 2012).

In general, there is a lack of strong empirical evidence in the relevant literature on the connection between micro and macro approaches. Riley and Robinson (2011) and Marrocu et al. (2012) consider both approaches, showing 'the positive influence of the internal intangible capital on company productivity levels and also the crucial role played by the external environment'. Other studies that examine the effect of intangible capital within businesses do not generally consider the potential effect of the local external environment on business performance. This research integrates both micro and macro perspectives to analyse how internal and external intangible capital influence the productivity of companies.

This study addresses the effect that the intangible capital of a company has on its efficiency, taking where its productive activity is geographically located into account with the objective of analysing the importance of the intangible capital endowment of that region. Therefore, to analyse how they are associated with company efficiency, both business and regional intangible capital are considered. Total factor productivity (TFP) is an indicator of efficiency since it includes the contribution to growth made by technological, organisational, and other improvements. Analysing the determinants of the productivity of companies and the impact of their environment is of great interest both for researchers and policy-makers due to the effect on economic growth. In this study, a model is specified and estimated in which TFP is explained by a company's internal and external intangible capital. The characteristics of the regional location are considered in terms of technological endowment, human capital, and entrepreneurial capital. Similarly, other agglomeration economies are considered, differentiating between economies of specialization (Marshall, 1890) and the productive diversity of the region (Jacobs, 1969).

This paper is divided into six sections. Section 2 presents a review of the literature. Section 3 presents the methodology used and Section 4 analyses the data used in the research. The empirical results are presented in Section 5 and Section 6 contains the main conclusions of the study.

2. Literature review

From the microeconomic approach, measuring intangible assets is, by its very nature, difficult (Riley & Robinson, 2011) and further complicated by the lack of an accurate definition (Webster & Jensen, 2006; Marrocu et al., 2012). As Riley and Robinson (2011) point out, 'intangible assets are those inputs into the production process for

which there is little traceable evidence in a standard accounting sense'. Intangible assets include knowledge and organisational capital that affect the productivity of the company. Shahzad, Bajwa, Siddiqi, Ahmid, and Raza (2016) conclude that knowledge management processes lead to organisational creativity and performance. Marrocu et al. (2012) indicate it is not so simple to determine whether elements, such as software, R&D expenditure, patents, economic competencies, and employee training, should be considered as current expenses or capital accumulation in the accounting procedure. In his seminal paper, Griliches (1979) includes knowledge, measured by R&D expenditure, patents, and new products as an input in the company production function in addition to physical capital and labour. Riley and Robinson (2011) estimate the determinants of productivity at the company level, measured not only in terms of labour productivity but also in terms of wages. Among the determinants, they consider the company's intangible capital and agglomeration economies with special emphasis on the economies that entail business and regional intangible capital. Piekkola (2014) also demonstrates that intangible capital improves company and regional performance. Similarly, Marrocu et al. (2012) analyse the effect that the intangible capital accumulated by a company and its local environment has on a company's productivity. According the authors, intangible capital includes human, technological, public or institutional, and social capital.

From the macroeconomic perspective and in line with Marrocu et al. (2012), the effects of intangible capital are generally interpreted as externalities that lead to agglomeration economies.

Agglomeration can be defined, simply, as the regional concentration of economic activity. In general, agglomeration economies are considered beneficial since they bring improvements to companies and local economies in terms of efficiency, such as the reduction of transaction costs, economies of scale, and specialization of the workforce (Krugman, 1991, 1998; Duraton & Puga, 2004). However, agglomeration economies do not have to be exclusively positive. For example, a negative effect is the congestion that the concentration of companies can generate (Swann, 1996).

In general, externalities are classified into two types: localisation or specialization, and urbanisation economies. The former refers to the concentration of companies of the same sector in one region (Marshall, 1890), while the latter is related to the size or productive diversity of the region (Jacobs, 1969). Duraton and Puga (2004) and Rosenthal and Strange (2004) offer comprehensive reviews of the literature on agglomeration economies from a theoretical and empirical viewpoint, respectively. These studies classify the sources of agglomeration economies into three types: sharing, matching, and knowledge spillovers. Sharing is related to the existence of economies of scale in production. Matching refers specifically to the labour market, in particular, to the way in which the supply and demand of employers and workers are met. Finally, according to Rosenthal and Strange (2004), knowledge spillovers are the most interesting from the viewpoint of the microeconomic foundation, but the authors recognise that identifying knowledge empirically can be difficult. Similarly, Griliches (1992) highlights the difficulty of directly measuring knowledge and presents a review of the literature that quantifies knowledge using indirect methods.

The contribution of investment in R&D to economic growth is recognised by both theoretical and empirical literature (Coe & Helpman, 1995; Griliches, 1998; Griliches & Lichtenberg, 1984; Guellec & Van Pottelsberghe de la Potterie, 2004; Jacobs, Nahuis, & Tang, 2002). Investment in R&D has been one of the most widely used variables as a proxy for knowledge or innovation. Goodridge et al. (2017) point to extensive literature that demonstrates the spillover effect of investment in R&D. At the industry level, Corrado, Hulten, and Sichel (2005) analyse the relationship between the growth of TFP and that of the stock of knowledge, distinguishing between R&D expenditure and other intangible expenditure. Findings reveal a significant correlation between growth of TFP and intangible capital.

Human capital is one of the most used factors in growth models (Barro, 1991, 2001; Barro & Lee, 1993; Barro & Sala-I-Martin, 2004; Becker, 1975; Mincer, 1984; Romer, 1986). Other studies relate human capital to the creation of businesses and technological diffusion. This approach is seen in a number of contributions, including Sevilir (2010), Kato and Honjo (2015), and Vila, Cabrer, and Pavia (2014), among others. Acemoglu and Angrist (1999) and Moretti (2000) measure the externalities of human capital through workers' educational level. Audretsch and Feldman (1996) consider innovative activity as a reflection of the level of research in universities, the investment in R&D, and the degree of qualified work. Blake, Sinclair, and Campos (2006) find that physical capital, human capital, innovation, and the competitive environment are determining factors in company productivity. In addition, Sun, Zhang, Zhang, Ma, and Zhang (2015) conclude that technological progress is the main factor in variations of TFP in the tourism sector.

With respect to entrepreneurial capital, Audretsch (2007) argues that policies to promote entrepreneurial activity generate economic growth. Acs, Estrin, Mickiewicz, and Szerb (2018) suggest that the positive relationship between entrepreneurship and economic growth can be traced back to Schumpeter (1934). Since then, extensive literature has set out to demonstrate the existence of this positive relationship. Wennekers and Thurik (1999) and, more recently, Carree and Thurik (2010) provide a review of the literature that covers the relationship between entrepreneurship and economic growth. From empirical evidence, the results lead us to conclude that entrepreneurial activity is a key factor in achieving an improvement in productivity and thus generating economic growth. Callejón and Segarra (1999) find evidence of a positive relationship between business dynamics and the growth of TFP. Similarly, Holtz-Eakin and Kao (2003) reveal that an increase in business birth rates leads to higher levels of productivity. Audretsch and Keilbach (2004, 2008), and Audretsch, Keilbach, and Lehmann (2006) also consider the rate of new business as a proxy for entrepreneurial capital and find that knowledge-intensive businesses increase economic growth. Van Stel, Carree, and Thurik (2005) conclude that entrepreneurship is directly linked to growth in rich countries and inversely linked in poorer countries. Erken, Donselaar, and Thurik (2018) infer that entrepreneurship activity has a significant impact on TFP. Similarly, using regional data from the Spanish economy, Rico and Cabrer-Borrás (2019) find that entrepreneurial capital, innovation, and human capital have a positive effect on regional productive efficiency.

3. Methodology

According to the neoclassical theory of economic growth, production is a function of two factors, physical capital and labour, while technological progress is regarded as a residual factor. Solow (1956) recognised that growth was influenced by technological change but, in the formalisation of the production function, he considered it to be an exogenous factor.

Subsequently, Romer (1986) and Lucas' (1988, 1993) models of endogenous growth introduced technological progress as an endogenous factor. They considered knowledge to be transmitted through externalities and to generate spillover effects on the economy.

The Cobb and Douglas (1928) production function is specified as follows:

$$Y_{it} = A_{it}K_{it}^{\alpha}L_{it}^{\beta} \tag{1}$$

where Y_{it} is the production in real terms of firm i in time t, A_{it} measures the technological advance or productive efficiency, K_{it} is the physical capital stock, L_{it} is the labour, whilst α is the elasticity of production for the physical capital factor and β the elasticity of production for the labour factor.

Taking logarithms from equation (1), the following equation is obtained:

$$\ln Y_{it} = \ln A_{it} + \alpha \ln K_{it} + \beta \ln L_{it} \tag{2}$$

TFP is defined as the part of production that cannot be explained by the inputs used in the production process. The growth of production can be decomposed into three sources: the growth of the labour factor, the physical capital factor, and that of TFP (Audretsch & Keilbach, 2004). According to neoclassical theory, the growth of TFP reflects unincorporated technological progress. However, in practice, the growth of TFP is obtained as a residual that also includes improvements in the efficiency of productive inputs.

Therefore, after estimating equation (2), TFP can be expressed as:

$$\ln A_{it} - \ln Y_{it} - \hat{\alpha} \ln K_{it} - \hat{\beta} \ln L_{it} \tag{3}$$

TFP for each company in the sample is calculated for each year of the sample period. A model is then specified that includes the characteristics of the company, such as intangible assets, benefits, the age of the company, the legal form, and the technological level used. Regional factors are also considered, such as the volume of human capital, the entrepreneurial capital, and the R&D expenditure of the region in which the company operates. In addition, the effect that other agglomeration economies can have on business productivity is taken into account, which is in line with Riley and Robinson (2011). In particular, the model includes measures of regional specialization (Marshall, 1890) and sectorial diversity of the regions (Jacobs, 1969).

In general, economic behaviour is subject to a strong tendency that is usually captured by a term of inertia. Hence, the specified model would be:

$$LnTFP_{ijt} = \alpha_1 + \alpha_2 LnTFP_{ijt-1} + \sum_{i=1}^{I} \beta_i X_{ijt} + \sum_{j=1}^{J} \gamma_j Z_{ijt} + Control\ V. + u_{ijt} \quad (4)$$

where vector X_{ijt} represents the characteristics of the company i in region j in year t, Z_{ijt} represents the regional characteristics of region j where company i is localised in year t, and the control variables include dummy variables of the regions, sectors, and time.

Since equation (4) includes a lag of the endogenous variable, a dynamic model is estimated using the method of instrumental variables to obtain consistent estimators.

The study proposes testing the following hypotheses empirically:

H1: The intangible capital of a company has a positive effect on its TFP.

H2: Regional human capital endowment positively affects companies' TFP.

H3: Higher regional R&D expenditure implies greater TFP.

H4: Entrepreneurship has a positive impact on companies' TFP.

H5: There are positive agglomeration economies due to the specialization and sectorial diversity of the regions.

4. Data and variables

The data used in this research come from different institutions, both public and private. The Iberian Balance Sheet Analysis System (SABI) database provides information on the economic and financial accounts of Spanish and Portuguese companies. From this database, and in line with Marrocu et al. (2012), a sample of Spanish companies with an asset size exceeding 30 million euros is extracted for the period 2006–2015. To obtain the sample, the following three conditions are set: the company must be active, it must not present negative personal funds, and it must provide information on the number of workers and intangible capital. After eliminating the observations that do not meet the conditions set, the sample consists of 35,779 observations. For each of the companies in the sample, information on the number of employees, the tangible fixed assets, the intangible fixed assets, the value added, the economic profitability, the date of incorporation, the legal form, the location of the company, and the productive sector to which the company activity belongs is obtained from SABI. Ten productive sectors are considered.[1]

The source of the stock of regional human capital comes from the estimates made by the BBVA-IVIE Foundation, while the R&D expenditure per inhabitant of each region for each year of the sample period is obtained from the National Institute of Statistics (INE). The indicator of entrepreneurship activity is obtained from the Global Entrepreneurship Monitor (GEM). GEM uses a survey of the adult population to obtain the percentage of entrepreneurial activity and to calculate the Total Entrepreneurial Activity (TEA) each year.

TFP is measured by the Solow residual as it is defined as the portion of output that is not explained by the inputs or basic factors used in production. For this, the added value of companies, in real terms, the number of employees and the volume of liabilities and capital are used. Once TFP is estimated for each of the years and companies considered,

econometric models are estimated to analyse and quantify the effect of intangible capital on TFP.

In relation to the variables that characterise the companies, the age of the company is the period in years since its establishment until the end date considered in the sample. The profitability is measured through the return on assets (ROA), which is defined as the quotient between the profit before interest and taxes and the total assets of the company. With the objective of measuring the possible different response of TFP to profitability, a dichotomous variable is generated that takes value one if the ROA of the company is positive and otherwise zero. To allow for the legal form of the company, a binary variable (PLC) is generated that takes value one if the company is constituted as a public limited company and otherwise zero.

Depending on the degree of technology used, the production sectors can be classified into technological and non-technological. The INE considers the following sectors as high and medium-high technology sectors:

- High technology: pharmaceutical industry (21), manufacturers of computer, electronic, and optical products (26), aeronautical and space construction and machinery (303), motion picture, video and television program activities, recording of sound, and music publishing (59), programming activities and broadcasting of radio and television (60), telecommunications (61), programming, consulting, and other activities related to computer science (62), information services (63) and, finally, research and development (72).
- Medium-high technology: chemical industry (20), manufacturers of weapons and ammunition (254), manufacturers of electrical equipment (27), manufacturers of machinery and equipment not specified elsewhere (28), manufacturers of motor vehicles, trailers, and semi-trailers (29), manufacturers of other transport equipment (30) except shipbuilding (301) and aeronautical and space construction and machinery (303), and manufacturers of instruments and medical and dental supplies (325).
- Other sectors not included in the two previous categories are classified as non-technological sectors.

With regards to business size, measured by the number of employees, four categories are considered: microenterprises (companies with fewer than 10 workers), small companies (between 10 and 50 workers), medium-sized companies (between 50 and 250 workers), and large companies (more than 250 workers).

The variable value added (VA) is used for the calculation of the representative variables of agglomeration economies. The coefficient of specialization compares the productive structures of the regions to the national average. A value close to zero will reflect similar structures between the region and the national set, while a value close to one will indicate very different productive structures.

$$AG\_Esp_j = \frac{1}{2} \sum_{k=1}^{n} \left| \left(\frac{VA_{kj}}{\sum_{k=1}^{n} VA_{kj}} \right) - \left(\frac{\sum_{j=1}^{17} VA_{kj}}{\sum_{k=1}^{n} \sum_{j=1}^{17} VA_{kj}} \right) \right| \tag{5}$$

The subscript k refers to sector k while the subscript j corresponds to region j.

An alternative and complementary analysis focuses on studying the evolution of sectorial participation in each region, not in comparative terms but in relation to the regional economy itself. Thus, the less homogeneous the sectorial distribution of value added is within a region, the greater both the diversity coefficient and sectorial diversity will be.

$$AG\_Div_j = \sum\nolimits_{k=1}^{n} \left(\frac{VA_{kj}}{\sum_{j=1}^{17} VA_{kj}} \right)^2 \tag{6}$$

5. Econometric results

Before reviewing the results of the estimation of the econometric model, a descriptive analysis of the correlation between the factors is presented. Table 1 reports the simple correlation between the variables considered as explanatory factors of TFP. As can be seen, there is a high collinearity between human capital and R&D expenditure in the regions. Similarly, the correlation between agglomeration measures (specialization and sectorial diversity) and human capital and R&D expenditure in the regions is also high. This highlights the fact that introducing these variables together in an econometric model could present problems of high multicollinearity. Similarly, the intangible capital of companies is correlated with human capital, R&D expenditure, and the sectorial diversity of the regions. Finally, the dummy control variables, which represent the regions and sectors to which the companies belong, can explain differences between the regions due to the different levels of human capital, expenditure on R&D, specialization, and sectorial diversity level. Therefore, these dummy variables will also be correlated with the variables that represent the spillover effects of the intangible capital of the regions and the economies on specialization and diversity.

Given the existence of significant correlations between the explanatory variables, different econometric models are estimated to analyse the variables that best explain TFP while avoiding the multicollinearity problems that can be generated when including all the variables together in the model. First, the characteristics of the company are taken into account. The following variables are then added as an alternative to this basic model: the control variables of the regions, the sectors, the regional variables of human capital and investment in R&D, entrepreneurial capital, the size of the company, and the variables that measure agglomeration economies.

The results of the different estimated models are presented in Tables 2–4. The models have been estimated in a manner consistent with the existence of heteroscedasticity in the sample.[2] As shown, TFP of a company presents inertia and the

Table 1. Correlation matrix between explanatory variables.

	Human capital	R&D	AG_Div	AG_Esp	TEA
R&D	0.73***	1			
AG_Div	0.57***	0.72***	1		
AG_Esp	0.55***	0.33***	0.27***	1	
TEA	−0.23***	−0.05***	0.28***	−0.07***	1
LOG (Intangible capital)	0.13***	0.16***	0.14***	0.03***	0.04***

Note: that *** denotes 1% significance.
Source: Compiled by the authors.

Table 2. Regression equation (4) with time dummy variables.

	Model 1	Model 2	Model 3	Model 4
Constant	1.488***	1.441***	1.433***	1.294***
LOG(PTF(-1))	0.459***	0.456***	0.454***	0.457***
LOG (Intangible capital)	0.014***	0.013***	0.012***	0.013***
ROA	0.019***	0.019***	0.019***	0.019***
ROA > 0	0.297***	0.301***	0.301***	0.289***
AGE	−0.004***	−0.004***	−0.004***	−0.004***
AGE∘2	0.001***	0.001***	0.001***	0.001***
PLC	0.037***	0.036***	0.036***	0.039***
High technology	0.113***	0.104***	0.102***	0.111***
Medium technology	0.049***	0.056***	0.045***	0.053***
Micro	0.179***	0.181***	0.176***	0.199***
Small	−0.021***	−0.019***	−0.021**	−0.020**
Medium	−0.039***	−0.033***	−0.034***	−0.038***
AG_Div		0.009***		
AG_Esp		0.232***		
Human capital			−0.001	
R&D			0.068***	
TEA(-1)				0.028***
Time	Yes	Yes	Yes	Yes
Sectors	NO	NO	NO	NO
Regions	NO	NO	NO	NO
R-squared	0.553	0.554	0.555	0.552
Adjusted R-squared	0.553	0.554	0.554	0.551
Akaike Info Criterion	1.311	1.308	1.307	1.263
Observations number	35779	35779	35779	35779

Note: that *** and ** denote 1% and 5% significance, respectively.
The model is estimated by the method of instrumental variables. The estimate is consistent with the existence of heteroscedasticity in the sample. PLC takes value one if the company is a public limited company and zero if otherwise.
Source: Compiled by the authors.

Table 3. Regression equation (4) with time and regions dummy variables.

	Model 1	Model 2	Model 3	Model 4
Constant	1.519***	1.466***	1.433***	1.214***
LOG(PTF(-1))	0.436***	0.467**	0.448***	0.468***
LOG(Intangible capital)	0.012***	0.012***	0.012***	0.012***
ROA	0.019***	0.019***	0.020***	0.019***
ROA > 0	0.307***	0.299***	0.304***	0.290***
AGE	−0.004***	−0.004***	−0.004***	−0.004***
AGE∘2	0.001***	0.001***	0.001***	0.001***
PLC	0.076***	0.036***	0.037***	0.036***
High technology	0.103***	0.097***	0.101***	0.099***
Medium technology	0.044***	0.041***	0.043***	0.042***
Micro	0.183***	0.173***	0.179***	0.194***
Small	−0.024**	−0.023***	−0.023***	−0.023**
Medium	−0.036***	−0.034***	−0.035***	−0.034***
AG_Div		0.001		
AG_Esp		−0.176		
Human capital			0.003	
R&D			0.026	
TEA(-1)				0.029***
Time	Yes	Yes	Yes	Yes
Sectors	NO	NO	NO	NO
Regions	Yes	Yes	Yes	Yes
R-squared	0.556	0.556	0.556	0.555
Adjusted R-squared	0.555	0.552	0.554	0.555
Akaike Info Criterion	1.306	1.306	1.305	1.256
Observations number	35779	35779	35779	35779

Note: that *** and ** denote 1% and 5% significance, respectively.
The model is estimated by the method of instrumental variables. The estimate is consistent with the existence of heteroscedasticity in the sample. PLC takes value one if the company is a public limited company and zero if otherwise.
Source: Compiled by the authors.

Table 4. Regression equation (4) with time and sectors dummy variables.

	Model 1	Model 2	Model 3	Model 4
Constant	1.507***	1.474***	1.511***	1.317***
LOG(PTF(-1))	0.449***	0.447***	0.443***	0.433**
LOG(Intangible capital)	0.012***	0.012***	0.011***	0.012***
ROA	0.019***	0.019***	0.019***	0.019***
ROA > 0	0.307***	0.309***	0.303***	0.302***
AGE	−0.003***	−0.003***	−0.003***	−0.003***
AGE^2	0.001***	0.001***	0.001***	0.001***
PLC	0.035***	0.034***	0.033***	0.037***
High technology	0.058***	0.051***	0.055***	0.056***
Medium technology	0.052***	0.049***	0.044***	0.052***
Micro	0.152***	0.159***	0.179***	0.179***
Small	−0.034***	−0.029***	−0.029***	−0.032***
Medium	−0.037***	−0.033***	−0.033***	−0.037***
AG_Div		0.008***		
AG_Esp		0.214***		
Human capital			−0.005	
R&D			0.064***	
TEA(-1)				0.033**
Time	Yes	Yes	Yes	Yes
Sectors	Yes	Yes	Yes	Yes
Regions	NO	NO	NO	NO
R-squared	0.558	0.559	0.560	0.556
Adjusted R-squared	0.558	0.559	0.559	0.555
Akaike Info Criterion	1.300	1.298	1.245	1.254
Observations number	35779	35779	35779	35779

Note: that *** and ** denote 1% and 5% significance, respectively.
The model is estimated by the method of instrumental variables. The estimate is consistent with the existence of heteroscedasticity in the sample. PLC takes value one if the company is a public limited company and zero if otherwise.
Source: Compiled by the authors.

estimated coefficient of its own history in all the estimated models ranges from 0.43 to 0.47, which means it would take about 1.8 years to recover from any shock that occurs. As expected, the intangible capital of a company positively affects its productivity. Therefore, investment in intangible capital has a positive effect on the company's efficiency and, in all likelihood, on the development of the region in which it is located. In addition, the profitability of the company positively affects its productivity and there is also evidence of a positive differential effect with respect to unprofitable companies.

The age of the company has a negative effect, which decreases very slowly given that age squared has a small but significant and positive coefficient. Similarly, there is evidence of a positive and significant differential effect of public limited companies with respect to companies with alternative legal forms. As expected, the technological level positively affects the efficiency of a company, given that there is a positive differential effect in companies with high and medium technology compared to companies classified in non-technological sectors, which is the reference category. Regarding the size of companies, microenterprises, that is, those with fewer than 10 workers, have a positive differential effect with respect to large companies, which is the reference category. Conversely, small and medium-sized companies have a negative differential effect with respect to large companies. This fact indicates that the size of the company does not have a linear effect on TFP but would likely take the form of a U if the size could be measured continuously.

Model 1 in Table 2 is the basic model. Model 2 includes the variables that reflect the agglomeration economies; it shows an improvement in results compared to the basic model. The model shows that there are positive agglomeration economies, both of specialization and of diversity. However, economies of specialization have a greater spillover effect than urbanisation economies. When considering the variables of human capital and R&D expenditure, which reflect regional intangible capital (Model 3), the model improves with respect to Model 1. Similarly, human capital does not appear to be a significant factor while expenditure on R&D does. The fact that human capital does not appear to be a significant factor could be due to the existence of collinearity between this variable and R&D expenditure in the region. Model 4 includes the variable TEA,[3] which is significant and positive, indicating that there is a spillover effect of the entrepreneurial capital on TFP of a company.

The estimated models included in Table 3 differ from those in Table 2 in that they include the dummy variables of the regions in which the company operates. As can be seen, the representative variables of the agglomeration economies and regional intangible capital are no longer significant and the gain in the adjustment to the data is very small. The loss of significance of the variables that represent the spillover effects is due to the existence of multicollinearity between the variables that characterise the region and the dummy variables that define them. This multicollinearity is due to the fact that the regional dummies capture the differences that the regions present in the variables that represent the spillover effects. Given that the improvement in the adjustment is very small, the regional dummy variables are ultimately not considered.

Finally, the estimated models included in Table 4 consider the dummy variables representative of the sector to which the company belongs. In all the models, the results obtained are the same as those obtained with the models presented in Table 2 but in all of them there is a significant improvement in the fit to the data in all of them; it is therefore appropriate to include the sectorial dummy variables in the model.

In summary, given that the coefficients of these variables are very stable, the results of the estimated models in terms of the characteristics of companies are robust. Similarly, the results indicate that both the internal and external intangible capital of a company positively affect its productivity. Therefore, investment in innovation by the company positively affects its efficiency but the context in which it is developed will also affect its productivity due to the spillover effects implied by the investment in intangible capital of the region. Moreover, it can be concluded that there are agglomeration economies mainly due to economies of specialization but also due to the sectorial diversity of the region.

These results are consistent with those of Riley and Robinson (2011), whose findings reveal that regional intangible capital intensity has a significant and positive effect over and above that of agglomeration, suggesting that there are also spillovers in intangible capital. In addition, as in Marrocu et al. (2012), these results confirm that, given the strong complementarities between the two channels of intangible capital, it is important to design policies that stimulate the accumulation of a company's internal intangible capital as well as favour the increase of intangible assets at a regional level.

6. Conclusions

From the microeconomic perspective, there is evidence that the productivity of a company is positively related to its intangible capital. However, it is important to complement this microeconomic perspective with the macroeconomic one to take the intangible capital endowment of the region where the company is located, and the generation and effect of agglomeration economies on local economic growth into account. This study merged both perspectives to better understand the effects that external and internal intangible capital have on companies' productivity.

From a microeconomic viewpoint, there is a strong inertia in TFP of Spanish companies throughout the period analysed. There is also evidence that productivity is positively related to a company's intangible capital. Productivity is also affected by a company's economic profitability and its age. Younger companies have a higher level of productivity than older companies. In addition, technology-intensive companies are more productive than non-technology-intensive companies. The size of the companies in Spain presents an irregular pattern since those of a smaller and larger size are more productive than those of intermediate size. A further line of research would be to analyse whether this is due to Spanish regulations, which may be discouraging companies from growing, keeping them at a non-optimal size that does not allow them to increase in productivity. Given that the estimated coefficients turn out to be very stable, the different estimated models lead us to conclude that the results are robust.

Regarding regional characteristics, it should be noted that agglomeration economies, R&D expenditure, and entrepreneurial activity are determining factors of TFP of Spanish companies.

The results of the estimated models indicate that Spanish companies' TFP is affected by investment in intangible capital as well as by the existence of regional spillover effects. TFP shows a greater increase in regions that invest more in intangible capital, in particular in R&D. In addition, there is evidence of positive agglomeration economies in the regions, both of the Marshallian and Jacobin type.

In light of the results obtained with regards to business and regional policies, greater investment should be encouraged in regional intangible capital as well as investment in innovation in companies as these are two complementary channels that increase efficiency. The promotion of investment in innovation by companies and regions would generate increases in the efficiency of the regions and would result in their economic growth.

Regional differences could be explained by R&D investment and agglomeration economies generated through externalities. It is clear that for a region to increase the productivity of its companies, it needs to increase its R&D investment and promote sectorial diversity and localisation of companies. To do this, authorities should ensure that the demand for adequate infrastructures and qualified workers can be met.

This study uses an aggregate measure of the intangible capital of companies. Future research could consider a disaggregated measure that includes R&D expenditure, patents, and even the quality of the workforce.

Notes

1. The productive sectors are agriculture, industry, construction, commerce, information and communications, financial activities, real estate activities, professional and scientific activities, public administration, and artistic activities.
2. The standard deviations of the estimators are consistent with heteroscedasticity.
3. A lag of TEA is considered.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Paz Rico ⓘ http://orcid.org/0000-0002-5634-6022

References

Acemoglu, D., & Angrist, J. (1999). *How large are the social returns to educations? Evidence from compulsory schooling laws* (National Bureau of Economic Research (NBER) Working Paper No. 7444). Cambridge. doi:10.3386/w7444

Acs, Z. J., Estrin, S., Mickiewicz, T., & Szerb, L. (2018). Entrepreneurship, institutional economics, and economic growth: an ecosystem perspective. *Small Business Economics*, *51*(2), 501–514. doi:10.1007/s11187-018-0013-9

Audretsch, D. B. (2007). Entrepreneurship capital and economic growth. *Oxford Review of Economic Policy*, *23*(1), 63–78. doi:10.1093/oxrep/grm001

Audretsch, D. B., & Feldman, M. (1996). R and D spillovers and the geography of innovation and production. *American Economic Review*, *86*(4), 253–273.

Audretsch, D. B., & Keilbach, M. (2004). Entrepreneurship capital and economic performance. *Regional Studies*, *38*(8), 949–959. doi:10.1080/0034340042000280956

Audretsch, D. B., & Keilbach, M. (2008). Resolving the knowledge paradox: Knowledge-spillover entrepreneurship and economic growth. *Research Policy*, *37*(10), 1697–1705. doi:10.1016/j.respol.2008.08.008

Audretsch, D. B., Keilbach, M., & Lehmann, E. E. (2006). *Entrepreneurship and economic growth*. New York, NY: Oxford University Press.

Barro, R. J. (1991). Economic growth in a cross section of countries. *Quarterly Journal of Economics*, *106*(2), 155–173.

Barro, R. J. (2001). Human capital and growth. *American Economic Review*, *91*(2), 12–17. doi:10.1257/aer.91.2.12

Barro, R. J., & Lee, J. W. (1993). International comparisons of educational attainment. *Journal of Monetary Economics*, *32*(3), 363–394. doi:10.1016/0304-3932(93)90023-9

Barro, R. J., & Sala-I-Martin, X. (2004). *Economic growth* (2nd ed.). Cambridge, MA: MIT Press.

Becker, G. S. (1975). *Human capital: A theoretical and empirical analysis, with special reference to education*. New York, NY: National Bureau of Economic Research (NBER).

Blake, A., Sinclair, M. T., & Campos, J. A. (2006). Tourism productivity. Evidence from the United Kingdom. *Annals of Tourism Research*, *33*(4), 1099–1120. doi:10.1016/j.annals.2006.06.001

Callejón, M., & Segarra, A. (1999). Business dynamics and efficiency in industries and regions: the case of Spain. *Small Business Economics*, *13*(4), 253–271.

Carree, M. A., & Thurik, R. (2010). The impact of entrepreneurship on economic growth. In Z. J. Acs & D. B. Audretsch (Eds.), *Handbook of entrepreneurship research* (pp. 557–594). New York, NY: Springer. doi:10.1007/978-1-4419-1191-9

Cobb, C., & Douglas, P. (1928). A theory production. *The American Economic Review*, 18(1), 139–165.

Coe, D. T., & Helpman, E. (1995). International R&D spillovers. *European Economic Review*, 38(5), 859–887.

Corrado, C., Haskel, J., Jona-Lasinio, C., & Iommi, M. (2012). *Intangible capital and growth in advanced economies: Measurement methods and comparative results. How large are the social returns to educations?* (IZA Discussion Paper No. 6733). Institute of Labor Economics (IZA), Bonn, Germany.

Corrado, C., Hulten, C., & Sichel, D. (2005). Measuring capital and technology: An expanded framework. In C. Corrado, J. Haltiwanger, & D. Sichel (Eds.), *Measuring capital in the new economy* (pp.11–45). Chicago, IL: University Chicago Press.

Corrado, C., Hulten, C., & Sichel, D. (2009). Intangible capital and U.S. Economic growth. *Review of Income and Wealth*, 55(3), 661–685. doi:10.1111/j.1475-4991.2009.00343.x

Duraton, G., & Puga, D. (2004). Micro-foundations of urban agglomeration economies. In J. V. Hendersom & J. F. Thisse (Eds.), *Handbook of regional and urban economics* (pp. 2063–2117). Amsterdam: Elsevier.

Erken, H., Donselaar, P., & Thurik, R. (2018). Total factor productivity and the role of entrepreneurship. *The Journal of Technology Transfer*, 43(6), 1493–1521. doi:10.1007/s10961-016-9504-5

Goodridge, P., Haskel, J., & Wallis, G. (2017). Spillovers from R&D and other intangible investment: Evidence from UK industries. *Review of Income and Wealth*, 63(S1), 22–48.

Guellec, D., & Van Pottelsberghe de la Potterie, B. P. (2004). From R&D to productivity growth: Do the institutional settings and the source of funds of R&D matter? *Oxford Bulletin of Economics and Statistics*, 66(3), 353–378.

Griliches, Z. (1979). Issues in assessing the contribution of research and development to productivity growth. *The Bell Journal of Economics*, 10(1), 92–116. doi:10.2307/3003321

Griliches, Z. (1992). The search for R&D spillovers. *The Scandinavian Journal of Economics*, 94(supplement), S29–S47.

Griliches, Z. (1998). *R&D and productivity: the econometric evidence*, Chicago, IL: University of Chicago Press.

Griliches, Z., & Lichtenberg, F. R. (1984). R&D and productivity growth at the industry level: Is there still a relationship? In Z. Griliches (Ed.), *R&D, patents, and productivity* (pp. 465–502). Chicago, IL: Chicago University Press and NBER.

Holtz-Eakin, D., & Kao, C. (2003). *Entrepreneurship and economic growth: The proof is in the productivity*. Syracuse: Center for Policy Research Working Paper, No. 50.

Jacobs, B., Nahuis, R., & Tang, P. J. G. (2002). Sectoral productivity growth and R&D spillovers in the Netherlands. *De Economist*, 150(2), 181–210.

Jacobs, J. (1969). *The economy of cities*. New York, NY: Random House.

Kato, M., & Honjo, Y. (2015). Entrepreneurial human capital and the survival of new firms in high- and low-tech sectors. *Journal of Evolutionary Economics*, 25(5), 925–957.

Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy*, 99(3), 399–483. doi:10.1086/261763

Krugman, P. (1998). What's new about the new economic geography? *Oxford Review of Economic Policy*, 14(2), 7–17. doi:10.1093/oxrep/14.2.7

Lucas, R. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, 22(1), 3–42. doi:10.1016/0304-3932(88)90168-7

Lucas, R. (1993). Making a miracle. *Econometrica*, 61(2), 251–272. doi:10.2307/2951551

Marrocu, E., Paci, R., & Pontis, M. (2012). Intangible capital and firms productivity. *Industrial and Corporate Change*, 21(2), 377–402.

Marshall, A. (1890). *Principles of economics*. London: Mcmillan

Mincer, J. (1984). Human capital and economic growth. *Economics of Education Review*, 3(3), 195–205. doi:10.1016/0272-7757(84)90032-3

Moretti, E. (2000). *Estimating the social return to higher education* (National Bureau of Economic Research (NBER) Working Paper No. 9018). Cambridge.

Piekkola, H. (2014). *Intangible capital agglomeration and economic growth: An analysis of regions in Finland* (Working Paper No. 21). University of Vaasa, Department of Economics, Vaasa, Finland. ISBN: 978-952-476-518-3.

Rico, P., & Cabrer-Borrás, B. (2019). Entrepreneurship, firms creation and regional performance. *European Journal of Management and Business Economics*, 28(2), 158–173. doi:10.1108/EJMBE-07-2018-0077

Riley, R., & Robinson, C. (2011). *Agglomeration spillovers from intangible capital: An analysis of UK city regions* (Innodrive Working Paper, No. 15). European Community's Seven Framework Programme.

Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, 94(5), 1002–1037. doi:10.1086/261420

Rosenthal, S., & Strange, W. (2004). Evidence on the nature and sources of agglomeration economies. In J. V. Henderson, & J. F. Thisse (Eds.), *Handbook of regional and urban economics* (pp. 2119–2171). Amsterdam: Elservier.

Schumpeter, J. (1934). *Theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle*. Cambridge, MA: Harvard University Press.

Sevilir, M. (2010). Human capital investment, new firm creation and venture capital. *Journal of Financial Intermediation*, 19(4), 483–508. doi:10.1016/j.jfi.2009.08.002

Shahzad, K., Bajwa, S. U., Siddiqi, A. F. I., Ahmid, F., & Raza, A. (2016). Integrating knowledge management (KM) strategies and processes to enhance organizational creativity and performance: an empirical investigation. *Journal of Modelling in Management*, 11(1), 154–179. doi:10.1108/JM2-07-2014-0061

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, 70(1), 65–94. doi:10.2307/1884513

Sun, J., Zhang, J., Zhang, J., Ma, J., & Zhang, Y. (2015). Total factor productivity assessment of tourism industry: Evidence from China. *Asia Pacific Journal of Tourism Research*, 20(3), 280–294. doi:10.1080/10941665.2013.877047

Swann, G. M. P. (1996). Technology evolution and the rise and fall of industrial clusters. *Revue Internationale de Systemique*, 10(3), 285–302.

Van Stel, A. J., Carree, M. A., & Thurik, A. R. (2005). The effect of entrepreneurial activity on national economic growth. *Small Business Economics*, 24(3), 311–321. doi:10.1007/s11187-005-1996-6

Vila, L. E., Cabrer, B., & Pavía, J. M. (2014). On the relationship between knowledge creation and economic performance. *Technological and Economic Development of Economy*, 21(4), 539–556. doi:10.3846/20294913.2013.876687

Webster, W., & Jensen, P. H. (2006). Investment in intangible capital: An Entreprise Perspective. *Economic Record*, 82(256), 82–96. doi:10.1111/j.1475-4932.2006.00296.x

Wennekers, A. R. M., & Thurik, A. R. (1999). Linking entrepreneurship and economic growth. *Small Business Economics*, 13(1), 27–55. doi:10.1023/A:1008063200484