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European Regional Policy

The 2019 assessment of the macroeconomic effects of the European Fund for Strategic Investments with the RHOMOLO-EIB model

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Abstract:

The European Fund for Strategic Investments (EFSI) is the financial pillar of the Investment Plan for Europe. It tackles the post-crisis investment gap in the European Union (EU) and aims to revive investment in key areas in all the EU Member States. EFSI was launched in 2015 jointly by the European Investment Bank (EIB) Group and the European Commission. Every year, macroeconomic impact assessments are carried out using the spatial dynamic RHOMOLO-EIB model in order to gauge jobs and growth impact of the EFSI-supported operations in the EU. This article illustrates the methodology used for the assessment and reports the result of the latest set of simulations, corresponding to the portfolio of all approved EFSI-supported operations as of the June 13th EIB Board of Directors meeting, 2019. According to the results, EFSI is contributing significantly to job creation and growth. The estimates suggest that, by 2019, more than 1 million jobs are expected to be created thanks to the approved operations (1.7 million by 2022), with a positive contribution to GDP of 0.9% (1.8% expected by 2022) over the baseline.

Keywords: Spatial general equilibrium; fiscal policy; investment.
JEL classification: C63; C68; E61.

Evaluación de 2019 de los efectos macroeconómicos del Fondo Europeo para Inversiones Estratégicas con el modelo RHOMOLO-EIB

Resumen:

El Fondo Europeo para Inversiones Estratégicas (FEIE) es el pilar financiero del Plan de Inversiones para Europa. Aborda la brecha de inversión posterior a la crisis en la Unión Europea (UE) y tiene como objetivo revivir la inversión en áreas clave en todos los Estados miembros de la UE. El FEIE se lanzó en 2015 conjuntamente por el Banco Europeo de Inversiones (BEI) y la Comisión Europea. Cada año, las evaluaciones de impacto macroeconómico se llevan a cabo utilizando el modelo espacial dinámico RHOMOLO-EIB para medir el empleo y el impacto de las operaciones respaldadas por el FEIE en la UE. Este artículo ilustra la metodología utilizada para la evaluación e informa el resultado del último conjunto de simulaciones, correspondiente a la cartera de todas las operaciones aprobadas respaldadas por el FEIE a partir de la reunión de la Junta Directiva del BEI del 13 de junio de 2019. Según los resultados, FEIE está

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contribuyendo significativamente a la creación de empleo y al crecimiento. Las estimaciones sugieren que, para 2019, se espera que se hayan creado más de 1 millón de empleos gracias a las operaciones aprobadas (1,7 millones para 2022), con una contribución positiva al PIB del 0,9% (1,8% esperado para 2022) respecto al escenario base.

Palabras clave: Equilibrio general espacial; política fiscal; inversion.
Clasificación JEL: C63; C68; E61.

1. Introduction

In 2014, the European Union (EU) was still facing the consequences of the 2008 economic and financial crisis. This led the European Commission and the European Investment Bank (EIB) to launch the Investment Plan for Europe, also known as the Juncker Plan (EU, 2015). It has three complementary pillars: The first pillar, the European Fund for Strategic Investments (EFSI), implemented by the EIB Group, aims to mobilise finance for investments. The second pillar is dedicated to support investment in the real economy, by improving the pipeline of investable projects and by strengthening the provision of advisory services to project promoters. The European Investments Advisory Hub and the European Investment Project Portal have been established to help investment finance reach the real economy. The third pillar focuses on enabling an investment friendly environment in Europe by removing barriers to investment both nationally and at EU level. The first pillar, EFSI, was set-up with the aim to mobilise at least €315 billion of investment in the EU by mid-2018. The key to fulfilling this objective was a €16 billion guarantee from the EU and €5 billion contribution from the EIB Group in support of EFSI. In December 2017, the European Council and the Parliament extended the duration of EFSI by two years, dubbed as EFSI 2.0, and increased its investment target to at least €500 billion by 2020 (EU, 2017). To this end, the EU Guarantee was also increased to €26 billion, and the EIB Group nominal contribution increased to no less than €7.5 billion.

EFSI supports strategic investments in key areas of European interest. The eligible sectors include the following: smaller companies, RDI, transport, energy, environment and resource efficiency, digital, and social infrastructure. EFSI 2.0 introduced two additional new sectors: bioeconomy and regional development. EFSI 2.0 also brought an enhanced focus on sustainable investments in all sectors to contribute to meeting COP21 targets and to help deliver on the transition to a resource efficient, circular and low-carbon economy (Rogelj et al., 2016). While being dependant of the demand-driven nature of EFSI, EFSI 2.0 set a new 40% target for EFSI financing under the Infrastructure and Innovation Window implemented by the EIB (excluding EFSI financing to SMEs and small Mid-Caps) in relation to project components that contribute to climate action. The implementation of EFSI and in particular the compliance with the objectives set in the EFSI Regulation are reported on an annual basis to the European Parliament and to the Council. These EIB Group Reports are public and accessible on the EFSI Steering Board page of the EIB website.[1] In addition, there is a regular assessment of the overall macroeconomic impact of EFSI operations. That is because, in addition to the direct impact of investments, these operations produce both indirect and induced effects in the economy.

Regular macroeconomic impact assessment of EFSI is carried out jointly by the EIB and the European Commission's Joint Research Centre (JRC), and the first assessment for the whole EIB portfolio, including EFSI, is explained in the full methodology note (EIB 2018).[2] The dynamic spatial Computable General Equilibrium (CGE) model RHOMOLO-EIB, parametrized on 267 NUTS2 regions of the EU and based on the RHOMOLO model developed by the JRC for territorial impact assessment (Lecca et al., 2018, 2019), is used in this context. The main difference between the two versions of the model lies in the modelling of the EIB-Group operations as loans financed by the Bank which differ from grants financed by taxes levied by the government which are normally analysed with the RHOMOLO model

[1] https://www.eib.org/en/efsi/governance/documents.htm "EFSI Implementation Reports".
[2] Independent evaluations are also available (see, for example, Camisão and Vila Maior, 2019).

(see, for example, Sakkas, 2018). CGE modelling is a common choice for ex-ante assessments (Nilsson, 2018), while econometric methods are more commonly used for ex-post types of analysis (see, among others, Budzinski, 2013). CGE models capture important structural and institutional characteristics of the modelled economies and permit to understand the economic mechanisms through which a policy intervention affects the macroeconomic variables of interest of interest to the researcher. This article reports the latest RHOMOLO-EIB results on the macroeconomic impact of the EFSI-supported operations approved as of the EIB Board of Director meeting on June 13th, 2019, and builds on the policy insight by Christensen et al. (2019) which only contains the main results of the analysis for a non-specialist audience.

The remainder of the article is organised as follows. Section 2 contains a non-technical overview of the RHOMOLO model and Section 3 explains the specific characteristics of its EIB version (the RHOMOLO-EIB model) used for the simulations to gauge the potential impact of EFSI. Section 4 illustrates the modelling results, and section 5 briefly concludes.

2. The RHOMOLO model

RHOMOLO is a recursively dynamic spatial CGE model used for policy impact assessment. It provides region-, sector- and time-specific results and its main features are as follows. It belongs to the CGE family of models with a micro-founded neoclassical equilibrium framework in which supply and demand are balanced through a system of relative prices and behavioural functions. Policy shocks are introduced as deviations from a benchmark reference scenario (currently calibrated on 2013 data) with consequences on the behaviour of the agents in the economy. This results in new counterfactual scenarios in which goods and factors are reallocated according to the new prices and it can be compared to the initial reference scenario in order to understand the effects of the policy. A key role is played by the spatial links, interactions and spillovers between the 267 NUTS2 regional economies of the EU endogenously modelled in RHOMOLO. The model is defined over ten economic sectors (reported in Table 1) which are connected via forward and backward value chains links.

Table 1.
The RHOMOLO-EIB sectors

Sectors NACE 2 codes	Sectors Description
A	Agriculture, Forestry and Fishing
B,D,E	Mining and Quarrying + Electricity, Gas, Steam and Air Conditioning Supply + Water Supply; Sewerage, Waste Management and Remediation Activities
C	Manufacturing
F	Construction
G-I	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles + Transportation and Storage + Accommodation and Food Service Activities
J	Information and Communication
K-L	Financial and Insurance Activities/ Real Estate Activities
M_N	Professional, Scientific and Technical Activities + Administrative and Support Service Activities
O-Q	Public Administration and Defence; Compulsory Social Security + Education + Human Health and Social Work Activities
R-U	Arts, Entertainment and Recreation + Other Service Activities + Activities of Households As Employers; Undifferentiated Goods- and Services-Producing Activities of Households for Own Use + Activities of Extraterritorial Organisations and Bodies

The spatial linkages among the EU regions include trade of goods and services, factor mobility, competition, and borrowing and lending of investment capital. The underlying data are organised in a multi-regional system of Social Accounting Matrices (SAMs) connected via trade flows estimated as explained in Thissen et al. (2019). In the SAMs, each element represents a flow of economic activities within the regional economies. The economic relationships between all the agents represent an equilibrium in which aggregate demand equals aggregate supply. All transactions in the economy are treated in the model as resulting from agents optimising decision-making. Households derive income from labour, physical capital, other financial assets, and government transfers. They maximise utility from consumption subject to a budget constraint with an exogenous saving rate. The government raises revenues via labour and capital income taxes and spends on goods and services, transfers to household and in public capital. These variables are typically set as exogenous policy variables in the model simulations, but a balanced budget rule is applicable if required (by letting any of the tax rate to adjust to achieve the balance).

Goods and services are consumed by households, governments and firms (the latter also consume intermediate inputs), and are produced in markets (perfect or imperfectly competitive) via the combination of value added (labour and capital) with domestic and imported intermediates. The production technology is represented by a multilevel Constant Elasticity of Substitution (CES) function. Public capital enters the production function as an unpaid factor following Barro (1990) and Glomm and Ravikumar (1994, 1997), among others. The public capital stock is accumulated through public investment in infrastructure, and while it is subject to depreciation, there are congestion effects modelled à la Turnovsky and Fisher (1995) and Fisher and Turnovsky (1998) so that the quantity of public services available to a producer declines as production increases.

Inter-regional trade is costly and transport costs are assumed to be of the iceberg type. Transport costs are specific to sectors and trading partners. They are asymmetric between regions. Transport costs are derived from the transport network model TRANSTOOLS which considers different modes of transport and computes transport costs and travelling time (for more detail see Petersen et al. (2009)). Labour market imperfections imply that wages are set above the market clearing level, resulting in unemployment. The model includes three different labour categories corresponding to the level of skill/education (low, medium and high). For each labour type, the default wage setting relationship is represented by a wage curve (Blanchflower and Oswald, 1994) so that low unemployment levels increase the bargaining power of the workers who are able to get higher real wages.

The model relies not only on data organised in SAMs, as mentioned above, but also on a number of parameters which are mostly derived from the literature. Since we abstain from reporting the actual equations of the model here, we invite the Reader to refer to Lecca et al. (2018) for the mathematical presentation of the RHOMOLO model, including the list of the main parameters and their numerical values.

3. Modelling the EFSI operations

It is important for the RHOMOLO-EIB simulations set up to reflect the way in which the EIB Group works. The basic version of RHOMOLO is normally used to analyse the effects of the EU structural investment funds provided as grants, which are assumed to be financed through non-distortionary taxation in all the EU Member States. In contrast, the EIB Group provides lending, which makes a difference in terms of financial flows both in their origin and in how the money is repaid. The EIB Group supports public or private investors in financing specific operations. This raises the capital stock through higher local investments in the specific region and sector where the operation takes place. Local investments stimulate demand for goods and services especially during the project implementation and construction periods. Such investments must be financed by the capital market, with the EIB Group issuing bonds to finance its support to the operations (which are co-financed by private investors and public institutions). These funds must be repaid over time, so while the initial impact on the recipient region is an inflow of funds, over time this becomes an outflow of funds when the loan has to be repaid to the lenders. The opposite is true for the regions providing the funding to other regions. These two effects (capital deepening and investments' financing) are labelled "investment effect" in the simulations presented in the next section.

There is an additional effect which is taken into account in the modelling simulations: the long-term "structural effect", which takes place once the investment is completed. The structural effect can take the form of higher productivity or lower transportation costs thanks to new infrastructure, for instance. The RHOMOLO-EIB allows for five structural channels: transport infrastructure, non-transport infrastructure, R&D, human capital, and industry and services. Each of these channels can increase factor productivity and/or stimulate trade (eventually affecting competitiveness) by expediting the availability of new technologies and production methods, making public and private infrastructures more efficient, and enhancing capital quality.

Thus, the investment effect entails direct effects (the combination of the direct economic effects of investment and the repayments of the financing) plus indirect economic effects in the supplier industries and induced effects from income and sector spending. The structural effect instead affects productivity, trade, and competitiveness. The RHOMOLO-EIB model permits to quantify the total effects on GDP and employment of all these channels in a general equilibrium setting.

Since the financial sector is not modelled explicitly, the financing effects are exogenously introduced as transfers in RHOMOLO. The EIB Group borrows funds on the capital markets to finance its lending activities to projects which are realised together with other co-investors. In effect, the EIB Group and its co-investors finance these investments with available funding from other sources in the economy. In the RHOMOLO-EIB model, the corresponding financial flows have to be explicitly introduced as input data to reflect the location and the amount of the financing as well as the timing of the repayments. Investment projects are financed by available income in the EU economies and abroad, and this has to be repaid over time from the borrowers to the lenders. While the investment project directly affects the capital stock in the borrowing region, the financing also affects income in the lending regions. Output in lending regions initially decreases as capital is invested in the borrowing regions, and then increases as repayments are made. The repayment period depends on the nature of the underlying investment and structure of the loan.

Lending draws on available income in the economy and from abroad. The source of such financing can be either income in the EU or income from abroad. The EIB Group finances its activities by issuing bonds on both European and non-European capital markets. Similarly, co-financing from other sources may come either from domestic sources or from abroad. The share of financing from the EU and from abroad is derived from internal EIB bond-holding data and from the balance of payments of the EU against the rest of the world. The former approximates the share of EU external funds attracted to the project by the EIB Group in support of the operation, financed by bond issuances. This is measured by the average share of the EIB bonds held outside the EU. The latter approximates the average foreign ownership of domestic EU assets as indicated by the financial account of the EU-wide balance of payments (reported by Eurostat). The source of financing matters for the overall impact. Financing from within the region implies that households residing in the region redirect savings or forgo current consumption to finance investments. Financing from within the EU implies a reallocation of income from lending regions to borrowing regions if more investment takes place in some regions than others, in proportion to regional income. Financing from outside the EU, in terms of the regional trade balance, implies importing resources through worsening of net exports. Hence, in the short run investments increase and net exports decrease. Over time, capital accumulation improves competitiveness and net exports rise allowing the borrowing region to pay back loans to external lenders. De facto, imports, in the form of intermediate goods, are financed via increased exports of final goods by the region.

The macroeconomic impact assessment of EFSI is based on a comprehensive dataset. Project level data is converted into portfolio data which are used in RHOMOLO-EIB. Each supported operation has a detailed set of data available on timing, implementation, location, sector, financing and objectives.[3] Modelling of the direct investment effect rely on start and end dates of the actual investments together with investment volumes over time. Furthermore, it is specified in which sector and in which location the investment takes place. The financing part of the investment effect relies on data on bond issuance, bondholding, lending and repayments. Modelling the structural effect through which investments impact the economy requires additional data input. Each EFSI supported operation needs to clearly contribute to set policy objectives and these are mapped to the five structural channels in RHOMOLO-EIB. This allows establishing a clear link from each supported operation to the structural channels in the model. Together with information on the timing, scope and location of the investment this ensures that the structural effect sets in once the operation is completed. The investment projects are converted into structural changes through a set of elasticities derived from the economic literature. For example, investments in R&D are converted into improvements in TFP through an elasticity that relate R&D spending to changes in TFP conditional on regional R&D intensity, whereas investments in human capital is converted into improvements in labour productivity through an elasticity in a Mincer-type equation (for a discussion of the structural transmission channels see EIB (2018)).

The results of the RHOMOLO-EIB simulations presented in the next section are therefore the result of the structure and assumptions of the RHOMOLO model[4] as well as of the specific treatment of the investment projects' financing made to reflect the working conditions of the EIB Group.

4. Results

The EFSI-supported projects affect the economy both in the short term (mainly via the investment effect) and in the long term (mainly through the structural effect). The short-term investment effect reflects higher demand for goods and services as the investments take place during the implementation and construction phase. The repayment of the loans used to finance the investments over time is also taken into account as explained in Section 3. The longer-term structural effect reflects the impact on the structure and competitiveness of the economy through changes in infrastructures, human capital, and productivity.

Figure 1 reports the estimated GDP and employment effects (in panels a and b, respectively) of the EFSI-supported operations approved between 2015 and June 2019. The total investments mobilised based on these approvals are expected to amount to some €408 billion over the time period. The results in Figure 1 show that the EFSI operations are expected to increase EU GDP by 1.76% by 2022, with the creation of more than 1.68 million jobs by the same year.

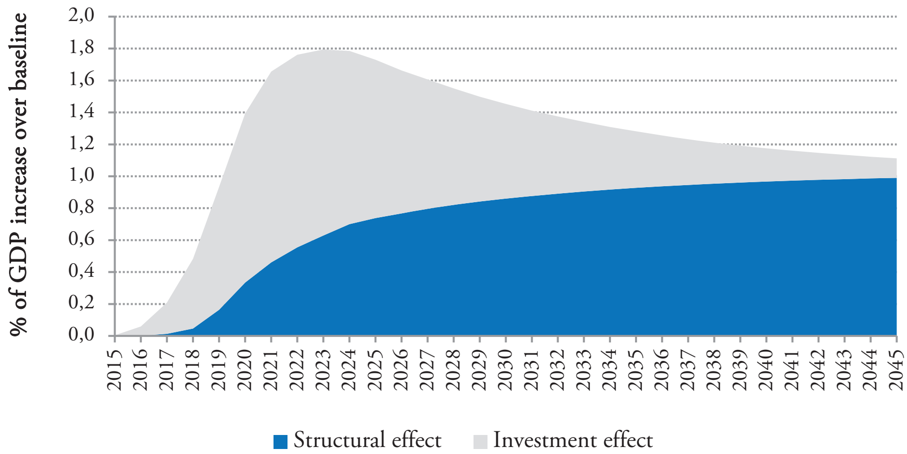
Figure 1 distinguishes between the investment and the structural effects and shows that the short-term impact is mainly driven by the investment effect which sets in quickly and fades out over time. The effects of investments are direct, indirect (with both forward and backward linkages along the value chain), and induced (additional effects on income and sector spending). As investment activities reach completion and repayment of loans begin, this effect starts to phase out while longer term structural effects grow over time as more investment projects reach completion and start affecting the structural functioning of the economy. The long-term structural effects are largely persistent, as enhanced production technologies, better private and public infrastructures and greater labour productivity have a lasting impact on the economy.

[3] Where data is not available ex-ante, proxies or estimates are used. As actual (ex-post) data becomes available the data is successively updated to reflect the most recent and most accurate information.

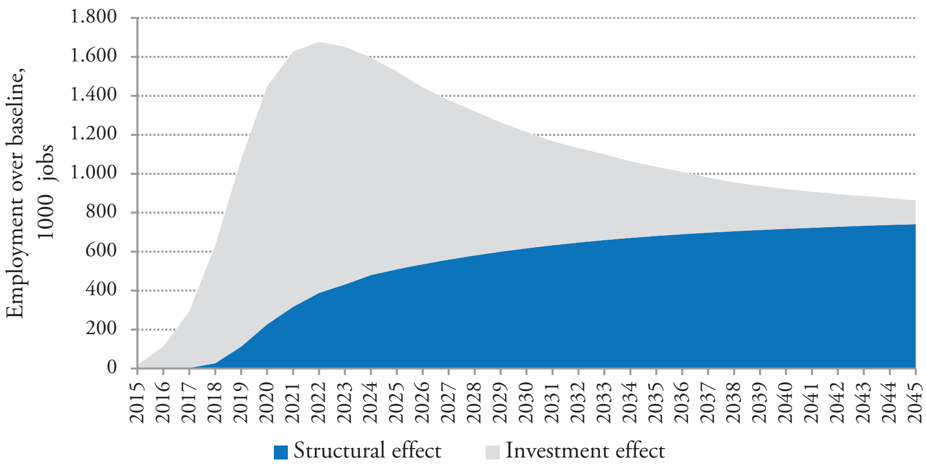
[4] RHOMOLO allows for perfect or imperfectly competitive product markets. RHOMOLO-EIB assumes that all product markets are perfectly competitive.

FIGURE 1.
Expected GDP (panel a) and employment (panel b) impact of EFSI-supported operations (based on approvals between 2015 and June 13, 2019)

Panel a:



Panel b:



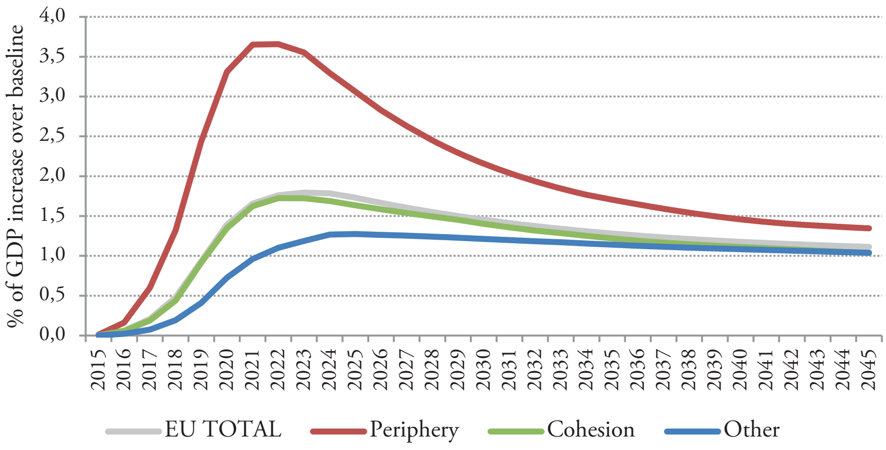
Source: RHOMOLO-EIB calculations.

The structural effect impacts the economy according to the profile of the investment. For instance, the effects of transport infrastructure investments for the construction of new transport routes and for the improvement of existing ones are assumed to affect the transport costs in RHOMOLO-EIB. This means that the structural effect of transport infrastructure projects implies a reduction in the bilateral iceberg costs between regions, and the scope of the change can be thought of as a subsidy equivalent. Reduced transport costs change the trade flows and the relative competitiveness of the regional industries, which effects GDP and employment for the regions which experience the reduction in costs. The subsequent changes in imports and exports would also affect welfare and the allocation of the factors of production. Finally, it should be noted that the impact of a better infrastructure would be greater in regions with more potential for trade expansion, such as regions that are already competitive but still lack transport links to reach additional markets. On the other hand, investments in human capital affect the productivity of labour, R&D investments affect total factor productivity, and investments in new capital formation different from transport are assumed to affect capital productivity.

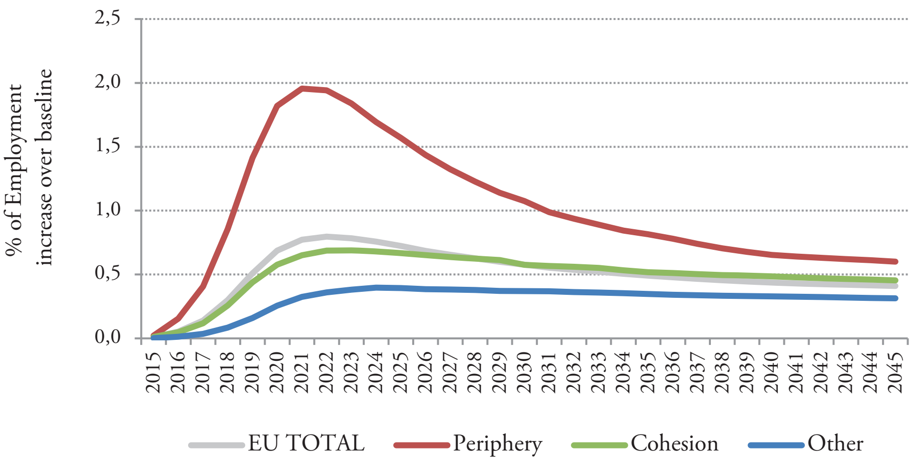
Given the nature of the RHOMOLO-EIB model, results can be analysed under different point of view by exploring both their geographical and their sectorial characteristics. Figure 2 demonstrates that EU regions and countries benefit in terms of jobs and economic growth, on average. When looking at percentage changes, it is clear that the countries that were hit the most by the 2008 economic and financial crisis (the EU periphery), and those lagging behind in terms of income (the cohesion countries), benefited relatively more than the most well-off countries (other countries). This is unsurprising as these countries receive a substantial part of EFSI lending. While the effects cannot be only linked to the level of local investments given the spill overs from one country to the rest, a key explanation lies also in the economic situation of the countries. Many regions in the periphery and cohesion countries experienced relatively high unemployment levels and relative low levels of investments increasing the scope of the investment effects. For the most well-off (other) countries the economic situation after the crisis was different with unemployment levels lower and investments levels typically higher. Hence, the investment effect is more modest and takes longer to pick up.

FIGURE 2.
Expected GDP (panel a) and employment (panel b) impact of EFSI-supported operations (based on approvals between 2015 and June 13, 2019) by macro-regions

Panel a:



Panel b:



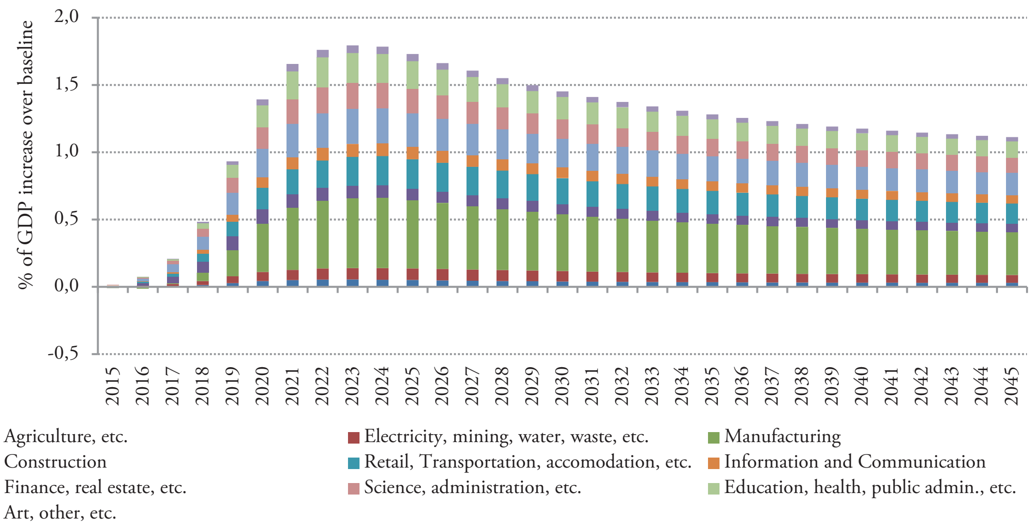
Source: RHOMOLO-EIB calculations.

It is equally interesting to look at the sectorial results of the simulations. Figure 3 shows the GDP effects of the EFSI-supported operations on the ten sectors in which the economy is disaggregated in the RHOMOLO-EIB model. In the short term, investments drive up demand which feeds into other sectors of the economy thanks to sectorial spillovers and indirect and induced effects. In the longer term all sectors benefit from the EFSI-supported operations thanks to structural effects. It should be noted that the results should be interpreted as deviations from a reference scenario without EIB interventions, hence, the impact of EFSI on GDP and employment in the manufacturing sector can be positive even if long term structural shift in the economy gradually reduces this sectors share of the economy. Such long-term structural shift in the economy would imply a long-term trend in the sector composition common to both scenarios (with EIB intervention and without EIB intervention). Therefore, the reported impact of EFSI on sectoral GDP and employment does not contain underlying long-term structural shifts in the economy.

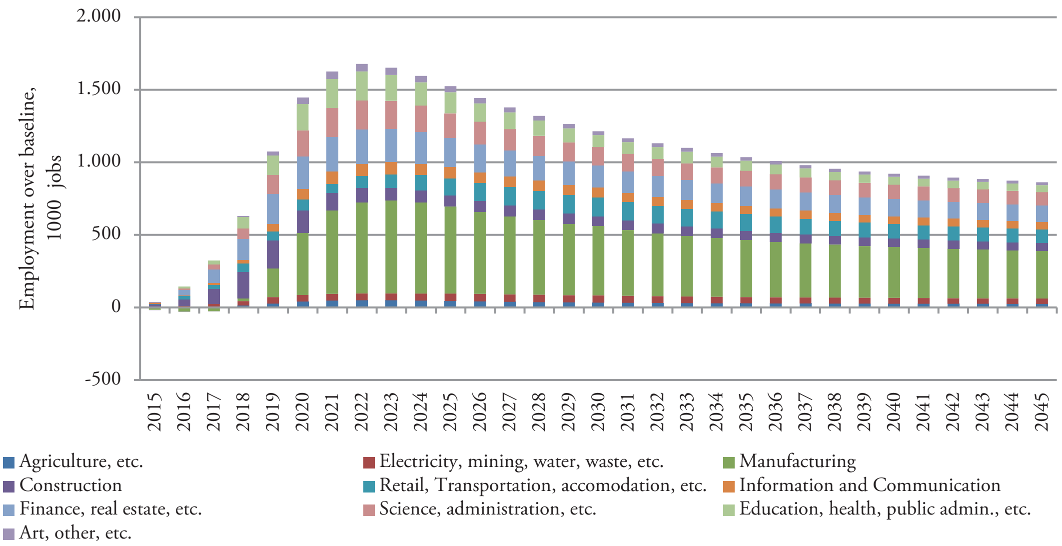
FIGURE 3.

Expected GDP (panel a) and employment (panel b) impact of EFSI-supported operations (based on approvals between 2015 and June 13, 2019) by sector

Panel a:



Panel b:



Source: RHOMOLO-EIB calculations.

5. Conclusions

This article reports the latest RHOMOLO-EIB results on the macroeconomic impact of EFSI in the EU. After introducing the main features and assumptions of the model, the article focuses on the employment and GDP impact of the EFSI-supported operations approved as of June 13th, 2019 and shows that by 2019 these operations are expected to create more than 1 million jobs over the baseline scenario, which is expected to become 1.7 million by 2022. The estimated contribution to GDP is quantified at 0.9% by 2019, expected to rise to 1.8% by 2022.

The analysis differentiates between investment and structural effects. The former has demand-side macroeconomic effects mainly due to the invested money during the implementation phase of the projects and the financing related to it. The latter affects the economy via the supply-side due to the long-lasting impacts of the EFSI- supported operations on transport costs and productivity.

While the model produces specific results in terms of number of jobs and GDP changes over its baseline, these results provide a sense of scope of the impact of EFSI-supported operations and should not be considered as forecasts. For the avoidance of doubt, while the RHOMOLO-EIB is a version of the well-established RHOMOLO model and therefore its results can be considered robust and credible, other models may deliver different results depending on their baseline calibrations, structure, and main assumptions. The JRC and the EIB Group are committed to continue to analyse the effects of the EFSI-supported operations, to further refine the analysis and conduct thorough sensitivity analysis, and to exploring the impact of additional economic channels (such as cross-regional spillovers).

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Government quality and regional growth in the enlarged European Union: Components, evolution and spatial spillovers

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Abstract:

This paper investigates the relationship between government quality and regional economic growth in 206 EU-28 regions during the period 2010-2017. We use the European Quality of Government Index (EQI), based on the pillars of quality, impartiality and corruption and provide results for both the aggregated index and its three components. We find a negative evolution of government quality across regions over the studied period. Overall, the econometric results, obtained via Ordinary Least Squares and Spatial Lag models suggest that improvements in the quality of government positively contribute to economic growth, although larger impacts are found for EU-15 regions in comparison with regions from countries that joined the European Union after 2004. Finally, we find that spatial spillovers matter, as a great proportion of the effect of government quality on growth is indirect. In that regard, when analyzing different components of government quality in the spatial models, a clear influence is found for corruption and impartiality, whereas results are weaker for the quality of public services.

Keywords: Government quality; Regional growth; Spatial spillovers.
JEL classification: O43; R11; R50.

Calidad de gobierno y crecimiento regional en la Unión Europea ampliada: Componentes, evolución y efectos de desbordamiento espacial

Resumen:

Este trabajo investiga la relación entre la calidad de gobierno y el crecimiento económico regional en 206 regiones de la UE-28 durante el período 2010-2017. Utilizamos el Índice Europeo de Calidad de Gobierno (EQI), basado en los pilares de calidad, imparcialidad y corrupción, y proporcionamos resultados tanto para el índice agregado como para sus tres componentes. Encontramos una evolución negativa de la calidad de gobierno en las regiones durante el período estudiado. En general, los resultados econométricos, obtenidos mediante Mínimos Cuadrados Ordinarios y modelos de retardo espacial sugieren que las mejoras en la calidad de gobierno contribuyen positivamente al crecimiento económico, aunque se identifican mayores impactos para las regiones de la UE-15 en comparación con las regiones de los países que se incorporaron a la Unión Europea después de 2004. Finalmente, los efectos de contagio espacial son importantes, ya que una gran proporción del efecto de la calidad de gobierno en el crecimiento es indirecto. En este sentido, al analizar los diferentes componentes de la calidad de gobierno en los modelos espaciales, se encuentra una influencia clara para la corrupción y la imparcialidad, mientras que los resultados son más débiles para la calidad de los servicios públicos.

Palabras clave: Calidad de gobierno; Crecimiento regional; Efectos de desbordamiento espacial.
Clasificación JEL: O43; R11; R50.

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1. Introduction

Since the seminal papers by North (1990) and Edquist (1997) there is a wide consensus on the idea that institutional quality—or quality of government—matters for economic and social progress. In this vein, the European Union (EU) has engaged quality of institutions as a mean of reduction of regional socio-economic disparities. Following the Copenhagen criteria from 2004,[1] any European state embracing the values of freedom, democracy, equality, rule of law and respect for human rights, as well as a well-functioning market economy, may apply to join the EU. In 2017, the EU Commission recognized tackling widespread corruption and introducing measures aimed at making government decisions more efficient and transparent to be as important as physical investment for regional development (EU Commission, 2017). Accordingly, the implementation of institutional reforms aimed at improving institutional quality can be a valuable tool for regional development strategies.[2]

Several empirical works have found a positive link between institutional quality and economic performance (e.g. Gwartney et al., 1999; de Haan and Sturm, 2000; Lundstrom, 2005). In particular, the protection of property rights and rule of law are especially relevant in generating sustainable growth (Rodrik et al., 2004; Acemoglu et al., 2005). Nevertheless, despite the abundance of contributions at the country level, or recent studies for particular countries (see Choi, 2018; Quah, 2017), not as many results have been yet delivered addressing regional level analyses on the issue (Rodríguez-Pose, 2013). Some exceptions are found for the European regional context, on which this paper focuses. Crescenzi et al. (2016) found a strong positive relationship between the quality of regional institutions and the returns of infrastructural investments. More similar to the context of our research, Rodríguez-Pose and Garcilazo (2015) disclose local institutional quality to be a vital factor in determining the rate of returns of Cohesion Policy investments. Ketterer and Rodríguez-Pose (2018) found a positive link between institutions and growth for the period 1995-2009 but considered only EU-15 regions. Nonetheless, the topic has become even more important after the latest EU enlargements of 2004, 2007 and 2013, which have remarkably increased development disparities across the Union. Moreover, the new members have institutional quality standards generally below the EU average, as their institutions might be still influenced by the pre-transition institutions, when these countries were ruled by a planned system.

This paper revisits the topic, but differs in several aspects from previous contributions, attempting to provide fresh evidence on this literature. First, it uses a broader and more updated dataset covering the period 2010-2017, including EU-15[3] regions and regions from countries that joined the EU after 2004[4], which might be relevant given the great disparities between these two groups. To date, most of the existent evidence at the regional level corresponds to the pre-crisis years, and it is generally confined to EU-15 regions. Second, we make use of the most recent edition of the European Quality of Government Index (EQI, see Charron et al. 2016; 2019), available for years 2010, 2013 and 2017. In contrast to previous regional analyses mostly relying on a single observation of institutional quality, we are able to analyze its recent evolution by using information from the three years. Charron et al. (2019) introduced the new wave of the EQI index but, to the best of our knowledge, empirical analyses making an effective use of the three waves are still yet to come. Third, we provide a disaggregated analysis for the government quality components, namely quality, impartiality and corruption, which entails the opportunity of delivering more accurate policy implications from the results. Fourth, we address the spatial relationship between government quality and economic growth and quantify the spillover effects.

[1] The criteria were introduced just before allowing for the entrance of Eastern and Central European countries into the EU, when these countries were in transition from an authoritarian regime based on a centralized economy to democracy and free market.

[2] In that regard, papers such as Basyal et al. (2018) attempted to find whether some particular institutional actions might improve government quality by reducing corruption levels.

[3] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.

[4] Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.

Based on the previous evidence for Europe and other geographical contexts, we expect a positive relationship between quality of government and economic growth. Also, spatial spillovers are remarkable in European regions (see Ezcurra and Rios, 2019). We therefore expect a notable role of the space in our context. Our results widely support these hypotheses. However, there are some interesting nuances: i) quality of government effects on growth are larger for the EU-15 regions; and ii) generally, clearer effects are found for the components of impartiality and corruption, whereas the effects of the quality component are weaker or non-significant in most models.

The remainder of this paper is structured as follows. In Section 2 we introduce the theoretical foundations and review the relevant literature. The dataset and the descriptive statistics are presented in Section 3. The econometric strategy is described in Section 4. In Section 5 we discuss the main results and, finally, the conclusions and policy implications are summarized in Section 6.

2. Literature review

The influence of institutions on economic development was fundamentally neglected by the mainstream of the economic theory until the nineties. Indeed, the Neoclassical growth models by Solow (1956), as well as the endogenous growth approach developed by Romer (1986) and Lucas (1988), considered economic growth as the result of the mere combination of physical capital, labor, technology and knowledge.

North (1990) suggested that formal institutions matter for economic development, insofar as transactions among individuals in a society are costly. Institutions can be understood as the rules of the game in a society or, more formally, as the humanly devised constraints that shape human interaction. Coherently, the major role of institutions would be that of reducing uncertainty by establishing a stable structure for human cooperation. In this prospective, institutions are bound to influence economic performance as they are capable of reducing transaction costs. Therefore, good institutional settings promote economic development by establishing an environment in which transactions take place under trust and order. Property rights are well-established, and people do not need to devote too many resources to their control and enforcement.

Building on North, numerous studies have highlighted that poor institutional quality makes the economic environment less efficient, entailing lower economic standards. Countries with high corruption, weak rule of law, and low impartiality are associated with, among others, poorer health (Holmberg and Rothstein, 2012), worse environmental outcomes (Welsch, 2004), greater income inequality (Gupta et al. 2002), and even lower levels of happiness (Veenhoven, 2010). Similarly, and more directly addressing our research question, examples of studies reporting a significant relationship between institutional quality and income per capita or income growth include Knack and Keefer (1995), Gwartney et al. (1999), de Haan and Sturm (2000) or Lundstrom (2005). Holmberg et al. (2009) reported positive effects of institutional quality on several welfare dimensions and Mo (2001) found a negative effect of corruption on income growth. There are several mechanisms. First, corruption is associated with less efficiency in the use of the available resources and in the provision of government services because of more inefficient regulations. Moreover, corruption might favor particular elites or social actors, widening economic and social disparities.

Focusing on the European regional context, Crescenzi et al. (2016) study the link between the quality of regional institutions and the rates of returns of infrastructural investments using data for 166 regions between 1995 and 2009. Their research concludes that better institutions lead to higher returns of investment and economic development. Rodríguez-Pose and Di Cataldo (2014) examine the impact of institutional quality on regions' innovative performance in a sample of 189 EU regions between 1997 and 2009, concluding that there is an institutional quality threshold effect for innovation. Accordingly, policies aimed at improving innovative performance are more likely to be effective in regions where institutional quality is sufficiently high. Nistotskaya et al. (2015) argue that regions where governments are perceived as impartial and free from corruption enjoy a more dynamic economic environment. These effects are found for a sample of 172 regions from 18 EU countries between 1990 and 2007. More recently, Ezcurra and Rios (2019) reported evidence from the last *Great Recession*, and positively linked quality of government with regional resilience.

More empirical evidence comes from recent studies for the Italian regional context. Lasagni et al. (2015) test the relevance of institutional quality in explaining firm productivity in 107 Italian provinces for the period 1998-2007, finding a key role for the local institutional context. Di Berardino et al. (2019) find that within-country human capital movements are modifying institutional quality, exacerbating the North-South divide in Italy. Coppola et al. (2018) conclude that, whereas quality of government has no implications for EU funds, it increases the impact of subsidies received by firms. Considering a cross-regional European sample, Rodríguez-Pose and Garcilazo (2015) analyze the relationship between institutional quality and the rates of returns of Cohesion Policy investments for a sample of 169 regions for the period 1996-2007, concluding that both EU investments and institutional quality make a difference for regional growth. Additionally, above a certain threshold of expenditure in investments, the quality of institutions becomes the basic factor determining regional growth rates.

From a theoretical point of view, D'agostino and Scarlato (2015) show a positive link between institutional quality and regional economic performance by constructing a three-sector semi-endogenous growth model with negative externalities related to the social and institutional variables affecting the innovative capacity of regional economic systems. Particularly, by applying their model to the Italian regions, they find the enhancement of socio-institutional conditions to be more effective for innovation capacity and economic growth in the lowest-ranked regions in terms of institutional and economic development.

Lastly, as regions are not isolated economic units, spatial spillovers are likely to be important in this context. In this vein, Bologna et al. (2016) show that gains from institutional reforms are not confined to the metropolitan area in which the reforms are enacted, being the effects noticeable in the neighboring regions too.

3. Empirical framework

3.1. The sample

The sample consists of 206 NUTS[5] 2 European regions from the EU-28. These territorial units are particularly meaningful from a policy perspective as they generally have considerable responsibilities in terms of policy competences, although this varies from one country to another. Throughout the analysis, particular attention will be devoted to the large heterogeneity that characterizes the EU regional economic development and institutional quality standards. To this purpose, two subgroups of regions will be compared: i) regions belonging to countries that were members of the EU prior to the enlargement of 2004 will be referred to as EU-15; ii) regions from countries that joined the EU after that year will be labelled as NMS (New Member States). In the sample, there are 149 EU-15 regions and 57 NMS regions. The dataset covers the period 2010-2017. Such reduced time span was selected due to data constrains in government quality, as the first edition of the EQI index corresponds to 2010.

[5] The NUTS classification (Nomenclature of Territorial Units for Statistics) is a hierarchical system for dividing up the economic territory of the EU for the following purposes: i) Collection, development and harmonization of European regional statistics; ii) Socio-economic regional analysis; iii) Framing of EU regional policies. In particular, the NUTS 1 level represents major socio-economic areas, the NUTS 2 level corresponds to basic regions for the application of regional policies and the NUTS 3 level are small regions for specific diagnoses.

3.2. Variables, sources and descriptive statistics

As a dependent variable, we use the growth of regional income per inhabitant, expressed in purchasing power standards (PPS), taken from Eurostat. This indicator has the advantage of allowing for meaningful comparisons of income by avoiding biases due to discrepancies in purchasing power across European regions. Table 1 summarizes some descriptive statistics for the entire period. The table discloses remarkable differences in both the average GDP per capita and growth rates. As expected, GDP per capita was lower for NMS regions over the studied period; in contrast, they grew faster than the EU-15 group, although disparities between the two groups reduced only slightly.

Government quality is proxied by the European Quality of Government Index (EQI), developed by the Quality of Government Institute - University of Gothenburg (see Charron et al., 2014, 2016, 2019). Data are currently available for years 2010, 2013 and 2017. The EQI index is especially appealing for analyses at the regional level in the European context, as it is based on the same territorial aggregation than most of EU regional statistics, which makes it totally compatible with the information provided by the European Statistical Office (Eurostat) and with the European Regional Policy.[6]

The index defines institutional quality as a multi-dimensional concept consisting of three components: quality of public services, impartiality and corruption. Specifically, quality and impartiality of regional governments are made out of residents' ratings of these two characteristics in the areas of public education and health care system, as well as in law enforcement and in the democratic procedures. Analogously, residents' perceptions and experiences with bribery define the indicator for control of corruption. Then, the three components are aggregated to construct a composite index. All the methodological details can be found in the seminal papers by Charron et al. (2014, 2016, 2019), as well as in the Database Codebook, available online.

The original index ranges from -3 to +3, with greater values representing greater government quality. With the aim of simplifying the interpretation of the estimates in the econometric models, we take the min-max normalized values of the variable, which range from 0 to 1,[7] also provided by the database. Unfortunately, EQI's observations are not as frequent in time as the rest of the variables in the dataset. Accordingly, the variable is treated as follows. Figures from 2010 are used for observations between 2010 and 2012, those from 2013 are used for observations between 2014 and 2016, and those from 2017 are used for that single year. This approach has an important drawback, as repeated values are assigned to several years. Accordingly, we implement alternative approaches to test for the sensitivity of the results. In particular, we provide results averaging data for the entire period (2010-2017) and for a two-period (2010-2013; 2014-2017) panel structure. Finally, for regions in Belgium, Sweden and Slovenia, government quality is only reported for NUTS 1 units. Then, we assign these scores to the related NUTS 2 units.

Table 1 also shows descriptive statistics for the EQI index. Large disparities are observed between EU-15 and NMS regions, with larger scores for the former group. Similarly, Figure 1 displays the cross-section distribution of the index, both across groups of regions and over time, and shows a decline in government quality, more remarkable between 2010 and 2013. The figure also shows that within-group heterogeneity is high. For example, in the EU-15 group we find regions from Italy, Greece and Spain on the left tail of the distribution, whereas on the right one we find regions from the Nordic countries, Austria and the Netherlands. The densities also suggest that convergence in government quality is not taking place, as their shape is highly persistent.[8]

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[6] The EU Regional Policy pays particular attention to the objective of convergence, which is addressed to the NUTS 2 level of disaggregation.

[7] Actually, the database provides these data on a 0-100 scale, but we rescaled the values to obtain larger and more easily readable coefficients in the econometric estimations.

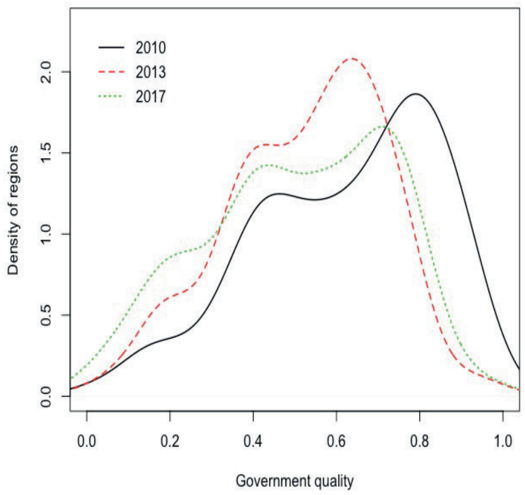
[8] Apart from the shape of the densities, an in-depth analysis of convergence would also require the study of the intra-distribution dynamics, which is beyond the scope of this paper.

TABLE 1.
Descriptive statistics for the main variables

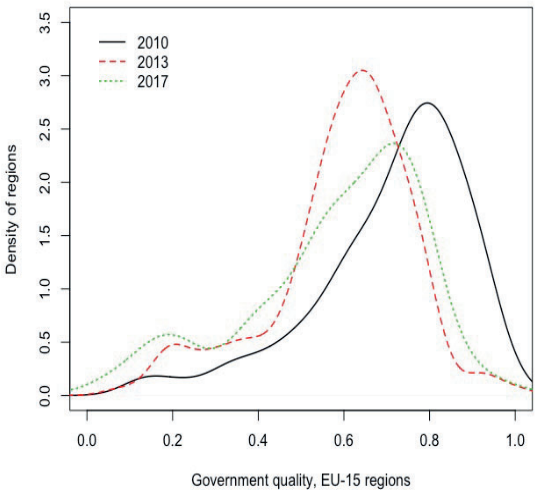
	Average values 2010-2017					
	GDP pc (PPS €)		GDP pc growth (%)		EQI index (0-1)	
	Mean	S.d.	Mean	S.d.	Mean	S.d.
EU-28	26,134	9,967	0.025	0.014	0.561	0.202
EU-15	29,195	8,861	0.020	0.012	0.638	0.172
NMS	18,132	8,125	0.039	0.011	0.360	0.123

FIGURE 1.
Kernel densities for government quality (EQI index)

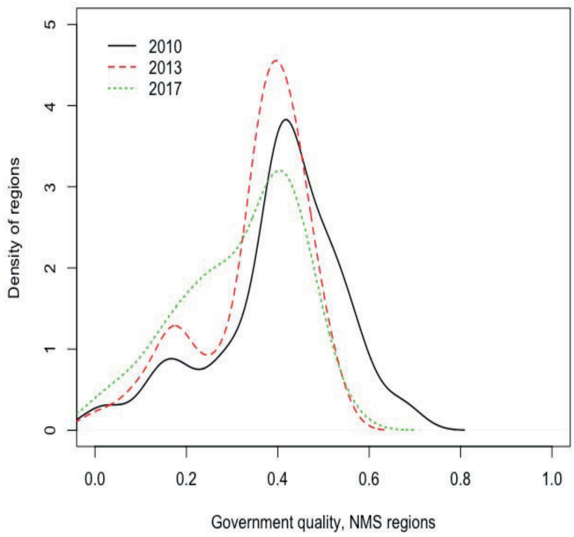
a) EU-28



b) EU-15



c) NMS



The dataset provides disaggregated information for the three components of the EQI index: quality, impartiality and corruption. Table 2 reports information for these indicators for years 2010, 2013 and 2017. Similarly to what is found for the aggregated index, a decline is observable between 2010 and 2013. In contrast, in 2017 impartiality and quality improved, while corruption levels worsened even more for the EU-15 group. In the NMS group corruption remained relatively stable. Considering the entire sample (EU-28), the components of quality, impartiality and corruption declined by 10.6%, 10.2% and 14%, respectively, between 2010 and 2017.[9]

TABLE 2.
Evolution of the government quality components

	Quality			Impartiality			Corruption		
	2010	2013	2017	2010	2013	2017	2010	2013	2017
EU-28	0.655	0.529	0.585	0.637	0.556	0.572	0.605	0.555	0.520
EU-15	0.713	0.579	0.639	0.704	0.602	0.624	0.673	0.616	0.568
NMS	0.472	0.375	0.413	0.439	0.406	0.408	0.402	0.364	0.367

As control variables we include the classical Solow variables, extensively used in the growth literature. We followed the seminal contributions by Barro (1991), Mankiw et al. (1992) and also more recent studies such as Crespo-Cuaresma et al. (2014), focused on the European context. The use of the Solow framework and Barro-type growth equations as a starting point when evaluating other theories in growth empirics is today widely supported (e.g. Durlauf et al. 2008; Henderson et al. 2012).[10]

Our first control is the initial level of GDP per capita, in our case year 2010. A negative coefficient would imply that conditional convergence is taking place, i.e. subject to other regional fundamentals, poorer regions grow faster than the richer ones. The rest of controls include the annual R&D investments as share of GDP, treated as a proxy of technological progress. Labor and physical capital are included into the model through the regional population growth rate and the gross fixed capital formation (share of GDP), respectively. Moreover, as a proxy of human capital, the percentage of highly educated workers (tertiary education) is also considered (see Dettori et al. 2012). Data for all these controls are provided by Eurostat. Finally, following Crespo-Cuaresma et al. (2014), qualitative features are also controlled for by means of two dummy variables. The variable "NMS" takes the value of 1 if the region belongs to the NMS group and 0 otherwise, while the variable "capital city" takes the value of 1 when a region hosts the country's capital city within its borders and 0 otherwise. Capital cities are generally a suitable environment for companies' economic activities because of urban agglomeration and economic dynamism. Therefore, this qualitative characteristic is expected to have a positive role in explaining regional growth.

4. ECONOMETRIC STRATEGY

We estimate several model specifications, differing in the controls included. In some models, we also include interactions between government quality and the dummy variable NMS in order to study whether different impacts are found between groups. The most general model takes the form:

$$y_{it} = \alpha + \beta QoG_{it} + \gamma X_{it} + \upsilon_t + \varepsilon_{it} \quad (1)$$

where the subscripts i and t represent a given region and year, respectively, y is regional output per capita growth, QoG represents either government quality or each of its three components, X is a vector of control

[9] Note that for the case of corruption greater values mean lower corruption.

[10] It is noteworthy to underline that as Durlauf and Quah (1999) argued, the fact that one particular theory could predict economic growth does not discredit other alternative theories as growth drivers. Thus, different baseline models could have been implemented (see also Henderson et al. 2012).

variables and υ stands for time effects. Finally, $\alpha, \beta,$ and γ are the model parameters and ε is the error term. The models are first estimated via Ordinary Least Squares (OLS).

Additionally, we consider several strategies to control for spatial spillovers. Given that the presence of unattended spatial spillovers in the data might produce non-robust estimates, testing for the existence of spatial dependence in our models is highly advisable. First, we run the Pesaran's (2004) test, which assesses in a panel data context the cross-sectional dependence of the residuals in the OLS models. After verifying this is actually the case (the null hypothesis of no cross-sectional dependence is rejected in all cases), we model the spatial effects by means of specific spatial models. Following Elhorst (2010) and LeSage and Pace (2009) we first run a Spatial Durbin Model (SDM), able to control for spatial spillovers in both the dependent and the independent variables. Formally:

$$y_{it} = \alpha + \rho W y_{jt} + \beta QoG_{it} + \eta WQoG_{jt} + \gamma X_{it} + \delta WX_{jt} + \upsilon_t + \varepsilon_{it} \tag{2}$$

where i and j are two given regions, ρ, η and δ are the spatial parameters and W is a matrix of spatial weights describing the neighboring relationship between regions. The rest of elements are common to Equation (1). To construct the W matrix, the inverse distance is first computed between all ij pairs. Then, the k-nearest neighbor criterion is followed, which considers the k closest regions to the geographical unit of interest as its neighbors. Although all the criteria to define the W matrix are debatable, growth determinants in the European regional context are not particularly affected by different specifications of the neighbor matrix. Crespo-Cuaresma et al. (2014) found analogous results using both distance-based and contiguity matrices, highlighting that the latter might capture regional spillovers appropriately. Also, LeSage (2014) postulated in favor of contiguity matrices, claiming the importance of setting a cut-off distance beyond which weights are zero and arguing that results from spatial models are relatively robust to changes in W. Following these arguments, pairs of neighbors in W are represented by ones, while the rest of pairs take the value of zero. Moreover, following the standard convention, we row-normalize W such that its rows sum one. Accordingly, elements in W are defined as follows:

- $w_{ij}(k) = 0 \quad if \ i = j$
- $w_{ij}(k) = 0 \quad if \ i \neq j, \ j \notin nb(i)_k$
- $w_{ij}(k) = 1/k \quad if \ i \neq j, \ j \in nb(i)_k$

where w_{ij} stands for the specific spatial link between regions i and j and $nb(i)_k$ refers to the neighborhood of region i for a given k. Given that EU NUTS 2 regions have generally from three to seven contiguous regions, we set $k = 5$ as a rule of neighboring.

Following the general-to-specific strategy proposed by Elhorst (2010), it is advisable to test whether the more comprehensive SDM can be simplified into a Spatial Lag Model—also known as Spatial Autoregressive Model (SAR), with spatial spillovers only in the dependent variable, or into a Spatial Error Model (SEM), with the spatial autocorrelation embedded in the error term. Formally, the SAR and SEM models are represented by Equations 3 and 4, respectively:

$$y_{it} = \alpha + \rho W y_{jt} + \beta QoG_{it} + \gamma X_{it} + \upsilon_t + \varepsilon_{it} \tag{3}$$

$$y_{it} = \alpha + \beta QoG_{it} + \gamma X_{it} + \upsilon_t + u_{it}, \quad u_{it} = \lambda W u_{jt} + \nu_{it} \tag{4}$$

where ε, u and ν are disturbances and the parameters ρ and λ summarize the strength of the spatial dependence. Despite models involving global spillover processes such as the SDM and the SAR have been criticized in growth contexts (see Corrado and Fingleton, 2012; Halleck-Vega and Elhorst, 2015), the literature is still inconclusive on this point.[11] In fact, other authors including Ertur and Koch (2007), Fischer (2011), D'agostino and Scarlato (2015) or Fiaschi et al. (2018) argue that these models can correctly capture technological and learning externalities, which are well-known growth drivers. Another example is Crespo-Cuaresma et al. (2014), who based their analysis of growth determinants for the European regions on SAR estimations. All the spatial models are estimated via Maximum Likelihood (MLE).

5. Results

5.1. Baseline estimations

According to the theoretical arguments, we expect positive coefficients for government quality (North, 1990), education and R&D investment (Dettori et al. 2012) and the dummies for capital city and NMS group (Crespo-Cuaresma et al. 2014). It is more difficult to forecast the sign for physical capital investment, as it can be generally more effective in developing economies. In our sample, despite the income heterogeneity, all regions are relatively developed (see Crespo-Cuaresma et al. 2014). Finally, in accordance with the theory of beta convergence, the initial level of regional income per capita is expected to exert a negative impact on the dependent variable. The same sign is expected for population growth.

Models 1 to 7 in Table 3 combine fixed and random effects estimations with different control variables. Although quality of government is not significantly associated to growth in Models 1 to 3, once important control variables such as R&D investment, capital city and especially the dummy variable NMS are included, its coefficient adopts the expected positive and significant effect. One potential explanation is that the different levels of quality of government and growth rates between former and new EU members may mask the effect of quality of government when the dummy variable is omitted.

Model 6 incorporates the interaction between government quality and the NMS dummy. A negative sign is obtained and, accordingly, government quality has a larger effect on growth in EU-15 regions. As NMS regions grew faster despite their comparatively lower government quality and the main effect for government quality remains positive—in fact this is the model yielding the largest coefficient—NMS regions are losing an important growth potential.[12] In other words, both their comparatively lower government quality and the lower capacity of their institutions to generate growth are slowing down their catching-up process with the EU-15. Given the interest of the European policymakers in reaching convergence, this has implications for the design of future policies. Despite the new members are slowly catching-up, there is a long way until they could reach the GDP per capita levels of the former EU-15 group. Strengthen the quality of their institutions could be an appropriate strategy to reduce the gap but, unfortunately, what we are actually witnessing is a general decline of government quality across the entire EU-28 in recent years.

Regarding the control variables, the initial level of income per capita is negative only when the NMS dummy is not included. Logically, when this variable is added, it captures the effect of the initial GDP, as the NMS coefficient is clearly positive (note that NMS regions have lower initial income levels). Population growth is negative in all cases, in line with the previous literature. More controversial are the results found for education, generally non-significant across models. In contrast, R&D investment exhibits a positive sign in all of them. We argue that this latter variable can be partially absorbing the effect of education, as they are positively correlated—higher R&D efforts take place in regions with more qualified

[11] In particular, one of the main shortcomings of SAR models is the imposition of the same proportional link between direct and indirect effects for all the regressors in the model.

[12] Similar results for NMS regions are found by Peiró-Palomino (2016) for the case of informal institutions (i.e. social capital). In particular, the author found a comparatively lower effect (in some cases even negative) of social capital on regional growth for NMS regions during the first years after the transition from the planned to the free market economy.

labor force. The effect of physical capital investment is non-significant, indicating that growth in the analyzed period is more driven by knowledge and institutional factors than by physical investment.

Finally, in Model 7 we run a fixed effects estimation with all the controls. Unfortunately, this procedure removes all the time invariant variables, including the dummy variable for NMS regions, in which we are interested. When comparing fixed and random models with the Hausman test, we are unable to compare the models including the time invariant controls. The test was performed for Model 4 and for that specification the fixed effects alternative was preferable. However, few clear insights can be obtained from the fixed effects estimation in Model 7, as only population growth remains significant, which are results difficult to reconcile with the well-stablished growth theory. In addition, as the NMS dummy becomes part of the fixed effects, we cannot test whether different impacts are found for these regions, as we do in Model 6. If the predominant source of variation is cross-regional instead of within-regional, which is our case, fixed effects estimations can be troublesome and produce inaccurate results (Barro, 2000; Partridge, 2005). The cross-regional variation of the EQI index is notably larger than that within-regional,[13] thus explaining in a large extent the puzzling results from the fixed effects models. In contrast, random effects models perform similarly to OLS cross-sectional models.

Given the particularities of our data, we prefer the random effects alternative for the subsequent analyses, even at the cost of assuming that, once initial GDP per capita and NMS are included in the model, the explanatory variables are not systematically correlated with the error term. Of course, this is debatable, but we consider ours as a balanced strategy given the counterintuitive results from the fixed effect models. Finally, Table 4 contains separate results for the three components of government quality using the most comprehensive specification and random effects estimations. The results suggest that all three components are positive and significant. In addition, their interaction with the dummy NMS is negative, in line with the results found for the aggregated indicator in Table 3. This corroborates the comparatively lower impact of government quality on growth in NMS regions.

[13] Note that we were forced to assign the same values to several years due to availability constraints, increasing the stability.

TABLE 3.
Government quality and GDP per capita growth

GDP pc growth	(1)		(2)		(3)		(4)		(5)		(6)		(7)	
Intercept	0.186	***	0.054	**	0.140	***	0.199	***	0.024		0.012		0.115	***
	(0.027)		(0.011)		(0.027)		(0.028)		(0.036)		(0.037)		(0.021)	
Initial GDP pc (logs)	-0.015	***			-0.011	***	-0.017	***	-0.000		0.000			
	(0.002)				(0.002)		(0.002)		(0.003)		(0.003)			
Government quality	0.003		-0.029		0.001		0.010	*	0.018	***	0.025	***	-0.042	
	(0.005)		(0.019)		(0.005)		(0.006)		(0.005)		(0.006)		(0.018)	
Population growth					-0.007	***	-0.007	***	-0.006	***	-0.006	***	-0.007	***
					(0.001)		(0.001)		(0.001)		(0.001)		(0.001)	
Education					0.026	**	-0.000		0.005		0.000		-0.049	
					(0.012)		(0.012)		(0.010)		(0.011)		(0.049)	
Physical capital					0.011		0.017		-0.016		-0.019		-0.144	
					(0.024)		(0.024)		(0.022)		(0.019)		(0.060)	
R&D investment							0.002	**	0.002	***	0.002	***	-0.005	
							(0.000)		(0.000)		(0.000)		(0.005)	
Capital city							0.012	***	0.000		0.000			
							(0.004)		(0.004)		(0.005)			
NMS									0.023	***	0.039	***		
									(0.003)		(0.006)			
Government quality x NMS											-0.037	***		
											(0.013)			
RE / FE	RE		FE		RE		RE		RE		RE		FE	
N	1,648		1,648		1,648		1,648		1,648		1,648		1,648	
R^2	0.242		0.204		0.270		0.285		0.324		0.329		0.126	
Joint significance	1,162.41	***	106.12	***	1,287.32	***	1,273.03	***	1,717.28	***	1,622.10	***	89.94	***

All the models include but do not report time effects. Robust standard errors are in parentheses. *, ** and *** denote 10%, 5% and 1% significant levels, respectively.

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TABLE 4.
Government quality components and GDP per capita growth

GDP pc growth	(1)		(2)		(3)		(4)		(5)		(6)	
Intercept	0.020		0.012		0.024		0.007		0.022		0.023	
	(0.038)		(0.037)		(0.037)		(0.037)		(0.035)		(0.035)	
Initial GDP pc (logs)	-0.006		0.000		-0.000		0.000		-0.000		-0.000	
	(0.001)		(0.003)		(0.003)		(0.003)		(0.003)		(0.003)	
Population growth	-0.006	***	-0.006	***	-0.006	***	-0.006	***	-0.006	***	-0.006	***
	(0.001)		(0.001)		(0.001)		(0.001)		(0.001)		(0.001)	
Quality	0.012	*	0.024	***								
	(0.006)		(0.006)									
Impartiality					0.017	***	0.030	***				
					(0.006)		(0.006)					
Corruption									0.020	***	0.029	***
									(0.006)		(0.005)	
Education	0.012		0.005		0.009		-0.000		0.005		-0.001	
	(0.006)		(0.011)		(0.010)		(0.011)		(0.011)		(0.011)	
Physical capital	-0.018		-0.021		-0.016		-0.018		-0.015		-0.023	
	(0.022)		(0.019)		(0.022)		(0.019)		(0.022)		(0.019)	
R&D investment	0.002	***	0.002	***	0.002	***	0.002	***	0.002	***	0.002	***
	(0.000)		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)	
Capital city	-0.000		0.000		-0.000		0.000		0.000		0.001	
	(0.005)		(0.005)		(0.004)		(0.005)		(0.004)		(0.004)	
NMS	0.022	***	0.039	***	0.022	***	0.044	***	0.023	***	0.042	***
	(0.003)		(0.005)		(0.003)		(0.006)		(0.003)		(0.006)	
Quality x NMS			-0.036	***								
			(0.010)									
Impartiality x NMS							-0.044	***				
							(0.011)					
Corruption x NMS											-0.043	***
											(0.012)	
N	1,624		1,624		1,624		1,624		1,624		1,624	
R^2	0.320		0.328		0.324		0.332		0.326		0.334	
Joint significance	1,670.63	***	1,655.83	***	1,655.83	***	1568,83	***	1,664.20	***	1,571.48	***

All the models are random effects estimations and include but do not report time effects. Robust standard errors are in parentheses. *, ** and *** denote 10%, 5% and 1% significant levels, respectively.

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5.2. Spatial spillovers

This section details the results from the spatial models, reported in Table 5. As explained in Section 4, the neighboring W matrix was specified using the *k*-nearest neighbor criterion, setting *k*=5. The Pesaran's (2004) tests (available at the bottom of the table) point to the existence of spatial dependence in the residuals of the non-spatial (OLS) estimations. After detecting the spatial autocorrelation, we estimate SDM models. As argued by LeSage and Pace (2009), SDM can provide unbiased estimates even if the true model is a SEM or a SAR.[14] Therefore, it is a wise starting point.

Table 5.
SAR estimations for government quality and GDP per capita growth

GDP pc growth	(1)		(2)		(3)		(4)	
Intercept	0.000		-0.002		0.000		-0.002	
	(0.034)		(0.034)		(0.034)		(0.032)	
Initial GDP pc (logs)	0.000		0.001		0.000		0.000	
	(0.003)		(0.003)		(0.003)		(0.003)	
Government quality	0.014	***						
	(0.005)							
Quality			0.000					
			(0.005)					
Impartiality					0.013	***		
					(0.002)			
Corruption							0.014	***
							(0.005)	
Population growth	-0.005	***	-0.005	***	-0.005	***	-0.005	***
	(0.001)		(0.001)		(0.001)		(0.001)	
Education	-0.002		0.002		0.005		-0.001	
	(0.010)		(0.010)		(0.010)		(0.010)	
Physical capital	-0.005		-0.006		-0.006		-0.005	
	(0.018)		(0.018)		(0.017)		(0.017)	
R&D investment	0.001	**	0.001	**	0.001	**	0.001	**
	(0.000)		(0.000)		(0.000)		(0.000)	
Capital city	0.001		0.000		0.001		0.001	
	(0.004)		(0.004)		(0.004)		(0.004)	
NMS	0.014	***	0.013	***	0.013	***	0.014	***
	(0.002)		(0.002)		(0.002)		(0.002)	
N	1,648		1,624		1,624		1,624	
Pesaran test in OLS model	144.42	***	141.88	***	142.29	***	142.61	***
LR-test (SAR vs. SDM)	10.57		11.26		10.84		10.71	
LR-test (SEM vs. SDM)	17.96	**	18.58	**	18.59	**	18.00	**
Rho	0.468	***	0.469	***	0.468	***	0.466	***
R^2	0.327		0.319		0.322		0.325	
Log-pseudolikelihood	3,811.87		3,748.68		3,750.80		3,751.61	

All the models are random effects estimations and include but do not report time effects. *k*-nearest neighbors, *k*=5. Robust standard errors are in parentheses. *, ** and *** denote 10%, 5% and 1% significant levels, respectively.

[14] See LeSage and Pace (2009) for the technical demonstration.

However, it is also advisable to test whether the SDM can be simplified into a SEM or a SAR (Elhorst, 2010). Then, we perform likelihood ratio tests (LR-tests, also available at the bottom of Table 5). The results indicate that the SAR model cannot be rejected in front of the SDM, while the SEM is rejected in all cases. We therefore report the SAR models in Table 5, as this is the preferred specification.

We find positive estimated coefficients for government quality. When focusing on the individual components, positive effects are found for impartiality and corruption, whereas a non-significant coefficient is obtained for the quality component. Analogously, the rest of the explanatory variables also disclose consistent coefficients with the results previously discussed. The average spatial autocorrelation is summarized by the *Rho* coefficient, around 0.46 in all the models and indicating a highly positive spatial autocorrelation.

In order to interpret the coefficients from the SAR model, direct and indirect impacts need to be computed, as these models generate spatial spillovers (see, for technical details LeSage and Pace, 2009). Then, changes in government quality in one region not only affect growth in that region, but also growth in its neighbors. Finally, the growth of the neighbors will have a positive feedback effect on the region where initially the variation in government quality took place, giving rise to the direct effect. In contrast, the indirect effect is the average impact of changes in government quality in one region on its neighbors' growth. The results are reported in Table 6. Interestingly, whereas the components of impartiality and corruption exhibit very similar impacts to those for the aggregated index, the effects for the quality component are non-significant. In terms of size, we find that the indirect effects are almost as large as the direct ones, indicating that the spatial spillovers play a remarkable role and should be taken into account. The total effects are the sum of both direct and indirect impacts.

TABLE 6.
Direct, indirect and total effects of government quality on GDP per capita growth

	SAR models (*k*=5)					
	Direct effects		Indirect effects		Total effects	
Government quality	0.014	**	0.011	**	0.026	**
	(0.006)		(0.005)		(0.011)	
Quality	0.009		0.007		0.017	
	(0.006)		(0.005)		(0.008)	
Impartiality	0.014	**	0.011	**	0.025	**
	(0.005)		(0.004)		(0.010)	
Corruption	0.015	***	0.012	**	0.027	**
	(0.005)		(0.005)		(0.010)	

Effects are computed departing from the estimates from Models 1 - 4 in Table 5. Standard errors are in parentheses. *, ** and *** denote 10%, 5% and 1% significant levels, respectively.

5.3. ROBUSTNESS TESTS

Different techniques are employed to check for the robustness of the results. First, given that we used repeated figures of quality of government for the intermediate years, we replicate the main models for different time periods. Table A1 in the Appendix A provides the results. In the table, columns (1) to (5) correspond to a cross-sectional framework, in which we average all the available information for the period 2010-2017. Columns (6) to (10) contain the results of a two-period panel data estimation. The first period averages all the time-varying information of years 2010-2013 and uses government quality data from 2010. The second period averages the time-varying data of years 2014-2017, while government quality is the average of the two available figures for that period, namely 2013 and 2017. The results are in all cases in line with the baseline estimations of Tables 3 and 4, both in terms of size of the coefficients and significance levels.

Second, with respect to the spatial analysis, the regressions are performed using different neighboring criteria, namely k=3 and k=7, that is, considering as neighbors the three and seven nearest regions, respectively. The results are reported in Table A2 of the Appendix A and are qualitatively analogous to those obtained with k=5. The quality component is non-significant or only weakly significant, whereas positive and significant coefficients, almost identical in size regardless of the matrix used, are found for impartiality and corruption.

6. Concluding remarks and policy prescriptions

This paper has assessed the role of government quality on European regional growth for the period 2010-2017. The findings largely support North's (1990) proposition according to which institutions drive economic performance, hence resulting as a valuable tool for achieving regional progress. In the framework of the European Regional Policy, this means that government quality should become an important tool to achieve regional convergence. Our analysis has shown that regions from the new EU members (NMS) have remarkably lower levels of government quality than the former EU-15 economies. Consequently, although the new members are growing comparatively faster, their low-quality institutions are decelerating the catching-up process. We argue that institutions need some time to improve. The NMS economies have completed the transition from a planned to a free market economy but, it is possible that their institutional frameworks have still reminiscences from the burdensome and inefficient institutional apparatus of the communist system.

Our results point to a positive role of government quality on economic growth, which is coherent with the previous findings by Rodríguez-Pose and Garcilazo (2015), Crescenzi et al. (2016) and Ketterer and Rodríguez-Pose (2018). With respect to the previous literature, we provide results for a more recent period of time. Also, we used richer information, as we considered the three available editions of the EQI index (2010, 2013 and 2017), analyzed individual components, and quantified spatial spillovers.

The data show a decline in government quality across all the EU-28, similar in size in both the EU-15 and the NMS groups. Then, the institutional distance between the two groups remained relatively stable over the studied period. Accordingly, policy efforts should be addressed to improve government quality all across the Union, with special emphasis in narrowing the gap between former and new members. In addition, the results from the spatial panel approach reveal the existence of positive feedback effects, implying the presence of virtuous reciprocal influences between neighbor regions. The results for government components provide additional clues on where policies should put the effort. In particular, once spatial spillovers are considered, having highly impartial and corruption-free institutions are those elements more directly related to growth. In contrast, a weaker or even a non-significant effect is found for the quality of government services.

In the light of our findings, some policy advices aimed at improving regional economic performance through government quality are presented. For instance, Alesina (2003) suggested that subnational administrations exerting their powers in smaller territories generally have to deal with less heterogeneous individual preferences. This feature would allow local governments to supply public policies that are closer to residents' preferences and increase their efficiency. Then, government reforms aimed at decentralizing the executive power and at establishing a clearer separation of the duties between central and subnational governments should be encouraged.

Other authors such as Padovano and Ricciuti (2009) found that higher competitiveness in the political arena improves the quality of local institutions. Thus, measures aimed at increasing democratic competitiveness and alternation between political forces, such as setting limits to the mandates of regional governors might be considered as well. This could help in improving the impartiality and the corruption components. All in all, institutions should be considered not always as a provider, but also as the object of public policies.

Finally, it must be acknowledged that the paper has also some limitations. One derives from the nature of the data on government quality, for which yearly information is not available. We attempted to address this issue by artificially assigning repeated values to intermediate years or averaging the data for different periods. Despite we obtain very similar results when using different temporal aggregations, results should be taken cautiously. Another important limitation is the potential existence of endogeneity, which is not treated in the paper and might be a promising avenue for future research.

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Appendix A. Robustness tests

Table A1.
Results for different periods

	Cross-section 2010-2017					Panel data 2010-2013 and 2014-2017				
GDP pc growth	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Intercept	0.058 *	0.053	0.057	0.052	0.056 *	0.027	0.024	0.026	0.020	0.017
	(0.034)	(0.035)	(0.033)	(0.032)	(0.033)	(0.034)	(0.035)	(0.034)	(0.033)	(0.035)
Initial GDPpc (logs)	-0.007 *	-0.006 *	-0.007 *	-0.006 *	-0.007 *	-0.003	-0.002	-0.003 *	-0.002 *	-0.002
	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Government quality	0.025 ***				0.033 ***	0.022 ***				0.029 ***
	(0.006)				(0.006)	(0.005)				(0.006)
Quality		0.019 ***					0.017 ***			
		(0.007)					(0.006)			
Impartiality			0.025 ***					0.022 ***		
			(0.006)					(0.005)		
Corruption				0.026 ***					0.022 ***	
				(0.007)					(0.006)	
Population growth	-0.004 **	-0.005 **	-0.007 **	-0.005 **	-0.002	-0.006 ***	-0.006 ***	-0.006 ***	-0.006 ***	-0.004 **
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Education	0.001	0.010	0.006	0.001	-0.008	0.003	0.010	0.007	0.005	-0.001
	(0.010)	(0.011)	(0.011)	(0.012)	(0.011)	(0.010)	(0.011)	(0.010)	(0.011)	(0.010)
Physical capital	0.049 *	0.050 *	0.048 *	0.052 **	0.040 *	0.016	0.017	0.016	0.018	0.008
	(0.026)	(0.026)	(0.026)	(0.026)	(0.022)	(0.023)	(0.023)	(0.023)	(0.022)	(0.019)
R&D investment	0.002 **	0.002 **	0.002 **	0.002 **	0.002 **	0.002 **	0.002 ***	0.002 **	0.002 **	0.002 **
	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capital city	0.004	0.003	0.003	0.004	0.004	0.002	0.001	0.001	0.001	0.002
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
NMS	0.021 ***	0.019 ***	0.020 ***	0.021 ***	0.040 ***	0.022 ***	0.020 ***	0.021 ***	0.022 ***	0.039 ***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.007)	(0.003)	(0.003)	(0.003)	(0.003)	(0.006)
Government quality x NMS					-0.046 ***					-0.038 ***
					(0.015)					(0.013)
N	206	203	203	203	206	412	406	406	406	412
R^2	0.481	0.456	0.481	0.489	0.509	0.300	0.288	0.300	0.300	0.316
Joint significance	22.14 ***	19.59 ***	20.82 ***	19.96 ***	24.73 ***	230.41 ***	210.36 ***	226.31 ***	213.97 ***	259.17 ***

Columns (1) to (5) correspond to a cross-section analysis averaging all the available data in the period 2010-2017. Columns (6) to (10) correspond to a two-period panel analysis, averaging the available data for periods (2010-2013) and (2014-2017). Panel data models are random effects estimations and include but do not report time effects. Robust standard errors are in parentheses. *, ** and *** denote 10%, 5% and 1% significant levels, respectively.

TABLE A2.
SAR estimations with alternative specifications of the spatial matrix (*k*=3 and *k*=7)

GDP pc growth	Panel data SAR models							
Intercept	0.005	-0.001	0.000	-0.004	0.003	-0.008	0.000	-0.003
	(0.033)	(0.034)	(0.034)	(0.035)	(0.033)	(0.034)	(0.032)	(0.032)
Government quality	0.014 ***	0.014 **						
	(0.005)	(0.005)						
Quality			0.009	0.009 *				
			(0.006)	(0.005)				
Impartiality					0.014 ***	0.014 ***		
					(0.005)	(0.005)		
Corruption							0.014 ***	0.014 ***
							(0.005)	(0.005)
LR-test (SAR vs. SDM)	6.61	11.01	8.90	10.48	8.83	10.11	8.41	9.96
K-nearest criterion	k=3	k=7	k=3	k=7	k=3	k=7	k=3	k=7
Rho	0.409 ***	0.510 ***	0.410 ***	0.515 ***	0.409 ***	0.514 ***	0.407 ***	0.512 ***
N	1,648	1,648	1,624	1,624	1,624	1,624	1,624	1,624
R^2	0.327	0.316	0.323	0.315	0.326	0.317	0.329	0.319
Log-pseudolikelihood	3,810.65	3,811.21	3,747.59	3,749.95	3,749.96	3,752.12	3,750.39	3,752.91

All the models are random effects estimations and include but do not report time effects and control variables. Robust standard errors are in parentheses. *, ** and *** denote 10%, 5% and 1% significant levels, respectively.

La adopción de la estrategia de servitización en las empresas manufactureras españolas: un análisis espacial por comunidades autónomas

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Resumen:

La servitización representa una estrategia de mercado muy atractiva para la industria manufacturera. De hecho, la evolución de la capacidad de los fabricantes para ofrecer servicios como complementos o sustitutos de los productos que fabrican ofreciendo soluciones óptimas a las demandas, ha mostrado un rápido crecimiento desde la década de 1980. Una extensa literatura ha descrito estas estrategias y ha demostrado que este fenómeno es generalizado y está aumentando en la mayoría de las economías desarrolladas. Sin embargo, existe poca evidencia empírica del alcance o las consecuencias de la servitización sobre el conjunto de las empresas manufactureras.

Teniendo en cuenta que la servitización es una estrategia en alza y cada vez más utilizada por parte de las empresas, y al mismo tiempo poco analizada con detalle desde la perspectiva espacial, este trabajo pretende profundizar en su estudio. Concretamente, el objetivo de este artículo es analizar si la estrategia de servitización presenta patrones de comportamiento similares en el territorio español mediante la aplicación de la técnica del análisis espacial. Para alcanzar esta meta, el estudio se realiza por comunidades autónomas para tratar de identificar la existencia de relaciones significativas entre la servitización y algunas variables económicas como la rentabilidad de las ventas, el tamaño de la empresa y los ingresos totales. Tras el análisis se demuestra que existe variabilidad de comportamiento en cuanto a la servitización en las diecisiete comunidades autónomas que forman el territorio español.

Palabras clave: Servitización; empresas manufactureras; estrategia; España.
Clasificación JEL: M21, L25, L60.

The adoption of the servitization strategy in Spanish manufacturing companies: a spatial analysis by autonomous communities

Abstract:

The servitization represents a very attractive market strategy for the manufacturing industry. In fact, the evolution of the capacity of manufacturers to offer services as complements or substitutes for the products they manufacture offering optimal solutions to the demands has also demonstrated a rapid increase since the 1980s. An extensive literature has described these strategies and has demonstrated that this phenomenon is widespread and is increasing in most developed economies. However, there is no empirical evidence of the scope or results of servitization on all manufacturing companies.

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Considering that servitization is a growth strategy and increasingly used by companies, but, not analyzed in detail from a spatial perspective. Thus, this work aims to focus on the spatial relationship. Particularly, the main aim of this paper is to analyze if the servitization strategy presents a similar pattern of behavior in the Spanish territory through the application of the spatial analysis technique. To achieve this goal, the study is carried out by autonomous communities in order to identify the presence of significant relationships between servitization and some economic variables such as the profitability of sales, the size of the company and total revenues. Finally, derived from the results obtained by the present study, it is shown that there is variability of behavior in terms of servitization in all autonomous communities that make up the Spanish territory.

Keywords: Servitization; manufacturing firms; strategy; Spain.
JEL classification: M21, L25, L60.

1. Introducción

La servitización en las empresas manufactureras es un hecho observable que está ganando mayor atención en los debates académicos de las últimas dos décadas y actualmente es una estrategia adoptada por múltiples empresas de fabricación.

El concepto de servitización fue descrito por primera vez en 1988. Desde entonces, varios autores como Oliva y Kallenberg (2003) o Slack (2005), entre otros, han estudiado su adopción como una estrategia de fabricación competitiva y han buscado comprender el desarrollo y las implicaciones del concepto de la estrategia de servitización. La competitividad de las empresas manufactureras se basa cada vez más en su capacidad para introducir servicios de valor añadido en sus operaciones y para ofrecer paquetes integrados de bienes y servicios.

El proceso de servitización ha sido descrito en la literatura como la evolución de las capacidades de los fabricantes para ofrecer servicios como complementos o sustitutos de los bienes que producen (Crozet y Millet, 2017) y estudiado principalmente en industrias manufactureras (Neely, 2008). Así mismo, la servitización se considera muy vinculada a la relación entre el fabricante y el cliente, al ser un proceso de adaptación de la oferta de servicios a la oferta de productos.

La estrategia de servicio se basa, en general, en cómo las empresas deben diferenciarse de sus competidores por medio de ofertas de servicios (Gebauer *et al.,* 2008). El estudio de Gebauer *et al.* (2010) argumenta que el establecimiento de una estrategia de servicio clara es un importante factor de éxito, permitiendo altos ingresos de servicio en empresas manufactureras. Una estrategia de servicio clara animará a las empresas a adoptar las medidas organizativas y la asignación de recursos apropiadas. No obstante, la adición de nuevos servicios a productos altamente aceptados, requiere de un proceso de desarrollo de los servicios claramente definido (Gebauer *et al.,* 2006).

2. Estado del arte

En esencia, el término "servitización” es ampliamente reconocido como el proceso de aumentar el valor añadiendo servicios a los productos (Vandermerwe y Rada, 1988). Es un medio para crear capacidades de valor añadido que son distintivas y sostenibles frente a los competidores (Baines et al., 2009). Autores como Neely (2008) consideran que el proceso de servitización puede ser visto como el desarrollo de las capacidades de innovación de una organización, en el sentido de que en lugar de ofrecer sólo productos se pasa a ofrecer sistemas de producto-servicio (Visnjic Kastalli y Van Looy, 2013). El principio fundamental de la servitización es ampliar el enfoque en el desarrollo de soluciones añadidas a los productos, la optimización de las ofertas para la satisfacción de las necesidades del cliente, de manera que para los clientes implica la adquisición de soluciones más que de productos (Fiksdal y Kumar, 2011).

Bajo estas ideas, las empresas manufactureras están atraídas principalmente por la servitización como un medio para crear beneficios y fortalecer la orientación al cliente (Baines et al., 2009) y diferenciación de productos (Sforzi y Boix, 2019). Para aprovechar estos beneficios creando oportunidades de servitizaciones exitosas, los manufactureros necesitan establecer una alineación apropiada entre las condiciones del mercado y de su organización.

El pensamiento tradicional sobre la servitización gira en torno a las empresas que venden paquetes de servicios y activos para aumentar los valores y las ventas (Vandermerwe y Rada, 1988). Esta estrategia puede fortalecer las relaciones con los clientes, también crear nuevos ingresos estables y establecer altas barreras para los competidores (Baines et al., 2009 y 2011). Además, la parte más importante es realizar un enfoque de servitización de manera efectiva. Para ello, las empresas se ven obligadas a modificar sus estrategias, funciones, tecnologías, personal para sostener los movimientos educativos en la propuesta organizacional y las competencias de la combinación de todos estos esquemas (Oliva y Kallenberg, 2003). Las empresas son conscientes de que la servitización territorial es un proceso de producción que vincula los servicios y la industria y puede potenciar el impacto local de la actividad manufacturera sobre la competitividad regional facilitando la difusión del conocimiento local (Lafuente et al., 2017). Los fabricantes tienen ahora tanto los incentivos y las oportunidades para ampliar sus ofertas y ofrecer soluciones que correspondan a las necesidades del cliente estén donde estén. La servitización ya no es una estrategia de negocio alternativa, sino una posible estrategia para la supervivencia (Slepniov et al., 2010).

En consecuencia, los servicios pueden representar la vía mediante la cual ofrecer una nueva fuente sostenible de ingresos para el fabricante, ayudando a: 1) superar el estancamiento de los mercados de productos tradicionales (Eggert et al., 2011; Slack, 2005; Gebauer y Fleisch 2007); 2) mejorar el crecimiento de ingresos y beneficios (Eggert et al., 2014); 3) proporcionar un flujo más estable de ingresos (Wise y Baumgartner, 1999); 4) aumentar la rentabilidad (Crozet y Milet, 2017; Gebauer et al., 2012; Kohtamäki et al., 2013; Dachs et al., 2014); 5) crear fuentes diversas para obtener ingresos (Baines y Lightfoot , 2013); 6) conseguir ofrecer una mejora en las respuestas a las necesidades del cliente (Ostrom et al., 2010); 7) ayudar en la apuesta por una continua innovación de productos (Eggert et al., 2011; Bustinza et al., 2019); y, 8) establecer mayores barreras de entrada a la competencia (Oliva y Kallenberg, 2003).

En consecuencia, siendo la servitización una estrategia en alza y cada vez más utilizada por parte de las empresas, y al mismo tiempo poco analizada con detalle desde la perspectiva espacial, este trabajo pretende profundizar en su estudio. Concretamente, el presente trabajo trata de identificar la existencia de relaciones significativas entre la servitización y algunas variables económicas mediante la técnica estadística del análisis espacial.

Investigaciones como las de Vendrell-Herrero y Wilson (2017) y Lafuente et al. (2017) sugieren que no todos los servicios empresariales tienen la misma importancia para los territorios servitizados. Además, otros estudios de Lafuente et al. (2017) proporcionan una clara evidencia del impacto territorial de la servitización sobre el desarrollo de sectores industriales vigorosos y, por consiguiente, en la creación de empleo.

Bajo esta idea, se argumenta que la servitización territorial contribuye a la consolidación y la resistencia del tejido industrial regional a través de economías de aglomeración interactivas, teniendo en cuenta que tales interacciones de red y servitización territorial pueden crear ventajas competitivas para las empresas, conduciendo a una mejora de la competitividad regional (Gomes et al., 2019; Lafuente et al., 2017; Lafuente et al., 2019).

Así mismo, la servitización territorial últimamente ha sido descrita como un proceso de desarrollo basado en la co-ubicación conjunta sinérgica entre las pequeñas y medianas empresas manufactureras (PYME) y las empresas de servicio de alto conocimiento (KIBS) (Lafuente et al., 2017), destacando los beneficios de interconexiones e interacciones entre complementarios y las empresas de fabricación (Gomes et al., 2019). De este modo, los académicos destacan los beneficios de las interconexiones e interacciones entre empresas de fabricación geográficamente cercanas y empresas de servicio generando ofertas innovadoras de producto-servicio diferenciadas e integradas. Gomes et al. (2019) aducen que las interacciones de red y la servitización territorial pueden crear ventajas competitivas para las empresas conduciendo a la competitividad regional. Además, también afirman que las regiones podrían volverse más resilientes no solo por las interconexiones entre las empresas manufactureras locales y empresas servitizadas, sino por el desarrollo del comercio exterior con empresas y compradores de otras regiones y países.

Sin embargo, la falta de estudios sobre el impacto de la servitización territorial es todavía muy amplia. A pesar de algunos esfuerzos recientes, se sabe relativamente poco sobre los impulsores y los efectos de la servitización territorial. No obstante, la integración de los servicios en las regiones es un ámbito poco analizado, siendo un tema de mejora de una economía local, dado que los resultados de un estudio regional pueden ofrecer la oportunidad de potenciar el crecimiento de las empresas manufactureras locales. Ello permitiría a estas compañías ser más competitivas, mejoraría la competencia a nivel empresarial local y ayudaría a crear nuevas oportunidades para desarrollar nuevas capacidades entre las regiones. Con este estudio se pretende ver el panorama de la estrategia de servitización en las regiones españolas y ver su eficacia en cada región, así como los impactos positivos en el desarrollo económico regional, la relación entre la implementación de los servicios y el desempeño de la empresa.

Concretamente, la pregunta de investigación que se plantea es la siguiente: en relación al comportamiento espacial de la servitización en España ¿existe variabilidad en las diecisiete comunidades autónomas que conforman el territorio español?

En este artículo el estudio territorial demuestra el impulso de otras comunidades autónomas influenciadas por una comunidad con éxito en aplicaciones de estrategias de servitización. Este aspecto podría ayudarles a mejorar la competitividad en sus negocios y a obtener mejores beneficios, resultando ambas ideas una motivación para que las empresas decidan incorporar de manera efectiva este tipo de estrategia.

3. Metodología

Para dar respuesta a la pregunta de investigación planteada, se ha considerado conveniente utilizar la técnica del análisis espacial, basada en métodos estadísticos y modelos matemáticos, mapas y herramientas de simulación. Esta técnica es empleada por muchas otras disciplinas además de la geografía, como por ejemplo la economía, la historia, la agronomía, la arqueología, y las ciencias del medio ambiente, entre otros (Pumain, 2004).

Introducido por primera vez en el año 1907 por Student, aunque los comienzos en el desarrollo de un campo separado de la estadística espacial se atribuyen a la obtención de los primeros índices formales para detectar la presencia de autocorrelación espacial en los años cincuenta con los trabajos de Moran (1948) y Geary (1954). El gran desarrollo de la econometría espacial se produce en los años ochenta y noventa, que se inicia con los trabajos de Cliff y Ord (1981) y con contribuciones concretas en el campo de la econometría espacial, así como varias colecciones de artículos, como los de Anselin y Florax (1995, 2000) y Fischer y Getis (1997). De esta forma, la importancia y relevancia de los métodos que analizan los efectos espaciales en los modelos econométricos se ha ido incrementando de forma notable.

La estadística espacial comprende todo análisis que tiene una dimensión espacial, ya sea que esta dimensión se refiera a la herramienta estadísticamente propiamente dicha, el objeto de análisis o a las variables utilizadas como descriptor del objeto (Jaría et al., 2010). En resumen, el análisis espacial pone en evidencia estructuras y formas de organización espacial recurrentes, que resumen por ejemplo los modelos centro-periferia, los campos de interacción de tipo gravitatorio, las tramas urbanas jerarquizadas, los diversos tipos de redes o de territorios, etc. (Moreno y Vayá, 2000). Analiza los procesos que se encuentran en el origen de esas estructuras, a través de conceptos como los de distancia, de interacción espacial, de alcance espacial, de polarización, de centralidad, de estrategia o elección espacial, de territorialidad. Los métodos utilizados para el análisis espacial son muy diversos. El empleo de la estadística clásica conduce a olvidar en un primer momento la localización de los objetos y, completada por la cartografía, encuentra luego, en un análisis en términos de residuos, los efectos espaciales. Por el contrario, los métodos de la geoestadística y de la morfología matemática, agrupados en la estadística espacial, analizan directamente las informaciones geo codificadas (Chasco, 2003).

El análisis espacial es la conjugación de técnicas que buscan separar, procesar, clasificar y presentar con criterios cartográficos el estudio cuantitativo y cualitativo de aquellos fenómenos que se manifiestan en el espacio. Utilizando métodos estadísticos, matemáticos, sistemas de información geográfica (S.I.G), utilización de mapas y diversos útiles de simulación.

Actualmente la evolución de los sistemas de información geográfica los ha convertido en una poderosa herramienta de análisis espacial, que permite evaluar escenarios geográficos de forma rápida y, en consecuencia, convertirse en apoyo para la toma de decisiones de diferentes procesos y actividades que ocurren en cualquier territorio.

Mediante la aplicación del mencionado análisis espacial, el cual ha sido poco aplicado en trabajos científicos en este ámbito hasta el momento, el presente trabajo pretende identificar la existencia de relaciones significativas entre las empresas manufactureras servitizadas y algunas variables económicas en los últimos años en las diecisiete comunidades autónomas (de ahora en adelante, CC.AA.) que forman el territorio español.

Para alcanzar este objetivo, esta investigación utiliza una base de datos de empresas manufactureras españolas sobre la que se realiza un análisis cuantitativo, la cual se construye como se detalla a continuación. Los datos del estudio se extraen de la base de datos SABI (Sistema Ibérico de Análisis de Balances) que contiene los valores financieros de 2 millones de empresas españolas y más de 500.000 de compañías portuguesas. Así, este trabajo se basa en los datos obtenidos de los informes anuales de las empresas seleccionadas del año 2016 por ser el único año con los datos más completos.

En la metodología de selección de los datos, se utiliza como referencia el trabajo de Neely (2008), cuyo principal objetivo es estudiar el alcance y la magnitud de la servitización a partir de una muestra de 13.775 empresas manufactureras (clasificadas como industriales según su código SIC, Standard Industrial Classification) que cotizan en la bolsa de 25 países, estableciendo que un 30% obtiene una parte significativa de su facturación en base a servicios.

En base a ello, primero se realiza la clasificación inicial de las empresas de SABI de sectores industriales de fabricación para extraer únicamente a las empresas manufactureras. Esto consiste en la selección de las compañías con códigos SIC primarios o secundarios entre el rango de valores de 10 a 39 inclusive. Esta selección inicial permite identificar 1.456.709 empresas manufactureras españolas.

Una vez identificadas las empresas manufactureras, se seleccionan las empresas de mayor dimensión (medidas en términos de ingresos y número de empleados, teniendo en cuenta aquellas con un volumen de ingresos con un mínimo de 50.000 euros y un número mínimo de 50 empleados), ya que son éstas las que pueden representar un mejor exponente de implementación de la estrategia de servitización (Neely, 2008); obteniendo una muestra de mil empresas. En este sentido, trabajos como el de Neely (2008) muestran que las empresas más grandes, medidas tanto en términos de número de empleados como de ingresos, tienden a servitizar más que las empresas más pequeñas. También Kwak y Kim (2016) concluyen que el tamaño de las empresas ayuda a observar su efecto en el rendimiento de las empresas.

El siguiente paso consiste en la clasificación de las empresas que implantan la estrategia de servitización, la cual se basa en las características clave que define la literatura sobre este fenómeno. En este sentido, Neely (2008) propone categorizar los servicios en las empresas manufactureras según los doce siguientes tipos: diseño y desarrollo de servicios, sistemas y soluciones, comercio al por menor y distribución, mantenimiento y soporte, instalación e implementación, servicios financieros, propiedad y bienes raíces, consultoría, outsourcing y servicios operativos, servicios de compras, servicios de arrendamiento, transporte y servicios de transporte de mercancías. Este trabajo considera que las empresas servitizadas son las que ofrecen al menos uno de estos servicios tipificados por Neely (2008), de manera que las empresas que no poseían alguno de ellos se consideraron en la categoría de “no servitizadas”.

Bajo estas características teóricas, se realiza un proceso de codificación manual de cada empresa una a una para la clasificación de las mil empresas seleccionadas a partir de SABI en las categorías de servitizadas o no servitizadas según las categorías de Neely (2008), y contabilizando la cantidad de servicios ofrecidos. Al final del análisis de las mil empresas manufactureras españolas, 73 fueron eliminadas al no tener las condiciones para ser codificadas. Dicha codificación se efectúa a partir de la información disponible en la página web corporativa de cada empresa filtrando los servicios que ofrecen cada empresa, y a partir de la información contenida en la base de datos FACTIVA se verificaron los datos de cada empresa respecto a SABI. Esta base de datos FACTIVA es una herramienta de investigación e información de negocios, propiedad de Dow Jones & Company. Se trata de la fuente líder mundial de noticias, datos e ideas sobre compañías, que ayuda a los profesionales en la toma de decisiones empresariales a través de su potente búsqueda de información sobre empresas.

El proceso de clasificación concluyó en una muestra final de 927 empresas (al descartar 73 empresas por falta de información, dado que durante el proceso sus páginas web estaban en mantenimiento o fuera de servicio). De la muestra final, se obtiene que un 41% de las empresas españolas son servitizadas y un 59 % no lo son. A continuación, se detallan las comunidades autónomas con el porcentaje de implementación de la estrategia de servitización. Concretamente, el 41% de las empresas servitizadas de la muestra (380 compañías) pertenecen a: Aragón, el 6.05%; Asturias, el 2.37%; Andalucía, el 3.42%; Cantabria, el 1.32%; Castilla y León, el 4.21%; Murcia, el 0.53%; Castilla y la Mancha, el 2.63%; Cataluña, el 22.11%; Extremadura, el 0.53%; Galicia, el 4.74%; Islas baleares, el 0.26%; La Rioja, el 0.79%; Madrid, el 24.74%; Navarra, el 5.26%; País Vasco, el 12.89%; Valencia, el 8.16%; e Islas Canarias, el 0%.

Cuando se estudia la variabilidad de un fenómeno particular en función de otros factores, se implementan modelos estadísticos (regresión múltiple, análisis de la varianza, análisis de la covarianza o modelo logarítmico), según la naturaleza de la variable endógena y de las variables exógenas, sin embargo, hay diferentes niveles de integración del espacio en los tratamientos estadísticos, según los métodos utilizados y los atributos elegidos para caracterizar los objetos estudiados. Las estimaciones de distancias son una de las bases fundamentales de las técnicas estadísticas, las cuales, unidas a los modelos de probabilidad, dan cuenta de la lógica inferencial y de decisión estadística, ya sea en la órbita fisheriana o en la bayesiana (Jaría et al., 2010). Para ampliar y tratar en detalle la aplicación de la metodología y la formulación matemática en que se fundamenta el análisis espacial, se puede consultar el trabajo de Jaría et al. (2010) el cual aplica esta técnica en un ámbito totalmente distinto.

Este trabajo intenta evaluar los comportamientos globales y locales de la variable endógena, así como de las distintas exógenas con el objetivo de analizar la posible existencia de autocorrelación espacial estadísticamente significativa. De modo que, el análisis espacial se lleva a cabo en dos fases: una fase exploratoria y otra fase confirmatoria. La primera pretende evaluar si la variable endógena y las distintas exógenas siguen algún patrón de comportamiento específico y, para ello, se utilizan herramientas gráficas como el mapa de cuantiles o el box-map (con ellas puede explorarse la distribución observada de cada variable). Asimismo, se explora la posible existencia de autocorrelación espacial estadísticamente significativa y para ello se emplea el estadístico estandarizado denominado “I de Moran” obtenido a partir de la simulación de “k” muestras a partir de los datos originales. Tal procedimiento se basa en la obtención del estadístico citado en cada una de las “k” muestras, derivándose su error estándar y procediéndose así a su significación estadística (modelo de muestreo “leave-one-out”) que en este caso se ha especificado en k=999 simulaciones. La estandarización de este estadístico obedece a la necesidad de fijar la norma de su variabilidad para facilitar su interpretación, al igual que se suele realizar en los diversos coeficientes de correlación (Jaría et al., 2010). Para concluir esta primera fase de análisis exploratorio y una vez analizados los esquemas de comportamiento a nivel global de las variables, es necesario detectar si existe algún comportamiento específico de estas variables a nivel local, ya que puede ser que una variable muestre a nivel global una distribución aleatoria, pero exista alguna o algunas observaciones que presenten esquemas de autocorrelación espacial a nivel local. Para poder analizar este fenómeno, se utiliza una de las cuatro herramientas habituales, concretamente el Cluster Map, que detecta comportamientos locales estadísticamente significativos.

Exploradas las variables especificadas en el modelo y previendo que puedan existir problemas de dependencia espacial, se pasa a la segunda y última fase de la metodología del análisis espacial. El objetivo de esta segunda fase es estimar el modelo por mínimos cuadrados ordinarios (MCO) para analizar si las variables exógenas propuestas predicen el comportamiento de la endógena y detectar si el modelo especificado es válido o es necesario descartarlo a favor de otro que recoja la dependencia espacial. Todos los análisis estadísticos descritos anteriormente se han llevado a cabo mediante el programa informático GEODA.

3.1. Variables analizadas

Para cada una de las CC.AA., se registró la variable servitización como variable criterio o endógena. La clasificación de las empresas que implantan la estrategia de servitización se basó en las características clave que define la literatura sobre este fenómeno. Es decir, para el estudio de este artículo, se consideró que las empresas servitizadas son las que ofrecen al menos uno de los servicios propuestos por Neely (2008). Además, como variables predictoras o exógenas se toman en cuenta los ingresos totales de la empresa, el porcentaje de la rentabilidad sobre las ventas (ROS), el tamaño de las empresas medido por el número de empleados (tamaño de la empresa), el beneficio antes de intereses, impuestos, depreciaciones y amortizaciones (EBITDA) y el endeudamiento. Todas ellas son medidas aceptadas por diferentes investigadores para demostrar el efecto de la servitización en las empresas manufactureras (Visintin y Rapaccini 2010; Gebauer, 2007; Neely, 2008; Suarez et al., 2013; Gebauer y Fleisch, 2007; Kwan y Kim, 2016; Li et al., 2015).

Las variables se registraron para todas las CC.AA. a partir de los últimos datos disponibles en la base de datos, correspondientes al año 2016.

4. Resultados

Del análisis exploratorio a nivel global de los mapas respectivos, se desprende que la variable endógena, la estrategia de servitización, muestra dependencia espacial positiva por la clara asociación de valores similares en el territorio analizado. Con los resultados obtenidos de los Box-Map de la variable, se puede afirmar que la mayoría muestran un comportamiento similar a nivel general. En algunos casos, ciertas comunidades autónomas como Cataluña y Madrid destacan por comportarse como valores extremos por la cola superior, es decir, muestran valores superiores al resto de sus comunidades vecinas.

En cuanto a las variables exógenas del modelo planteado (ingresos de las empresas, EBITDA, porcentaje de la rentabilidad sobre las ventas, tamaño de la empresa y endeudamiento), todas ellas presentan una situación muy similar a lo que sucedía con la interpretación de los mapas de cuantiles de la variable endógena, es decir, a nivel intuitivo parece que todas ellas muestran dependencia espacial positiva, ya que predominan valores parecidos en áreas próximas del territorio. No obstante, los Box-Map de algunas variables predictoras dan lugar a unas interpretaciones de comportamientos atípicos interesantes de comentar. En cuanto al EBITDA, algunas comunidades autónomas como Cataluña, Madrid y las Islas Baleares destacan por presentar valores extremos espaciales por la cola superior, es decir, muestran valores superiores al resto de las comunidades autónomas. En cuanto a la rentabilidad sobre las ventas (ROS), es interesante mencionar que su comportamiento de valores atípicos es igual que la variable exógena comentada anteriormente, es decir, algunas comunidades autónomas como Cataluña, Murcia y Madrid también destacan por mostrar valores extremos superiores al resto.

De forma análoga al paso anterior, se analiza la existencia de autocorrelación espacial tanto de la variable endógena como de las exógenas, pero esta vez mediante la obtención del estadístico I de Moran, el cual proporciona el signo de la dependencia existente. En la mayoría de ellas puede concluirse a simple vista que existe autocorrelación espacial (en algunos casos positiva, como es el caso del tamaño de la empresa e ingresos totales de la empresa y en otros casos negativa, como sucede con las variables EBITDA, ROS y endeudamiento), aunque en algunos casos concretos la dependencia espacial parece ser leve o inexistente característica que define su comportamiento. La Tabla 1 muestra la comparación-resumen elaborada mediante los resultados de las 999 permutaciones aleatorias. De esta forma es posible concluir de forma estadísticamente solvente si existe o no autocorrelación espacial y en caso afirmativo, poder interpretar su sentido (positivo negativo).

TABLA 1.
Resumen de resultados con indicación del valor de la I de Moran y de su significación

Variable endógena y exógenas	Significación (p-value)	Estadístico I de Moran
Servitización	0.0040 ***	0.3469
Ingresos	0.0120**	0.1326
Rentabilidad sobre las ventas (ROS)	0.3870	-0.0664
EBITDA	0.0010***	-0.4423
Tamaño de la empresa	0.0030 ***	0.2169
Endeudamiento	0.0010***	-0.4223

* p< 0.10; **p< 0.05; ***p< 0.01
Fuente: Elaboración propia.

A partir de la información de la Tabla 1 pueden extraerse algunas consideraciones con relación a la dependencia espacial que presentan las variables analizadas. La variable endógena (servitización) presenta autocorrelación espacial positiva estadísticamente. En el caso de las variables exógenas, todas ellas a excepción de la rentabilidad sobre las ventas, presentan autocorrelación espacial estadísticamente significativa. En concreto, el tamaño de la empresa presenta dependencia espacial positiva, así como los ingresos. En cambio, el EBITDA y el endeudamiento siguen un comportamiento de autocorrelación espacial con signo negativo. De este análisis se desprende que todas las variables del modelo, tanto endógena como exógenas, presentan algún patrón de dependencia espacial por ligero que sea.

Por último, y para concluir esta primera fase del análisis exploratorio, se analizaron los Cluster Map en los que la variable endógena, así como las variables exógenas presentan comportamientos a nivel local.

Por lo que respecta a la variable endógena, la servitización, destaca el comportamiento de la comunidad autónoma de Madrid por ser un cluster espacial de valores altos, es decir, Madrid y sus vecinas concentran valores significativos elevados respecto al resto. En el caso de las comunidades autónomas de Cantabria, La Rioja, Islas Baleares, Murcia, Islas Canarias, Castilla-la Mancha y Extremadura sucede todo lo contrario, es decir, se trata de clusters espaciales de bajos valores.

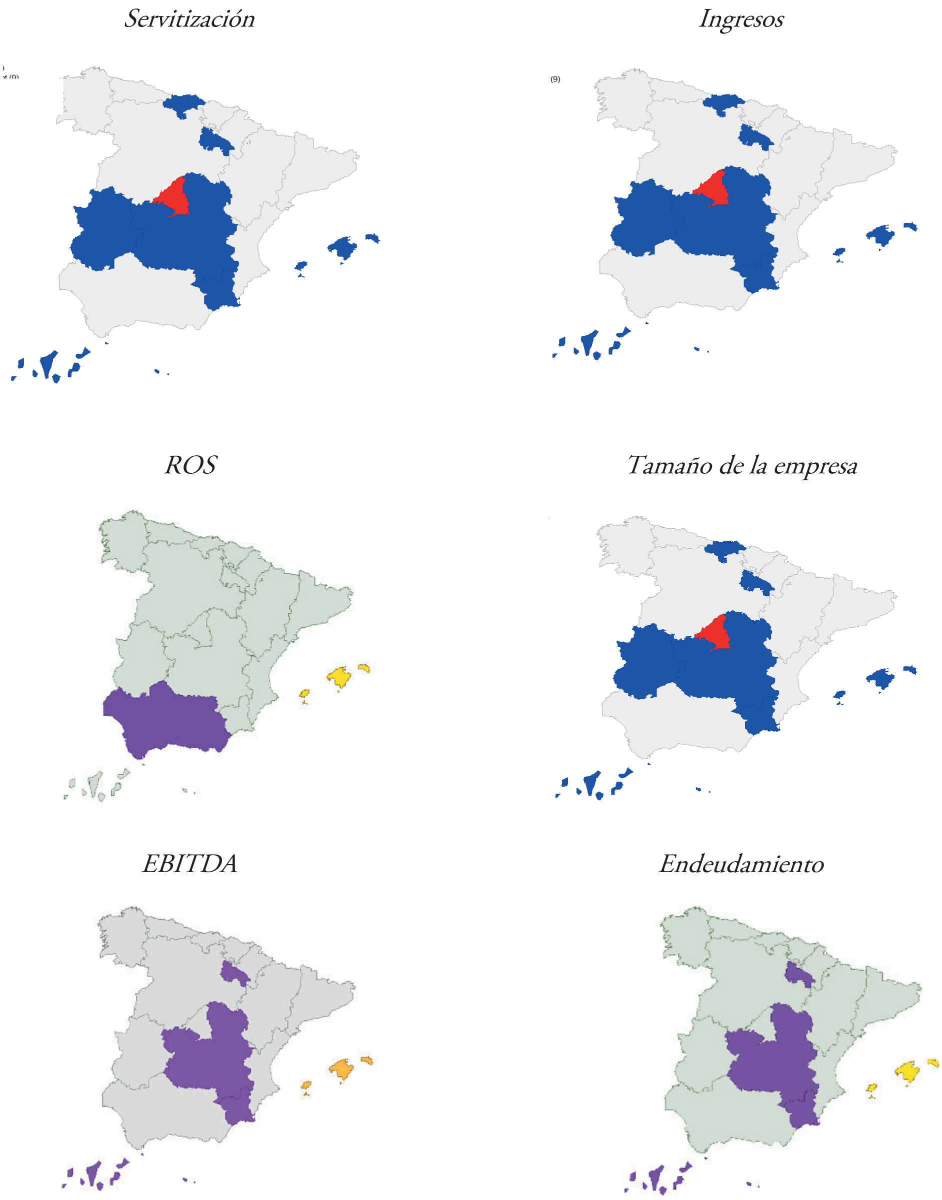
Asimismo, es interesante analizar el comportamiento de las distintas variables exógenas que se plantean en este estudio. Respecto a la variable rentabilidad sobre las ventas (ROS) puede afirmarse que la comunidad autónoma de Baleares presenta un comportamiento de outlier espacial de valor elevado, mientras que la comunidad de Andalucía es un outlier de valores bajos. En cuanto al beneficio de la empresa antes de intereses, impuestos, depreciación y amortizaciones (EBITDA) y el endeudamiento, cabe destacar que para estas variables la comunidad autónoma de Baleares presenta un comportamiento de outlier de valores elevados y las comunidades autónomas de La Rioja, Castilla-La Mancha y Murcia presentan outliers espaciales de valores bajos.

Por último, teniendo en cuenta los ingresos de las empresas, el tamaño de la empresa destaca la comunidad de Madrid por ser un cluster de valores elevados, mientras que las comunidades autónomas de Cantabria, La Rioja, Baleares, Murcia, Castilla-la Mancha y Extremadura se caracterizan por presentar el caso opuesto.

Estas conclusiones extraídas a nivel local sobre el comportamiento significativo de las variables se resumen de manera visual en la Figura 1.

A partir de este primer análisis inicial de las variables especificadas del modelo (tanto endógena como exógenas) cabe destacar que, a nivel global, las variables servitización, ingresos, número de empleados, ROS, EBITDA y endeudamiento presentan autocorrelación espacial. A nivel local, todas y cada una de las variables muestran comportamientos de autocorrelación espacial. Por lo tanto, puede afirmarse que las citadas variables pueden ocasionar problemas en la estimación de los parámetros (OLS) del modelo y será mediante el análisis confirmatorio que podrá detectarse si es necesario hacer la estimación mediante otro modelo que recoja los efectos espaciales.

FIGURA 1.
Mapas descriptivos del comportamiento local de las variables analizadas



Gris: No significativo. Rojo: Delimitación de alta significación con alta significación. Azul oscuro: Delimitación de baja significación con baja significación. Lila: Delimitación de baja significación con alta significación. Amarillo: Delimitación de alta significación con baja significación.
Fuente: Elaboración propia.

TABLA 2.
Estimación del modelo por MCO

Data set:	**CCAA**		
Dependent Variable:	Servitización	Number of Observations:	17
Mean dependent var:	5.26	Number of Variables:	6
S.D. dependent var:	7.02	Degrees of Freedom:	13
R-squared:	0.93	F-statistic:	35.60
Adjusted R-squared:	0.90	Prob (F-statistic):	3.83371e-007
Sum squared residual:	63.89	Log likelihood:	-38.48
Sigma-square:	4.91	Akaike info criterion:	88.96
S.E. of regression:	2.21	Schwarz criterion:	94.62
Sigma-square ML:	3.36		
S.E of regression ML:	1.83		

Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Probability**
CONSTANT	0.28	0.76	0.37	0.71
INGRESOS	-5.44172e-010	1.98234e-010	-2.74	0.01
ROS	1.75714e-011	3.33647e-009	0.005	0.99
EBITDA	5.6403e-005	0.00039	0.14	0.88
NUMERO DE EMPLEADOS	0.00064	0.00014	4.37	0.00
ENDEUDAMIENTO	5.6403e-004	0.00037	0.12	0.86

REGRESSION DIAGNOSTICS			
MULTICOLLINEARITY CONDITION NUMBER	4022.25		
TEST ON NORMALITY OF ERRORS			
TEST	DF	VALUE	PROB
Jarque-Bera	2	21.78	0.00002
DIAGNOSTICS FOR HETEROSKEDASTICITY			
RANDOM COEFFICIENTS			
TEST	DF	VALUE	PROB
Breusch-Pagan test	5	52.68	0.00
Koenker-Bassett test	5	15.61	0.008
DIAGNOSTICS FOR SPATIAL DEPENDENCE			
FOR WEIGHT MATRIX: ccaa_1			
(row-standardized weights)			
TEST	MI/DF	VALUE	PROB
Moran's I (error)	-0.1094	-0.32	0.74
Lagrange Multiplier (lag)	1	0.08	0.76
Robust LM (lag)	1	0.58	0.44
Lagrange Multiplier (error)	1	0.34	0.55
Robust LM (error)	1	0.84	0.35
Lagrange Multiplier (SARMA)	2	0.92	0.62

Fuente: Elaboración propia.

Según los datos obtenidos en la estimación, pueden extraerse algunos resultados relevantes. En cuanto al ajuste, el porcentaje de variación explicado por el modelo se sitúa en un 93,19% (R^2 =0.9319). Por lo tanto, podría decirse que la capacidad de predicción de la endógena proporcionada por las exógenas es muy elevada.

En relación con las variables explicativas del modelo, cabe destacar que cuatro de las cinco propuestas son significativas. Específicamente, la rentabilidad sobre las ventas (ROS) presenta una correlación positiva con la servitización la cual indica una clara dependencia espacial.

En cuanto a los ingresos de las empresas en este estudio hay que destacar que presentan una relación negativa con la servitización, es decir, no se puede afirmar que exista una dependencia espacial en los ingresos netos de las CC.AA. con más empresas servitizadas, una hipótesis a estos resultados podría envolverse a las distintas normativas autonómicas aplicada a las empresas. Aunque la adopción de la estrategia de servitización puede ser una opción para que un fabricante haga crecer su negocio, varios autores coinciden en que vender ofertas de servicios con valor añadido no siempre produce los retornos esperados en los ingresos de la empresa (Gebauer et al., 2005; Neely, 2008).

Otra variable exógena también significativa para describir el comportamiento de la endógena es el tamaño de la empresa (medido por el número de empleados), la cual presenta una relación positiva. Este hecho se debe a que las empresas de mayor tamaño son las que presentan mayores grados de servitización o, en otras palabras, son las que más tienden a decantarse por la estrategia de servitización (Kwak y Kim, 2016). Por último, el endeudamiento y el beneficio de la empresa antes de tener en cuenta los intereses, impuestos, la depreciación y las amortizaciones (EBITDA) presenta una relación positiva con la variable objeto de estudio.

Para contrastar la heteroscedasticidad en los errores del modelo (distinta variabilidad en las estimaciones de los errores de los parámetros), el test de Breusch-Pagan resultó no significativo (BP = 52.6; df = 5; P = 0.00), de modo que se asume que la varianza de los términos de error es constante. Para el análisis de la posible existencia de dependencia espacial en el modelo, el valor de la I de Moran también resultó no significativo (I = -0.32; P = 0.74), lo cual conlleva la ausencia de dependencia espacial. Finalmente, los valores de Lagrange resultaron no significativos (P_{values} entre 0.35 a 0.76), con lo que se puede concluir que el resultado de la estimación supone un ajuste suficiente a los datos originales del modelo propuesto y, por lo tanto, la validación implícita de los valores estimados mediante OLS de cada parámetro.

5. Conclusiones

Aunque la literatura previa ha enfatizado en la importancia de la implementación de la estrategia de servitización, todavía existe un largo recorrido por abordar por parte de las empresas españolas. Un dato revelador en este sentido es que, en España, para la muestra analizada, menos de la mitad de las empresas (41%) incluyen el proceso de servitización dentro de su estrategia empresarial. Así mismo, De la Calle y Freije (2016) confirman el interés de las empresas manufactureras españolas por intentar el proceso de servitización en algún momento. De este modo, tal como ya anticiparon algunas investigaciones en otros países, como los trabajos de Gebauer et al. (2005; 2012), Neely (2008) o Crozet y Millet (2017), se demuestra también en el caso español que la adopción de la servitización es un proceso lento en las empresas. Ello abre una futura línea de investigación sobre el análisis de rentabilizar la estrategia de servitización a largo plazo.

Una vez realizado el estudio completo de la variable endógena y las distintas variables exógenas del modelo planteado en cuanto a la autocorrelación espacial y, estimados los parámetros de ese modelo, concluimos en los aspectos que se exponen a continuación.

A nivel global, todas las variables presentan comportamientos de autocorrelación espacial, es decir, lo que sucede en una comunidad autónoma sí está influenciado por lo que sucede en el resto de sus comunidades vecinas.

Considerando los resultados a nivel local, puede afirmarse que todas las variables analizadas, incluida la endógena, presentan comportamientos de autocorrelación espacial.

Teniendo en cuenta la variable servitización, una conclusión esperada sobre la comunidad autónoma de Madrid, es que ésta destaca por ser un cluster espacial de valores altos. Es decir, es una situación en la que Madrid y sus comunidades vecinas concentran valores significativamente elevados respecto al resto. El trabajo de Gomes et al. (2019) muestran a Madrid como una de las regiones con mayor porcentaje de empresas manufactureras servitizadas, este dato soporta el resultado obtenido en este trabajo, ya que en base a la información extraída de SABI se puede afirmar que del 100% de empresas servitizadas en el territorio español, el 25% pertenecen a la comunidad de Madrid.

En cambio, en las comunidades autónomas de Cantabria, La Rioja, Baleares, Andalucía, Castilla-la Mancha y Extremadura sucede todo lo contrario, se trata de clusters espaciales de bajos valores, es decir, en estas comunidades autónomas es donde menos empresas adoptan la estrategia de servitización.

En referencia a las variables exógenas planteadas en el modelo, en determinados casos algunas comunidades autónomas destacan por comportarse de manera significativamente diferente al resto. Las conclusiones más relevantes giran en torno a la rentabilidad sobre las ventas (ROS), donde la comunidad autónoma de Baleares presenta un comportamiento de outlier espacial de valores elevados, mientras que la comunidad de Andalucía es un outlier de valores bajos, donde ella y sus vecinas concentran valores bajos respecto a sus vecinas.

En el caso del beneficio del EBITDA y endeudamiento, cabe destacar que para esta variable Baleares es la comunidad autónoma que destaca por ser un outlier de valores elevados, mientras que las comunidades autónomas de La Rioja, Castilla-La Mancha y Andalucía presentan casos de outliers espaciales de valores bajos.

Por último, por lo que a los ingresos y el tamaño de la empresa se refiere, de nuevo la comunidad de Madrid destaca por ser un cluster de valores elevados, mientras que el País Vasco, La Rioja, Baleares, Andalucía, Castilla-la Mancha y Extremadura son el caso totalmente opuesto, o sea, son clusters de valores bajos.

Teniendo en consideración los distintos patrones de comportamiento espacial de cada una de las variables analizadas, con el análisis se demuestra que existe variabilidad de comportamiento en la servitización en las diecisiete CC.AA. que conforman el territorio español.

Asimismo, y tal como se puede deducir de todo lo mencionado anteriormente, la estrategia de servitización se configura como una vía de oportunidad para las empresas manufactureras españolas, dado que puede ayudarles a mejorar la competividad en sus negocios y a obtener mejores beneficios, resultando ambas ideas una motivación para que las empresas decidan incorporar de manera efectiva este tipo de estrategia. Ello coincide con trabajos previos como el de Crozet y Millet (2017), en el que se estima el impacto de la servitización en el desempeño de la empresa, para el caso francés.

Consecuentemente, tanto las propias organizaciones como las autoridades públicas del territorio español deben centrar sus esfuerzos en la búsqueda de estrategias para garantizar la viabilidad futura de las empresas, construyendo y aprovechando nuevas oportunidades.

Con este trabajo ha quedado demostrado el comportamiento espacial de la servitización en las comunidades autónomas españolas, lo cual da respuesta a la pregunta de investigación inicialmente formulada. A raíz de las conclusiones que se han extraído, el presente estudio es el inicio de futuras investigaciones como, por ejemplo, un análisis por provincias que podría resultar de gran utilidad para añadir nuevos argumentos y reforzar las conclusiones obtenidas y comparar los resultados a nivel más local.

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Articles

Inventors' working relationships and knowledge creation: a study on patented innovation

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Abstract:

This study explores the knowledge-creation process that arises from inventors' working relationships and its impact on company innovation. Innovation is measured by a company's patenting activities. Our analysis is based on an original database built using OECD micro data obtained from patent applications at the European Patent Office (EPO). An empirical analysis was carried out on a body of firms located in the Italian region of Veneto. Our results reveal that the inventors' working relationships have a significant impact on a company's innovation – innovation which is also dependent upon both geography and timescales. Inventors' working relationships thus produce productivity effects, in terms of patenting activity, both in the short and long term and these impacts are also dependent upon geographical distance.

Keywords: working relationships; knowledge creation; patenting activity; inventor productivity.

JEL classification: O3, R1, J24.

Relaciones laborales entre inventores y generación de conocimiento: un estudio sobre innovación patentada

Resumen:

Este estudio explora el proceso de generación de conocimiento que surge de las relaciones laborales entre inventores y su impacto en la innovación empresarial. La innovación se mide por la cantidad de patentes de una empresa. Nuestro análisis parte de una base de datos propia construida a partir de micro datos de la OECD obtenida a partir de solicitudes de patentes en la Oficina Europea de Patentes (EPO). Se realiza un análisis empírico sobre un grupo de empresas ubicadas en la región italiana de Véneto. Nuestros resultados revelan que las relaciones laborales entre inventores tienen un impacto significativo en la innovación empresarial, innovación que también depende tanto de la geografía como de la dimensión temporal. Las relaciones laborales entre inventores, por tanto, tienen un efecto sobre la productividad en términos de patentes, tanto a corto como a largo plazo, y este impacto depende también de la distancia geográfica.

Palabras clave: Relaciones laborales; generación de conocimiento; patentes; productividad de inventores.

Clasificación JEL: O3, R1, J24.

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1. Introduction

In this article we explore the role of the inventors' working relationships and mobility in the process of enhancing knowledge creation and also in terms of innovation activity. What we mean by innovation is the registration of new patents at the European Patent Office (EPO).

Our analysis aligns with the literature on the knowledge-based view of a firm and the transfer of knowledge through the staff's working relationships and collaborations (Howells, 1996). Within the knowledge-based view of a firm, knowledge is treated as the most strategically important of the firm's resources and is viewed as residing within the individual (Grant, 1996). Therefore, the individual is central in the process of creating and storing knowledge: Knowledge is embodied in the individual (Nonaka, von Krogh, & Voelpel, 2006). It follows then, that one of the questions that arises from considering this paradigm is how to enhance the knowledge-creation process within a firm with this in mind.

At the core of the organisational knowledge-creation theory is the identification of the factors that enable knowledge creation for the purpose of improving innovation and learning (Nonaka & von Krogh, 2009; Nonaka et al., 2006; Von Krogh, Ichijo, & Nonaka, 2000). For the purposes of our analysis, it is fundamental to briefly define knowledge. According to the original definition by Polanyi (1966), knowledge is *tacit and explicit* along a *continuum.*[1] We can identify tacit knowledge with *knowing how,* and explicit knowledge with *knowing about* facts and theories. These two types of knowledge differ in relation to their transferability mechanisms – mechanisms for transference across individuals, space and time. Explicit knowledge is revealed through communication and it is usually formalized in documents such as patents, licences, R&D, procedures etc. Tacit knowledge is non-codified, disembodied know-how that is acquired via the informal assimilation of learned behaviours and procedures (Howells, 2002). All tacit knowledge is stored within individuals and it is revealed through its application (Grant, 1996; Howells, 1996; Mascitelli, 2000; Nonaka, 1994).

The first step in the process of knowledge creation is the sharing of tacit knowledge (von Krogh et al., 2000). The process starts when team members meet to share their knowledge (much of which is tacit) in order to work together on the same project. Then, tacit knowledge loses some of its 'tacitness' through the process of externalization (Nonaka & von Krogh, 2009). This conversion from tacit to explicit knowledge is important for the process of expanding knowledge. Several examples of the conversion of tacit knowledge into explicit knowledge are reported in the literature. Among the most cited, Flanagan, Eckert and Clarkson (2007) showed that the 'tacit overview knowledge' of senior designers was fundamental in facilitating communication across large-project teams. Nonaka and Takeuchi (1995) showed that a young engineer acquired tacit knowledge that allowed him to develop a new machine for producing bread – knowledge that he obtained from working side by side with a master baker at a nearby hotel.

Howells (1996) clearly described the fundamental role played by inter-firm and inter-organizational tacit know-how acquisition in the process of knowledge creation. Moreover, he explained how this inter-firm tacit knowledge acquisition can occur through across-firm staff collaborations and staff mobility. Staff working off site and collaborating with other firms can be a source of knowledge flows that enhance the firm's innovation capacity. In these cases, continuous interactions with staff working on inter-organizational projects can better facilitate the transfer of tacit knowledge – when compared to short and/or infrequent visits. On the other hand, 'the process of workers moving from one job environment with its set of innate tacit skills to a different working environment often facilitates this tacit knowledge transfer, but also enhances new tacit know-how learning as well' (Howells, 1996, p. 102). The hiring of new personnel is one of the central sources of knowledge acquisition and creation (Grant, 1996; Leonard & Sensiper, 1998).

[1] See Nonaka (1991, 1994) and Nonaka and von Krogh (2009) for a discussion.

Taking its cue from this literature, the main goal of this article is to verify whether across-firm staff working relationships and staff mobility are responsible for the knowledge creation that improves innovation. Specifically, we analyse the role played by inventors' working relationships and inventor 'mobility'. Then, two different channels of knowledge transmission and creation are studied. Concerning the former, and following the idea of von Krogh et al. (2000) discussed above, we assume that (by participating in innovation projects managed by different firms) inventors share their knowledge with colleagues with different innovation experiences. Then, inventors mutually absorb and transfer their tacit knowledge. This knowledge-sharing process creates knowledge that, finally, improves the innovation activity of the firms that the inventors collaborate with. Thus, we empirically test the hypothesis that the higher the number of inventors' collaborations, the higher the innovation output of the firms they work for becomes. Concerning the latter, following Grant's (1996) and Howells' (1996) ideas that personnel hiring facilitates knowledge creation, we assume that the inventors' new collaborations allow the transfer of inventor knowledge to the new firm. Thus, we test the hypothesis that stipulates that inventors collaborating for the first time with a new firm improve the firm's innovation by means of knowledge creation.

In the last fifteen years, some studies have focused on the effect of worker interactions/mobility on firm innovation and overall economic performance by looking at different perspectives, using alternative datasets and different empirical specifications. The contribution of Agrawal, Cockburn, and McHale (2006) underlines that 'an important component of the knowledge associated with patented inventions may be held tacitly by skilled engineers'. Tacit knowledge and not only codified knowledge appears to be important: it belongs to the researchers and engineers who take part in the patenting process and can be transferred through their social relationships. Such knowledge can spread when the inventors interact with other people, in particular with other inventors.[2] Singh and Agrawal (2011) showed that recruiting an individual from outside an organisation enhances a firm's access to external ideas. By employing patent data from the United States, they found that a recruit's prior ideas are used in the new firm by the recruit herself building upon her own prior ideas after arriving at her new firm. Moreover, regarding the temporal pattern of knowledge diffusion, they found that the role of the recruit persists over time to a surprising degree. In a recent article, Head, Li, and Minondo (2019), by studying academic citations and educational histories of mathematicians from the world's top 1,000 math departments, found that past colocation, alma mater relationships and advisor-mediated relationships are important elements that, together with co-authorships, help reduce the negative impact of geographic barriers on citation. The knowledge spillover channel has been recently analysed through immigration flows to the United States. Agrawal, McHale, and Oettl (2019) investigated whether the recruitment of foreign-trained scientists enhances U.S. science research or causes harm by displacing better-connected, domestically trained scientists. They developed a model that was simulated using bibliometrics data, assuming that every foreign-trained scientist displaces an appropriately matched domestically trained scientist. The simulation results do not show any evidence that foreign-trained scientists supplant better-connected, domestically trained scientists.

Using a survey of Finnish high-technology firms, Simonen and McCann (2008, 2010) studied the effect of worker mobility on the probability of innovation, taking into account the geographical extension of mobility (the same sub-region *versus* different sub-regions). They showed that human capital mobility improves innovation performance if it occurs between different areas. The geographical area of reference coincides with Finnish commuting areas and identifies Finland's local labour markets. Boschma, Eriksson, and Lindgreen (2009) addressed the issue of mobile workers' skill portfolios and its effect on a company's economic performance. They showed how worker mobility affects a company's economic performance

[2] This work followed the methodological approach of Jaffe and co-authors (Jaffe, 1986; Jaffe, Trajtenberg, & Henderson, 1993) which laid the foundations of a literature that analyses the issue of knowledge diffusion using databases containing patent registrations (Almeida & Kogut, 1999; Verspagen & Schoenmakers, 2004; Fischer, Scherngell, & Jansenberger, 2006; LeSage, Fischer, & Scherngell, 2007).

depending on the mix of geographical proximity and competences.[3] Boschma et al., (2009) argue that 'the effects of labor mobility on firm performance depend on whether new employees are recruited from the same region or from other regions'. Eriksson (2011) empirically confirmed these results.

Our study's contribution to the literature on the consequences of workers' professional relationships with patented innovation is distinguished by the following factors: first, a focus on inventors, who are the keepers of patented knowledge; secondly, a definition of mobility that allows for the transmission of tacit knowledge accumulated by inventors; and thirdly, the recognition of inventors' simultaneous working relationships as possible channels of knowledge transmission. These relationships are not codified by any agreement between firms; they depend on the professional activity of inventors, of which the firms they work for may not be aware. The focus of our study is interesting from a policy point of view. Indeed, by jointly evaluating the roles played by inventors' mobility and working relationships on companies' innovation activity, we are able to sketch some preliminary evaluations of policy strategies. We know that interfirm mobility is important for the circulation of ideas and knowledge diffusion. On the other hand, it depends on the recruitment of new personnel, which can be costly for a firm. Moreover, higher worker mobility can be detrimental for company investment in human capital because firms are worried about their inventors leaving. On the contrary, inventors' working relationships are a means of sharing and transferring knowledge that allows companies to take advantage of knowledge flow without additional cost. Moreover, knowledge transmission does not necessarily imply the departure of inventors from the company of origin.

Inventors' professional relationships are the focus of a recent contribution that studied how inventors' interactions affect productivity in innovation. Akcigit, Caicedo, Miguelez, Stantcheva, and Sterzi (2018) studied European inventors' productivity within the structure of inventor research teams and interactions with others. Differently from our contribution, their focus was on inventors' interactions within the same firm and interactions related to past co-inventorships. Thus, the relationships of inventors were codified by either belonging to the same firm or having been working in the past on the same patent through agreement between firms. Moreover, they studied inventors' individual productivity and not productivity at the firm or applicant level, as we do in our study. The results of Akcigit et al. (2018) are extremely interesting because they show that inventors' knowledge is built through interactions with others, and interactions are fundamental for enhancing individual productivity.

Due to data constraints, our study is unable to analyse the effects of social relationships that may arise from other sources aside from inventors' professional relationships. In fact, the database does not include information on the organisation's social capital or the inventors' social environment and social habits. However, we are aware of the role that social relationships in general may play in enhancing the flow of knowledge and innovation. The social capital literature provides some evidence on the topic. For example, Ruiz-Ortega, Parra-Requena, and García-Villaverde (2013), using survey data from companies with more than five employees in the footwear sector in Spain, showed that firms located in industrial districts have greater social capital and acquire more knowledge than firms outside these districts. However, the advantages of firms located in industrial districts were not confirmed when they focused on innovation performance. Differently, Parra-Requena, Ruiz-Ortega, García-Villaverde, and Rodrigo-Alarcón (2015) found that external social capital does affect innovativeness. In particular, firms with a high degree of trust and cognitive proximity in their relationships tend to develop innovativeness. Saint Ville, Hickey, Locher, and Phillip (2016) studied the role of social capital in developing agricultural knowledge networks and the ability of farming households to innovate in Caribbean smallholder farming communities. Their study's results support the view that, by utilising their social networks to increase their connection to a larger number of farmers, smallholders can improve their adaptive capacity to facilitate knowledge exchange,

[3] Developing the idea of Boschma and Iammarino (2009), Boschma et al. (2009) studied Swedish firm performance at plant level – measured by growth in labour productivity between 2001 and 2003 – as a function of labour mobility, as measured by the number of highly skilled job movers. They split mobility into intra-regional and inter-regional mobility according to the local labour market (LLM) definition. Boschma et al. (2009) define LLMs according to a specific commuting-minimising algorithm.

increase access to resources and connect to sources of support. Thus, social networks have a potentially significant role to play in improving smallholder agricultural system innovation in the Caribbean context.

A different approach to the study of social interaction and knowledge flow is embedded in the literature that employs agent-based simulation techniques to study the exchange of knowledge among employees and how organisations can encourage individual knowledge sharing behaviour. As an example, Wang, Gwebu, Shanker, and Troutt (2009) showed that the greater the personal benefit from contributions, the higher the levels of knowledge sharing. Kollock (1998) found that contribution to the sharing of knowledge is more likely when individuals have the ability to punish the defectors.

Our analysis was carried out on all firms established in Veneto, a north-eastern Italian region, who filed patents with the EPO in the pre-crisis period, 1998–2007. By limiting our study to one region, we were able to develop and document a precise procedure for cleaning the data that we may extend to the whole of Italy in the future. We chose Veneto because it is one of the most dynamic regions in Italy; historically, it has been characterised by its well-developed manufacturing industry composed of national and international companies. Veneto has also been characterised by a good technological profile and innovativeness. Whereas in the past, this was largely concentrated in big firms, nowadays, because of the delocalisation and deindustrialisation processes that have taken place in the region along with all advanced economies, industrial development is widespread across a wide number of small firms that are active both in traditional and more technologically advanced sectors. We deliberately limited the period of analysis to the pre-crisis years in order to avoid confounding factors from the crisis.

The paper is structured as follows. In Section 2, we describe the original dataset. Section 3 covers the empirical model and the constructed measures of inventor mobility and working relationships. The results are discussed in Section 4.

2. Data

We carried out the analysis on data from the OECD-REGPAT database (December 2010 edition). OECD-REGPAT is a database that includes two main types of micro data on patents: patent applications filed with the EPO in the period 1977–2007 and patent applications filed under the Patent Co-operation Treaty (PCT) at the international phase in the period 1977–2008. We chose to work only on that part of the database containing EPO applications because the PCT archive is much smaller than the EPO archive[4]. We therefore preferred to use the EPO archive to ensure that we included the largest possible number of firms and inventors innovating in the region.[5]

OECD-REGPAT is a very rich database: every record contains information on each patent application filed by one or more applicants, resulting from the contribution of one or more inventors. Every single record can be linked to information on each applicant and inventor participating in the project. The variables include the EPO application number, the application identifier, i.e., a surrogate key identifying patent applications, the EPO patent publication number and the priority year, i.e., the year of first filing. The priority year is the date closest to the actual date of invention and it is used as a proxy for the date of invention. Further information is related strictly to the inventors and applicants listed in each application. This information, together with patent data, allowed us to identify simultaneous and subsequent inventor working relationships and to measure the variables of interest (discussed in the next

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[4] For the region of study, in the period covered by OECD-REGPAT (1977–2008), 8059 patent applications were filed under the EPO compared with 3621 filed under the PCT. The difference in the size of the two archives could be because it is much more expensive to file under the PCT than under the EPO.

[5] However, by choosing the EPO database, we excluded patent applications filed with the Italian Patent Office. This choice allows us to deal with patents that, on average, are expected to have a higher commercial value, since applying to the EPO is more expensive and time-consuming than applying to national patent offices only (Hoekman, Frenken, & Van Oort, 2009).

section). In other fields, for every applicant and every inventor we gathered their identification codes[6], full names and addresses, and country and NUTS3 regions of residence.

Despite the relative improvement in the data quality of recent OECD-REGPAT releases, the dataset presents serious problems for the identification of applicants and inventors.[7] To solve these problems, we made considerable efforts to clean the data and then to correctly identify the applicants and inventors through the unambiguous assignment of personal identification codes, addresses, municipalities of residence and company locations.[8]

After cleaning the data, the matrix we used for the study consisted of approximately 3500 inventors who, between 1998 and 2007, collaborated with over 2000 patent applicants in the Veneto region. In this period, the number of patent applications in the whole region exceeded 4700 applications.[9] At this stage, in addition to the original information available from the dataset, we were able to exactly identify any inventors and the applicants they collaborated with at any time, the inventor's correct residential address (street and city) and the location of each applicant in every year (street and city). This allowed us to establish inventors' exact patenting activity by year, applicant and city, and their new patenting activities at any time. Accordingly, by going back to the applicant with which an inventor cooperated, it was possible to measure the transmission of knowledge channels and the sharing that occurred through inventors' working relationships. We discuss these measures in the following section.

3. The empirical model

3.1. The variables of interest

Our main research goal was to test whether inventors' working relationships facilitate the sharing of tacit knowledge among inventors, giving rise to applicant-level positive knowledge effects that increase innovation activity. Before describing the measures of mobility and work relationships we constructed, we would like to specify a few matters related to the procedure of data construction. First, when building the measures of interest, the data on the Veneto region were matched to the whole OECD database in order to observe inventors' mobility and work relationships with applicants in the rest of Italy and in the world. At a later stage, data were delimited to the region of Veneto. Secondly, always in the phase of data construction, the whole original time series were kept in memory and used to construct a measure of the stock of patents at applicant level for the period prior to the one of interest.

As previously anticipated, we studied two different measures of inventors' working relationships. The first relates to the applicant's engagement of 'new' inventors, that is, inventors who had not worked for the applicant before. This *mobility* of inventors could provide a source of new knowledge for the applicant, increasing the firm's ability to patent (see the literature discussed in the Introduction). The second measure relates to the working relationships that inventors simultaneously have with different applicants in the absence of patenting agreements between the applicants themselves. Our hypothesis is that these relationships (which we call *connections*) help in sharing the knowledge among inventors and thus increase the amount of knowledge that inventors provide to each applicant that they work for. The

[6] Both identification codes are surrogate keys borrowed from the original PATSTAT database.
[7] This issue, known in the literature as the 'who is who' problem (Trajtenberg, Shiff, & Melamed, 2006), comes from two main kinds of errors that affect the correct identification of persons and firms. The first type of problem comes from erroneous or varied spelling of names of individuals, for example, Guiseppe instead of Giuseppe, Il'ya instead of Illya, Gian Carlo instead of Giancarlo or Jan-Douwe instead of Jan Douwe. The second type of error comes from writing the name of the applicant, usually a company, in various ways, for example, Glaxo, Glaxo Wellcome, GlaxoSmithKline or GSK. Additional problems arise in those cases where two different addresses are listed in relation to a single inventor. These cases need further investigation to decide whether there are two inventors with the same name or one inventor who has moved.
[8] Upon request, we can provide more details on the cleaning procedure.
[9] These applications are summed at the firm level by year. We ended up with around 3300 observations organized by firm and year.

number of inventors' *connections* for each applicant can be a proxy of the potential flow of knowledge from which the applicant may benefit. All things being equal, we can imagine that two applicants with the same number of inventors but with a different number of inventors' *connections* may benefit from different externalities and thus have different potential patenting outputs.[10]

Let us turn now to a more detailed description of these variables. *Mobility* was designed to capture the inflow of knowledge for which a mobile inventor can be responsible. This knowledge can be either strictly related to a specific patent the inventor developed in the past or more generic, i.e., related to the inventor's past research experience and the skills accumulated in his/her professional history. We defined a mobile inventor towards applicant i at time t as an individual being already registered in the dataset in correspondence with any applicant and any patent filed in any year $t - x$ (with $x > 0$), and participating at time t in the production of a patent for applicant i that he/she had not worked for before. Notice that, given our definition, an inventor who collaborates with two different applicants at the same time t is not a mobile inventor. *Mobility* was then measured at firm i in year t as the sum of mobile inventors 'towards' firm i at time t.

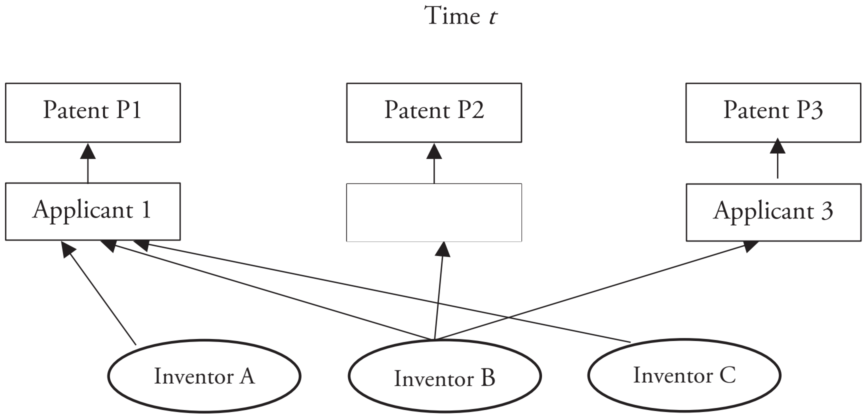
The measure of mobility that we propose can capture the transfer of any type of knowledge – specific or generic – that the inventor may be responsible for when he/she 'moves' to the 'new' applicant. Our measure is similar to the measures used in Simonen and McCann (2008, 2010) and Boschma et al. (2009), where the focus is on the potential effect of worker mobility to be detected at the destination firm. The difference between our study and these contributions relies on the data used and, consequently, on the types of workers under observation: in our case, solely inventors.

The *connections* variable was designed to capture the extent of applicant-level knowledge creation arising from inventors' current patenting collaborations. As previously explained, our hypothesis was that the greater the number of different applicant patenting projects the inventor participates in, the greater his/her knowledge and the potential externality for any applicant he/she works for. We measured *connections* of applicant i at time t as the number of applicants to which applicant i is 'connected' at time t through their inventors' working relationships. The *connections* variable was normalised by the number of inventors who took part in the considered patent and was constructed in such a way that it excludes multiple counting and those cases of inventors whose applicants co-participated in the same patent. This exclusion was motivated by the fact that we aimed to capture the potential effect of the flows of knowledge that arise only from inventor working relationships that are not related to co-operation agreements between the relative applicants. Let us go through a simple example to better understand the construction of *connections*.

Figure 1 shows the case of Applicant 1 who at time t files Patent P1 in collaboration with Inventors A, B, and C. At the same time t, Inventor B is collaborating with Applicant 2 on Patent P2 and Applicant 3 on Patent P3. According to the definition of our measure, the Applicant 1 *connections* variable is equal to 2/3: two applicants (Applicants 2 and 3) linked to Applicant 1 through Inventor B, divided by the number of inventors working on Patent P1.

[10] We measure the *mobility* and *connections* variables without counting those relationships between applicants who belong to the same group of companies and controlling for cases of 'false' mobility due to changes of company type or name.

FIGURE 1.
An example of inventor–applicant working relationships



Mobility and *connections* constituted our ‘basic’ explicative variables. Later in this section, we go through the details of the geographical disaggregation of these variables and the dynamic specification of the model. Before doing that, we give a brief explanation of the dependent variables we used. We remind readers that our analysis aims to evaluate the potential effects of inventors’ working relationships and mobility in terms of the production of patents at the applicant level.

The simplest variable of interest suitable for measuring the patented activity of each firm/applicant *i* in any year *t* is the *sum of patents*: the total number of patents registered at the EPO by applicant *i* at time *t*. However, this measure of patenting activity may present some limits in representing real patent output when the company has partnered with other companies to carry out the patenting project. In these cases, the patent is the result of the effort of different entities and is shared by all of them, according to the quotas declared to the EPO. In these cases, a better measure of patented activity is given by the *weighted sum of patents* registered by firm *i* at time *t*, where each patent of firm *i* is weighted by the firm’s participation share in the production of the patent. The *sum of patents* and the *weighted sum of patents* of each applicant *i* in year *t* are the two measures of patenting we used as dependent variables in the empirical analysis.

Table 1 summarises the distribution of the *sum of patents*, *mobility*, and *connections*. More than 20% of our observations record more than 1 patent application and almost 5% of cases registered 4 or more patents. Around 12% of observations record at least 1 mobile inventor, while *connections* are less frequent. Tables A1 and A2 in the Appendix include descriptive statistics for the variables of the estimated models.

According to the literature discussed in the Introduction, firm proximity can play an important role in driving knowledge spillovers and externalities. To investigate the geographical model of knowledge diffusion, we separated the geographical extent of *connections* and *mobility* by looking at the place of origin and destination for each relationship.[11] The idea was to evaluate whether a knowledge flow occurs according to the degree of geographical proximity between the origin and destination territory.

[11] As previously explained, we carried out this phase of data construction on the whole OECD-REGPAT database, including all countries. This allowed us to identify inventors’ mobility and connections beyond the border of the region.

TABLE 1.
Number of observations by number of patents, inventor *mobility* and *connections*

	Observations (%)
Number of patents	
1	2587 (78.8)
>1	696 (21.2)
Of which	
2	415 (12.6)
3	129 (3.9)
4	65 (2)
5+	87 (2.7)
Mobility	
0	2900 (88.3)
1	340 (10.4)
2+	43 (1.3)
Connections	
0	3055 (93)
1	153 (4.7)
2	49 (1.5)
3+	26 (0.8)
Total	*3283 (100)*

The territorial unit of reference we use is defined by the non-administrative territorial unit of the Local Labour System (LLS) as defined by the Italian Institute of Statistics in 1997 (a similar definition is used in Boschma et al. (2009) for Sweden). LLSs are constructed on commuter routes between home and work, as identified in the most recent population census. They are aggregations of municipalities that identify homogeneous labour markets and functional economic areas. As already argued in previous studies on the topic, LLSs are appropriate units for studying widespread urban areas as they most closely correspond with economic and functional areas and local labour markets (Boschma et al., 2009).

We defined *local*, *regional* and g*lobal* c*onnections* as follows: *local connections* exist when the applicants involved are located within the same LLS (intra-LLS *connections*); *regional connections* take place when inventors' working relationships connect applicants established in different LLSs of Veneto; *extra-regional connections* couple any applicant of Veneto to applicants established outside Veneto (either in Italy or a foreign territory). Similarly, we defined *local mobility* as when inventors 'move' inside the same LLS, *regional mobility* as when inventors move between firms/applicants located in different LLSs of Veneto and *extra-regional mobility* as when inventors 'move' to the observed applicant from firms located outside the region (either in Italy or a foreign territory).

The geographical specification of the variables of interest adds a further element to the analysis: the time needed for *connections* and *mobility* to affect patenting output. As shown in most recent contributions to the study of the effects of labour market relationships on the transfer of knowledge, relationships that occur within the same LLS may involve firms that are more closely 'related', in terms of production specialisation and worker competencies, than firms belonging to different LLSs or different regions/countries. Thus, the transfer of knowledge may be faster when relationships are within the same LLS than between different LLSs or regions/countries. For this reason, we add the time dimension to the geographical specification and end up with a time-space specification for both *connections* and *mobility.*[12]

Therefore, the different measures of the *connections* variable are evaluated both at the same time (*t*) the patenting output was observed and estimated (variable *connections*) and at different time lags (variables *connections lag i – j years*). When lagged, the *connections* variable measures relationships that occurred in the past – in years t – *1*,.., t – *i,* t – *j* – and is meant to capture the lagged effect of knowledge diffusion. For simplicity, we grouped lagged *connections* at five-year intervals after carrying out robustness checks for different time intervals and making sure that the dynamics were satisfied regardless of the chosen interval.[13] As the *mobility* variable already measures the 'movement' of inventors between time *t* and any time $t - x$ (with $x > 0$), the temporal specification simply details the time interval (always at five-year intervals).

3.2. The econometric model

Our aim was to empirically test whether inventors' working relationships, measured by *connections* and *mobility*, are responsible for the sharing and creation of knowledge and whether or not they positively affect patenting. The econometric model was estimated for all firms that apply for a patent at any time t in the period 1998–2007 and the dependent variable is one of the measures of patenting activity, as explained in the previous sections.

Data on patent applications of firm *i* at any time *t* are typical count data. The clear discrete nature of these data and the preponderance of small values suggest that we can improve on least squares with a model that accounts for those characteristics using the Poisson regression model.

A Poisson regression is a form of generalised linear model where the response variable is modelled as having a Poisson distribution; random variables with non-negative integer values are modelled as Poisson distributions. A random variable Y is said to have a Poisson distribution with the parameter μ, $Y \approx P(\mu)$ if it takes integer values $y = 0, 1, 2, \dots$ with the probability:

$$Pr\{Y = y\} = \frac{e^{-\mu}\mu^{y}}{y!} \quad (1)$$

For $\mu > 0$, the mean and the variance of this distribution can be shown to be: $E(Y) = var(Y) = \mu$. Since the mean is equal to the variance, any factor that affects one will also affect the other.

The Poisson regression model stipulates that a sample of n observations $y_1, y_2, \dots, y_n$ can be treated as realisations of independent Poisson random variables, with $Y_i \approx P(\mu_i)$ and y_i taking integer values. A common transformation of the Poisson regression model is given by the log-linear Poisson model, where μ_i depends on a vector of explanatory variables x_i through a log-linear model such as:

$$\log(\mu_i) = x_i'\beta \quad (2)$$

in which the regression coefficient β represents the expected change in the log of the mean per unit change in the predictor x_i. In other words, increasing x_i by one unit is associated with an increase of β in the log of the mean.

By exponentiating equation (2), we obtained a multiplicative model for the mean itself:

$$\mu_i = \exp\{x_i'\beta\} \quad (3)$$

[12] As previously discussed, we worked on the original time-series of the database to construct the lagged measures of *mobility* and *connections*.
[13] Upon request, we can provide the tables with these estimations.

where the exponentiated regression coefficient $\exp\{\beta\}$ represents a multiplicative effect of the j-th predictor on the mean.

The problem with the Poisson regression model is that the assumption that the conditional mean and variance of Y are equal may be too strong, given X. Inappropriate imposition of this restriction may produce spuriously small estimated standard errors. In addition, the model is based on the assumption that events occur independently over time.

A way to correct these issues is to allow for unexplained randomness by replacing equation (2) by the stochastic equation:

$$\log(\mu_i) = x_i'\beta + \varepsilon_i \qquad (4)$$

where the error term is assumed to be normally distributed.

Equation (4) represents a natural generalisation of the Poisson regression model, where the error term can reflect a specification error such as unobserved omitted exogenous variables (Cameron & Trivedi, 1986). This also allows for cross-firm heterogeneity.

The generalised Poisson regression model is very similar to the non-negative binomial model. In fact, the two models differ only in the distribution of the error term: the error is assumed to be distributed according to a normal density function for the generalised Poisson regression and according to a gamma distribution in the non-negative binomial case. Actually, the negative binomial model is a more general model than the generalised Poisson regression because it allows for the variance to exceed the mean. However, under a specific assumption on a parameter of the gamma distribution, mean and variance converge and the non-negative binomial model becomes identical to the Poisson. In deciding which model to use, we took account of the distribution of the dependent variables of interest. It is clear that the distribution of the number of patents is not characterised by over dispersion. Indeed, its variance is lower than its mean. However, the variance becomes slightly larger than the mean when we derive the weighted sum of patents. However, as the difference between the variance and the mean was negligible, it was not appropriate to adopt the non-negative binomial model and we decided to use the generalised Poisson regression model.

Given the longitudinal dimension of our data, we estimated the model as the following:

$$\log(\mu_{it}) = cons + \alpha_t + \beta * connections_{it} + \delta * mobility_{it} + \gamma * patstock\_past_i + \varepsilon_i \qquad (5)$$

where each applicant i is observed in each year t of the period 1998–2007.

The specification includes the above-discussed variables of interest, *connections* and *mobility*, together with the variable *patstock_past* measured at the applicant level. The variable *patstock_past* is defined as the stock of patents registered by each applicant in the decade prior to the period of interest (1988–1997). When estimating the model for the weighted sum of patents, we measured *patstock_past* by the weighted stock of patents (always registered in the period 1988–1997). The inclusion of the stock of patents and weighted stock of patents at the applicant level allows us to investigate the existence of persistence in patenting. According to the empirical evidence, pre-existing knowledge stocks are important for innovation (Roper & Hewitt-Dundas, 2008) and for patenting activities (Cefis & Orsenigo, 2001). Therefore, we expected the variable to have a positive and significant effect. To complete the model specification, random effects at the applicant level were also included to capture the role played by applicant unobservables, together with a time trend, α_t.

We carried out the initial empirical analysis using the specification without geographical disaggregation but including the lagged variables (*base model*). In a second step, we added the geographical specification for the explicative variables (local, regional and global) and estimated the *geographical model*. Estimation results for the *base model* are reported in Table 2; those concerning the *geographical model* are shown in Table 3. We estimated both models using the two dependent variables: the *sum of patents* and the *weighted sum of patents*. Before estimating the different specifications, we carried out a correlation analysis to ensure that the explanatory variables were not causing multi-collinearity problems.[14]

4. Results

In this section, we discuss the results of the estimates of the econometric model illustrated in Section 3, which allows us to evaluate the effect of inventors' working relationships on patenting.[15]

We processed equation (5) to the two different specifications: the *base model* and the *geographical model*. We ran both specifications using the two alternative dependent variables: the *sum of patents* and the *weighted sum of patents*. Table 2 lists the estimated coefficients, the marginal effects and the usual statistics.

The general result that emerges from the different specifications of the base model is that there exists a growing trend in patent production: the higher the number of patents filed by the firm in the period 1988–1997, the higher the sum of patents produced yearly by the firm in the observed sample. This result indicates the existence of some degree of persistence in patenting activities at the firm level, confirming what previous empirical studies have shown (see for example, Cefis & Orsenigo, 2001).

We now turn to the results for the variables that measure inventor mobility and working relationships. The overall result is that both the *mobility* and *connections* variables can explain the production of patents. This is so even in the simple *base model* where the territorial extension of the relationships is not investigated. However, some caveats are necessary. Inventor mobility enhances patenting activity, but only when the period between when the patent was registered with the leaving applicant and filed with the destination applicant is not greater than five years. After five years, inventor mobility has no significant positive effect on innovation at the destination firm. This result shows that mobility has knowledge productivity effects if the contribution of the incoming inventor affects the production of new patents in the short term. Indeed, this outcome shows that the ability of an inventor to increase the patenting activity of a firm is negatively correlated to the time lag between the moment in which the inventor filed the last patent with the originating company and the time he records the first patent with the destination company. If this period is longer than five years, the incoming inventor will not significantly contribute to increase innovation in the 'recruiting' firm.

Now let us concentrate on the estimation results for inventors' patenting relationships measured by the variable *connections*. The variable has significant and positive effects on the creation of knowledge: coefficients and marginal effects are mostly significant, regardless of the time span that elapses between the year in which inventors' working relationships occurred and the year of observation of the company's patenting output.[16] However, this effect appears to increase over time: relations that occurred several years earlier (11–15 years) have a much higher marginal effect on the production of patents than relations that occurred in recent years (1–5 years) or in the same year of observation. As we see in the discussion of the geographical model, this outcome is partly due to the correlation between the time and the spatial extent of the area of influence of inventors' working relations. However, some caution has to be taken in interpreting the results. In fact, the increasing effect detected as the time lag increases may also be linked to inventors' characteristics, in particular to their working experience. Connections that are more distant in

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[14] We can provide the correlation matrix on request.

[15] We remind readers that, by construction, the *connections* and *mobility* variables are net of relationships occurring between applicants that belong to the same business group and net of 'false' mobility.

[16] The estimation results using 5-year lagged connections show some discontinuities of significance (1–5 and 11–15-year lags are significant while 6–10 and 16–20 year lags are not). This is probably due to a numerosity effect when grouping connections every five years. Indeed, when we initially ran the model with 1-year lagged connections, we found some regularities in the effect of 1-year lagged connections and an increasing effect of connections with time. Then, we decided to use 5-year lagged connections to reduce the length of tables. If there is interest, we can provide the tables with the results of the model with 1-year lagged connections.

time may be those of inventors with a longer working experience. Thus, the coefficient increases over time because it also captures the effect of the human capital that inventors accumulate over time.

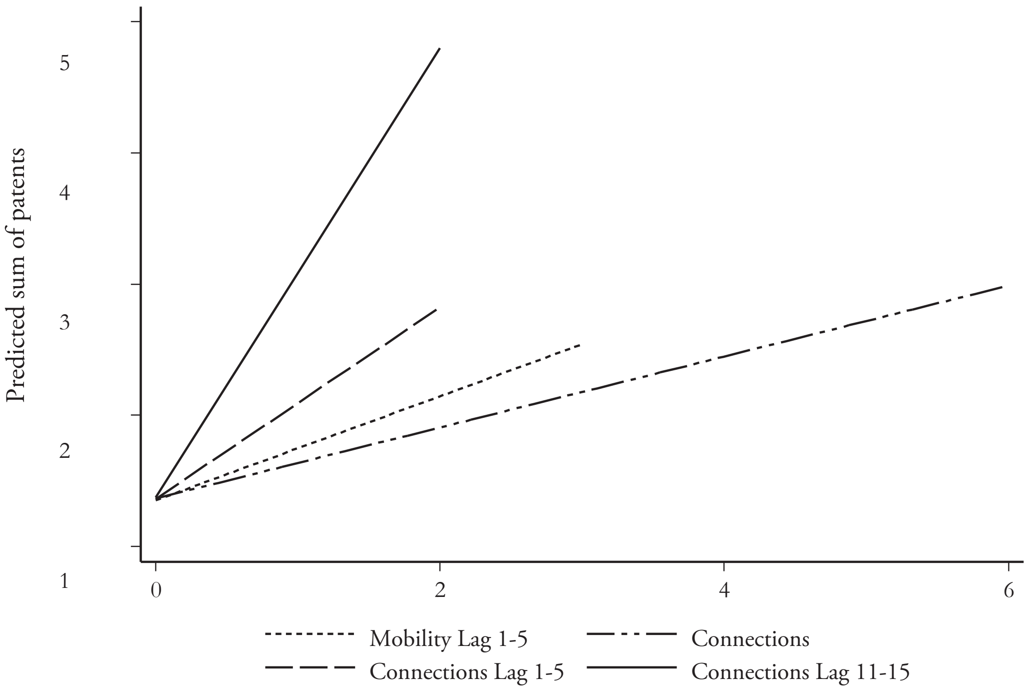
TABLE 2.
Base model. Estimation results

	Dependent variable			
	Sum of patents$_{it}$		Weighted sum of patents$_{it}$	
	Coef.	Marg. effect	Coef.	Marg. Effect
Time trend	0.02***	0.03***	0.02***	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)
Stock of patents (1988–1997)	0.02***	0.02***		
	(0.00)	(0.00)		
Stock of weighted number of patents (1988–1997)			0.02***	0.02***
			(0.00)	(0.00)
Mobility				
Lag 1–5 years	0.09**	0.13**	0.09*	0.11*
	(0.05)	(0.06)	(0.05)	(0.06)
Lag 6–10 years	0.03	0.03	0.05	0.06
	(0.09)	(0.12)	(0.09)	(0.12)
Lag 11–15 years	0.04	0.05	0.07	0.09
	(0.13)	(0.17)	(0.13)	(0.16)
Lag 16–20 years	–-0.24	–0.32	–0.23	–0.28
	(0.26)	(0.35)	(0.27)	(0.33)
Connections	0.11***	0.15***	0.07*	0.09*
	(0.04)	(0.05)	(0.04)	(0.05)
Lagged connections				
Lag 1–5 years	0.18**	0.25**	0.20**	0.25**
	(0.08)	(0.11)	(0.09)	(0.11)
Lag 6–10 years	0.16	0.21	0.15	0.19
	(0.11)	(0.14)	(0.11)	(0.14)
Lag 11–15 years	0.32**	0.44**	0.33**	0.42**
	(0.14)	(0.19)	(0.15)	(0.18)
Lag 16–20 years	0.27	0.36	0.22	0.28
	(0.17)	(0.23)	(0.18)	(0.23)
Constant	–37.26***		–43.45***	
	(10.85)		(11.22)	
Ln(μ)	–2.54***		–2.33***	
	(0.09)		(0.09)	
Observations	3 283		3 283	
Number of applicants	2 018		2 018	
Wald test Chi^2	120.75***		110.56***	

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Note: The variable *connections* is normalized by the number of inventors by firm and year.

To better summarise and understand the role played by the variables of the *base model* in explaining the production of patents, in Figure 2 we plot the line that interpolates the relationship between each variable with a statistically significant coefficient and the prediction of the dependent variable (predicted sum of patents). The graph clearly shows the positive relationship between the different variables of interest and the predicted sum of patents filed yearly at the EPO, confirming the importance of inventors' working relationships for the creation of new knowledge and patented innovation. The most significant effect is due to the *connections* variable, especially in the long term.

FIGURE 2.
Base model. Linear interpolation of the *predicted sum of patents* in relation to *mobility* and c*onnections*.



Note: only for statistically significant covariates

We can move now to the discussion of the estimation results for the geographical model (Table 3).

The geographical specification confirms the path dependency and the positive time trend of patenting: the time trend and the coefficients of the stock of patents in the period 1988–1997, whether weighted or unweighted, according to the dependent variable used, are significant, positive and stable. In general, the estimated coefficients of the *geographical model*, when significant, are greater than those predicted in the *base model*. This suggests that we underestimate the innovative effects of knowledge flows if we fail to consider the geographical dimension.

Table 3.
Geographical model. Estimation results

		Dependent variable			
		Sum of patents$_{it}$		Weighted sum of patents$_{it}$	
		Coeff.	Marg. effect	Coeff.	Marg. effect
Time trend			0.03***	0.02***	0.03***
Stock of patents (1988–1997)		0.02***	0.02***		
Stock of weighted number of patents (1988–1997)				0.02***	0.02***
Mobility					
Local mobility	*Lag 1–5 years*	0.12*	0.16*	0.12*	0.15*
	6–10 years	–0.03	–0.04	–0.01	–0.01
	11–15 years	0.04	0.05	0.07	0.08
	16–20 years	–0.21	–0.28	–0.21	–0.26
Regional mobility	*Lag 1–5 years*	0.04	0.05	0.04	0.05
	6–10 years	0.08	0.11	0.08	0.11
	11–15 years	–0.01	–0.01	0.02	0.03
	16–20 years	–0.28	–0.33	–0.22	–0.25
Extra-regional mobility	*Lag 1–5 years*	0.14	0.19	0.12	0.15
	6–10 years	0.09	0.12	0.12	0.16
	11–15 years	0.10	0.14	0.13	0.18
	16–20 years	–0.35	–0.39	–0.32	–0.34
Connections					
Local connections		0.12**	0.16**	0.08	0.10
Regional connections		0.12	0.16	0.07	0.09
Extra-regional connections		0.00	0.01	–0.02	–0.02
Lagged connections					
Local connections	*Lag 1–5 years*	0.18*	0.24*	0.19*	0.24*
	6–10 years	0.17	0.23	0.18	0.23
	11–15 years	0.71***	0.96***	0.72***	0.90***
	16–20 years	0.42	0.56	0.48	0.60
Regional connections	*Lag 1–5 years*	0.47*	0.62*	0.50**	0.63**
	6–10 years	–0.21	–0.28	–0.35	–0.44
	11–15 years	–1.00	–1.34	–0.94	–1.18
	16–20 years	0.06	0.08	–0.14	–0.17
Extra-regional connections	*Lag 1–5 years*	–0.08	–0.11	–0.03	–0.04
	6–10 years	0.30	0.40	0.30	0.38
	11–15 years	0.12	0.16	0.16	0.20
	16–20 years	0.43*	0.57*	0.44*	0.56*
Constant		–37.19***		–43.47***	
Ln(μ)		–2.57***		–2.36***	
Observations		3 283		3 283	
Number of applicants		2 018		2 018	
Wald test Chi²		139.05***		129.41***	

For reasons of space, standard errors are not reported. *** p<0.01, ** p<0.05, * p<0.1.
Note: The variable *connections* is normalized by the number of inventors by firm and year.

Regarding the measures of inventors' *mobility* and *connections*, the geographical model adds some interesting elements to the understanding of the mechanisms of the transfer of knowledge in the hands of inventors. For mobility, the results of the base model hold in the geographical specification: mobility significantly affects patenting only if the incoming inventor participates in some patenting output in the short term. However, the geographical specification clearly shows that inventor mobility affects the creation of knowledge at a very local level only if mobility occurs within the same LLS. *Connections*, in contrast, have local, regional and extra-regional effects and time plays some role in shaping these effects. While local connections significantly affect the innovation output in the very short term and in the medium to long term, regional connections have an effect in the medium term only and extra-regional connections in the long term. Thus, the geographical model seems to highlight the importance of time in determining the significant impact of working relationships that go beyond the LLS in spatial terms.[17]

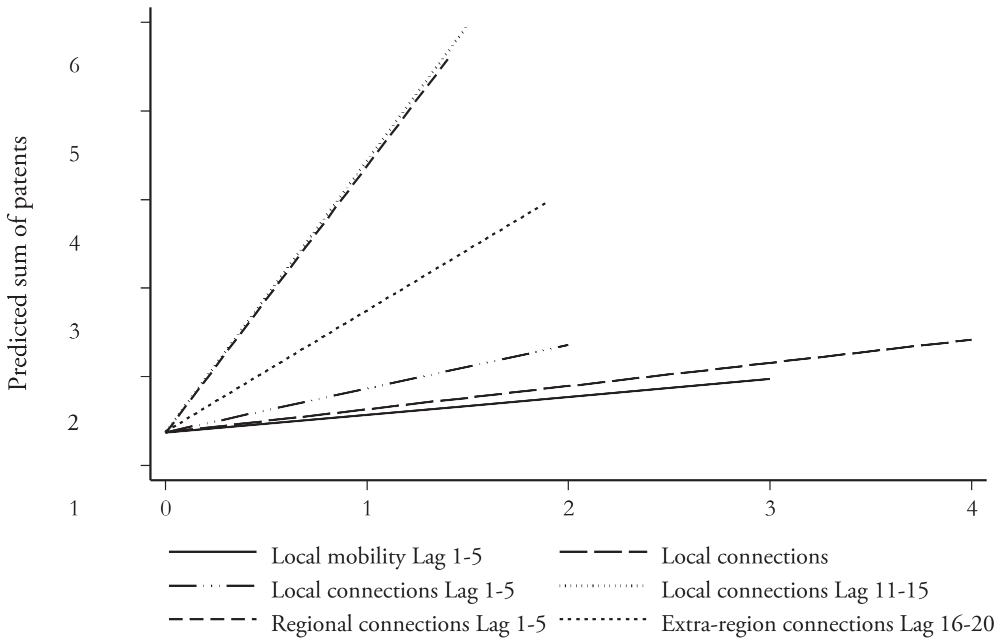
Turning to the size of the innovation effect, we can see that regional and extra-regional connections have innovation effects (marginal effects) sharply higher than the effects of local connections in the very short and the short term. This seems to support the outcomes of some empirical studies showing that human capital's working relationships improve knowledge creation and/or innovation if they occur between different areas.

In particular, our results fit well with Simonen and McCann (2008) who, working on a sample of Finnish high-technology firms, found that human capital inputs sourced from the local area are negatively associated with both product innovation and new products to market. On the other hand, human capital inputs acquired from other areas (and from the same sector) are positively related to product innovation. Simonen and McCann (2010) confirmed these results. They did not find evidence for a positive innovation role played by local labour markets. On the contrary, they detected a positive role played by human capital acquired from the same industry but from other regions. Also, Boschma et al. (2009), studying labour mobility in the entire Swedish economy, confirmed that the effects of labour mobility on firm performance depend on whether new employees are recruited from the same region or from other regions. However, since they were able to disentangle the types of skills of labour inflows, they showed that worker inflows from the same region contribute positively to plant performance when they are of unrelated skills with respect to internal skills. On the contrary, mobility across regions only has a positive effect on productivity growth when it concerns new employees with related skills.

We summarise the results of the geographical model in Figure 3. This shows the pairwise relationship between the predicted sum of patents and each variable with statistically significant effects. The figure clearly shows the positive relationship between the variables of interest and the predicted patenting activity, and how the spatial extent of inventors' relationships and time play a joint role in explaining the production of patents. Thus, the pattern of knowledge creation is not unique. For inventors' mobility, knowledge externalities occur in the short term and within very narrow boundaries (within LLSs). Otherwise, inventors' *connections* are responsible for knowledge externalities that spread beyond the local system where knowledge comes from.

[17] As for the base model (see Footnote 16), the regressions were first run with 1-year lagged connections. Then, since this model showed some regularities in the effects of 1-year lagged connections, we simplified the specification by grouping connections in 5-year lagged variables.

FIGURE 3.
Geographical model. Linear interpolation of the *predicted sum of patents* in relation to *mobility* and *connections*.



Note: only for statistically significant covariates

5. Conclusions

In this article, we study inventors' working relationships and mobility and their role in mediating the sharing of tacit knowledge. We evaluate the effects of these externalities on innovation, which we measure by patenting activity. This work fits into the branch of literature that highlights the role played by labour markets in the transmission of knowledge, in particular of knowledge tacitly held by individuals taking part in patenting processes.

The study adds something new to the literature. First, besides considering inventors' mobility, we also take into account a possible source of knowledge externality – inventors' working relationships (*connections*) – which has not been considered in any previous research. The peculiarity of these relationships is that they are not codified by any formal agreement between firms, unlike co-inventorships and multi-firm collaborations. As *connections* depend only on inventors' professional activities, the firms they work for may not be aware of them. Whereas inventors' *mobility* implies that inventors leave one firm to join a new one, *connections* highlight the working relationships that occur simultaneously and through multiple firms. This simultaneity gives rise to knowledge externalities across firms and can positively affect knowledge creation and the production of patents.

The article also explores the spatial extent and the dynamic pattern of the spread of knowledge and it contributes to the wide literature on knowledge externalities. To do so, we measured inventors' mobility and working relationships (*connections*). We took into account the territorial dimension, i.e., the LLS location of those firms involved by inventor's relationships/mobility. Thus, we captured the local, regional and extra-regional extent of the knowledge externalities and we measured their short- and long-term effects.

We carried out the analysis on the population of those firms located in Veneto which filed patents with the EPO in the pre-crisis period (1998–2007). After cleaning the data, we measured the patenting activity and the variables of interest year by year at the firm level. We ended up with an unbalanced panel of 2018 applicants filing at least one patent with the EPO in the period 1998–2007. We estimated the patenting model using a Poisson specification and exploited the panel dimension.

Our results confirm the role played by human capital in the transmission of knowledge. Specifically, inventors are responsible for positive externalities that benefit the companies with whom they patent. Such externalities, which arise and spread through labour relations and mobility, enhance companies' capacity for patenting. However, in general, *connections* have a higher positive impact on patenting activity than *mobility*.

By focusing on the spatial extent of inventors' *mobility* and *connections*, we have contributed to a better understanding of knowledge spillovers. In line with most of the literature on worker mobility and the transfer of knowledge, we found that the transfer of knowledge that occurs through inventors' mobility is localised and has a significant effect on patenting only within the borders of the specific LLSs where it takes place and when the production of new knowledge occurs in the short term. However, we also obtained original results because knowledge externalities that occur through inventors' working relationships have local, regional and extra-regional effects. This study shows the existence of a complex pattern of knowledge relationships, where both local and distant working relationships play a role in the transfer and creation of knowledge. Inventors' working relationships thus produce productivity effects, in terms of patenting activity, that are driven by factors related to the spatial extent of these relationships, in particular to the skill content of local and more extended relationships. Thus, not only local relationships, supported by physical proximity, but also distant relationships can be important for company performance. We contend that distant relationships can be relevant for the transfer of those skills that are not similar to those existing in the knowledge base of the firm but which are complementary to them. Although we could not control for inventors' competences and skills, our findings support previous research findings that company performances are affected by worker relationships, depending on a mix of geographical proximity and competences (Boschma et al., 2009; Eriksson, 2011).

Our results are of particular significance in relation to the territorial context of our study, the Veneto region. Strong local relations characterise the productive structure of Veneto, where face-to-face interactions are widespread and regularly occur, thus supporting a preliminary hypothesis of a localised knowledge diffusion, supported by territorial and physical proximity. However, our results emphasise that beyond the role of proximity in generating knowledge spillovers and productivity effects, working relationships among inventors channel knowledge diffusion on a much broader scale.

From a policy point of view, our results suggest that increasing investment to promote inventors' opportunities to connect with other firms' inventors can be a smart strategy to enhance knowledge transfer and creation inside firms. The channels of inventors' and researchers' professional relationships appear to be a more effective conduit of knowledge creation to positively affect firms' patenting activity than interfirm workers' mobility. This implies that, even in the presence of non-compete covenants, a company's innovation capacity can be enhanced through channels that include opportunities for its inventors to connect with other firms' inventors. Indeed, we think that a practical example of these types of policies is illustrated by the European Commission's Erasmus+ programme of recent years. With respect to the past, the programme presents interesting lines of intervention for the learning mobility of workers. Key Action 1 of the programme provides that organisations can engage in a number of development activities that include improvement of the professional skills of their staff through the arrangement to send or receive staff to or from participating countries.

Our study lacks some possible further analysis on the sector of activity and the geographical extent of the working relationships that affect innovation. Future research should focus on building a better understanding of the geographical extent of the benefits at industry level. Unfortunately, databases on patents do not provide information on the industrial sector that the applicant belongs to. Thus, this type of analysis would need to involve the merging of patent data with other databases.

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APPENDIX

TABLE A1.
Base model: descriptive statistics

	Mean	St. Dev.
Number of patents	1.442	1.415
Weighted number of patents	1.365	1.434
Stock of patents 1988–1997	1.886	8.832
Stock of weighted sum of patents 1988–1997	1.863	8.738
Mobility		
Lag 1–5 years	0.083	0.308
Lag 6 to10 years	0.029	0.173
Lag 11 to 15 years	0.013	0.118
Lag 16 to 20 years	0.004	0.070
Connections		
Number of connections#	0.066	0.337
Lag 1–5 years	0.030	0.171
Lag 6–10 years	0.016	0.131
Lag 11–15 years	0.007	0.083
Lag 16–20 years	0.006	0.081

Normalized by the number of inventors by firm and year.

TABLE A2.
Geographical model: descriptive statistics

		Mean	St. Dev.
Number of patents		1.442	1.415
Weighted number of patents		1.365	1.434
Stock of patents (1988–1997)		1.886	8.832
Stock of weighted sum of patents (1988–1997)		1.863	8.738
Mobility			
Local mobility	*Lag 1–5 years*	0.049	0.238
	6–10 years	0.016	0.132
	11–15 years	0.007	0.089
	16–20 years	0.003	0.058
Regional mobility	*Lag 1–5 years*	0.020	0.149
	6–10 years	0.006	0.080
	11–15 years	0.003	0.052
	16–20 years	0.001	0.030
Extra-regional mobility	*Lag 1–5 years*	0.012	0.119
	6–10 years	0.005	0.071
	11–15 years	0.003	0.055
	16–20 years	0.001	0.025
Connections			
Local connections		0.046	0.265
Regional connections		0.014	0.150
Extra-regional connections		0.006	0.080
Lagged connections			
Local connections	*Lag 1–5 years*	0.020	0.149
	6–10 years	0.009	0.103
	11–15 years	0.003	0.049
	16–20 years	0.001	0.024
Regional connections	*Lag 1–5 years*	0.006	0.057
	6–10 years	0.004	0.052
	11–15 years	0.001	0.028
	16–20 years	0.003	0.062
Extra-regional connections	*Lag 1–5 years*	0.003	0.055
	6–10 years	0.003	0.057
	11–15 years	0.002	0.061
	16–20 years	0.002	0.046

Normalized by the number of inventors by firm and year.

Servicios “Smart” y valor de los destinos turísticos inteligentes: análisis desde la perspectiva de los residentes

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Resumen:

Los destinos son considerados marcas que deben gestionarse adecuadamente para aumentar, no sólo la llegada de turistas, sino también la calidad de vida de los residentes. El valor de marca juega un papel importante en el logro de tales objetivos. Simultáneamente, la integración de las TIC en el territorio ha llevado al concepto de "destinos inteligentes". En este contexto, el objetivo del trabajo es desarrollar un modelo de valor de los destinos inteligentes desde la perspectiva de los residentes (actor clave de los destinos ya que proyectan su imagen e influyen en la experiencia turística). En particular, nuestro modelo incluye servicios inteligentes relacionados con seguridad, salud, patrimonio, movilidad y medio ambiente. Nuestros resultados confirman que el valor del destino inteligente está formado por el reconocimiento, imagen, calidad percibida y lealtad. Además, los servicios de seguridad, medio ambiente y movilidad son los principales antecedentes del valor del destino inteligente.

Palabras clave: Inteligente; servicios; valor; destino; residentes.
Clasificación JEL: L83; M15; M31.

Smart services and equity of smart tourism destinations: analysis from the perspective of the residents

Abstract:

Tourist destinations are increasingly considered as brands that need to be managed to increase not only the arrivals of tourists, but also the quality-of-life of residents. Thus, brand equity plays an important role in the achievement of those objectives. Simultaneously, the integration of ICT has leaded to the concept of “smart tourist destinations”. With this in mind, the main goal of our paper is to develop a model of smart destination equity from the point of view of residents (i.e. a key stakeholder of tourist destinations since they project the image of their places and influence the tourist experience). In particular, our model includes smart services linked to safety, health, heritage, mobility, and environment. Our results confirm that smart destination equity is formed by awareness, image, perceived quality, and loyalty. In addition, smart services related to safety, the environment and mobility are the main factors influencing smart destination equity.

Keywords: Smart; services; equity; destination; residents.
JEL classification: L83; M15; M31.

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1. Introducción

Hoy en día, existen dos tendencias especialmente importantes en relación con las estrategias de gestión y comercialización de los territorios. Por un lado, los territorios se conciben cada vez más como marcas que deben ser adecuadamente gestionadas para alcanzar sus objetivos en términos de llegadas de turistas o calidad de vida de los residentes, entre otros (Boes, Buhalis & Inversini, 2016; Buhalis & Amaranggana, 2014; Caragliu, Del Bo & Nijkamp, 2011). Por otro lado, el crecimiento exponencial de las Tecnologías de la Información y Comunicación (TIC) conlleva nuevos desafíos y oportunidades en la gestión de los territorios (Falconer & Mitchell, 2012). En este contexto se ha acuñado el término "inteligente" (Smart), que representa la integración de las TIC dentro del territorio (muy especialmente dentro de las ciudades), con objeto de mejorar la eficiencia de los servicios y, en consecuencia, la calidad de vida de los ciudadanos (Vicini, Bellini & Sanna, 2012).

En particular, las TIC ofrecen un gran potencial para aumentar la competitividad de las ciudades mediante el desarrollo de herramientas que permiten una gestión y coordinación más eficiente de los servicios públicos, como son la gestión de residuos, el ahorro de energía o el control del tráfico (Bakici et al., 2013). Además, las TIC permiten el desarrollo de nuevos servicios de valor añadido basados en el suministro de información en tiempo real sobre diferentes cuestiones de la ciudad: densidad del tráfico, rutas de transporte público, disponibilidad de aparcamiento o accesibilidad del patrimonio cultural y de otros recursos turísticos. Estas nuevas aplicaciones tecnológicas permitirán que los ciudadanos estén más conectados, mejor informados y más comprometidos con la ciudad. En definitiva, harán que las ciudades sean más accesibles y agradables tanto para los residentes como para los visitantes (Buhalis & Amaranggana, 2014).

El Internet inalámbrico y el desarrollo de la web 2.0 permiten una mayor interconectividad e interactividad entre administraciones públicas, ciudadanos y empresas (Vicini et al., 2012). Por lo tanto, las personas no solo pueden acceder a una gran cantidad de información y servicios de valor añadido, sino que también pueden interactuar con la ciudad, los proveedores de servicios y con otros ciudadanos y visitantes, generando nueva información (por ejemplo, advertencias sobre atascos y accidentes) y, por lo tanto, agregando valor a esos servicios y aplicaciones. Estas capacidades proporcionadas por las TIC han dado paso a una atención creciente sobre la participación de residentes y visitantes en el desarrollo de la ciudad, su empoderamiento en los procesos de toma de decisiones urbanas y su participación en la co-creación de servicios de alto valor añadido.

No cabe duda de que las aplicaciones TIC tienen un enorme potencial para la industria del turismo, especialmente para el posicionamiento y la gestión de los destinos turísticos (Buhalis & Amaranggana, 2014). En primer lugar, tecnologías como el Internet móvil, la geolocalización o la realidad aumentada permiten mejorar las experiencias de los turistas en el destino, a través del suministro de información en tiempo real o de aplicaciones innovadoras para disfrutar de los productos y servicios turísticos. Asimismo, las TIC también mejoran la eficiencia al reducir el tiempo y los costes necesarios para proporcionar servicios públicos a los turistas. En este sentido, el desarrollo de las tecnologías inteligentes y su aplicación a la gestión del turismo en los territorios han dado paso al concepto de "destino inteligente".

Este concepto ha suscitado recientemente el interés de profesionales de distintos países (Guo, Liu & Chai, 2014, López de Ávila, 2015, Wang, Li & Li, 2013). Sin embargo, hasta la fecha, la mayoría de la investigación académica sobre destinos inteligentes es conceptual (Boes et al., 2016) y se centra principalmente en el turismo de negocios y en las actividades de co-creación para mejorar la experiencia de destino (Buhalis & Amaranggana, 2014; Gretzel, Werthner, Koo & Lamsfus, 2015; Wang et al., 2013). Bajo estas circunstancias, se espera que nuestro estudio contribuya a la literatura desarrollando y probando empíricamente un modelo de valor del destino inteligente desde el punto de vista de los residentes. En particular, nuestro modelo teórico incluye cinco tipos de servicios inteligentes: seguridad, salud, patrimonio, movilidad y medio ambiente. Este enfoque es especialmente interesante para los responsables en materia turística ya que los residentes son una figura clave para proyectar la imagen del destino inteligente y para influir en la calidad de la experiencia de los visitantes (San Martín, García-de los Salmones & Herrero, 2018).

2. Revisión de la Literatura

2.1. Destinos inteligentes

La aplicación de la tecnología en el sector turístico se ha denominado turismo "digital" o "inteligente". En particular, la implementación de la inteligencia en los destinos turísticos se ha convertido en una cuestión crítica (Jovicic, 2017) ya que el turista más conectado, mejor informado y más comprometido interactúa dinámicamente con el destino, co-crea productos turísticos y añade valor para compartir (Neuhofer, Buhalis & Ladkin, 2012). Las organizaciones turísticas interconectadas brindan a los turistas servicios en tiempo real y personales, y simultáneamente recopilan datos para la optimización de su gestión estratégica y operativa (Gretzel et al., 2015; Wang et al., 2013). Por lo tanto, el concepto "inteligente" se ha convertido en un componente vital en el campo del marketing de los destinos turísticos (Boes et al., 2016; Jovicic, 2017).

En esta línea, el destino inteligente se puede considerar como "un sistema turístico que aprovecha la tecnología inteligente para crear, administrar y ofrecer servicios/experiencias inteligentes, y se caracteriza por un intercambio de información intensivo y la co-creación de valor" (Gretzel et al., 2015, p.3). Con un enfoque similar, Segittur (2015), una de las instituciones líderes en el campo de los destinos inteligentes, define este fenómeno como "un espacio innovador, accesible para todos, establecido sobre una infraestructura tecnológica de vanguardia que garantiza el desarrollo sostenible del territorio, facilita la interacción e integración del visitante con el entorno y aumenta la calidad de su experiencia en el destino, así como la calidad de vida de los residentes". Por lo tanto, este enfoque se basa en el uso de las TIC para mejorar la experiencia turística, la sostenibilidad del destino y la calidad de vida de los residentes (Boes et al., 2016). Finalmente, adoptando un enfoque tecnológico (Buonincontri & Micera, 2016; Ivars-Baidal, Celdrán-Bernabeu, Mazón & Perles-Ivars, 2017), los destinos inteligentes pueden considerarse plataformas en las que la información sobre recursos, actividades y productos turísticos puede integrarse instantáneamente y proporcionarse a turistas, empresas y organizaciones a través de una variedad de dispositivos (Wang, Li & Li, 2013; Zhang, Li & Liu, 2012).

Estudios previos han señalado que los destinos inteligentes contribuyen, no sólo a la satisfacción del turista, sino también a la calidad de vida de los residentes (Boes et al., 2016; Buhalis & Amaranggana, 2014; Caragliu et al., 2011; Ivars-Baidal et al. al., 2017; Seggitur, 2015). En particular, un enfoque de gestión inteligente conducirá al desarrollo y crecimiento de la industria turística en el territorio, con externalidades positivas a través de la creación de empleos y riqueza para la población local. Además, los residentes pueden disfrutar de muchos de los servicios de alto valor añadido en destinos inteligentes, poniendo a su disposición servicios públicos más eficientes y accesibles, y mejorando su conocimiento y uso (incluido el disfrute del patrimonio y de las atracciones turísticas).

En cuanto a la naturaleza de los servicios inteligentes, las TIC tienen aplicaciones en campos muy diversos relacionados con la gestión de los destinos turísticos. En este sentido, el marco conceptual propuesto por Segittur (2015) para el éxito de los destinos turísticos inteligentes considera cinco tipos de servicios de alto valor añadido para turistas y residentes:

- *Movilidad*: sistemas orientados a una gestión eficiente del transporte público y de los recursos de movilidad (por ejemplo, acceso al territorio y a sus atractivos turísticos). Los servicios de movilidad se erigen en un factor clave en los destinos inteligentes (Boes et al., 2016; Buonincontri & Micera, 2016), incluida la provisión de información en tiempo real sobre tráfico, aparcamiento, rutas de transporte público y reserva de servicios en línea.

- *Patrimonio*: sistemas de acceso en tiempo real a la historia y las actividades culturales del destino, facilitando una mejor promoción y una experiencia turística de mayor calidad (Buonincontri & Micera, 2016; Del Vecchio et al., 2017; Ivars-Baidal, 2017, Wang et al., 2016). Esto incluye aplicaciones de realidad aumentada, geolocalización, inmersión histórica a través de dispositivos ópticos, así como mapeo y holografía de video.
- *Medioambiente*: sistemas para mejorar la eficiencia en la gestión de la energía y el turismo sostenible, que conducen a ahorros importantes. La gestión ambiental inteligente, que incluye aplicaciones en las áreas de iluminación pública, recolección y tratamiento de residuos, así como la implementación de energías renovables, es un pilar recurrente en la mayoría de los marcos conceptuales sobre destinos inteligentes (Boes et al., 2016).
- *Seguridad*: sistemas orientados a mejorar la seguridad pública (Wang et al., 2016), tales como la monitorización por video remoto en áreas inseguras, informes electrónicos de la policía o sensores de ubicación en eventos masivos. Estas aplicaciones pueden ser de especial interés para reducir el riesgo percibido en destinos considerados inseguros o en el caso de eventos masivos. Además, los sistemas de seguridad inteligente pueden ser muy útiles para mejorar las percepciones de los residentes sobre los problemas de seguridad asociados con el turismo (por ejemplo, la delincuencia o la prostitución).
- *Salud*: sistemas de salud y prevención orientados a turistas y residentes (Almobaideen et al., 2017; Wang et al., 2016), como son el acceso remoto a registros médicos electrónicos, aplicaciones de salud preventiva, lectores de códigos de barras incorporados a los alimentos con información nutricional, o geolocalización de farmacias.

Según Segittur (2015), estas cinco áreas propuestas para el desarrollo de servicios inteligentes en destinos turísticos tienen impactos positivos en la economía local, debido al surgimiento de nuevas oportunidades de negocios en el campo de Internet, *Big Data* y sistemas *CRM*. Si bien este marco de servicios inteligentes se ha aplicado en diferentes territorios, hasta el momento no existe ningún estudio que brinde evidencia empírica que respalde: 1) la capacidad explicativa del marco mencionado; y 2) la validez de instrumentos específicos para medir, de una manera fiable, las evaluaciones de los usuarios sobre los servicios inteligentes ofrecidos por los territorios.

2.2. Servicios inteligentes y valor de marca para los destinos inteligentes

En la literatura de marketing, el concepto de "valor de marca" se originó en un intento por definir la relación entre clientes y marcas desde un punto de vista estratégico (Wood, 2000). En particular, Keller (1993, 2003) y Aaker (1991) desarrollaron el modelo de valor de marca basado en el consumidor, relacionado con las percepciones y reacciones de los individuos hacia las marcas. Según Aaker (1991), el valor de marca es un concepto multidimensional que incluye un conjunto de activos y pasivos vinculados con una marca, su nombre y símbolo, que suman o restan del valor proporcionado por un producto o servicio a los clientes. El valor de marca no se puede entender completamente sin examinar los factores que contribuyen a su formación en la mente de los consumidores (Yasin, et al., 2007). Con respecto a esto, cuatro dimensiones están bien establecidas en la literatura: reconocimiento de la marca, imagen/asociaciones de marca, calidad percibida de la marca y lealtad a la marca (Aaker, 1996; Keller, 2003).

Aunque esta teoría se aplicó inicialmente a bienes tangibles (Anselmsson, Johansson & Persson, 2007), con el tiempo se ha extendido a otros campos, como es el caso de los territorios. Así, se han publicado estudios relacionados con el valor de marca para los países (Herrero, San Martín & García de los Salmones, 2016; Pappu & Quester, 2010; Zeugner-Roth, Diamantopoulos & Montesinos, 2008), las ciudades (Lucarelli, 2012; Shafranskaya & Potapov, 2017) y los destinos turísticos (Boo, Busser & Baloglu, 2009; Kladou & Kehagia, 2014; Konecnik, 2006; Pike & Bianchi, 2016; San Martín et al., 2017, 2018).

Estos trabajos previos coinciden en que los destinos son marcas (Cai, 2002; 2010; Gartner, 2014) instaladas en la mente de los individuos –turistas y residentes–, y cuyo poder radica en las percepciones formadas en torno a la misma a partir de sus experiencias y aprendizajes a lo largo del tiempo.

Centrando nuestra atención en los destinos turísticos, cabe destacar que no existen estudios que analicen específicamente el valor de marca para un destino inteligente, lo que podría explicarse por la reciente aparición de este tipo de territorios. Además, los trabajos previos sobre destinos tradicionales han adoptado la perspectiva de los turistas, no la de residentes (Merrilees, Miller & Herington, 2009). Dado que los residentes son una pieza fundamental de la marca destino (Braun, Kavaratzis & Zenker, 2013) y que los territorios inteligentes pueden mejorar de forma significativa no sólo la experiencia de los turistas sino también el bienestar de los residentes (Boes et al., 2016; Buhalis & Amaranggana, 2014; Ivars-Baidal et al., 2017), resulta crucial analizar las percepciones de este colectivo interno de los destinos. Por lo tanto, teniendo en cuenta esta brecha en la literatura, el presente trabajo se centra en el valor de marca de los destinos inteligentes según la óptica de sus residentes.

En primer lugar, consideramos que el valor de marca de los destinos inteligentes es un concepto multidimensional conformado por cuatro dimensiones: reconocimiento, imagen, calidad percibida y lealtad (Konecnik, 2006; Herrero et al., 2017; Pike & Bianchi, 2016). El reconocimiento de marca consistiría en el reconocimiento del territorio como un destino inteligente por parte de sus residentes. La imagen de marca, concebida como el conjunto de asociaciones vinculadas con la marca (Konecnik, 2004), estaría compuesto en este caso por las percepciones de los residentes sobre los atributos de su territorio como destino inteligente. En línea con Keller (2003), la calidad percibida estaría relacionada con los juicios elaborados por los residentes en torno a la forma en que su territorio como destino inteligente satisface sus necesidades. Finalmente, la lealtad a la marca estaría representada por la disposición de los residentes a recomendar a otras personas su territorio como destino inteligente (Chen & Myagmarsuren, 2010; Prayag & Ryan, 2012; Herrero et al., 2017), convirtiéndose de este modo en embajadores de la marca destino (Braun et al., 2013).

En segundo lugar, nuestro estudio tiene como objetivo examinar los factores que influyen en el valor del destino inteligente según la óptica de los residentes. De acuerdo con Wong & Teoh (2015), el valor de la marca destino puede ser el antecedente y el resultado de la competitividad del destino. Por lo tanto, se espera que las percepciones de los atributos funcionales que determinan la competitividad del destino (los más tangibles y medibles, como son las atracciones o las infraestructuras) sean un precursor fundamental del valor de marca. En el caso de los destinos inteligentes, los factores que influyen en la competitividad serán principalmente los relacionados con los servicios de seguridad, salud, patrimonio, movilidad y medioambiente (Segittur, 2015). Adoptando el razonamiento esgrimido por Wong & Teoh (2015), se considera que estos servicios inteligentes conducirán a una mayor competitividad del destino puesto que pueden mejorar la economía local y las oportunidades de empleo (Segittur, 2015). En consecuencia, las percepciones positivas de los residentes en torno a los servicios inteligentes llevarán a un valor del destino inteligente más fuerte al reforzar el conjunto de los principales activos vinculados con la marca destino: reconocimiento, imagen, calidad percibida y lealtad. En consecuencia, se formulan las siguientes hipótesis de investigación (véase modelo teórico en la Figura 1):

H1. Existe una relación positiva entre los servicios inteligentes de seguridad y el valor del destino inteligente para los residentes.

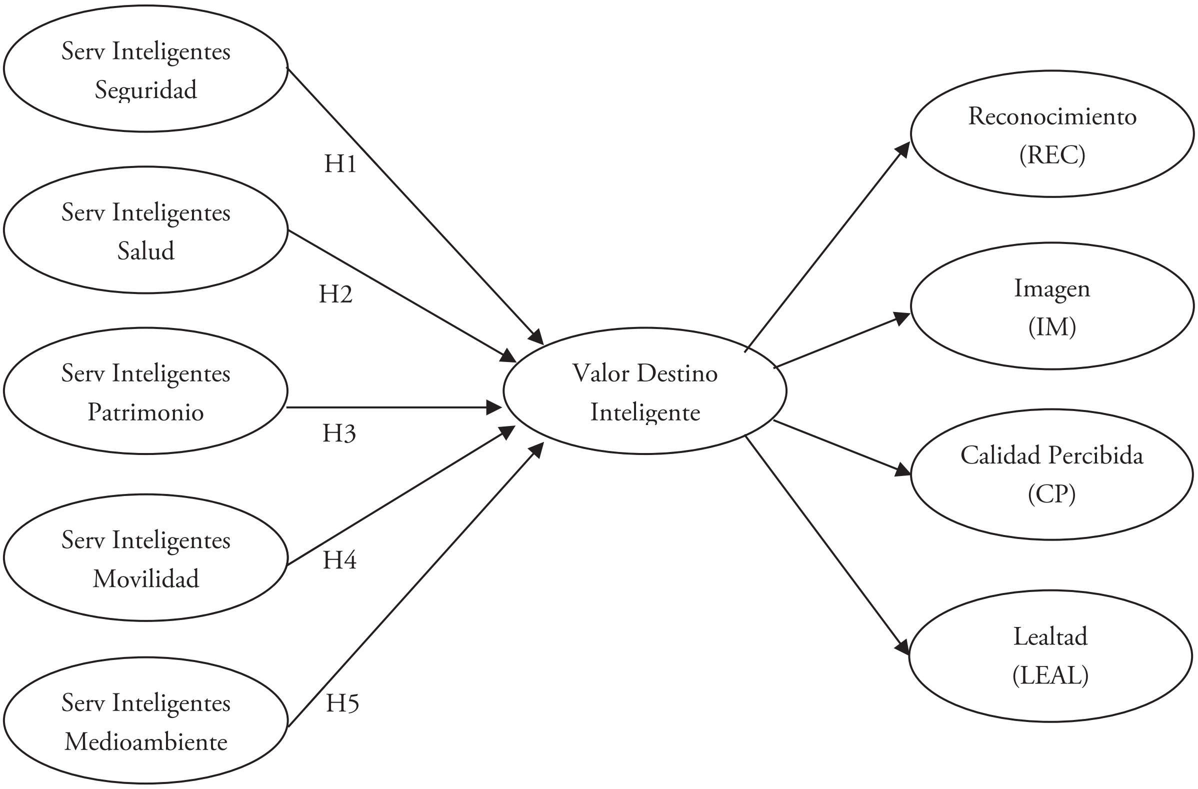
H2. Existe una relación positiva entre los servicios inteligentes de salud y el valor del destino inteligente para los residentes.

H3. Existe una relación positiva entre los servicios inteligente de patrimonio y el valor del destino inteligente para los residentes.

H4. Existe una relación positiva entre los servicios inteligentes de movilidad y el valor del destino inteligente para los residentes.

H5. Existe una relación positiva entre los servicios inteligentes de medioambiente y el valor del destino inteligente para los residentes.

FIGURA 1.
Modelo teórico de valor del destino inteligente



Fuente: Elaboración propia.

3. Metodología de investigación

Al objeto de testar las hipótesis se llevó a cabo una investigación empírica apoyada en encuestas personales a ciudadanos del destino objeto de estudio (la ciudad de Santander, en el norte de España). A este respecto, es importante destacar que el destino se encuentra en España, un lugar de estudio interesante para recoger datos sobre este particular, pues se sitúa en el tercer puesto en el ranking de países en número de llegadas de turistas internacionales (OMT, 2017), y es internacionalmente reconocida como un país líder en el desarrollo de proyectos de destinos inteligentes. Además, y ya a nivel ciudad, Santander está incluida en una investigación experimental pionera a nivel mundial que supone el desarrollo de aplicaciones y servicios propios de una ciudad inteligente.

El universo de la muestra lo componen residentes de Santander mayores de 18 años. El cuestionario incluía los siguientes bloques: (1) las percepciones de los residentes de los diferentes servicios inteligentes ofrecidos por la ciudad; (2) las medidas de las cuatro dimensiones del valor de un destino inteligente (reconocimiento, imagen, calidad percibida, lealtad); y (3) las características sociodemográficas de la muestra. Las variables del modelo teórico se midieron con escalas multi-atributo adaptadas de estudios previos, al objeto de asegurar la validez de contenido (Tabla 1). En particular, el "valor del destino inteligente" fue medido tomando como referencia los estudios de Konecnik & Gartner (2007), Boo et al. (2009), y Pike et al. (2010). La medida de "servicios inteligentes" fue inicialmente diseñada considerando las cinco categorías establecidas por Segittur (2015). Para cada una de ellas, incluimos tres ítems que resumían el principal contenido de cada categoría. Posteriormente, dichos ítems fueron examinados, en algunos casos mejorados, a través de una revisión de expertos académicos. Finalmente, todos los constructos fueron sometidos a un pre-test para asegurar su calidad.

TABLA 1.
Escalas de medida

Seguridad [a] *Videocontrol del tráfico en túneles y áreas peligrosas* *Aplicaciones para presentar quejas electrónicas (p.ej., denuncias en caso de robo)* *Sistemas de video-vigilancia y control en áreas turísticas*
Salud [a] *Aplicaciones web con información de interés en temas relacionados con la salud* *Aplicaciones web para localizar farmacias y otros puntos de salud* *Aplicaciones móviles con información personalizada para pacientes*
Patrimonio [a] *Rutas turísticas con sistemas de geolocalización* *Guías de video y audio-guías en museos y otras atracciones turísticas* *Sistemas de realidad aumentada*
Movilidad [a] *Aplicaciones móviles para aparcamiento* *Sistemas de información de tráfico y transporte público* *Red Wi-Fi abierta*
Medioambiente [a] *Sistemas inteligentes para la regulación del alumbrado público* *Sistemas inteligentes para medir las condiciones ambientales (p.ej., contaminación del aire)* *Sistemas de riego inteligentes en parques y jardines*
Reconocimiento [b] *Santander es un destino turístico inteligente reconocido* *Santander es un destino turístico inteligente famoso* *Santander es un destino turístico inteligente conocido*
Imagen [b] *Santander tiene una gestión turística innovadora* *Santander tiene una gestión eficiente del turismo* *Santander tiene una gestión sostenible del turismo* *Santander tiene una gestión integrada de sus servicios turísticos*
Calidad percibida [b] *Los sistemas de gestión inteligente de Santander son atractivos para los turistas* *Los sistemas de gestión inteligente de Santander cubren las necesidades de los turistas* *Los sistemas de gestión inteligente de Santander mejoran la experiencia de los turistas*
Lealtad [b] *Animaré a mi familia y amigos a visitar el destino turístico inteligente Santander* *Recomendaría Santander como un destino turístico inteligente si alguien me lo pidiera.* *Hablaría bien de Santander como un destino turístico inteligente*

[a] Las evaluaciones de servicios inteligentes se miden a través de una escala de siete posiciones (1= muy negativa; 7= muy positiva).
[b] Las dimensiones de valor se miden a través de una escala de Likert de siete posiciones (1= totalmente en desacuerdo; 7= totalmente de acuerdo).
Fuente: Elaboración propia.

La muestra de residentes fue seleccionada mediante el procedimiento por cuotas, controlando las características de la población en términos de edad y género sobre la base de estadísticas oficiales. Posteriormente, en una segunda fase, utilizamos un muestreo por conveniencia, realizando las encuestas en las principales zonas de Santander y obteniendo 833 respuestas válidas (la Tabla 2 recoge el perfil sociodemográfico de la muestra de residentes).

Tabla 2.
Perfil sociodemográfico

Variable	%	Variable	%
Género		*Edad*	
Masculino	47.0	Menos de 30	25.0
Femenino	53.0	Entre 30-55	43.7
		Más de 55 años	31.3
Nivel de estudios		*Ocupación*	
Sin estudios	7.0	Trabajador en activo	44.7
Estudios primarios	17.2	Estudiante	21.3
Estudios secundarios	35.3	Ama de casa	12.5
Estudios universitarios	40.5	Retirado/Sin empleo	21.5

Fuente: Elaboración propia.

4. Resultados

Antes de estimar el modelo se examinó el Método de la Varianza Común (CMV), ya que los datos se han recogido a partir de un único instrumento. Más en concreto, se utilizó el factor único de Harman (Podsakoff et al., 2003), a través de la realización de un análisis factorial exploratorio (fijado en la extracción de un solo factor sin rotación) para los 26 ítems incluidos en los 9 factores, al objeto de determinar la varianza total del factor único extraído y estimar si ésta se hallaba por debajo del valor de corte de 50%. Los resultados obtenidos con el software IBM SPSS 21 indican que un único factor general solo representa el 37.5% de la varianza total explicada en los 26 ítems, lo que sugiere que no hay problemas con el CMV.

Posteriormente, se estimó un Modelo de Ecuaciones Estructurales basado en la covarianza, usando un procedimiento robusto de estimación de máxima verosimilitud, al objeto de evitar problemas de falta de normalidad en los datos. En primer lugar, el modelo se estimó con un Análisis Factorial Confirmatorio (CFA) para evaluar las propiedades psicométricas de las escalas de medición (fiabilidad y validez). A continuación, se estimó el modelo estructural para contrastar los efectos causales directos establecidos en las hipótesis de investigación.

4.1. Estimación del modelo de medida

Una primera estimación del modelo de medida mostró problemas de validez convergente en las escalas utilizadas para medir "servicios inteligentes de movilidad" y "reconocimiento", ya que la carga factorial de los ítems SIM2 y REC2 tenían valores por debajo de 0,4. Por lo tanto, y de acuerdo con el enfoque propuesto por Hair et al. (2010), eliminamos estos ítems de las escalas y estimamos nuevamente el modelo. Los resultados obtenidos en la estimación del modelo de medida revisado confirman la bondad del ajuste de la estructura factorial a los datos.

En particular, consideramos tres criterios de ajuste: medidas de ajuste absoluto, medidas de ajuste incremental y medidas de parsimonia (Hair et al., 2010). Estas estadísticas las aporta el software EQS 6.1, ampliamente utilizado en la literatura de Ecuaciones Estructurales (Hair et al., 2010): Bentler-Bonett

Normed Fit Index (BBNFI), Bentler-Bonett Non-Normed Fit Index (BBNNFI) y Error cuadrático medio de aproximación (RMSEA) para la medición del ajuste general del modelo; Índice de Ajuste Incremental (IFI) e Índice de Ajuste Comparativo (CFI) como medidas de ajuste incremental; y χ^2 Normado para la medición de la parsimonia del modelo. Los resultados resumidos en la Tabla 3 confirman que las estadísticas BBNFI, BBNNFI, IFI y CFI exceden claramente el valor mínimo recomendado de 0,90. RMSEA se encuentra dentro del límite máximo de 0,08, y χ^2 Normado toma un valor por debajo del valor recomendado de 3.0 (Hair et al., 2010).

La fiabilidad de las escalas de medición se evalúa usando Alpha de Cronbach, fiabilidad compuesta y coeficientes AVE (Bagozzi & Yi 1988). Los valores de estas estadísticas están, en todos los casos, por encima o muy cerca de los valores mínimos requeridos de 0,7 y 0,5 respectivamente (Hair et al., 2010). Solo en el caso de "servicios inteligentes de patrimonio" y "servicios inteligentes de movilidad", se obtuvieron valores ligeramente por debajo de los niveles recomendados, lo cual es generalmente aceptado en investigaciones exploratorias que analizan constructos poco estudiados, como estos servicios de turismo inteligente. En consecuencia, los resultados obtenidos apoyan la fiabilidad interna de los constructos (Tabla 3). La validez convergente de las escalas también se confirma. ya que todos los ítems son significativos a un nivel de confianza del 95% y sus coeficientes lambda estandarizados son superiores a 0,50 (Steenkamp & Van Trijp 1991).

TABLA 3.
Modelo de medida (Análisis Factorial Confirmatorio)

Factor	Variable	Coef. Estand.	R^2	Alpha de Cronbach	Fiablidad Compuesta	AVE	Bondad de Ajuste
Servicios inteligentes de seguridad (SISE)	SISE1	0.68	0.46	0.76	0.76	0.52	Normed χ^2 = 2.74 BBNFI = 0.94 BBNNFI = 0.95 CFI = 0.96 IFI = 0.96 RMSEA = 0.05
	SISE2	0.78	0.60				
	SISE3	0.69	0.47				
Servicios inteligentes de salud (SISA)	SISA1	0.83	0.69	0.83	0.82	0.61	
	SISA2	0.75	0.57				
	SISA3	0.76	0.58				
Servicios inteligentes de patrimonio (SIP)	SIP1	0.66	0.43	0.68	0.68	0.42	
	SIP2	0.55	0.30				
	SIP3	0.72	0.51				
Servicios Inteligentes de Movilidad (SIM)	SIM1	0.74	0.54	0.67	0.68	0.52	
	SIM3	0.70	0.48				
Servicios Inteligentes de Medioambiente (SIMA)	SIMA1	0.71	0.50	0.77	0.78	0.54	
	SIMA2	0.79	0.63				
	SIMA3	0.69	0.48				
Reconocimiento (REC)	REC1	0.86	0.74	0.80	0.80	0.67	
	REC3	0.77	0.59				
Imagen (IM)	IM1	0.82	0.67	0.89	0.90	0.68	
	IM2	0.85	0.73				
	IM3	0.83	0.68				
	IM4	0.80	0.64				
Calidad Percibida (CP)	CP1	0.87	0.76	0.90	0.90	0.75	
	CP2	0.86	0.75				
	CP3	0.86	0.74				
Lealtad (LEAL)	LEAL1	0.88	0.78	0.92	0.92	0.79	
	LEAL2	0.90	0.82				
	LEAL3	0.89	0.80				

Fuente: Elaboración propia.

Para analizar la validez discriminante de las escalas se siguen los procedimientos propuestos por Anderson & Gerbing (1988) y Fornell & Larcker (1981). El enfoque propuesto por Anderson & Gerbing (1988) es una prueba básica de validez discriminante basada en el análisis de los intervalos de confianza para las correlaciones entre constructos. De acuerdo con este método, se admite la validez discriminante de las escalas utilizadas en esta investigación, ya que ninguno de los intervalos de confianza para la correlación entre pares de factores contiene el valor 1. El procedimiento propuesto por Fornell & Larcker (1981) se considera una prueba más exigente de validez discriminante (Grewal et al., 2004) y requiere la comparación de la varianza extraída para cada par de constructos (coeficiente AVE) con la estimación de la correlación al cuadrado entre dichos constructos. Si las varianzas extraídas son mayores que la correlación al cuadrado, existirá validez discriminante. Se comprueba que sólo tres de los cuarenta y cinco pares de constructos no pasaron la prueba, si bien en esos casos las diferencias entre el coeficiente AVE y las correlaciones al cuadrado son muy pequeñas. Además, los problemas detectados en la validez discriminante, de acuerdo con el procedimiento propuesto por Fornell & Larcker (1981), afectan a las escalas que miden servicios inteligentes, que pueden justificarse por la proximidad entre los diferentes tipos de servicios. De acuerdo con estos resultados, existe un apoyo razonable para la validez discriminante de las escalas utilizadas en esta investigación (Tablas 4 y 5).

Tabla 4.
Resultados del procedimiento de Anderson y Gerbing

	SISE	SISA	SIP	SIM	SIMA	REC	IM	CP
SISE	0.79, 0.89							
SISA	0.72, 0.86	0.70, 0.82						
SIP	0.56, 0.72	0.60, 0.75	0.73, 0.89					
SIMA	0.58, 0.72	0.51, 0.65	0.58, 0.72	0.42, 0.60				
REC	0.28, 0.45	0.23, 0.40	0.20, 0.38	0.25, 0.44	0.24, 0.42			
IM	0.43, 0.57	0.30, 0.45	0.29, 0.46	0.28, 0.46	0.44, 0.59	0.58, 0.72		
CP	0.40, 0.54	0.31, 0.46	0.34, 0.50	0.31, 0.48	0.36, 0.52	0.64, 0.76	0.73, 0.82	
LEAL	0.34, 0.48	0.26, 0.42	0.26, 0.42	0.25, 0.43	0.28, 0.44	0.55, 0.68	0.61, 0.72	0.74, 0.82

Fuente: Elaboración propia.

Tabla 5.
Resultados del procedimiento der fornell y larcker

	SISE	SISA	SIP	SIM	SIMA	REC	IM	CP	LEAL
SISE	0.52[a]								
SISA	0.70	0.61[a]							
SIP	0.62	0.57	0.42[a]						
SIM	0.40	0.45	0.65	0.52[a]					
SIMA	0.43	0.34	0.42	0.26	0.54[a]				
REC	0.14	0.10	0.08	0.12	0.11	0.67[a]			
IM	0.25	0.14	0.14	0.13	0.26	0.42	0.68[a]		
CP	0.22	0.15	0.17	0.16	0.19	0.49	0.60	0.75[a]	
LEAL	0.17	0.11	0.11	0.11	0.13	0.38	0.44	0.60	0.79[a]

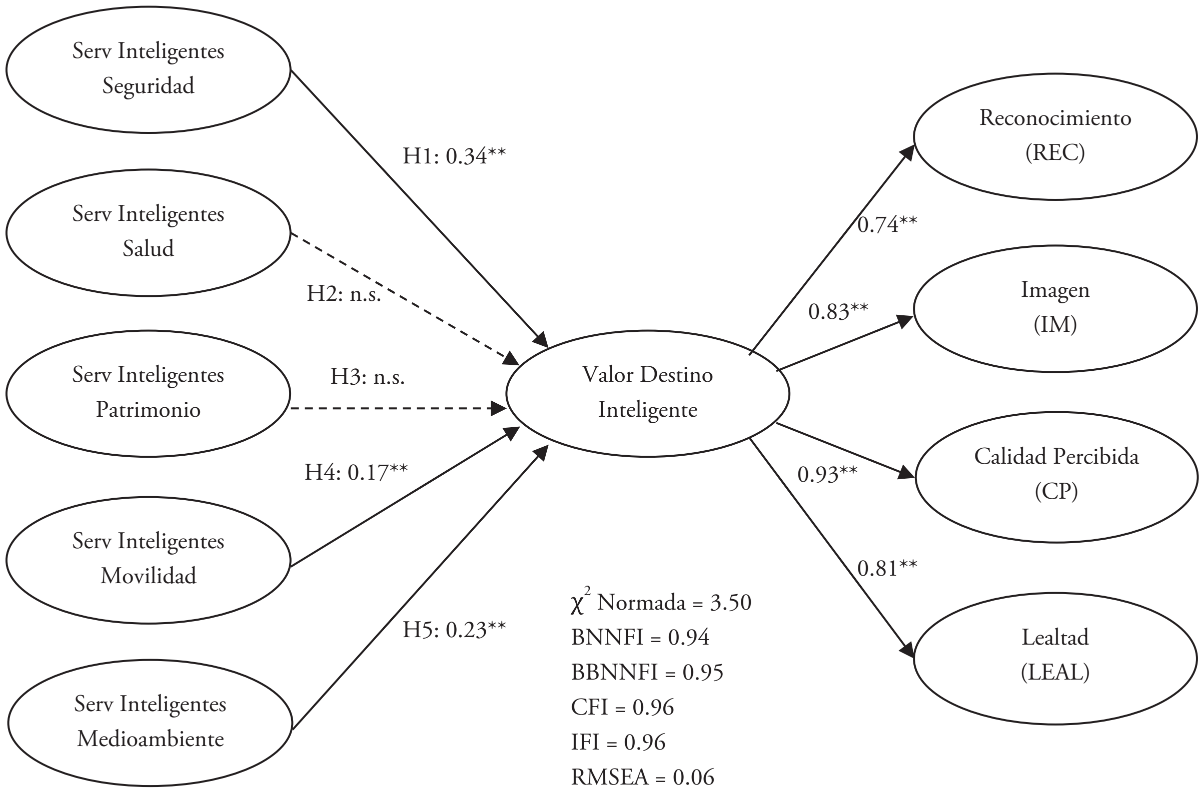
a= Coeficiente AVE. Los elementos fuera de diagonal son las correlaciones al cuadrado entre constructos
Fuente: Elaboración propia.

4.2. Estimación del modelo estructural

Una vez examinadas las propiedades psicométricas de las escalas, el modelo se estimó utilizando el procedimiento de estimación de máxima verosimilitud robusta. Los resultados obtenidos confirman todos los efectos causales propuestos en nuestro modelo teórico, excepto la influencia de los servicios inteligentes de salud (H2) y los servicios inteligentes de patrimonio (H3) sobre el valor del destino inteligente. Por lo tanto, el modelo original fue reformulado para excluir las relaciones no significativas (Hair et al. 2010). La Figura 2 resume los resultados para la estimación del modelo de investigación re-especificado, indicando los índices de bondad de ajuste del modelo estructural, las estadísticas de R^2 para cada variable dependiente, los coeficientes estandarizados para cada relación, y los valores de "p" para evaluar la significatividad. Los resultados confirman la especificación correcta del constructo "Valor del destino inteligente" como un factor de segundo orden, ya que todas las cargas son significativas y superiores a 0,50. Por lo tanto, de forma similar a estudios anteriores sobre el valor de marca de destino (Konecnik, 2006; Konecnik & Gartner, 2007), el "Valor del destino inteligente" se constituye como un factor de segundo orden formado por cuatro dimensiones: reconocimiento, imagen, calidad percibida y lealtad.

Con respecto a las hipótesis de investigación propuestas, la evidencia empírica obtenida muestra que el valor del destino inteligente sólo se ve influida significativamente por tres tipos de servicios inteligentes: seguridad (H1), movilidad (H4) y servicios medioambientales (H5). Por lo tanto, las percepciones de los ciudadanos sobre su ciudad como destino inteligente dependen de las infraestructuras tecnológicas implementadas para garantizar la seguridad física de los turistas durante su estancia, el acceso a información precisa sobre transporte público, tráfico y estacionamiento, y la gestión inteligente del riego, iluminación y contaminación en la ciudad. Por el contrario, el valor del destino inteligente no está significativamente influido por los servicios de salud (H2) y los servicios de patrimonio (H3), lo cual tiene implicaciones relevantes para las estrategias de comercialización y gestión del destino.

Figura 2.
Estimación del modelo



Fuente: Elaboración propia.

5. Conclusiones

Nuestro estudio contribuye a la literatura sobre valor de marca de destino mediante el desarrollo de un modelo específico para destinos inteligentes, teniendo en cuenta el punto de vista de los residentes (a diferencia del enfoque tradicional centrado en la figura del turista). Particularmente, nuestra investigación empírica confirma, de acuerdo con estudios previos, que el valor del destino inteligente (tal y como lo perciben los residentes) es un constructo multidimensional compuesto por: reconocimiento, imagen, calidad percibida y lealtad. En consecuencia, el valor del destino inteligente es un fenómeno complejo que estudios futuros deberían examinar desde una perspectiva multidimensional, para capturar su verdadera naturaleza y examinar su influencia en las actitudes y comportamientos de los diversos actores o *stakeholders* del territorio -residentes o turistas, entre otros-.

Nuestro modelo teórico también incluye diferentes tipos de servicios inteligentes como posibles impulsores del valor del destino inteligente. Considerando las implicaciones de gestión para los territorios en general, y para los territorios inteligentes en particular, el hecho de que los servicios inteligentes tengan un efecto significativo en el valor del destino inteligente implica que el apoyo de los ciudadanos al proyecto estará condicionado por sus percepciones de los servicios inteligentes proporcionados por el territorio. Específicamente, los responsables de la toma de decisiones deben ser conscientes de que es extremadamente importante proporcionar servicios de alta calidad desde el comienzo del proyecto, si quieren que los residentes lo respalden. Sin embargo, hay que tener en cuenta que no todos los servicios inteligentes de alto valor son igual de importantes. Por un lado, los servicios de seguridad, los ambientales y los de movilidad parecen ser especialmente relevantes para que los ciudadanos formen sus percepciones de valor del destino inteligente. Todos estos tipos de servicios inteligentes están directamente relacionados con las infraestructuras urbanas, es decir, con el gobierno local, por lo tanto, los gerentes de destino deben enfocarse en ofrecer servicios de alta calidad en estas áreas, y en desarrollar campañas de comunicación efectivas en los medios tradicionales y sociales para que los ciudadanos sean conscientes del valor de los servicios inteligentes brindados en el territorio.

Por otro lado, los servicios de salud y los patrimoniales no tienen una influencia significativa en la formación del valor del destino inteligente. En este sentido, los servicios de salud pueden no ser tan relevantes para los residentes ya que su información médica está disponible en el sistema de salud local y es posible que ya conozcan la ubicación de las farmacias y los centros médicos. Por lo tanto, este tipo de servicios deberían centrarse en los turistas, que pueden necesitar asistencia sanitaria en un territorio menos conocido para ellos. Los servicios inteligentes patrimoniales merecen una consideración especial desde una perspectiva de gestión, ya que el patrimonio generalmente se considera un pilar del posicionamiento de destino y del valor de marca. Nuevamente, este tipo de servicios inteligentes puede no ser tan relevante para los residentes ya que generalmente tienen un conocimiento profundo del patrimonio del territorio. Por el contrario, los responsables de la toma de decisiones públicas deberían centrarse en los servicios de patrimonio inteligente para los turistas, ya que deberían ser útiles para mejorar sus experiencias de destino.

El presente estudio tiene varias limitaciones que deberían abordarse en futuras investigaciones. Por un lado, el hecho de que el trabajo empírico se llevó a cabo en un destino específico puede representar una limitación en la generalización de nuestros resultados. Por lo tanto, sería interesante examinar la capacidad explicativa de nuestro modelo conceptual en otros destinos inteligentes en España y otros países. Por otro lado, la estimación del modelo se realizó para todos los residentes. Sería interesante examinar la capacidad explicativa del modelo dependiendo de diferentes variables, como por ejemplo considerando la participación o la identificación de los residentes con el destino inteligente como variables moderadoras. El modelo podría enriquecerse incluyendo otras variables como antecedentes (por ejemplo, actitud general hacia la "realidad inteligente") o consecuencias (por ejemplo, apoyo para el desarrollo turístico) del valor del destino inteligente. Finalmente, este estudio contribuye a la literatura académica mediante el desarrollo de instrumentos específicos para medir las evaluaciones de los servicios inteligentes, que podrían aplicarse a otros colectivos de interés, como son los turistas.

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Articles

The spatial dynamics of land use surrounding the Spanish property bubble (1990-2012)

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Abstract:

Although the recent *housing boom & bust* in Spain has triggered significant transformations in its urban fabric, the geographical dimensions of this economic phenomenon and its spatial impacts on the local urban structure have not yet been described in depth. Following the latest published data from CORINE *Land cover* (2012), this study undertakes a dynamic multi-scale spatial analysis of data representing urban land cover over a 22-year span, contributing to the understanding of four main issues: (i) the total amount of change, (ii) its proportion in comparison with the initial stage of geographical distribution, and the (iv) the implications for the metropolitan and regional urban layout.

This quantification describes the outlying regional structure of Spain's urbanization process during the last decades in Europe, showing great acceleration and a significant transformation in land use patterns, as well as major differences in rates and components on smaller scales, using an integrated growth index.

Keywords: Real estate bubble; CORINE Land Cover; land use; Spanish urban structure; regional studies; spatial dynamics.

JEL classification: O2; R0; Z0.

Dinámicas espaciales de ocupación de suelo en torno a la burbuja inmobiliaria española (1990-2012)

Resumen:

Utilizando los datos de ocupación de suelo de CORINE Land Cover (2012), este trabajo propone un análisis multiescalar, cuantitativo y espacial de las dinámicas de urbanización antes, durante y después de la burbuja inmobiliaria española, aportando una visión inédita del fenómeno en cuatro aspectos interrelacionados: (i) la magnitud absoluta del cambio, (ii) su proporción respecto al estado inicial, (iii) su variación temporal respecto a los usos del suelo, y (iv) sus implicaciones para los distintos componentes del sistema urbano español. El estudio precisa el lugar destacado del caso español en el continente europeo, y evidencia, a nivel provincial, una fuerte transformación del modelo de ocupación del territorio o las desigualdades en el ritmo y componentes del proceso, mediante la utilización de un índice integrado de crecimiento.

Palabras clave: Burbuja inmobiliaria, CORINE Land Cover, Ocupación del suelo, Sistema urbano español, Estudios regionales, Dinámicas espaciales

Clasificación JEL: O2; R0; Z0.

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Summary

Taking the data on land use from the CORINE Land Cover (2012) report, this study proposes a multiscale, quantitative and spatial analysis of the dynamics of urbanization before, during and after the Spanish property bubble, providing an unprecedented view of the phenomenon in four interrelated aspects: (i) the absolute scale of the change, (ii) its proportion with respect to its initial status, (iii) its variation over time, as regards different land uses, and (iv) its implications for the different components of Spain's urban structure. The study points to Spain's prominent role within the European continent and, at province level, testifies to a major transformation of the land cover model across this territory, and the unequal pace and components of the process, through the application of an integrated growth index.

1. Introduction

The *real estate bubble*[1] which occurred in Spain and other countries between the end of the 90s and 2008 was a property-based and economic phenomenon whose *boom and bust* was of an unprecedented scale and speed, and which caused a growing social and media impact, given its direct relationship with the subsequent recession in the construction sector, public works and the country's overall economy.

Within this context, the objectives of this study are:

- To present the dimensions and peculiarities of the urban growth associated with the most recent Spanish real estate bubble through the study of data on the urban and regional effects of this unique process.
- To describe, analyse and characterize the spatial dynamics in land use in Spain, principally through the quantification and spatial analysis of the European database, CORINE Land Cover (CLC), in its different editions, taking metrics associated with the changes during the period studied. With this aim in view, absolute and relative increases in different types of land use were measured, aggregating the results on a national and provincial scale, and providing an interpretation of land use in terms of the urban setting.
- To propose a method for the comparison of spatial growth by types of urban structure at the province level.
- To contrast the results obtained with interpretations of the transformation undergone by Spain in terms of model or main urban features.

Given the importance of the CLC data in this study, the period was set between the CLC's first and last data series, from 1990 to 2012, as will be explained later.

The article consists of four chapters after this introduction: the second contains a review of the scientific literature on the subject; the third addresses the methodology and sources used to establish the descriptive scope; the fourth presents the results referring to Spain as a whole and to provincial distribution; and the fifth is devoted to discussing the results and presenting the conclusions.

2. Bibliographical review of the Spanish property bubble

The *real estate bubble* is not a new phenomenon in Spain (Naredo, 1998, Rodríguez, 2006) and should be set against the backdrop of the general phenomenon that occurred worldwide[2].

[1] It should be clarified from the start that the term "property bubble" is used in this study to refer not only to its economic significance, as a process of speculative price increases in certain property (residential, tertiary, industrial) but also to the accelerated process of urbanization and land use as a result of housing construction and other property (infrastructure, equipment), that accompanied this..

[2] Perhaps the first references to this global bubble are the series of articles and reports published in specialized media such as The Economist: "Bubble Troubles" 16/02/2002, referring to the financial bubble; "Castles in Hot Air" and "House of Cards", both dated

As in other countries, in the Spanish case the study of the property bubble began with the analysis of the increasing rise in sector prices in economics magazines and observatories (Falcón, 2003, Sánchez, 2003, García Montalvo, 2004 and 2005). Shortly after this, analysis of this phenomenon began on its dimensions in geographical terms - the subject of study here - and whose first approach must surely be the article by Serrano (2004), which provides data and maps on residential growth by province from 1950. These sources witnessed the fact that the greatest growth from that date up to 2001 was in the provinces or regions with the greatest demographic weight and population growth (Madrid, and the Basque Country), but also in tourist areas and areas closely linked to the leisure industry (Canary Islands and the Valencia region). Likewise, Catalonia, where both dynamics overlap, although that study did not analyse each of the decades and the trends observed between each. Serrano does, however, compare percentage increases in the housing stock between 1991 and 2001, for example, and notes that these trends clearly differ from those over the entire period, pointing the way to signs of change to a new situation. Thus, the Canary Is. and Madrid (43% and 30%) dictated the pace of residential growth over that decade, followed by the Rioja region and Navarre (29% and 27%), which is somewhat surprising. Catalonia, in contrast, fell below the Spanish average (20% as against 22%) and Valencia positioned itself almost at mid-level (21%). Still to be researched is whether these signs of change in residential distribution in Spain have subsequently accelerated or have followed a different pattern.

In the following years, two seminal studies were also published on the analysis of the consequences of the *bubble* in terms of land cover: '*El tsunami urbanizador español y mundial*' (tr: the Spanish and world property tsunami: Fernández Durán, 2006) and *'La década prodigiosa del urbanismo español (1997-2006)* ('The prodigious decade of Spanish town planning 1997-2006) (Burriel, 2008). In the first and more extensive of these studies, we see how the escalation of urbanization in the 1990s in Spain was "substantially more pronounced than at European scale, which was already high – an increase of 6% in that period – more than 25% of previously urbanized land" (Fernández Durán, 2006, 24). The author attributes this enormous growth to the explosion in infrastructure; metropolitan restructuring; large public projects; the growth of tourism and domestic demand; as well as a greater concentration within the capital, all of which appear to indicate significant changes in the Spanish model of urban land use.

The second article emphasizes the building *fever* and compares the number of homes starting construction per 1,000 inhabitants in 1996 and 2006, by province, showing how Madrid and Barcelona occupied the lower echelons, compared to Malaga, Almeria, Alicante, Castellon and Guadalajara, at the top of the list. This would appear to point to major changes in the distribution of the property stock and changes in the distribution model of available housing. Likewise, we shall attempt to verify here the features of transformation in the land use model put forward by these authors.

With reference to the regional sphere, the studies that show changes in certain property dynamics are of interest here. Thus, both Mazón (2005) and Vera (2005), highlight the boom in residential tourism in Alicante, i.e. the construction of housing, whether a second home or not. Vera points to the phenomenon of housing around golf courses as a specific type, this subject leading to numerous subsequent studies, such as those contributed at the first residential tourism conference (*I Congreso de Turismo Residencial*) held at the University of Alicante in November 2005.

At the conference, under the general theme of 'Growing Urban Planning. From Utopia to Reality', 64 papers were presented, about half of which dealt with growth and transformation over the previous two decades in several different Spanish geographical areas: the Andalusian coast (7 papers), the Levante coast

29/05/2003, on the inflation in housing prices; or "In come the Waves" (16/06/2005), which already discussed the largest bubble in the history of house prices and showed how Spain had reacted between 2003 and 2005. Spain was the European country where the largest price rises occurred (17.2% and 15.5% annually, respectively), behind only South Africa and Hong Kong: together with South Africa, Ireland and Britain, prices between 1997 and 2005 prices increased by more than 140%.

or interior (another 7), Castilla y León (4), Balearic Is. (3), Canary Is. (3), Madrid (3), Castilla-La Mancha (2), Cantabria (1), and Aragon (1) as well as others of more general content.[3]

More recently, in Spain's 2016 Sustainability Report, the Observatory on Sustainability (OS) presented a comprehensive study of changes in land use in Spain (1987-2011), with the same CLC data as used in this study: the 1990, 2000, 2006 and 2012 editions (these last published in 2015), where they underline that between 1990 and 2012 artificial (urbanized) land almost doubled in Spain. Industrial, commercial and infrastructure-based land cover multiplied by three and artificial green areas by four (OS 2016, 367). However, the 2016 Sustainability Report does not present the Spanish case within the European context, nor does it delve into the distribution of national growth by province, issues that are addressed in this article.

On existing research, this study will take steps in two directions, (i) through an overview of the evolution in the settlement model through the comparative interpretation of dynamics at regional and state level, and (ii) as far its spatial interpretation at the level of province, to understand this model in detail and in comparative terms within the Spanish urban system, using the data updated to 2012.

3. Sources and methodology

3.1. The time frame of the "bubble" and the editions of the CLC

When, as is this case, the aim is to analyse the urban consequences of the "bubble" through CLC data, we note that its editions (1990, 2000, 2006, and 2012) do not fit adequately with the period of greatest property growth, since: to include the initial years of this phenomenon (1996-1999), the 1990 CLC would be essential and, if we wished to include its final and culminating years (2006-2008) only the 2012 CLC (prepared in 2011) could be referred to, as the 2006 CLC (with references to 2005) would exclude these years. Given that the focus of this study is to examine the town planning and spatial consequences of the most recent "real estate bubble", it has been considered suitable to define the period of study as that of the first and last CLC edition: 1990 and 2012, conscious of the fact that, although they do not fit the precise beginning and end of the most recent bubble, they include this in its entirety, together with other years, whose relatively small weight in the whole picture should not significantly bias the conclusions drawn.

3.2. Characteristics of "*Corine Land Cover*": CLC

The CLC database on land use, which deals with the surface area taken up by various classes of land over the years 1990, 2000, 2006 and 2012, as well as the specific changes that have occurred between them (EEA, 2007), is of special interest to urban planning studies. This is especially the case of studies which examine artificial land (Table 1), since its geometry and distribution can, *a priori,* explain the spatial dynamics of the urbanization process that will enable us to characterize this with a certain degree of precision (Siedentop and Meinel, 2004; Díaz-Pacheco y Gutiérrez, 2013).

[3] Although this will not be the object of this study, another relevant issue (and present in some previous studies) is the causes of all these bubbles, an issue that requires in-depth analysis. It seems clear what González Marroquín et al. show statistically (2013) for the case of Asturian growth between 1996 and 2006: the low relevance of endogenous factors (population growth, economic growth, or new infrastructures) as opposed to exogenous factors. There are few studies that relate the bubble to the political shade of corporations nationally, such as Esteban & Altuzarra, 2016; or to corruption (Jerez, 2012).

TABLE 1.
Classes of artificial land, CLC

Class 1: ARTIFICIAL LAND
Class 11: Urban Fabric
Class 111: Continuous Urban Fabric
Class 112: Discontinuous Urban Fabric
Class 12: Industrial, commercial
Class 121: Road and rail networks and associated land, rail networks.
Class 122: Road and rail networks, and associated land
Class 123: Port areas
Class 124: Airports
Class 13: Mine, dump and construction
Class 131: Mineral extraction sites
Class 132: Dump sites
Class 133: Construction sites
Class 14: Artificial, non-agricultural
Class 141: Green urban areas vegetated
Class 142: Sports and leisure facilities

Source: EEA (2006).

In the CLC editions, the scale is 1:100000, the minimum surface detection area is 25 ha, and the minimum width for the inclusion of linear elements detected:100m (EEA, 2007), providing exhaustively validated information, albeit with certain limitations, however with a subject-based and geometrical precision estimated at more than 85% (Heymann et al., 1994, EEA, 1997, 2000, 2007).[4]

For this study, the Stock and Change methodology was considered the most appropriate. A detailed description of this can be found in Haines-Young (1999) and EEA (2006). We should indicate that measuring may be subject to limitations arising from technical characteristics. This should not be ignored and, as in the case of classification errors, have made is advisable to consider only the classes up to the second subject area level (11, 12, 13 and 14).[5] Classification errors are fewer in artificial land classes (Batch et al., 2006) and decrease with the increase in the aggregation scale (Díaz-Pacheco and Gutiérrez, 2-013).

3.3. Measurement of the deviation in growth

Usually the description of the scale of growth is in absolute and/or relative figures, since no methodological references to consider both indicators at the same time have been found. However, in this study some provinces stood out due to large scale land cover in absolute terms, while others did so because of the disproportion as regards initial cover and, in some cases, in both parameters. The question is thus how to compare them.

For this purpose, we proposed to carry out an integrated study of both indicators using simple statistical apparatus, with easily understandable results. Thus, both indicators (absolute and relative growth) have been considered in relation to their basic measurements of central trend and dispersion, mean and standard deviation, measuring the number of times that each value significantly exceeds these.

[4] The limitations resulting from the minimum surface area represented mean that small changes in urbanized land can be masked (Siedentop and Meinel, 2004). Thus, statistical areas that arise from larger surface area land use will reveal relatively lower growth.
[5] Subject-based and geometrical inconsistencies between the different editions are due to a lack of harmonization (Díaz-Pacheco, Gutiérrez, 2013, Barreira, González and Bosque, 2012). These inconsistencies have led to the application of certain criteria such as, for example, considering the result during a period where the increase was negative, as zero, so as not to introduce apparent 'decreases' in land, which are extremely unlikely. Likewise, the dynamism of certain classes of land can produce negative growth between the different editions of the CLC.

This is defined as "Integrated rate of disproportion in growth as compared to the average", or "Degree of disproportionate growth" as an exploratory variable, equal to the sum of exceeding the value of the mean (=1) plus the number of times that the province exceeds the standard deviation in either of the two variables.

$$GD_i(I_{1i}, I_{2i}) = f(I_{1i}) + f(I_{2i})$$

Where:

I_{1i} = Absolute increase in class C1 of the province i

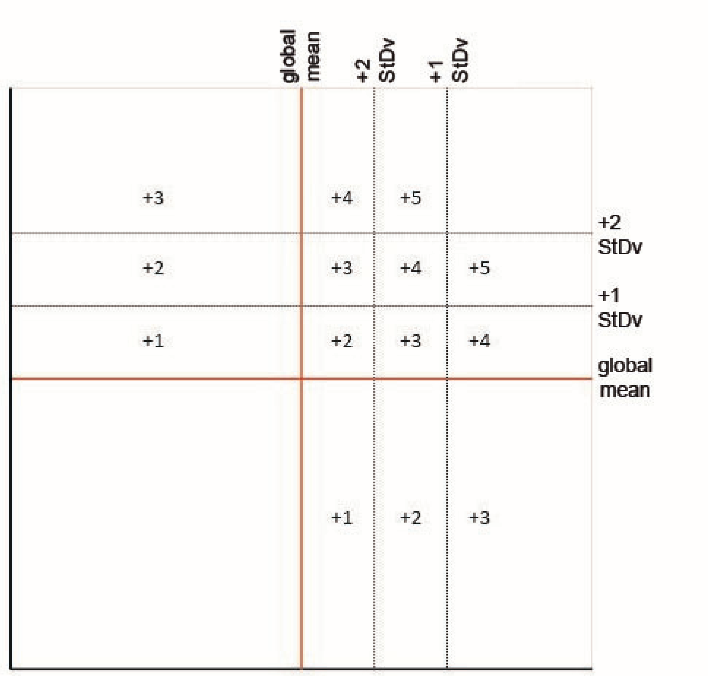
I_{2i} = Relative increase in class C1 of the province i

$f(I_{ji})$= discrete function, in intervals defined as a function of the mean μ_j and standard deviation σ of the variable I in province i and that takes the following values:

$$f(I_j) = \begin{cases} 0 & \forall I_j \ / \ 0 \leq I_j \leq \mu_j \\ 1 & \forall I_j \ / \ \mu_j \leq I_j \leq \mu_j + \sigma_j \\ 2 & \forall I_j \ / \ \mu_j + \sigma_j \leq I_j \leq \mu_j + 2\sigma_j \\ 3 & \forall I_j \ / \ \mu_j + 2\sigma_j \leq I_j \end{cases}$$

This results in a scale with a range from 0 to 6 (from lowest to highest disproportion), which can be seen in the diagram in Figure 1.

FIGURE 1.
Proposal for scale in the Integrated Index or Degree of disproportion in provincial growth



Class C1 absolute growth 1990-2012 (hectares)

Source: In-house.

4. Results

4.1. Some figures for land cover in Europa (2000-2012)

Table 2.
Evolution of Class 1 CLC and land consumption in Europe (36 countries)

Countries	Occupied land use in mha		Increase 2000-2012		Percentage: 35 countries	Population 2012	Land consumption
	2000	**2012**	**mha**	**%**		**inhab./1000**	**ha/1000 inhab.**
Spain	755.9	974.1	218.2	28.9	19.8	46.773	21
France	2642.9	2791.3	148.4	5.6	13.5	65.660	43
Turkey	1141.1	1244.6	103.5	9.1	9.4	74.849	17
Germany	2772.6	2851.3	78.7	2.8	7.1	80.426	35
Italy	1385.5	1460.6	75.1	5.4	6.8	59.540	25
Holland	449.6	505.3	55.7	12.4	5.1	16.755	30
Poland	1191.4	1243.0	51.5	4.3	4.7	38.063	33
Portugal	287.2	323.2	36.0	12.5	3.3	10.515	31
UK	1748.2	1781.0	32.8	1.9	3.0	63.700	28
Albania	48.0	77.6	29.6	61.5	2.7	2.900	27
Greece	255.4	281.6	26.1	10.2	2.4	11.045	25
Sweden	591.5	613.9	22.3	3.8	2.0	9.519	64
Ireland	130.9	151.2	20.4	15.6	1.8	4.587	33
Czech Rep.	464.6	484.9	20.3	4.4	1.8	10.511	46
Hungary	533.3	552.6	19.3	3.6	1.7	9.920	56
Norway	246.3	264.4	18.1	7.4	1.6	5.019	53
Denmark	306.1	323.9	17.8	5.8	1.6	5.592	58
Rumania	1463.8	1480.3	16.5	1.1	1.5	20.058	74
Finland	442.2	457.6	15.5	3.5	1.4	5.414	85
Cyprus	64.5	77.4	12.9	20.0	1.2	1.129	69
Croatia	160.3	173.1	12.7	7.9	1.2	4.268	41
Austria	392.3	404.3	12.0	3.1	1.1	8.430	48
Slovakia	261.2	270.3	9.2	3.5	0.8	5.408	50
Bosnia and Herzegovina	58.7	66.5	7.8	13.3	0.7	3.828	17
Serbia	269.8	276.8	7.1	2.6	0.6	7.199	38
Iceland	31.0	37.2	6.3	20.3	0.6	321	116
Belgium	618.8	624.6	5.8	0.9	0.5	11.128	56
Lithuania	205.6	211.0	5.4	2.6	0.5	2.988	71
Estonia	80.6	85.8	5.3	6.6	0.5	1.323	65
Bulgaria	510.6	515.2	4.5	0.9	0.4	7.306	71
Latvia	81.6	84.0	2.4	2.9	0.2	2.034	41
Macedonia	34.0	35.8	1.8	5.4	0.2	2.069	17
Slovenia	53.2	54.6	1.4	2.6	0.1	2.057	27
Switzerland	264.9	266.0	1.1	0.4	0.1	7.997	33
Luxemburg	21.6	22.5	0.9	4.1	0.1	531	42
Montenegro	13.3	14.1	0.8	5.7	0.1	621	23
Total: 36	**19978.5**	**21081.5**	**1103.0**	**5.5**	**100**	**609.482**	**45**

Source: In-house from CLC data.

Over the course of these 12 years, artificial surface land use in Europe increased in all of the 36 countries considered by the CLC by slightly more than 1.1mha. This is where Mediterranean countries concentrated 57.9% of their growth, and Spain showed itself to be the country with the highest rate of urban development, with 218m hectares developed between 2000 and 2012: alone, Spain contributed 19.8% to the total, as compared to 13.6% for the second country in line (France: 148mha). Within Spain, occupied land accounted for more than 30% of existing land use, as compared with 5.6% in France and 5.5% in the 36 countries on average, only behind Albania in relative land use (61%, with 29.6 mha). This data therefore confirms Spain as the main protagonist of the phenomenon of the *property bubble* in Europe. If, with the CLC data for the same period, we analyse how the different land use classes have evolved, we can verify that Spain was at the head of growth in land use, particularly in the following classes:

- In class 12 land (industrial, commercial and transport infrastructure), with 94mha and a 63.5% increase from 2000, against a 16.8% growth rate and 479mha for all 36 countries.
- For class 14 land (artificial vegetated areas), where Spain recorded 106mha, an even greater percentage increase is observed: 68.8%, compared to 8.5% for the 36 countries as a whole.
- The relative growth of class 11 also greatly exceeds that of all 36 countries taken together, with a relative growth rate in Spain of 9.6%, as compared with 2.2% for the entire group.

This data indicates a major change in the spatial structure of the components of the urban environment in Spain, very marked when compared with the countries in Spain's continental environment.

4.2. Overall changes in artificial land use in Spain (1990-2012)

4.2.1. Land, annual pace and densities

The review of the literature on the Spanish case leads us to confirm the idea that, over the period considered, Spain experienced "an exceptional property boom, in terms of its intensity and duration", whose "result has been exaggeratedly high urban growth" (Burriel 2008, one). The main results seen in the successive editions of the CLC and the changes observed there can be summarized for Spain in the following tables:

Tables 3 to 7.
Total land cover by urbanized land; Total growth in urbanized land; Annual average growth; Growth relative to 1990; and annual rate of change

Table 3. Total urbanized land use according to CLC

Year	Area (hectares)
1990	1,002,648
2000	1,195,859
2006	1,395,783
2012	1,507,192

Table 4. Relative growth 1990

Year	%	Δ%
2000	19.3	19.3
2006	39.2	19.9
2012	50.3	11.1

Table 5. Total urbanized land use growth according to CLC

Period	Change (hectares)
1990-2000	193,211
2000-2006	199,924
2006-2012	111,409
1990-2012	504,544

Table 6. Average annual growth

Period	Average Δ (hectares)
1990-2000	19,321.1
2000-2006	33,320.7
2006-2012	18,568.2
1990-2012	22,933.8

Table 7. Average annual rate of change

Period	%	Δ%
1990-2000	1.93	
2000-2006	3.32	71.85
2006-2012	1.85	44.22
1990-2012	2.29	

Source: In-house, from CLC data for 1990 to 2012.

Undertaking overall quantification of artificial land in the successive editions of the CLC, a significant increase in the annual rates of absolute and relative growth over the period from 2000 to 2006 can be seen, followed by its subsequent fall in the next edition of the CLC report, for the period 2006 to 2012.

TABLE 8.
Evolution of land use per inhabitant in Spain from 1990-2012

CLC Edition	Class 1 (ha)	Population / 1000	ha/1000 inhab.	Δ Annual ave. (ha)
1990	1,002,648	38,853	25.81	
2000	1,195,859	40,263	29.70	0.39
2006	1,395,783	44,009	31.72	0.34
2012	1,507,192	46,773	32.22	0.08

Source: In-house, from CLC data.

To address the question of whether or not the development model was more widespread, artificial land use per inhabitant was calculated and a significant increase was observed (+24.8% between 1990 and 2012), which would imply an equivalent decrease in gross population density.[6]

4.2.2. Components of land use in Spain

To determine to what extent land use over the period produced a new spatial model for use and what its key features were, we analysed CLC figures for large components: urban fabric (class 11), industrial, commercial units and infrastructure (class 12); artificial vegetated surfaces (class 14) and construction sites (class 133).

Table 9.
Evolution of urbanized land use components in Spain

	Class 11		Class 12		Class 133		Class 14		Total C1*
CLC Edition	mha	%	mha	%	mha	%	mha	%	mha
1990	791	78,8	173	17,3	21	2,1	18	1,8	1.003
2000	879	73,5	240	20,1	42	3,5	36	3,0	1.196
2006	919	65,8	296	21,2	136	9,7	45	3,2	1.396
2012	939	62,1	371	24,5	145	9,6	57	3,8	1.512

Source: In-house, based on CLC data.

Table 10.
Components of the land use model for 1990 and the model covering from 1990 to 2012

	Class 11		Class 12		Class 133		Class 14		Total C1*
CLC Edition	mha	%	mha	%	mha	%	mha	%	mha
1990	791	78,8	173	17,3	21	2,1	18	1,8	1.003
1990-2000	88	46	66	34	21	11	18	9	193
2000-2006	40	20	57	28	94	47	9	4	200
2006-2012	20	17	74	64	9	8	13	11	116
1990-2012	149	29,2	197	38,7	124	24,4	39	7,7	509

Source: In-house, based on CLC data.

This data verifies the significant variations in the proportions of components, with a strong trend towards change for the totality of transformed land, where residential areas (mostly included in class 11) lose weight when compared to industrial, commercial and infrastructure-based land cover and artificial vegetated areas, pointing to the creation of a new urban model consistent with the increase in per capita land use analysed above. The change in the urban model was progressive, as can be seen when comparing the CLC data on 1990, 2000, 2006 and 2012. Although between 1990 and 2000 residential land still represented the largest surface area between 2000 and 2006 (46%), in the midst of the property bubble industrial, commercial and infrastructure land use came to represent the highest proportion (28% as against 20% for residential). Particularly during the property bubble and later, between 2006 and 2012, industrial, commercial and infrastructure-based land cover reached 64% of the total.

[6] This could be due to various causes, including its reduction in purely residential projects (in part, due to the significant demands of land for equipment and infrastructure under regional and state legislation; the increase in single-family housing types); the relative increase in non-residential uses (production, commercial, infrastructure, large equipment, etc.) but also to the drop in the average size of households (3.26 family members in 1991 to 2.58 in 2011), that by itself accounts for an increase in the order of 26% in homes needed per each 1,000 inhabitants: from 306.7 to 387.8 in the period. Lastly, is the increase in the sale of houses to people not residing in Spain who, in their vast majority, are not included in the population figures.

FIGURE 2.
Evolution of artificial land use components (urbanized) as per CLC series

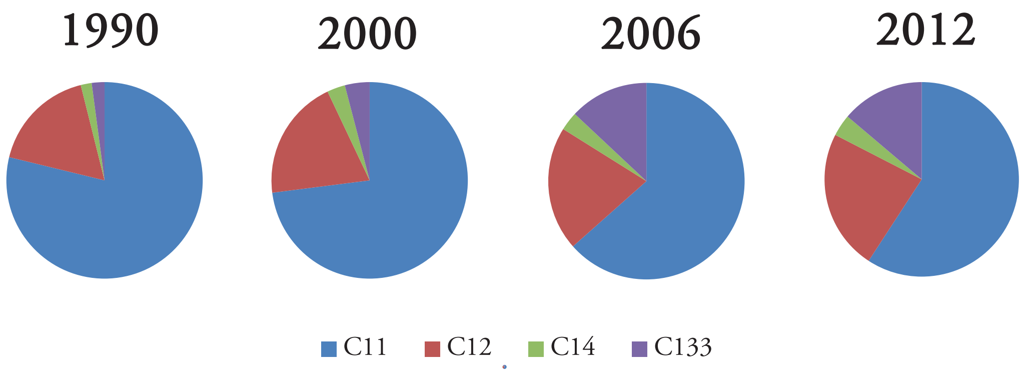
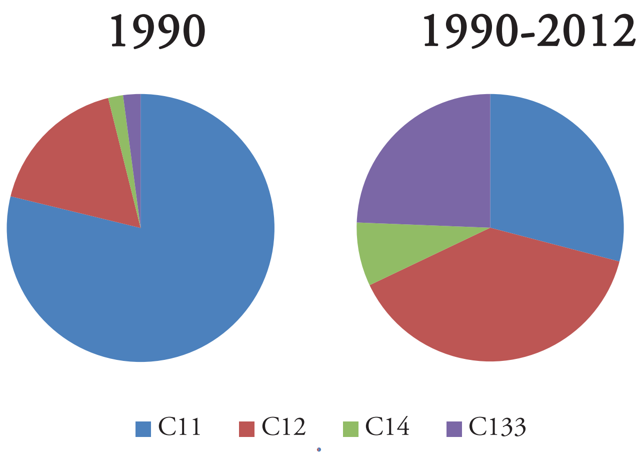


FIGURE 3.
Comparison of components (classes) of artificial land in 1990 and total urbanized land use between 1990 and 2012.



Source: CLC and in-house.

In short, in absolute terms, over the course of the 22 years of the bubble, 197mha of natural areas (39%) were converted to industrial, commercial or infrastructure land use, (class 12) and 39mha to artificially vegetated land (class 14), together totalling 237 mha (46%), as compared with 149 mha of exclusively residential land use (29%). This would indicate that, in addition to its undeniable residential component, the most recent property bubble in Spain led to a different model of land cover, with a high proportion of industrial, commercial and infrastructure-based land use, with the addition of artificial vegetated surfaces.

4.3. The regional distribution of urban growth in Spain

4.3.1. Growth in the provinces

Analysing the phenomenon in absolute terms, the highest growth (first quartile) occurs in provinces with metropolitan settlements (Madrid, Valencia, Malaga, Barcelona or Seville) and in those affected by tourist development on the coast (Alicante, Murcia or Balearic Islands), as well as in Zaragoza, Navarre, Toledo and León, which could be considered as regional centres among all these, Madrid stands out, doubling the growth figures for the next in line, Alicante.

Table 11.
Absolute and relative increase in land use (classes 11, 12, 133 and 14) and Degree of Disproportionate growth in the Spanish provinces

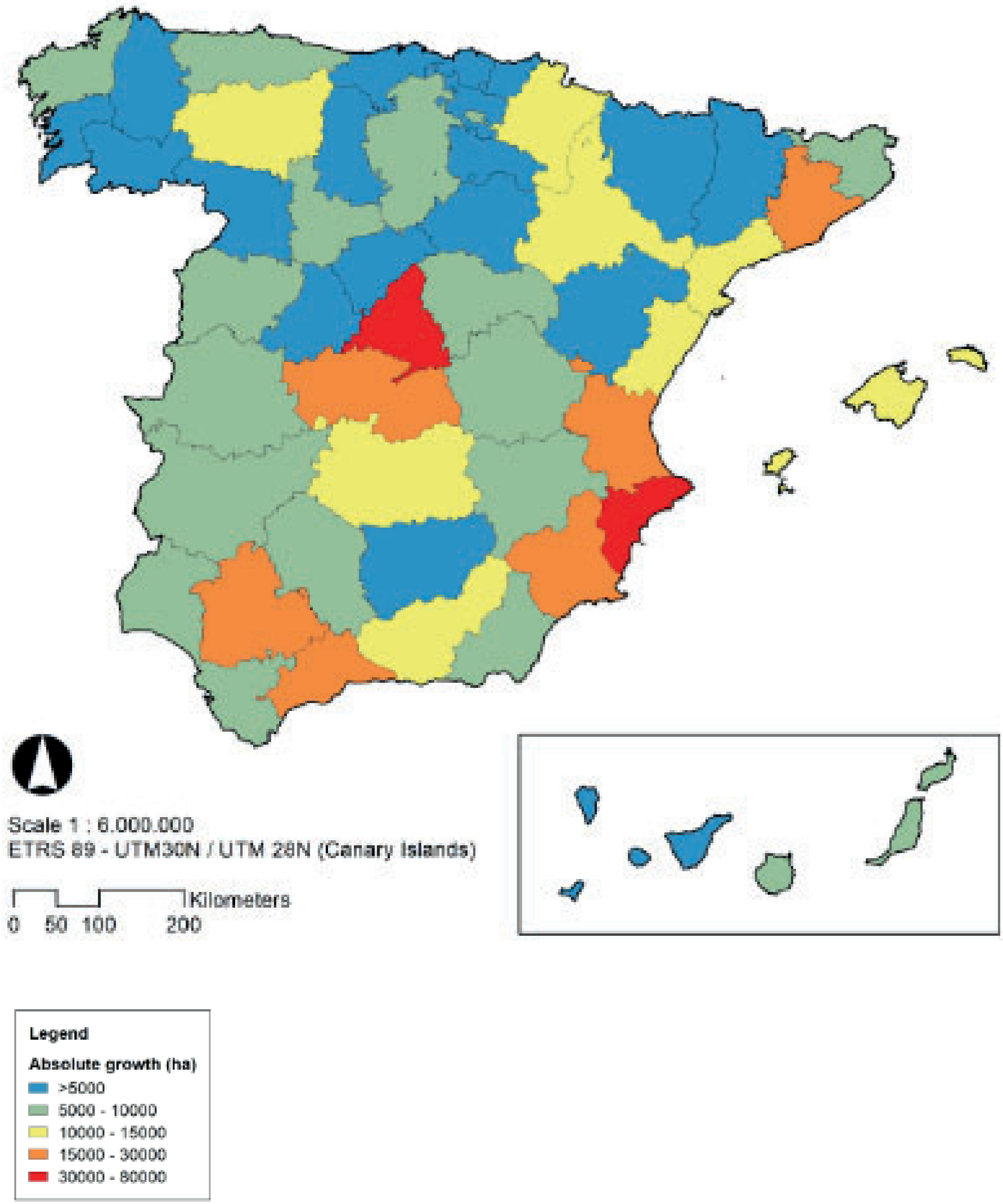
	Absolute increase			Relative increase				Disproportion	
Province	Mha.	% del total	Quartiles	Province	Mha. 1990	+%		Provinces	GDESP
Madrid	79.5	15.8	100% 291mha 57%	Soria [m]	0.7	273.1		Madrid	5
Alicante	30.9	6.1		Huesca [m]	3.1	147.9		Toledo	5
Valencia	28.8	5.7		Valladolid	7.1	140.5		Murcia	5
Murcia	25.6	5.1		Castellon	7.9	137.7		Navarra	4
Barcelona	21.3	4.2		Navarra	9.9	132.8		Ciudad Real	4
Sevilla	20.4	4.0		Salamanca	6.6	130.5		Leon	4
Toledo	18.5	3.7		Zamora	3.3	129.8		Salamanca	4
Malaga	15.4	3.0		Burgos	5.9	129.8		Soria	4
Zaragoza	13.5	2.7		Murcia	20.7	124.1		Valladolid	3
Navarre	13.2	2.6		Caceres	4.9	118.6		Alicante	3
Illes Balears	13.0	2.6		Ciudad Real	10.4	109.9		Castellon	3
Leon	11.8	2.3		Alava	3.0	106.1		Burgos	3
Ciudad Real	11.4	2.3	75% 123mha 24%	Toledo	17.9	103.3		Cordoba	3
Castellon	10.9	2.2		Leon	11.5	102.3		Zaragoza	2
Granada	10.8	2.1		Palencia	3.7	98.6		Malaga	2
Tarragona	10.5	2.1		Guadalajara	8.3	97.1		Valencia	2
Valladolid	9.9	2.0		Cuenca	5.7	93.8		Badajoz	2
Cadiz	9.8	1.9		Albacete	5.9	93.8		Alava	2
Badajoz	9.7	1.9		Badajoz	11.6	83.2		Albacete	2
Salamanca	8.6	1.7		La Rioja	4.8	79.1		Caceres	2
Cordoba	8.4	1.7		Madrid	102.9	77.2		Cuenca	2
Guadalajara	8.1	1.6		Cordoba	10.9	76.6		Guadalajara	2
Burgos	7.7	1.5		Zaragoza	17.9	75.8		Huesca	2
Huelva	6.2	1.2		Alicante	41.3	74.8		Zamora	2
Almeria	5.9	1.2		Almería	8.3	70.7		Sevilla	1
Caceres	5.9	1.2		Teruel	2.9	69.0		La Rioja	1
Las Palmas	5.8	1.2	50% 57mha 11%	Huelva	9.4	66.6		Almería	1
Albacete	5.5	1.1		Granada	16.4	65.8		Granada	1
Cuenca	5.3	1.1		Malaga	24.2	63.5		Huelva	1
Girona	5.3	1.0		Sevilla	32.8	62.1		Illes Balears	1
Asturias	5.2	1.0		Illes Balears	21.2	61.3		Palencia	1
Corunna	5.0	1.0		Jaén	7.6	60.4		Barcelona	0
Huesca	4.6	0.9		Segovia	6.9	59.0		Vizcaya	0
Jaén	4.6	0.9		Lugo	4.6	53.9		A Coruña	0
Zamora	4.2	0.8		Avila	4.5	52.8		Asturias	0
Cantabria	4.1	0.8		Cadiz	19.7	49.9	Media: 50.3	Cantabria	0
Segovia	4.1	0.8		Valencia	69.2	41.6		Las Palmas	0
La Rioja	3.8	0.8		Lleida	8.1	36.1		S. Cruz de Te	0
S. Cruz de Tenerife	3.6	0.7	25% 31mha 6%	Las Palmas	17.9	32.4		Girona	0
Palencia	3.6	0.7		Ourense	3.4	28.3		Tarragona	0
Alava	3.2	0.6		Cantabria	14.5	28.3		Cádiz	0
Vizcaya	3.0	0.6		Asturias	19.1	27.4		Avila	0
Lleida	2.9	0.6		Tarragona	41.2	25.6		Guipúzcoa	0
Pontevedra	2.7	0.5		S. Cruz de Tenerife	18.2	20.0		Jaén	0
Guipúzcoa	2.5	0.5		Guipúzcoa	12.6	19.9		Lleida	0
Lugo	2.5	0.5		Girona	36.4	14.4		Lugo	0
Avila	2.4	0.5		Pontevedra	22.0	12.4		Ourense	0
Teruel	2.0	0.4		Vizcaya	24.2	12.2		Pontevedra	0
Soria	2.0	0.4		Barcelona	180.1	11.8		Segovia	0
Ourense	1.0	0.2		A Coruña	51.3	9.8		Teruel	0

Source: In-house, based on CLC data.

FIGURE 4.

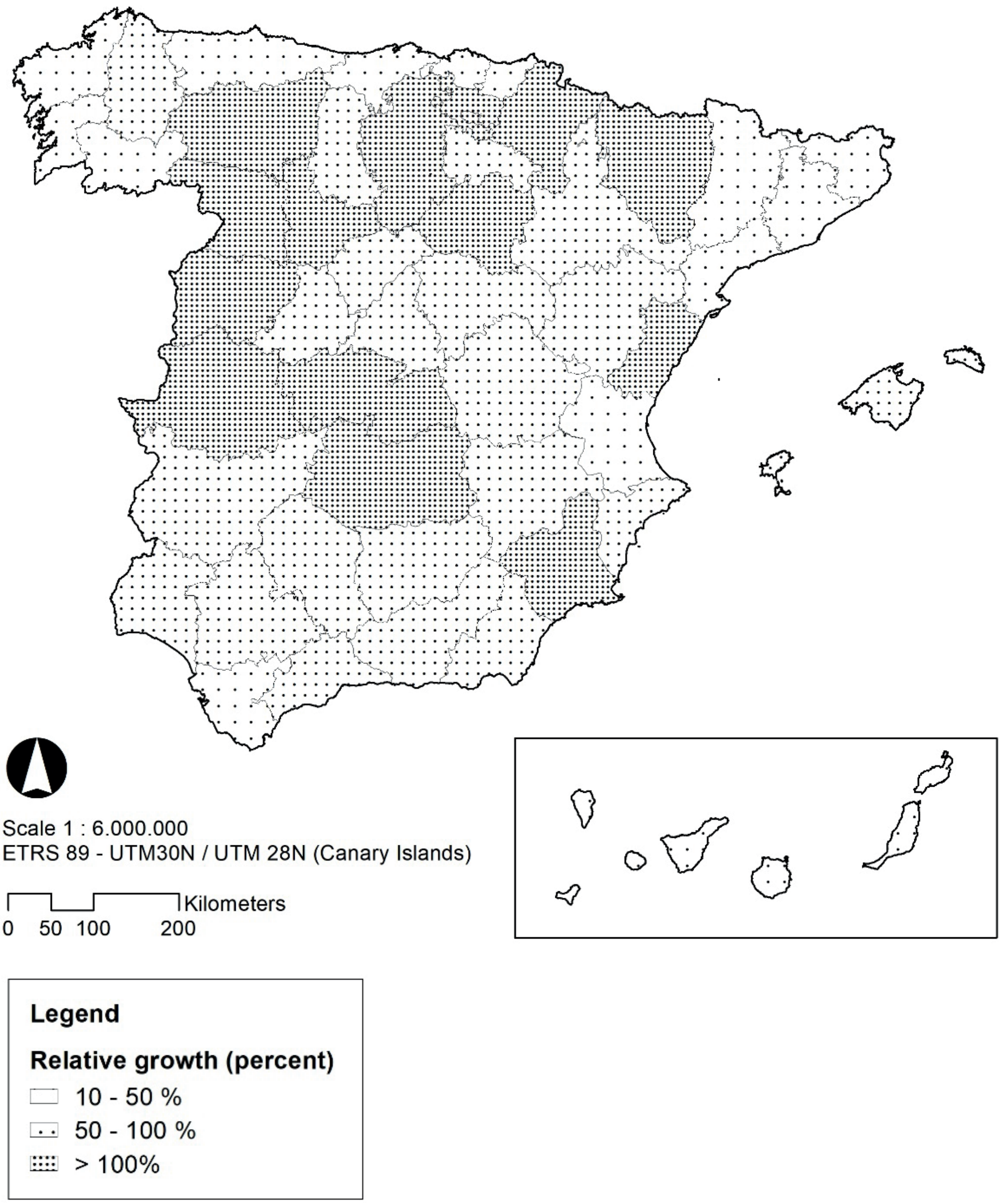
Province-based growth distribution from 1900-2012 in absolute terms (Ha)

Absolute growth in Class 1, identified by CLC between 1990 and 2012



Source: In-house from CLC data on Class 1 land use.

FIGURE 5.
Distribution of growth by province: 1900-2012, in relative terms (percentage as against 1990)
Relative growth in Class 1, identified by CLC between 1990 and 2012



Source: In-house from class 1 CLC data.

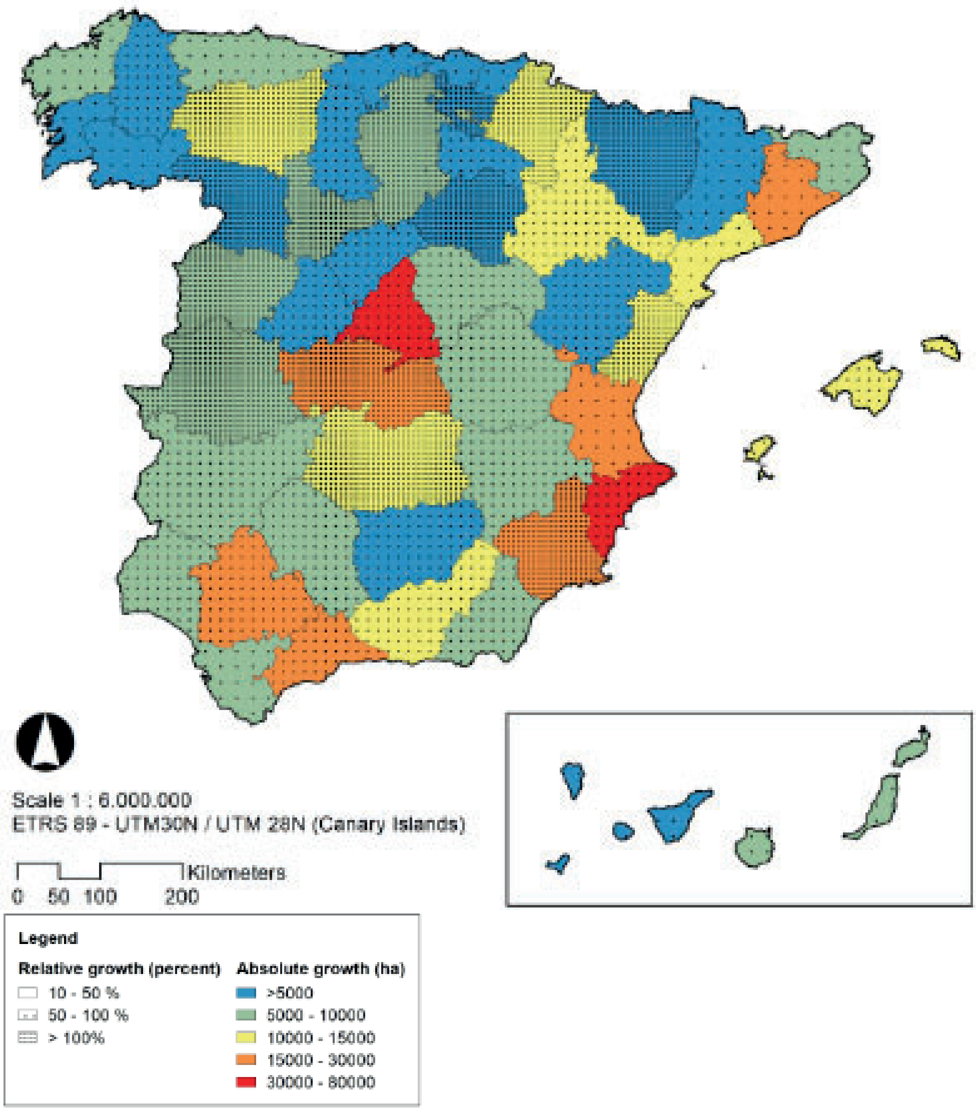
If we consider growth in relative terms, that is, the proportion of growth on occupied land in 1990, this changes the order of priority: the greatest growth in this case was found to be almost exclusively in the interior, particularly several provinces within Castilla la Mancha and Castilla y Leon, with no direct relationship with the dynamics of coastal tourist centres or regional hubs. This situation is naturally due, in large part, to the fact that any small relative growth in provinces with large scale previous land use of land (Valencia or Barcelona, for example), meant large scale extension in terms of hectares, placing them at the top of the list in absolute figures, and vice versa (Soria, for example). However, this obvious fact does not explain the specific location of the greatest relative provincial growth levels, which seem to point to the existence of different models of provincial growth over the period, as will be explained later.

To bridge the disparity between absolute and relative growth results, both variables were analysed together, graphically (Figure 6) and statistically (Figure 7).

FIGURE 6.

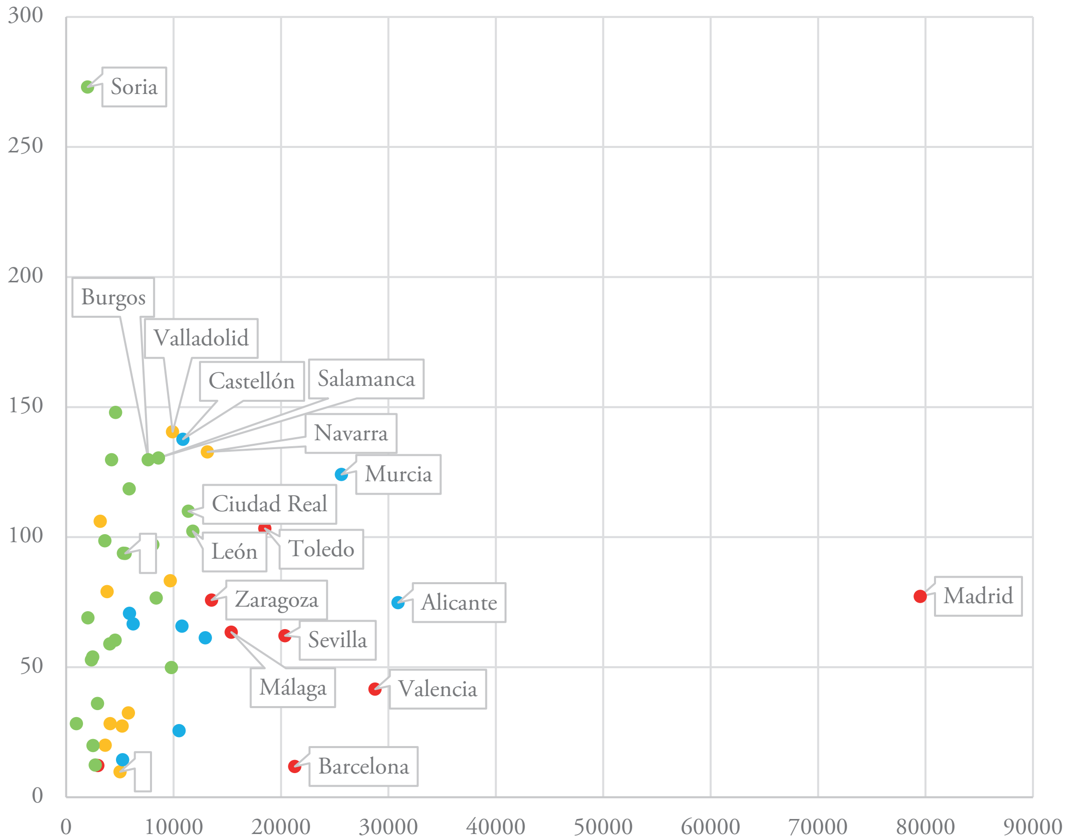
Distribution of growth by provinces from 1900-2012, in absolute and relative terms (hectares and percentage)

Growth in Class 1, identified by CLC between 1990 and 2012



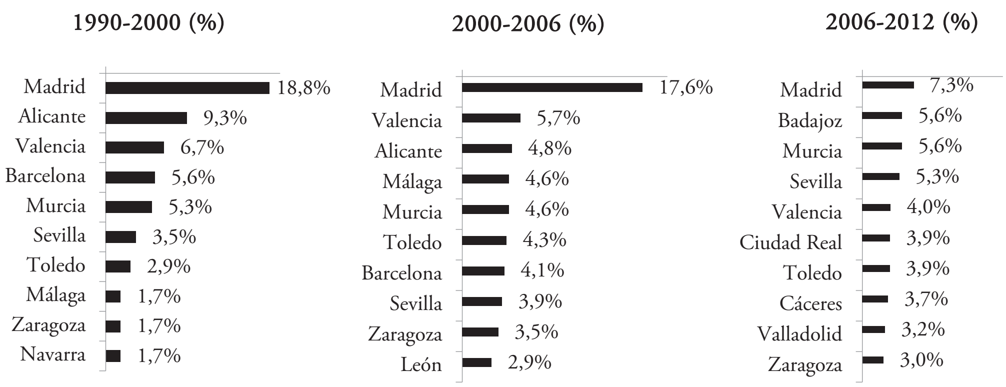
Source: In-house from class 1 CLC data.

FIGURE 7.
Growth identified by CLC between 1900 and 2012, in absolute and relative terms (x axis in percentages and y axis in ha.)



Source: In-house, based on data from Class 1, CLC.

FIGURES 08, 09 AND 10.
Provinces with greatest land use growth in Spain, by periods



Source: In-house based on CLC data.

Taking the integrated statistical analysis described in the methodology, what has been termed disproportionate growth was highlighted, since differential characteristics were observed that led us to propose a typology of disproportions that significantly, though not exactly, corresponded to the different province types.

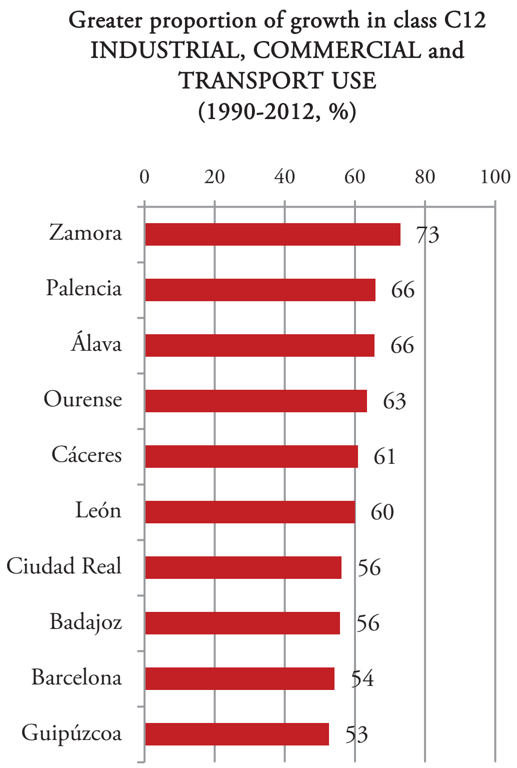
The most relevant quadrants in the graph are the ones above and, on the right, particularly the upper right, where the provinces with increases in occupied land and relative growth above average values are located (> 10,091 ha and> 50.3%).

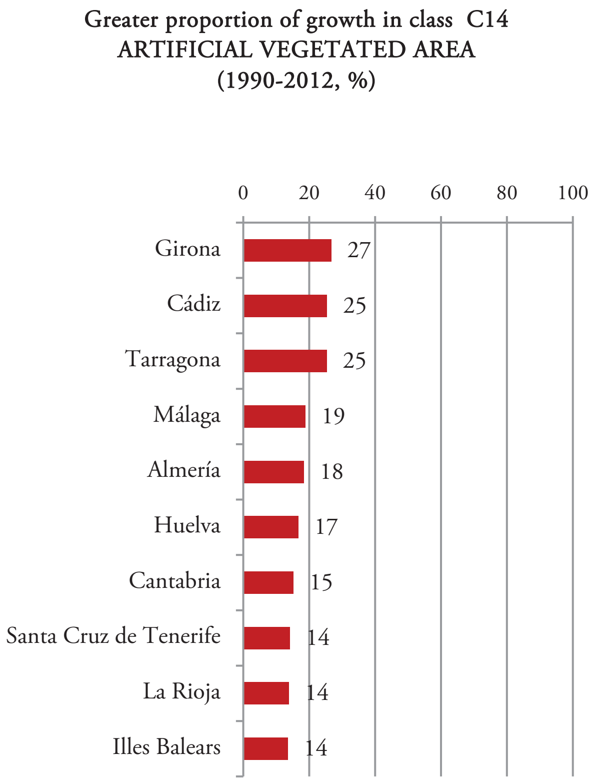
Observing the evolution by provinces, initially unequal land consumption becomes evident: in the first period (1990-2000) 45.7% of growth was concentrated within only five provinces (Madrid, Alicante, Valencia, Barcelona and Murcia) while, in the provinces next in line, development was distributed throughout the rest of the country, so that in the most recent period, 2006-2012, the first five provinces only accounted for 27.9%.

Regarding the disaggregation of growth by subclasses of land, the conclusion in section 4.2 was confirmed; the appearance of a new production and infrastructural model (to be added to the residential one), and we can now identify how this was reflected in the development of some provinces.

FIGURES 11 AND 12.

Provinces with the highest proportion of land use growth in Spain, for Classes C12 and C14



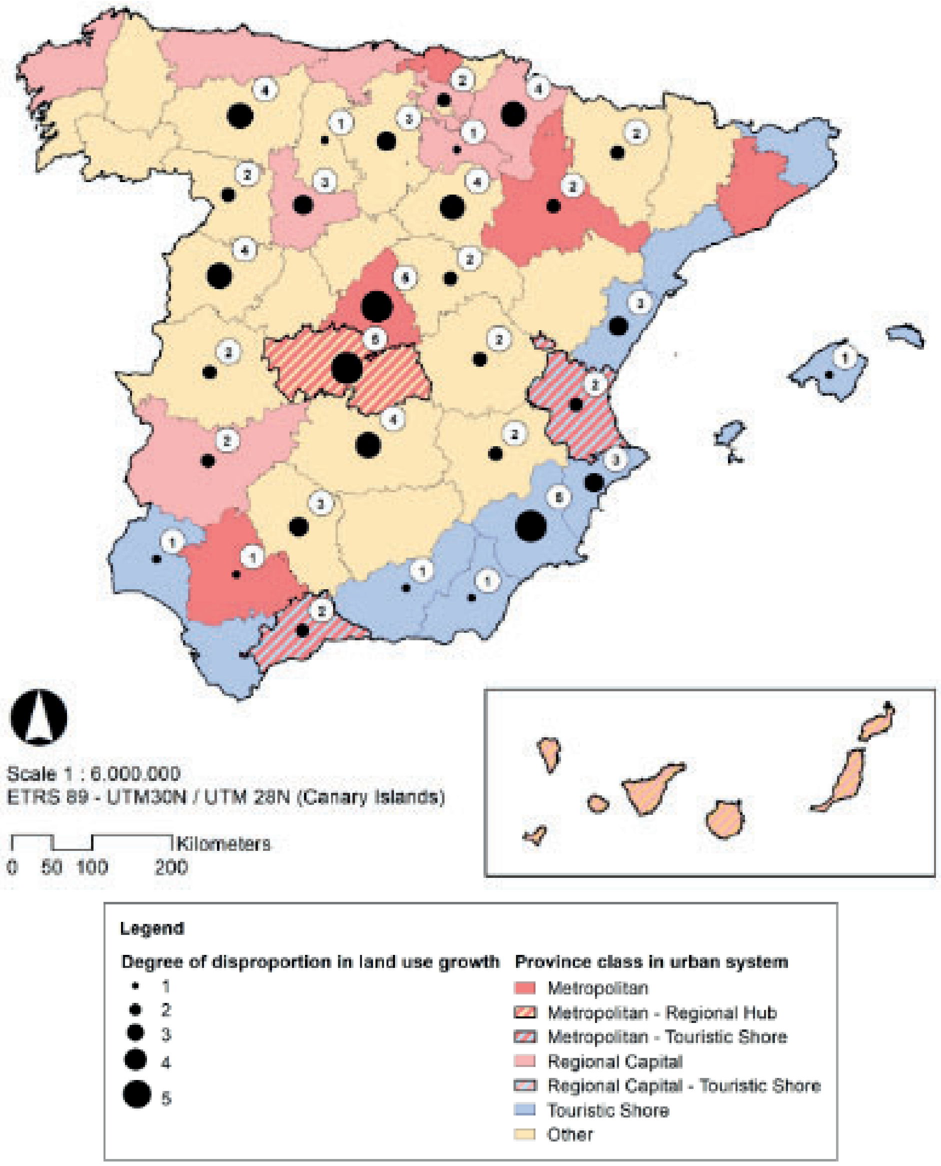


Source: in-house based on CLC data.

The growth in several interior provinces with no industrial tradition is striking, such as those in the north of Castilla-León: Zamora (73%), Palencia (66%) and León (60%), Extremadura (Caceres and Badajoz) or Ciudad Real, also located in the interior of the peninsula.

The analysis of growth in terms of "disproportionate growth" (see definition in section 3.2), provides the results shown in Table 10 and Figure 13, which are discussed in the following section.

FIGURE 13.
Types of provinces and degree of disproportion in the growth in land use, 1990-2012
Province class and degree of disproportion in CLC Class 1 growth 1990-2012



Source: CLC and in-house.

5. Discussion

Transformation in the land use model during the bubble

The data provided by this study shows that between 2000 and 2012, during the housing bubble and the consequences it produced, in Europe, Spain was by far the country with the greatest growth in land use (218,000 ha, 19% of the European total). And this also occurred at a faster pace. This is consistent with other evidence in the same direction, such as the increase in prices, or urbanization in the previous decade, "substantially more pronounced than in Europe as a whole" (Fernández Duran 2006, 24).

This impressive growth had also already been highlighted in terms of housing permits approved or completed construction in the hottest years of *the Bubble* (658,000 homes completed in 2006 and 812,000 approved, according to the Spanish Statistics Institute, INE), in 2007, when the fall in the subprime mortgage market took on a global and irreversible character (Pérez, 2014, Burriel 2008). In 2010 Serrano put forward a valuation of occupied land in the most pronounced period of the Bubble, based on data from Spain's Observatory on Sustainability: between 1997 and 2007, 290,800 new hectares had been developed for uses related to urbanization (Serrano, 2010, 41), so this research confirms what was indicated for other periods within the study.

However, with regard to the result for land use per inhabitant (a decrease of 25% from 1990-2012), the question arises as to whether the decrease in overall density in Spain was due to a reduction in the density of residential areas or, precisely, to the increase in classes 12 and 14, which came largely outside these.

Although these results do not seem to encourage the idea that there has been a general transformation across the board: a "transformation in the urban model of vertical to horizontal land use" (OS 2016, 366-367), this source, CORINE, does not allow us to reach any conclusive results for the time being.[7]

Another of the most striking results of the research is that the spatial dynamics of the emerging city over the period 1990-2012, considered in isolation, is profoundly different from pre-1990 as regards its main components. Class 11, with residential areas that were 78.8% of land use before 1990, only accounted for 29.2% in the developments of the period 1990-2012, that is, a proportion of less than half, while class 12 (commerce, industry, infrastructure) gained weight from a very minority position, 17.3% before 1990, to take first place in new development (38.7%) and class 14, before this practically insignificant (1.8%), grew to 7.7% of new city construction between 1990 and 2012. This is a change that some authors, such as Fernández Durán, pointed to in their study. This author talks about an "explosion in infrastructures" and "large public projects" (Fernández Durán, 2006, 24). This drastic change in model, due to the extraordinary amount of non-residential land use (infrastructure, industry etc.) had not, however, been indicated by those who had focussed on the "residential" component of the Spanish real estate bubble (Burriel, 2008; Gaja, 2008; Pérez and Gil, 2014), a perception that should be extended thanks to the data presented here.[8]

The evolution of growth in the provinces

Regarding Spain's metropolitan areas, this study considers the seven largest, in line with the most recent classification (Roca et al., 2012), which defines 20 main metropolitan systems, the principal ones being: Madrid, Barcelona, Seville, Valencia, Bilbao, Corunna and Malaga, all with more than one million inhabitants (data from INE: National Statistics Institute, 2001). As regards their analysis, it must be said that few papers analyse these from a comparative standpoint. Among these, we would mention Feria's (2016), which highlights the dynamism and expansion of the Mediterranean metropolitan areas and those of the islands' coastline (Canary and Balearic Is.), thanks to tourism.

However, the study run here points to the importance of other factors, such as the disproportionate growth of Madrid (grade 5), but also Zaragoza and Toledo (grade 2), both far from the coast. It is striking,

[7] Rather, they appear to indicate that this appreciable reduction in overall density is not so much due to a change in urban morpho-typologies as to the rise in urban components other than residential, such as production-based, commercial, infrastructure, green spaces and sports amenities. Previous studies such as Pozueta's (2013), based on licences granted between 1996 and 2005, pointed in this direction: compared to an average of 28% of single-family dwellings over the total for the whole of Spain. Only two large regions with low land cover, such as Castilla La Mancha or Extremadura, reached proportions of single-family homes near half of the residential stock (47.86% and 44.79% respectively).

[8] In general, not only these authors but the great majority, in fact, emphasize the impressive increase in the number of homes built over this period, as compared with previous years, analysing the progressively increasing numbers of municipal licenses or finished housing, which constitutes the more accessible data accounting for this phenomenon. However, in these cases there are practically no specific references to any increase in land use other than residential. Hence, this explains the picture of a fundamentally residential bubble in general - both in the media and in scientific publications up to now.

on the other hand, that with the index used, the dominant disproportion between metropolitan areas is only slight (grade 1), in provinces such as Valencia, Malaga and Seville.

It is Madrid's position as a global hub, with the consequent demand for land that this implies, along with other factors of an institutional and production-based nature (Santiago, 2005), that explains its enormously disproportionate growth before, during and after the bubble: Madrid obtains grade 5, while the next metropolitan area in line is grade 3. In the case of Zaragoza, the disproportion is most likely explained by the coincidence of several factors: from the unstoppable trend towards population concentration in the regional capital (Lardies et al., 2011), to other factors such as its logistic location, the arrival of the AVE high-speed train, and the 2008 Expo. With regard to Toledo, the study shows that, after the conclusion of that period, the overflow of the metropolitan phenomenon in Madrid resulted in a greater impact in Toledo than in Guadalajara, as indicated by the housing figures (Burriel, 2008, Cebrián and García, 2011). This also serves to qualify its growth, as Toledo is the site of a significant proportion of the new industrial, commercial and infrastructure land (surprisingly more than Zaragoza, for example) and not just a sprawling residential city (Cebrián and García, 2011). On the contrary, we should mention Barcelona, which did not record disproportionate growth, despite having absolute growth figures higher than some of the previous cases. Something similar occurred in the case of Vizcaya.

On the development of coastal, tourism-based provinces, tourist housing complexes are another well-known factor, in fact, this is the second of the "situations that represent current urbanization processes in Spain", according to Valenzuela and Salom (2008). This phenomenon gave rise to systematic coastal land use, with a major environmental impact due to the quality of the ecosystems there and the scarcity of land as a resource. For these reasons this phenomenon merited a specific indicator in the reports from Spain's Observatory on Sustainability. Using CLC, that is, the same source as this study, the 2016 report found that 43% of the land on Spain's Mediterranean coastal strip (taking the first 500 metres) had already been built on (OS, 2016, 376).

Regarding the provincial distribution of coastal development and compared to the previous era, when massive growth in the Canary Islands (Serrano, 2008) was particularly striking, the results of this study show that in this phase the south-eastern area of the Mediterranean coast (Castellon, Alicante and Murcia) became more significant. As in the case of the Canary Islands, the Balearic Islands did not present growth as disproportionate as in the central Mediterranean area and only stand out in terms of anticipating and launching the bubble, with consequently greater growth in the first period. In this new period, it is the province of Murcia that stands out (grade 4), due to its smaller extension, to a greater extent even that Alicante (grade 3), although Alicante underwent the second largest development in absolute figures for the whole of Spain.

Turning to leisure-related construction, Murcia follows Alicante also in terms of the development of residential estates linked to golf courses (class 14), in second place nationally, just behind Madrid. The Alicante model had already been typified by other authors (Mazón, 2005, Vera, 2005), precisely due to the construction of second homes, and among these those linked to the construction of golf courses. In fact, the appearance on the Mediterranean coast of housing complexes with golf courses - one of the characteristic construction types in the period studied and with the greatest impact on land use - has produced a specific genre, with several studies on this coming specifically from PhD research (Martínez 2006, Lorca, 2007, Villar, 2008 and 2013, Demajorovic 2011, Babinger, 2012, and Morote 2014).

A third characteristic of the growth of Spanish urban development during the bubble that is, perhaps, less known - but which is relevant to this study - is the impact that Spain's autonomous regional model has had. In Valenzuela (2012) the subject is treated from several different perspectives, concluding that the increasing weight of urbanisation was due to urban growth in regional (Autonomous Community) capital cities. The comparative analysis now undertaken on the development of regional capitals (excluding those of large urban agglomerations) shows that this process of concentrated development continued over that period, at least in the case of autonomous communities without large urban concentration (Valladolid for Castilla-Leon, Toledo for Castilla-La Mancha, Badajoz for Extremadura and Corunna for Galicia). In addition, the disproportionate development of at least three regional centres: Ciudad Real, León and Navarre, is particularly notable, the last of which has maintained growth rates as high as in studies on previous periods (Serrano, 2008) and has developed a considerable proportion of the national total of industrial, commercial and infrastructural land.

In the case of the capital of Castilla-León, in the province of Valladolid, despite the unbalanced development, this may be due to factors such as the arrival of the AVE high-speed line and the building expectations arising from new developments (see Plan Rogers in Soria and Díez, 2011).

Furthermore, the results obtained confirm the great weight of industrial, commercial and infrastructure-based uses in the provinces. Authors such as Fernández Duran (2006), Pitarch (2011) and Díaz Orueta (2011) have characterized the importance of components other than residential in development associated with the "real estate bubble", from large-scale commercial distribution to logistics parks, both uses that require large amounts of land. Likewise, the so-called infrastructure bubble (Segura, 2013) that has led Spain to have the highest rates of motorways per 1,000 inhabitants, or the construction of the world's third largest high-speed rail network, only behind China and Japan, could also explain the importance of this type of uses, unprecedented in the history of Spanish urban development. The relative weight of this land use during the bubble was very considerable, reaching between 60 and 70% of new land in provinces with an industrial tradition (Álava, Guipuzcoa or Barcelona), but especially in inland provinces that did not have this (Zamora, Palencia, León, Caceres and Badajoz).

Finally, looking at provinces with lower population density, it is evident that the analysis of growth, not in absolute terms but percentage of land use in 1990, has revealed the relevance and consistency of these provinces as a group, as well as their character of "post-bubble", that is to say, their bubble occurred after that of metropolitan and coastal-tourist developments and possibly mimicking this phenomenon elsewhere. Using a similar ratio (homes built per 1,000 inhabitants), Burriel's study (2008) found similar results: it was not Madrid or Barcelona that grew the most but Málaga, Almería, Alicante, Castellón and Guadalajara.

6. Conclusions

The most significant conclusions from the analysis of land for artificial uses, taking the data from CORINE for the years 1990, 2000, 2006 and 2012, are as follows:

1. The study offers precise data on the impressive scale of the Spanish property bubble at European and even national level. From a quantitative point of view and on a European scale, between 2000 and 2012 Spain recorded the largest amount of artificial land use in Europe (218,200 ha), developing more than Germany, Britain and Italy combined, and 47% more than the country in second place, France.

   As regards the entire period of study over the history of Spanish urban development (1990-2012), in these 22 years the urbanized surface area of Spain increased by 504,543 ha, equivalent to half of the already occupied land taken up by cities, towns and infrastructure before 1990 and with a greater surface area than, for example, a country such as Holland.

2. On the land use model of this development, the data show the progressive change over the period analysed, highlighting the greater proportion of industrial, commercial and infrastructure uses as opposed to residential. This change contrasts with what occurred in Europe and became more acute during and after the bubble (CORINE data for 2000-2006 and 2006-2012). These uses came to represent 64% of total land use over that last period analysed, compared to 17% for residential land use (between 2000 and 2006 the proportion was 28% for industrial, commercial and infrastructure, compared to 20% for residential). Consequently, if we were to define the Spanish real estate bubble by land use, we would be talking not so much of a residential land bubble but an "infrastructure, industrial, commercial and residential

bubble". As for the gross density of development, this fell by 25% over the 22 years, nevertheless the causes are difficult to specify with the available data. In any case, however, with these figures we cannot talk about transferral from a model "of vertical land use to a horizontal one".

3. Regarding the provincial distribution of the land use process, the contribution is twofold, since both the provinces that concentrated growth and those that led it are fully described, taking an integrated method to consider absolute and relative growth at the same time.[9] Regarding the previous dynamics of Spanish land development, this method confirms the importance of the metropolitan or coastal-tourism dynamics, but with several notably new features: the enormous development in Madrid (5) and, Toledo, collaterally (5) which contrasts with Barcelona or Vizcaya (Biscay) (0) and, in general, the lower development of the rest of the traditional metropolitan areas, all below grade 2, except Zaragoza (3). Regarding coastal tourism areas, the development of the southern Mediterranean coastline (Murcia, grade 4, Alicante and Castellon, grade 3) is more significant than that of the Canary Is. and Balearic Is. that formed part of the previous stage. Finally, this method of comparison attributes great prominence to an element that had scarcely been observed before: what occurred in inland Spain: a crown of regional hubs around Madrid, with extremely disproportionate growth (Navarre, grade 4 and Valladolid, grade 3, both regional capitals, and above all, León, Ciudad Real and Salamanca, all ranked grade 4) - even those with very low population figures, such as Soria (4).

4. The analysis of the three periods, 1990-2000, 2000-2006 and 2006-2012, reveals the provinces that acted as a primer for land use during the bubble (Madrid, Alicante, Valencia and Barcelona), with one significant difference: while Madrid continued to lead the process until the end, Valencia and Alicante did so only until 2006, while Barcelona did so only until 2000. This also shows the progressive spread of the phenomenon: if, during the first period, the five provinces with highest participation accounted for 46% of occupied land, in the last period the first five totalled only 28%.

5. In the same vein, the last contribution would be to highlight a later land use bubble: that of inland provinces around Madrid (including the two Castillas and Extremadura), probably due to the "contagious" effect from metropolitan and coastal-tourist areas. A characteristic of this delayed bubble was that it was to have very significant proportions of industrial, commercial and infrastructure-based land in areas such as, for example, Zamora (73%) or Palencia (66%), areas without any industrial tradition.

Although the aim of this study was not to delve into the actual causes of the property bubble, it does provide us with a number of lessons to be learned from; firstly, it confirms the over-investment in fixed capital (infrastructures and industrial, commercial and residential land) made by this country, especially in Madrid, in peripheral regional centres, and provinces with lower population; and secondly, the power of the "contagious" effect of dynamics of this type is particularly striking, evident throughout the sequence of land uses described.

Finally, and considering possible future lines of research, one with the greatest potential would be to specify with appropriate data (such as the Spanish Land Register or *Catastro*), to what extent the Spanish urban model has undergone a transition from vertical land use to horizontal.

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[9] The method is called 'degree of disproportion' and measures the number of cases where the mean value and standard deviation for both variables are exceeded (either one or the other), offering a simple and objective "ranking", between 1 and 5.

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The influence of educational attainment on convergence in Spanish and Portuguese regions

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Abstract:

This article empirically analyses regional convergence between Spanish and Portuguese NUTS-3 regions during the period 2000-2015, considering the spatial dependence between these units and the role of educational attainment in this process. After some considerations regarding the model to be estimated, exploratory spatial data analysis (ESDA) is applied to detect two regional clusters grouped by regional product per inhabitant: high-income regions (located in the north-eastern third of the Iberian Peninsula) and low-income regions. For both clusters, various models of educational attainment are examined. These models reveal the presence of regional convergence, and enable us to detect the spatial spillovers that drive this process, which differ between the two clusters. In particular, we observe the influence of tertiary education on the reinforcement of income convergence within the high-income cluster, while for the low-income cluster this role is largely played by secondary education, but in the opposite direction.

Keywords: regional convergence; educational attainment level; spatial spillovers; Iberian regions; Spatial Durbin Model.

JEL classification: Q18; R11; R12.

Influencia del nivel educativo en la convergencia de las regiones españolas y portuguesas

Resumen:

En este artículo se analiza la convergencia regional entre las regiones españolas y portuguesas NUTS-3 durante el periodo 2000-2015, prestando especial atención a la dependencia espacial existente entre dichas unidades, así como al papel del nivel educativo en dicho proceso. Después de unas consideraciones relativas al modelo a estimar, el análisis exploratorio de datos espaciales permite detectar la existencia de dos clústeres regionales en Producto Regional por habitante: regiones de renta alta (situadas en el tercio nororiental de la península ibérica) y las regiones de renta baja. Tras explorar diferentes modelizaciones que integran el nivel educativo para ambos clústeres, los resultados obtenidos nos permiten afirmar la existencia de convergencia regional, así como estimar los desbordamientos espaciales que derivan de ese proceso, también diferentes para ambos clústeres. En concreto, se observa el efecto positivo que la educación terciaria tiene en el refuerzo de la convergencia en renta para el clúster de renta alta, mientras que para el de renta baja dicho papel lo desempeña en buena medida la educación secundaria, pero en sentido contrario.

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Palabras clave: convergencia regional, nivel de logro educativo, desbordamientos espaciales, regiones ibéricas, Modelo Espacial de Durbin.
Clasificación JEL: Q18, R11, R12.

1. Introduction

Traditionally, analyses of regional convergence have focused on single-country territorial areas, due to the impact of borders and differences in institutional frameworks on the distribution of economic activity (Barro & Sala-i-Martin, 1990). However, increasing EU integration has led to the analysis of supranational areas becoming common (Borsi & Metiu, 2015; Geppert & Stephan, 2008; Lopez-Bazo, 2017), generally with national units, but more and more with regional units. In this regard, per capita incomes across European regions are neither equal nor constant, thus giving rise to regional convergence clusters across Europe (Quah, 1996). Since geographical and national factors underlie many dynamics of inequality, research in this field usually focuses on countries with common features, for example, those in Western Europe, Central and Eastern Europe or the Mediterranean region.

Econometric applications tend to assume that the development of human capital is an exogenous[1] determinant of income convergence dynamics in European regions. In other words, the sufficiency or otherwise of the stock of human capital in these economies affects their ability to imitate technical progress (Kutan & Yigit, 2007). To the extent that improvements in educational level are a catalyst of innovation and technology, they accelerate progress towards full convergence. For this reason, human capital investment in less developed areas contributes to reducing regional inequality (Fleisher, Li, & Zhao, 2010). However, as has been shown for Eastern European regions (Crespo Cuaresma, Havettová, & Lábaj, 2013), the lag between making an initial investment and reaping its benefits differs among countries and regions.

The question of regional convergence within Spain and Portugal (which jointly form the Iberian regions) has been widely considered in recent years, from multiple perspectives: by territorial unit (NUTS 2 or NUTS 3), by time period, including or excluding the spatial component, according to the dependent and independent variables analysed and, within these, the inclusion or otherwise of human capital. Most such studies have been performed on an individualised, country-by-country basis (Badia-Miró, Guilera, & Lains, 2012; Ligthart, 2002; Tortosa-Ausina, Pérez, Mas, & Goerlich, 2005), although, in some cases, a global perspective has been applied (Melchor-Ferrer, 2018; Viegas & Antunes, 2013). In this context, studies have highlighted the existence of two differential patterns of behaviour in the Iberian regions (Marelli, 2007; Viegas & Antunes, 2013): i) convergence among Spanish regions has ceased, while it has continued in Portugal; ii) Spanish regions, in general, have grown more strongly than those in Portugal. Like most such studies, we include a comparative analysis to reveal similarities and differences and, ultimately, to determine the suitability of addressing convergence in the Iberian regions jointly. Conversely, the spatial polarisation of economic activities in the Iberian regions may reflect the existence of different spatial regimes, in a pattern that transcends national boundaries.

Among the previous studies that include the level of educational attainment as an independent variable (see Table 1), the vast majority take into account spatial feedback effects and examine a time period that finishes before 2008, hence excluding the impact of the major economic changes that have taken place in recent years. Our literature review also shows that no previous studies in this field have focused on Iberian regions in particular. The contribution of the present study, therefore, is to extend the findings of previous empirical research. The growing integration between the Spanish and Portuguese economies, the free movement of labour and the significant rise in levels of educational attainment (in the latter respect, especially around Lisbon, Porto and Coimbra) all highlight the need to analyse the differential impact of educational attainment on regional income and convergence among the Iberian regions. In

[1] However, Crespo Cuaresma et al. (2018) propose a model that is capable of accounting for simultaneity in the relationship between human capital and output growth.

addition, as the literature suggests there may be differentiated behavioural patterns between these regions, they are analysed in order to identify spatial clusters.

TABLE 1.
Key findings of empirical studies of human capital and regional growth in Spain and Portugal at the NUTS 3 level

	Authors	Information and analysis			Major findings
		Data	Spatial	Panel data	
Spain	Buendía & Sánchez de la Vega (2015)	1985-2007	Yes	Yes	Empirical results show significant and positive spillovers in labour productivity. Slight impact of human capital (tertiary studies) on labour productivity.
Spain	Gómez-Antonio & Fingleton (2012)	1985-2001	Yes	Yes	There is evidence in support of the wage equation involving market potential, human capital and public capital. The elasticity associated with human capital is statistically significant but small.
Spain	Mella & Chasco (2006)	1985-2001	Yes	No	Human capital is strongly significant and positively related to urban per capita GDP growth. This influence is greater than for capital growth.
Spain	Ramos, Suriñach & Artis (2010)	1980-2007	Yes	Yes	Analysis revealed a positive impact of human capital (secondary studies) on regional growth, and the existence of negative geographical spillovers associated with tertiary studies.
Portugal	Cardoso & Pentecost (2011)	1991-2008	No	Yes	Secondary and tertiary education has played a positive role in regional growth and convergence because the skills needed to adopt the new technologies are provided by higher levels of education.
Portugal	Guerreiro (2013)[2]	1991-2002	Yes	Yes	A strong significant association was observed between the coefficient for the labour force and the uptake of higher education, demonstrating the importance of this variable as a determinant of wage growth and convergence.
Portugal	Martinho (2011)	1996-2002	Yes	No	The level of educational attainment influences productivity convergence, and raises the value and statistical significance of convergence coefficients.

In the first section of this paper we address methodological issues related to the theoretical framework applied, mainly concerning the general convergence model and the estimation methods that will be applied. In the second section, we define the study variables, the data sources and the model specification.

[2] This author synthetizes several works published regard the income convergence between Portuguese NUTS 3 regions.

With this information, in the third section we perform an exploratory spatial data analysis (ESDA) of gross regional product per capita (GRPpc) in the Iberian regions to determine whether this variable is randomly distributed within the space and to identify the regional clusters. In section four, we discuss the model obtained and remark on the influence of tertiary education on regional growth for the high-income cluster, while for the low-income cluster this role is largely played by secondary education, but in the opposite direction.

2. Methodology

Spatial factors are increasingly significant in analyses of economic growth, as revealed by abundant empirical evidence, especially in terms of capital – physical, human and technological (Ertur & Koch, 2007; Ezcurra & Rios, 2015; Fingleton & López-Bazo, 2006; Kubis & Schneider, 2012; Naveed & Ahmad, 2016). The latter studies show that geographic location has a marked impact on regional growth performance. Spatial econometrics is a subfield of econometrics dealing with spatial interaction effects among geographical units (Elhorst, 2014). Key contributions to this field have been made by Anselin (1988; 1995), LeSage (2008) and Arbia (2006), among others. To address this question, some regional economists have suggested incorporating spatial heterogeneity and dependence within regional growth specifications (Fingleton & López-Bazo, 2006; Rey & Montouri, 1999).

The traditional determinants of regional growth are subtly altered when the spatial effect is taken into consideration, and so these effects should be included in the specifications for empirical analyses of growth. The spatial econometric approach has been used in various studies in conjunction with convergence models, whether unconditional (Rey & Montouri, 1999) or conditional (Fingleton & López-Bazo, 2006; López-Bazo, Vayá, Mora, & Surinach, 1999). In both cases, the results obtained provide strong evidence for the existence of spatial externalities, reflecting the need to account for spillover shocks among regions.

In the present study, the model used for analysis is defined taking into account that we wish to estimate both direct and indirect effects on growth rates in the Iberian regions, using a conditional beta-convergence model, incorporating three indices of human capital to analyse their impact on regional growth. Traditional views on convergence (Barro & Sala-i-Martin, 1992) suggest that regions with lower income per capita present faster growth than those with higher initial values (absolute convergence). However, the structural characteristics of regions may give rise to the existence of various steady states, which is a typical feature of conditional convergence models. These models may be estimated by incorporating different explanatory variables (in addition to the previous value of GRPpc) to act as proxies of the steady state. Therefore, the starting point for defining our model is that of a traditional conditional convergence equation, adapted to incorporate the spatial component in the dependent and explanatory variables, and in the disturbance term.

The starting point to select the spatial econometric model that best fits the subject matter is the General Nesting Spatial (GNS) model for panel data, using the following equation (Elhorst, 2014):

$$\left(\frac{1}{T}\right) ln\left(\frac{y_t}{y_{t-T}}\right) = \alpha_t + \mu + W\left(\frac{1}{T}\right) ln\left(\frac{y_t}{y_{t-T}}\right)\delta + ln(x_{t-T})\beta + W ln(x_{t-T})\theta + u_t$$

$$u_t = \lambda W u_t + \varepsilon_t \tag{1}$$

where:

$\left(\frac{1}{T}\right) ln\left(\frac{y_t}{y_{t-T}}\right)$ is the cumulative annual growth rate of the GRPpc for each region (in vector form), measured over T-year periods;

W is the spatial weight matrix;

$W\left(\frac{1}{T}\right) ln\left(\frac{y_t}{y_{t-T}}\right)$ is the spatial autoregressive component of the GRPpc;

$ln(x_{t-T})$ is the matrix of exogenous explanatory variables T years ago;

$Wln(x_{t-T})$ is the interaction effect of explanatory variables T years before;

$\alpha_t, \mu,$ and u_t are, respectively, the vector of time period fixed or random effects, the spatial fixed or random effects, and the disturbance term of the different units; and

λ, Wu_t and ε_t are vectors, respectively, the spatial autocorrelation coefficient, the interaction effects among the disturbance terms of the different units, and the disturbance terms.

The GNS model can be simplified in alternative specifications depending on the value of the parameters δ, θ and λ in order to estimate the spatial error model (SEM), the spatial Durbin model (SDM) or the spatial autoregressive model (SAR), among others. These models include one or more spatial lags in the dependent variable (SAR and SDM), the explanatory variables (SDM) and the error term (SEM).

The SDM model provides a general starting point for estimating the spatial regression model, since this model subsumes the others mentioned and captures both the direct effect of neighbours' expected outcome on own outcomes and the indirect effect on other regions (LeSage, 2008). LeSage and Fischer (2008) provided a framework for interpreting the resulting estimates which has been generally accepted as the standard approach for spatial models. It is based on analysing three types of impact on economic growth rates arising from changes in explanatory variables: i) the direct effect, summarising the impact of changes of an explanatory variable in region i on the dependent variable, both within region i and within its neighbours; ii) the indirect effect on the dependent variable for region i of changes in independent variables within neighbouring regions; iii) the average total effect, a scalar summary measure that includes both direct and indirect effects. To make statistical inferences about these effects, it is necessary to calculate dispersion measures, using Markov Chain Monte Carlo simulation.

The explanatory power of each component of regional growth is determined via maximum likelihood (ML) estimation of the panel data model, considering four options: no fixed effects, spatial fixed effects, time-period fixed effects and both spatial and time-period fixed effects. In general, the fixed effects model is the most appropriate, because the impact of neighbouring units can only be measured when these units form part of the sample. However, the assumption of zero correlation between the random effects and the explanatory variables can only be tested after Hausman's specification test has been performed. If fixed effects are detected, the next step is to consider the geographic location, because this factor can reveal differences in patterns of behaviour between regions other than improvements in GRPpc. Evidence of such differences would suggest the existence of spatial externalities, and we would then have to incorporate the spatial dimension into the estimation in order to assess its strength (Fingleton & López-Bazo, 2006).

Detecting and analysing the type of spatial dependence model developed, and determining which model is most appropriate, is crucially important to the correct specification and application of an estimation method. To achieve robustness against model misspecifications such as non-constant error variances in a regression model and non-normality, Anselin (1988) proposed incorporating heteroscedasticity in the model estimation using a ML estimator, assuming that the disturbance terms are distributed independently and identically for all spatial and time-period units. However, when spatial specific effects are assumed to be fixed, the log-likelihood function provides a unique numerical solution for the spatial parameter, and must be transformed to take into account the endogeneity of the lagged dependent variable by using a Jacobian iteration method[3]. For this reason, we estimated the model by the concentrated ML estimation procedure proposed by Elhorst[4].

[3] See Elhorst (2014) in chapter 3 for details.

[4] Matlab routines for this procedure, called "sar_panel_FE", are available online at https://spatial-panels.com/software/ This file includes a normalization procedure where each element of W is divided by its largest characteristic root (Kelejian & Prucha, 2010).

The presence of endogeneity is a common occurrence in almost any empirical regression, and may result from measurement errors for explanatory variables or from omitting variables correlated with explanatory variables included (Elhorst, 2010a). Failing to account for these objections increases the risk of obtaining biased estimation results. The remedy proposed by Elhorst (2003) is to introduce a variable intercept μ_j representing the effect of the omitted variables that are peculiar to each spatial unit considered. As the parameters are fixed but different across spatial units, each spatial unit is treated separately. Nevertheless, as noted in LeSage and Pace (2009) we can identify the presence of omitted variables given two circumstances (Lacombe & LeSage, 2015): omitted variables that are correlated with the explanatory variables included, and spatial dependence in the disturbances within the model. In the resulting SDM model, β is replaced by $\beta + \gamma = \emptyset$, as $\beta = \theta/(-\delta)$. It is then possible to identify γ, and when $\gamma \neq 0$ we can assert the presence of omitted variables. A simple (analogous) way to test this would be to use the reported t-statistics for the indirect effects that are available for ML estimates, since where there is no omitted variables bias, the indirect (spillover) impacts are not significantly different from zero.

3. Data sources and model specification

3.1. Study variables and data sources

The GRPpc data were obtained from the Regional Economic Accounts (ESA-2010) published by Eurostat. This database presents data for gross regional product (at current market prices). The deflator index for the corresponding NUTS-2 region was then applied in order to express GRP in constant 2000 euros. The model specification includes 82 different units, corresponding to the NUTS-3 Iberian regions (except Ceuta and Melilla, two Spanish enclaves in North Africa), and eleven observations for each group: 2000-2010 for the explanatory variables and 2005-2015 for the independent variable, taking into account that the cumulative growth rate is measured over a five-year period. In total there were 902 observations, 627 for the Spanish regions and 275 for the Portuguese ones. In all cases, a large number of observations were analysed, thus ensuring ample degrees of freedom.

To analyse the impact of human capital on regional growth, with respect to levels of educational attainment, we focused on the population aged 15 years and older. The education data analysed correspond to the highest level achieved by each member of this population. Specifically, we examined three aggregate statistics based on the International Standard Classification of Education: i) primary education (levels 1 and 2); ii) secondary education (levels 3 and 4); iii) tertiary education (levels 5-8). The data are expressed as the share of each population group of the total for these categories.

The Eurostat Database does not provide data at the NUTS-3 level and so we took the national statistics consistent with this classification. For the Spanish regions, we consulted the database developed by Bancaja Foundation and the Valencian Institute of Economic Research (2014) for the period 1977-2013. For the Portuguese regions, the Francisco Manuel dos Santos Foundation manages the PORDATA database, which compiles educational information sourced from public census records. The latter are published every ten years (2001 and 2011 for our analysis period); in our study, the data for the remaining years were obtained by linear interpolation.

3.2. Model specification

To analyse the spatial convergence in the Iberian regions and the impact of human capital in this process, certain considerations should be taken into account. First, as pointed out above, panel data models will be used, and therefore spatial fixed or random effects will also be considered. Second, in order to model interactions between the spatial units in the dataset, we will use the spatial weight matrix described in the following section. Finally, the growth rate used is annual cumulative, with $T = 5$. As conditional explanatory variables, we consider the initial level of educational attainment, measured by the share of the population aged 15 years and over that has successfully completed primary, secondary and tertiary studies (Pe_{t-5}, Se_{t-5} and Te_{t-5} ,respectively). Hence, equation [1] is modified as follows:

$$\left(\frac{1}{5}\right) ln\left(\frac{y_t}{y_{t-5}}\right) = \alpha_t + \mu + W\left(\frac{1}{5}\right) ln\left(\frac{y_t}{y_{t-5}}\right)\delta + ln(y_{t-5})\beta_1 + Wln(y_{t-5})\theta_1 + ln(Pe_{t-5})\beta_2 +$$

$$Wln(Pe_{t-5})\theta_2 + ln(Se_{t-5})\beta_3 + Wln(Se_{t-5})\theta_3 + ln(Te_{t-5})\beta_4 + Wln(Te_{t-5})\theta_4 + u_t$$

(2)

$$u_t = \lambda W u_t + \varepsilon_t$$

Equation [2] is a GNS model, not SDM (when λ=0), and can be simplified to become SAR (when λ=0 and θ_1=θ_2=θ_3=θ_4=0) or SEM (when δ=0 and θ_1=θ_2=θ_3=θ_4=0). Therefore, according to the above-noted advantages of taking the SDM model as a starting point, the equation to be estimated would read as follows:

$$\left(\frac{1}{5}\right) ln\left(\frac{y_t}{y_{t-5}}\right) = \alpha_t + \mu + W\left(\frac{1}{5}\right) ln\left(\frac{y_t}{y_{t-5}}\right)\delta + ln(y_{t-5})\beta_1 + Wln(y_{t-5})\theta_1 + ln(Pe_{t-5})\beta_2 +$$

$$Wln(Pe_{t-5})\theta_2 + ln(Se_{t-5})\beta_3 + Wln(Se_{t-5})\theta_3 + ln(Te_{t-5})\beta_4 + Wln(Te_{t-5})\theta_4 + \varepsilon_t \quad (3)$$

4. Exploratory spatial data analysis

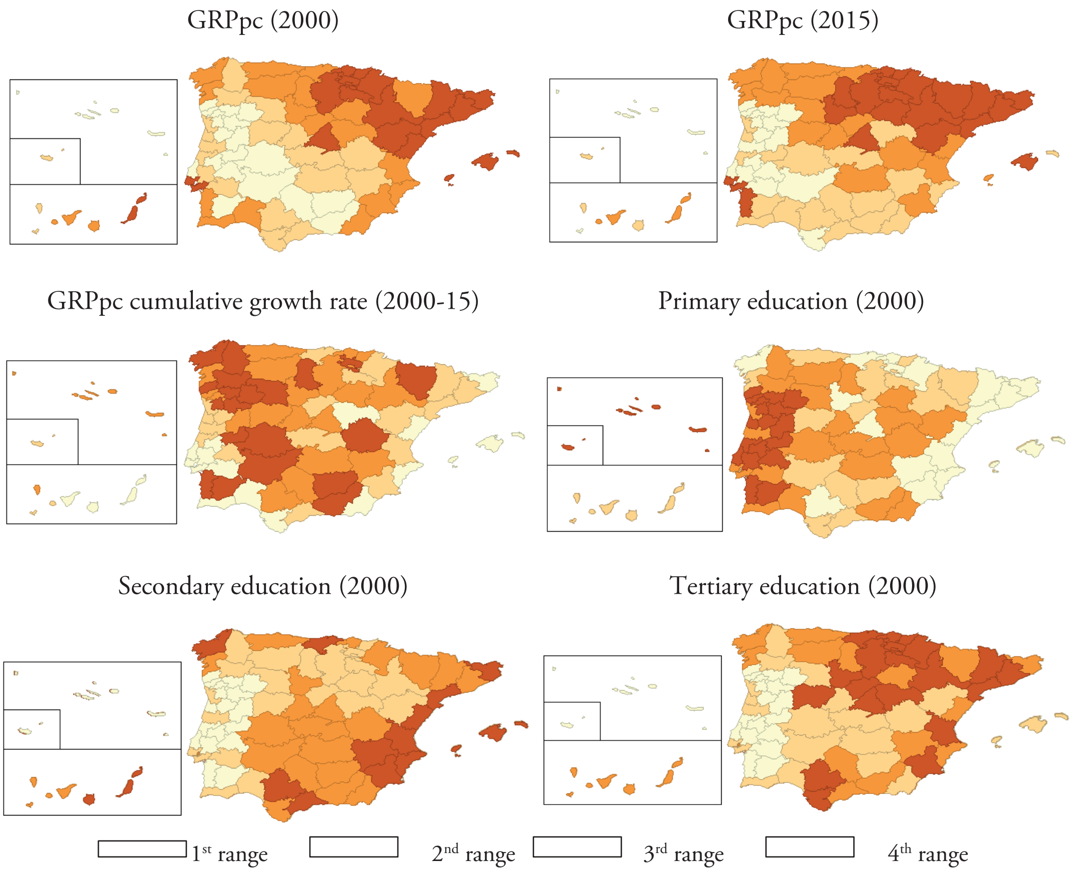
4.1. GRPpc and educational attainment level in Iberian regions: a preliminary analysis

From the quartile maps (see Figure 1), it is immediately apparent that in 2000 the GRPpc for all Portuguese regions except Lisbon, Algarve and Alentejo Litoral was in the third or fourth quartile. Within Portugal, the highest values were recorded for the coastal regions and those bordering Lisbon. However, with respect to the cumulative growth rate during the period 2000-2015, almost all of the Portuguese regions bordering Spain, especially those in the north-west, presented higher rates than the Spanish regions. This fact could indicate the presence of spatial autocorrelation between these regions and neighbouring ones in Spain.

In 2000, the levels of educational attainment were low in almost all Portuguese regions and, therefore, the secondary and tertiary levels were of less relative importance. The regions of Porto, Coimbra, Lisbon and Algarve presented the highest weights in the latter respect, but were still in the third quartile and therefore below most Spanish regions. The situation in Spain during this period was quite different: i) in 2000, no regions were in the fourth quartile for secondary and tertiary educational attainment; ii) the Spanish regions in the third quartile were mainly inland, in the north and south of the country, respectively, for both levels.

In general, the differences between Spanish and Portuguese regions in 2000 are evident; however, the disparities decreased during the study period, and the regional groupings based on national boundaries were less apparent. However, the strengthening relationship between Spanish and Portuguese regions, especially for the cross-border regions (e.g. Euroregions such as Euroace -Alentejo, Centro and Extremadura- or Galicia and northern Portugal) makes it necessary to consider alternative clusters that could include regions of both countries.

FIGURE 1.
Quartile map of GRPpc and levels of educational attainment



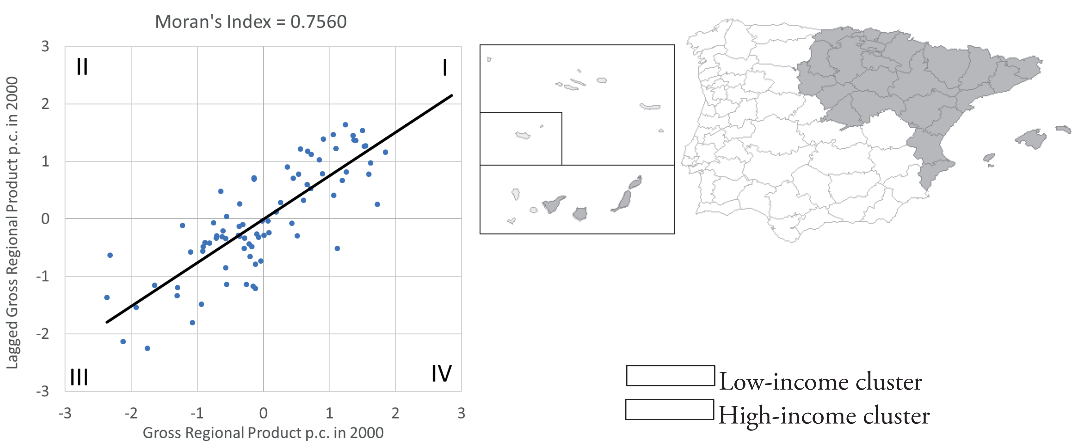
4.2. Selection of the regional clusters

In order to identify regional clusters, we followed the selection procedure described by Mella and Chasco (2006) in their study of urban growth in Spain. These authors used ESDA to detect spatial polarisation, expressed in terms of different spatial regimes. However, before applying this approach to the Iberian regions, it is necessary to select the most appropriate spatial weight matrix (W), comparing the model performance for each individual W. The first step in this process is to construct the W that contains information on the "neighbourhood" structure for each location (Anselin, 2003). However, the correct specification of the elements of this matrix, w_{ij} (which typically reflects the "spatial influence" of unit $_j$ on unit $_i$) is one of the most controversial methodological issues in spatial econometrics (Gibbons & Overman, 2012), reflecting the need to avoid spurious correlations, and therefore special care must be taken to choose appropriate spatial weights. As Leenders (2002, p. 26) says: "virtually any conclusion depends on the specification of W. It is therefore of vital importance to have justification for the W applied in the research". In the present study, we considered specifications based on the geographical distance between the k-nearest neighbours ($k = 2$ to 10) computed from the distance between the centroids of the regions (Le Gallo & Ertur, 2003).

When ML estimation is used, the matrix that best describes the data is that corresponding to the model which presents the lowest parameter estimate of the residual variance (Elhorst, Zandberg, & De Haan, 2013). Thus, for the Iberian regions we used the 2-nearest neighbours, a matrix that obtained a much better fit than the alternatives.

Once the weight matrix had been selected, the next step in our study was to analyse the Moran scatterplot for GRPpc. As can be seen in Figure 2, the Moran index revealed positive spatial autocorrelation in Iberian regions for GRPpc in 2000. This is consistent with the fact that almost all regions were in quadrants I and III. In the first case, this indicates that high-income regions were surrounded by high-income neighbours, while in the second case, low-income regions were surrounded by similar neighbouring regions. In the map shown in Figure 2 (right), the regions located in quadrant I in 2000 are highlighted to identify spatial clusters (Mella & Chasco, 2006). It can be appreciated that most of these regions are located in the north-eastern quadrant of the Iberian Peninsula. By this approach, we established two subsets of observations: the regions located in quadrant I and other regions (henceforth, high-income and low-income clusters, respectively).

FIGURE 2.
Moran scatterplot for GRPpc and clusters map by income level in 2000



Notes: The spatial weight matrix used is 2-nearest neighbours.

Moran's index was calculated for the high-income and low-income clusters in 2000, obtaining 0.325 and 0.437, respectively. This result implies the presence of spatial heterogeneity in 2000, in the sense that the subset selected shows a different degree of spatial dependence. However, this is purely exploratory and does not guarantee the existence of a spatial regime. For this purpose, we also estimated a regression model to the standardised GRPpc (as the explanatory variable) and its spatial lag (as the dependent variable) for the clusters observed in 2000, subsequently applying the Chow test[5]. The test result (see Table 2) is highly significant for GRPpc clusters in 2000 and, therefore, we reject the null hypothesis that the coefficients of the linear regressions on different clusters in 2000 are equal. Therefore, in the rest of this paper we use two sub-samples: i) a high-income cluster, composed of the 30 regions highlighted in Figure 2 (right); and ii) a low-income cluster, composed of the 52 remaining regions.

Having identified the spatial regime present in the Iberian regions, we now repeat the spatial weight matrix selection procedure previously applied to these clusters in order to obtain the local indicators of spatial association (LISA). Finally, for the high-income and low-income clusters, considered separately, the matrices used were those for 3 and 2-nearest neighbours, respectively.

[5] Chow test is a particular case of the Wald statistic in which the constraint is applied according to the spatial regime structure adopted.

TABLE 2.
Chow test for clusters based on GRPpc (2000)

Cluster	Intercept term	Estimated coefficient	Adj. R^2
High-income cluster	0.556*** (3.177)	0.386** (2.481)	0.180
Low-income cluster	-0.271*** (-2.774)	0.490*** (4.577)	0.295
Chow test for selected/unselected subsets: distrib. = F(2.78), ratio = 8.851, p-value = 0.000			

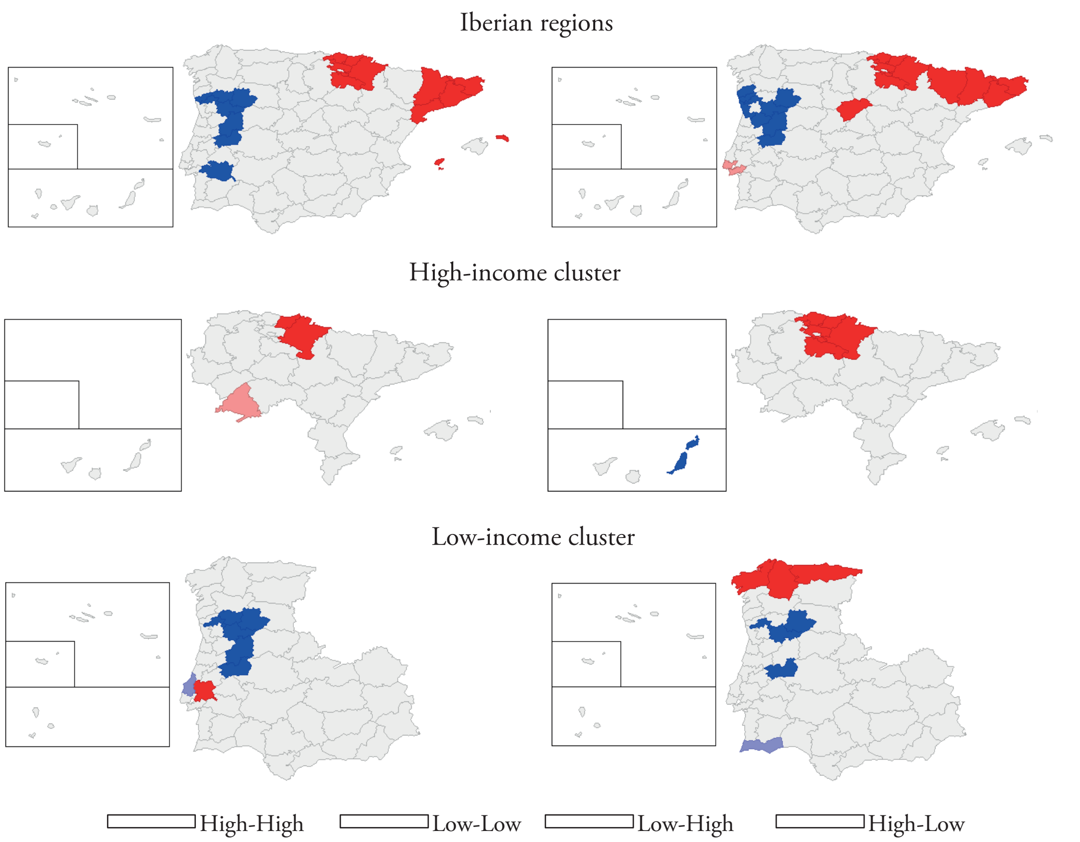
Note: T-statistics shown in parentheses. Statistical significance: * at 10% level, ** at 5% level, *** at 1% level.

4.3. Analysis of local spatial autocorrelation

There were remarkably few interactions between the Spanish and Portuguese regions when the 2-nearest neighbour matrix was adopted. For the Spanish regions, only five NUTS-3 units presented a spatial interaction with neighbouring Portuguese regions: Huelva with Baixo Alentejo, Salamanca and Zamora with Terras de Trás-os-Montes, Orense with Alto Tâmega and Pontevedra with Alto Minho. Among the Portuguese regions, only Alto Tâmega exerted a spatial influence (on Orense).

The LISA for GRPpc in 2000 for the Iberian regions revealed a positive autocorrelation of high values for Catalonia, Balearic Islands and the cluster formed of the Basque Country, Navarre and La Rioja, in Spain (see Figure 3). In Portugal, most of the inland regions (almost all bordering with Spain and in northern Portugal) showed a positive autocorrelation of low values. This can also be seen in 2015, but with certain differences, namely the positive autocorrelation of high values for all Spanish regions bordering France as well as for Segovia (near Madrid), and the negative autocorrelation of high values for Lisbon.

FIGURE 3.
LISA cluster map for GRPpc in 2000 (left) and 2015 (right)



Regarding the high-income cluster in 2000, three Spanish regions presented an autocorrelation of high values: this autocorrelation was negative for Madrid and positive for Guipuzcoa and Navarre. In the latter case, this situation was reinforced in 2015, since it is possible to identify a cluster of high values composed of Basque Country, La Rioja and Navarre NUTS-2 regions. In contrast, Lanzarote and Fuerteventura, two of the Canary Islands, presented a positive autocorrelation of low values.

The LISA cluster maps for the low-income cluster show that in 2000 many Portuguese regions (mainly Centro and Norte NUTS-2 regions bordering or very near Spain) presented a positive autocorrelation of low values. This reflects the existence of different patterns and behaviours between coastal and inland regions of continental Portugal. Two Portuguese regions near Lisbon showed autocorrelation but with different signs: positive of high values for Leiziria do Tejo and negative of low values for Oeste. The situation in 2015 was slightly different in two ways: i) most of the Portuguese regions bordering Spain did not show positive autocorrelation of low values (except for Trás-os-Montes, Douro and Beira Baixa); and ii) for the Spanish regions, the geographical distribution of the positive autocorrelation of high values reveals a spatial association in the coastal Atlantic regions. This would point to the existence of a strong economic relationship among the north-western regions of the Iberian Peninsula.

5. Empirical results

5.1. Model selection

In line with the methodological approach outlined in section 1, we estimated and analysed the alternative specifications underlying the panel data model defined in equation [3] by the ML estimator. To decide which spatial panel data model best describes the data, we applied the following selection framework developed by Elhorst (2010b): i) determine the significance of spatial and/or time-period fixed effects and whether they should be treated as fixed or as random effects; ii) determine which type of spatial interaction effects should be considered (observing whether the SDM model can be simplified in the SAR or SEM model).

Regarding the significance of spatial and/or time-period fixed effects, a non-spatial panel data model was estimated and the classic Lagrange Multiplier tests (and their robust versions) were applied, both for spatial errors and for omitted spatial lags in the panel data. These tests examine the residuals of the non-spatial model with and without spatial or time-period fixed effects, follow a chi-square distribution, and can take the form of a likelihood ratio (LR) test with N or T degrees of freedom, respectively. The corresponding LR test was performed to investigate the (null) hypothesis that the spatial or time-period fixed effects are jointly non-significant. The results obtained (see Table 3) indicate that both hypotheses must be rejected for the three regional clusters considered (with $p < 0.01$). Accordingly, the model can be performed with spatial and time-period fixed effects.

In the classical panel data literature, individual effects can be treated as fixed or random. To evaluate whether a spatial random effects model is more appropriate than a spatial fixed effects model, we estimated a spatial random effects model (with time-period fixed effects) by ML including spatially-lagged variables, both independent and dependent. The Hausman test compares random and fixed effects estimators and tests whether or not the random effects assumption is supported by the data (Millo & Piras, 2012). The test results (see Table 3) show that the probability value for all regional clusters is less than 0.1, and so the random effects model is rejected in favour of the fixed effects model.

Having determined the joint significance of spatial and time-period fixed effects, we then ascertained which type of spatial interaction effects should be accounted for in a SAR, SEM or SDM model. To do so, we first conducted a SDM estimation, supported by a Wald and LR test to verify whether the model can be simplified to a SAR or SEM model. The results obtained (see Table 3) suggest that the most suitable approach is a SDM model with fixed spatial and time-period effects for the Iberian regions and the low-income cluster, while for the high-income cluster a SAR model is most appropriate.

TABLE 3.
Model specification test

	Iberian regions		High-income cluster		Low-income cluster	
Test	*Statistic*	*Prob. Value*	*Statistic*	*Prob. Value*	*Statistic*	*Prob. Value*
LR joint sig. spatial fixed effects	1210.420	0.000	491.882	0.000	677.599	0.000
LR joint sig. time-period fixed effects	524.399	0.000	216.289	0.000	293.009	0.000
Hausman test	75.225	0.000	15.131	0.087	65.363	0.000
Wald test for spatial lag model	58.715	0.000	4.150	0.386	56.987	0.000
LR SDM against SAR test	62.737	0.000	3.684	0.451	60.274	0.000
Wald test for spatial error model	78.572	0.000	11.343	0.023	62.643	0.000
LR SDM against SEM test	85.742	0.000	12.495	0.014	67.633	0.000

Notes:
- LR joint significance spatial and/or time-period fixed effects with probability greater than 0.05 implies rejection of spatial and/or time-period fixed effects, respectively.
- LR spatial Durbin model against spatial lag/error model test with probability lower than 0.05 points spatial Durbin model cannot be simplified with respect to the spatial lag model or the spatial error model.

5.2. Estimating the direct and indirect effects of levels of educational attainment on regional growth

The contribution of educational attainment to GRPpc growth in the Iberian regions considered varies according to the determinants considered (see Table 4). Focusing on the initial GRPpc, the estimated coefficients for all regional groupings are negative (which is in line with the literature on regional convergence) with values ranging from -0.147 to -0.143, for the Iberian regions and the low-income cluster, respectively. The positive sign of the autoregressive parameter for these two regional clusters implies that when a region with initially low levels of per capita income has neighbours with high economic growth rates, spatial spillovers hinder growth in this region. Specifically, the value of the autoregressive parameter indicates that a 10% increase in GRPpc growth in a region produces an increase of 1.8% to 1.54% in the growth of neighbouring regions. On the other hand, the autoregressive parameter for the high-income cluster is negative (-0.133), indicating that regions with high economic rates exert a negative impact on the growth of neighbouring regions. This is consistent with the presence of increasing marginal returns in regions such as Madrid, Barcelona and Basque Country. In either case, the coefficients for the three clusters are significant at 1%.

Levels of educational attainment are important explanatory variables of regional economic growth in Iberian regions and low-income clusters, as reflected in the following results obtained (see Table 4):

a) The sign of the estimated coefficients is positive (which is consistent with previous research findings on economic growth) and significant at 1%, except in the low-income cluster for tertiary education in neighbouring regions.

b) Primary and secondary education levels are positively related to regional growth (significant at 1%) in the Iberian regions and especially in the low-income cluster. On the other hand, for the secondary educational level the coefficients obtained are greater than for the other educational levels, both for the regions in question and for their neighbours, at rates generally exceeding 50%. This indicates that the regions with a moderate educational level (or surrounded by others with a similar level) tend to grow faster than those with a higher educational level. Moreover, the coefficients obtained for a given region are lower than for its neighbours, suggesting that spatial effects have a significant impact on educational attainment.

c) The coefficients obtained for tertiary education are significant both for the region and for its neighbours. However, the values are low (around half those for the other education levels) and their impact on GRPpc growth is less significant.

Regarding the high-income cluster, a notable finding is the non-significance of the coefficients obtained for primary and secondary education. This means that only the coefficient for tertiary education is significant (at 5%) and it is negative, in contrast to the other clusters. The negative sign of the estimated coefficient for tertiary education indicates that regions with higher levels of human capital tend to grow less. Although this may seem contradictory, we must take into account that regions with high levels of human capital tend to have higher incomes and therefore it is more difficult to maintain high rates of growth.

In general, the initial GRPpc and the autoregressive component present the highest coefficients and significance. For the Iberian regions and the low-income cluster, the level of educational attainment seems to exert a positive influence on regional growth. We surmise that these interactions enhance the convergence effect, but this hypothesis is subject to confirmation by the analysis of direct and indirect spatial effects.

TABLE 4.
Estimation results for conditional beta-convergence

Determinants	Iberian regions SDM	High-income cluster SAR	Low-income cluster SDM
log GRPpc	-0.147*** (-28.895)	-0.145*** (-23.032)	-0.143*** (-20.76)
log primary education	0.017*** (5.398)	-0.003 (-0.563)	0.031*** (5.124)
log secondary education	0.020*** (3.936)	-0.014 (-1.526)	0.031*** (4.522)
log tertiary education	0.010*** (3.021)	-0.014** (-2.305)	0.016*** (3.737)
W·GRPpc growth rate	0.180*** (5.421)	-0.133*** (-2.811)	0.154*** (3.659)
W·log GRPpc	0.015* (1.810)	-	0.027*** (2.688)
W·log primary education	0.021*** (5.111)	-	0.035*** (4.321)
W·log secondary educat.	0.030*** (4.502)	-	0.048*** (5.503)
W·log tertiary education	0.017*** (4.300)	-	0.012** (2.443)
R^2	0.898	0.918	0.895
Corrected R^2	0.648	0.689	0.667
Residual variance (σ^2)	3.300E-05	2.400E-05	3.300E-05
Log-likelihood	3419.874	1305.585	2168.731
Observations	902	330	572

Note: T-statistics shown in parentheses. Statistical significance: * at 10% level, ** at 5% level, *** at 1% level.

The impact of the explanatory variables is interpreted by estimating their total effects, as the algebraic sum of the direct and indirect consequences. With regard to direct impacts, the following observations can be made (see Table 5):

a) For the GRPpc, the effects are significant (at 1% level) for the three regional clusters, with a greater effect for the Iberian regions, followed very closely by the high-income cluster (-0.1478 and -0.1452, respectively). In the first case, this means that when the initial GRPpc increases on average by 10%, its cumulative growth rate falls by 1.48%. This negative impact is slightly greater than the value of the parameter obtained for the Iberian regions and the high-income cluster (-0.009 and -0.005, respectively). In contrast, for the low-income cluster this impact is lower (0.006). In either case, the feedback effects between the growth of a region and that of its neighbours are not very important.

b) The direct effects of initial human capital are not very important, with parameter values (when significant) ranging from 0.0116 to 0.0341. For the Iberian and low-income clusters, the direct effects are positive and higher than the estimated coefficients, especially for secondary education in the latter cluster (0.003). This suggests that low-income regions with a growing share of the medium educational level tend to achieve higher rates of growth. With respect to tertiary education for the high-income cluster, the direct effect is negative, significant at 5% and very similar to the coefficient obtained, and therefore we conclude there are no feedback effects.

TABLE 5.
Estimation of direct, indirect and total effects.

Variable	Direct effect	Indirect effect	Total effect
Iberian regions			
GRPpc	-0.1478*** (-28.91)	-0.0135* (-2.038)	-0.1613*** (-22.899)
Primary education	0.0184*** (5.877)	0.0272*** (5.714)	0.0456*** (7.751)
Secondary education	0.0223*** (4.479)	0.0379*** (4.793)	0.0603*** (6.228)
Tertiary education	0.0116*** (3.493)	0.0216*** (5.034)	0.0332*** (6.993)
High-income cluster			
GRPpc	-0.1452*** (-22.625)	0.0174*** (2.812)	-0.1278*** (-21.91)
Primary education	-0.0026 (-0.566)	0.0003 (0.530)	-0.0023 (-0.566)
Secondary education	-0.0138 (-1.513)	0.0017 (1.289)	-0.0122 (-1.511)
Tertiary education	-0.0144** (-2.290)	0.0018 (1.652)	-0.0127** (-2.315)
Low-income cluster			
GRPpc	-0.1424*** (-20.80)	0.0062 (0.683)	-0.1363*** (-12.694)
Primary education	0.0330*** (5.641)	0.0450*** (5.335)	0.0780*** (9.174)
Secondary education	0.0341*** (4.928)	0.0600*** (6.165)	0.0941*** (7.729)
Tertiary education	0.0169*** (4.003)	0.0162*** (3.192)	0.0331*** (5.696)

Note: T-statistics shown in parentheses. Statistical significance: * at 10% level, ** at 5% level, *** at 1% level.

The values for the indirect effects of GRPpc (i.e. their impact on the neighbouring regions as reflected in the region in question) are lower than those for the direct effects, while for educational attainment, in general, they are higher. The following major findings in this respect were noted:

a) GRPpc is significant at 1% for the high-income cluster, with a coefficient of 0.0174. In this case, the indirect effect of GRPpc suggests that increased GRPpc in neighbouring regions has a positive impact on the economic situation of the region, which seems intuitively plausible and is consistent with the presence of agglomeration economies. Consequently, for the high-income cluster, the (positive) indirect effect of initial GRPpc reduces the (negative) total effect by 12%.

b) The indirect effect of primary education in the Iberian and low-income clusters is positive, with values of 0.0272 and 0.045, respectively. In either case, this counteracts the indirect effect of GRPpc. The same applies to the case of secondary education, although this presents particularly high values in comparison with all educational levels. The indirect effect of tertiary education is weaker, especially in the low-income cluster. This finding reflects the importance of the synergies created in the low-income cluster when regions increase their human capital; in other words, when the value of human capital of a given region, or that of its neighbours, rises, this drives the growth of GRPpc of the neighbours or the region in question, respectively. In the high-income cluster, however, the indirect effect of any educational level is not significant.

Our analysis of indirect impacts, significantly different from zero, highlights the presence of omitted variables related to all educational levels in the low-income cluster (and, by extension, in the Iberian regions). This is consistent with the existence of additional factors that may affect regional growth (e.g. investment in educational systems, productive structure, productivity growth, innovation efforts, etc.).

In view of the above considerations, we conclude that educational attainment levels in high-income and low-income clusters play differing roles in their respective patterns of regional convergence. In the high-income cluster, improvements in tertiary education seem to have a limited negative impact on regional growth[6], while for the low-income cluster the positive effect is to a large extent achieved by improvements in secondary education. The total effect for primary education for the low-income cluster is positive and significant; its value is lower than for secondary education but around twice that for tertiary education.

6. Conclusions

Although GRPpc in the Iberian regions rose during the period 2000-2015, the regional distribution was uneven. Most Spanish regions grew at above-average rates, while the opposite was true for the Portuguese ones, where initial values were below the average for the Iberian regions (except for Lisbon, Alentejo Litoral and Algarve). A preliminary spatial analysis showed that the lowest GRPpc values were in the south-western third of the Iberian Peninsula. This spatial distribution is not random; Moran's index test reveals the presence of spatial autocorrelation. According to the LISA, most of the Portuguese regions bordering Spain present a positive autocorrelation of low values, while the regions with a positive autocorrelation of high values are Spanish, and mainly located in the north-eastern quadrant of the Iberian Peninsula. These results highlight the existence of differing behaviour patterns between these regions and the others (high-income and low-income clusters, respectively).

The impact of the explanatory variables on the growth of GRPpc is observed by estimating their total effects as the algebraic sum of the direct and indirect effects. For GRPpc, the effects for the high-income cluster are similar to those for the low-income cluster. In both cases, the direct effects are negative (which is in line with previous research findings) and significant. On the other hand, for the high-income cluster the indirect effects are non-significant and, therefore the spatial effects of GRPpc on regional convergence are irrelevant.

Analysis of the results for each national cluster reveals certain differences: firstly, for the low-income cluster the relationship between the level of educational attainment and the growth of GRPpc is positive, regardless of the level considered. Secondly, only tertiary education is significant for the high-income cluster, while for the low-income cluster the coefficients for secondary education present high values in comparison with all educational levels. In contrast, the indirect effect of tertiary education is weaker, especially in the low-income cluster. This finding reflects the importance of the synergies created in the low-income cluster when regions increase their human capital; in other words, when the value of human capital of a given region, or that of its neighbours, rises, this drives the growth of GRPpc of the neighbours or the region in question, respectively.

On balance, we conclude that for the high-income cluster there is a negative relationship between the initial level of tertiary education and the growth of GRPpc, which reflects the existence of spatial spillovers (especially around Madrid, Barcelona and Basque Country) which reinforce that of the negative effect of the initial GRPpc. In contrast, for the low-income cluster the positive effect of secondary and tertiary educational levels does not exceed the negative effect of the GRPpc. This shows the importance for poor regions of improving the level of educational attainment in the low-income cluster, particularly in secondary studies, because of the reinforcement of the convergence process.

[6] Sánchez de la Vega (2015) demonstrated the limited impact of tertiary studies on the productivity growth.

Regarding potential avenues for further analysis, it is important to consider other variables that might be related to GRPpc growth, such as unemployment rates (differentiated by level of education), the EU structural funds received by the regions or the level of public investment in the education system.

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Articles

Spatial diffusion of economic growth and externalities in Mexico

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Abstract:

Economic growth and externalities are rooted in spatial dynamics, however, their spread over space is not unlimited. In this document it is estimated the strength spatial externalities from capital on output and the spatial spillover of the economic growth for Mexican municipalities at different distances. The estimation is carried out implementing a Spatial Durbin Model with distance-based spatial weight matrices in a panel data structure from 1988 to 2013. The results show evidence of weak spatial externalities from capital on output at short distances, say 20 or 60 km. Additionally, it is found that the diffusion of economic growth is directly related to distance, moreover, there is evidence in favor about the convergence hypotheses, finding out that distance between stationary states is insufficient to explain differences among municipalities' growth rates, but geographical distance matters as well.

Keywords: Economic growth; Externalities; Spatial Convergence.
JEL Classification: R11; R12.

Difusión espacial del crecimiento económico y de las externalidades en México

Resumen:

El crecimiento económico y las externalidades están vinculados a la dinámica espacial, sin embargo, su difusión sobre el espacio no es ilimitada. En este trabajo es estimada la fuerza de las externalidades espaciales del capital físico en la producción, así como la difusión del crecimiento económico en los municipios de México a diferentes distancias. La estimación es llevada a cabo a través de un Modelo Espacial Durbin con matrices de peso espaciales basadas en la distancia con una estructura de datos panel, de 1988 a 2013. Los resultados muestran evidencia de débiles externalidades espaciales del capital sobre la producción en cortas distancias, por ejemplo 20 o 60 km. Por otro lado, se encuentra que la difusión espacial del crecimiento económico está relacionada directamente con la distancia, más aún, existe evidencia en favor de la hipótesis de convergencia, encontrando que la distancia entre estados estacionarios es insuficiente para explicar las diferencias en las tasas de crecimiento, sino que también la distancia geográfica importa.

Palabras clave: Crecimiento económico; externalidades; Convergencia espacial.
Clasificación JEL: R11; R12.

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1. Introduction

Regional economic growth is a topic that has attracted increasing attention over the last three decades. One of the early works is Richardson (1973), who studies economic growth at a disaggregated level within a regional framework. Theoretical advances on knowledge interdependence, technological spillovers, and human capital by Arrow (1962); Romer (1986); Lucas (1988); just for mention a few, became the foundations for modern regional analysis.

The underlying idea behind those documents, which combine the so-called engine of growth with the regional approach, is that human or physical capital externalities are transmitted from one region to another, under the fact that territories are not isolated and they interact with one another (Isard, 1960).

Despite a significant number of papers analyzing output and output growth rate from many perspectives in Mexico, no one has pointed out the role of the spatial externalities from capital on output at municipality level. On the other hand, the spatial effects of the economic growth in Mexico is wide covered in the literature using all aggregation levels available, although the role of distance on the dimensions like output or output growth rate is null. The goal of this document is to estimate and to analyze the spatial externalities from capital on output, and the output growth rate diffusion over space. To that end, it is taken the model from Romer (1986) and add elements of the model developed in Vayá et al. (2004) to measure the strength of the spatial externalities from capital on output and the spillover of economic growth for the Mexican municipalities.

The structure of the document is as follows; Section 1 presents relevant literature on the externalities of economic growth. Section 2 describes the theoretical models used to carry out the analysis. The econometric exercise is conducted in Section 3 where the specifications are presented. In Section 4 are presented and discussed the results. The document ends with some concluding remarks and suggestions for future research.

2. Economic growth and spatial externalities

One of the early works addressing spatial effects on economic growth is Bernat (1996). The author evaluates Kaldor's laws for the U.S. economy considering the states as units of analysis. A key assumption is the existence of spatial effects not only in the manufacturing sector but by geographical location as well. The analysis shows clear support for the first two Kaldor's laws and marginal evidence in favor of the third one.

There are factors rooted in the physical space that were virtually ignored by earlier authors who worked on growth and convergence, Rey and Montouri (1999) overcomes this shortcoming. The authors tackle the question of regional income convergence from a spatial econometric perspective. They were pioneers on the analysis of this issue utilizing spatial econometric techniques. Beyond corroborating the convergence hypotheses for U.S. states, they find strong evidence of spatial autocorrelation across states on the economic growth rate. This means that, in the path of economic growth along with the diminishing income gap, states do not exhibit independence from one another, but instead converge like their regional neighbors.

Based on Romer (1986), López-Bazo et. al. (1998) develop a theoretical and empirical model, later extended in Vayá et al. (2004). In this last, the authors take a regional context and decompose the internal and external effects of physical and human capital. They use spatial econometrics techniques to show that intraregional returns on human capital and intraregional returns on physical capital are significant enough to raise the growth rate in an entire region.

Ertur and Koch (2007), on the other hand, study the impact of physical capital externalities at steady states. They develop a spatially augmented Solow model to assess the spatial effects on production and the growth rate. Their results show evidence in favor of conditional convergence. The authors also replicate the exercise for each country in the sample and obtain an individual convergence speed rate; and find evidence that knowledge interdependence generates spatial externalities in neighboring countries. Furthermore, they highlight the relevance of distance and the role that plays when externalities extend over space. They also confirm that the intensity of those externalities declines as the distance between two countries increases. This result is consistent with benefits of agglomeration and the existence of increasing returns.

In the same vein of analysis, Rodríguez-Pose and Villarreal (2015) study the impact of investment on innovation on economic growth in Mexico using states as units of analysis. They find that, although innovation has veered in the right direction in recent years, it is not enough to tow the Mexican economy faster than current levels of growth, which implies the absence of externalities. The analysis shows high concentration of investment in knowledge, but only a few states benefit with this kind of capital flows.

Dall'erba and Llamosas-Rosas (2015) approach the externalities issue by dividing capital into human, private and public to assess its impact on economic growth in the U.S. states. Their approach combines neoclassical, endogenous growth, and new economic geography theories which in the past were considered separately. One of the main findings, among others, is the impact that private capital has on income; which is two or three times higher than public capital.

Recently, Jung and López-Bazo (2017) introduce the absorptive capacity of regions on the capital accumulation and spatial spillovers across economies for the case of Europe. They focus on the externalities derived from the physical and human capital in European regions. Their results confirm that neighborhood matters and find that local externalities lead to economic growth and increase the capacity of the surrounding neighbors.

The literature about spatial externalities and growth for the case of Mexico is scarce. Most of the literature focuses on growth and convergence.[1] The bulk of documents use states as observation unit; hence, the analyses ignore multiple socio-demographic and economic processes at local level and does not necessarily consider factors like regional specialization, planning, and natural resources. One way to overcome these shortcomings is to consider a lower level of data aggregation, like municipalities. At this aggregation level is possible to capture inter-state relationships as well as local productivity characteristics, among other.

Valdivia (2007) for instance, focuses on the growth dynamics of municipalities from 1993 to 2003. He considers the spatial heterogeneity of municipalities which is split into core and periphery categories. His results provide evidence in favor of unconditional convergence between 1993 and 2003. These results are in contrast of the findings in previous works that consider states as unit of analysis like Esquivel (1999) or Ruiz (2000). Carmeño et al. (2009) study manufacturing value added per worker in northbound border municipalities and southbound border U.S. counties. Their results contrast with Validia (2007) as they find divergence. However, it is important address that Carmeño, *et. al.* (2009) focus on a sample of municipalities without considering spatial interactions, whereas Valdivia (2007) employs spatial econometric techniques to capture the spatial dimension.

Recently, Díaz, Fernández, Garduño and Rubiera (2017) show the existence of club convergence in the border municipalities of Mexico, which appear to be associated with Mexico City's loss of competitiveness following the implementation of the North America Foreign Trade Agreement (NAFTA). These authors use a panel data model with a spatial lag to assess the convergence from 1980 to 2010, they conclude that, trade openness has generated regional divergence in the country.

[1] See for example Esquivel (1999), Ruiz (2000), Carrillo (2001), Carmeño (2001), Rodríguez-Benavides, Mendoza-González and Venegas Martínez (2016), Ocegueda (2007), Díaz-Bautista (2008), among others.

Rodríguez-Gámez and Cabrera-Pereyra (2019) develop a study where it is addressed upon the absolute as well as the conditional convergence hypotheses with spatial econometric techniques, using the municipalities as observation unit. These authors find evidence that corroborates the fact that poor municipalities grow faster than rich ones, furthermore, from 2009 to the last, municipalities depend on their own productive characteristics more than spatial interactions for developing, pointing out that, geographic location has become irrelevant for the municipalities' economic growth in recent years.

It is important to recognize that externalities are not randomly distributed in space, these are located and rooted to a specific place (Marshall, 1920) (Muñiz, 1998). Territories obtain benefits from other because of geographic location. Even their position in space plays a role when externalities exist.

A common assumption is that externalities are transmitted to the nearby locations, but, what does 'nearby' mean? Clearly, diffusion of externalities across space is not unlimited, it is reasonable the existence of a distance threshold for their influence. If this were not the case, we would not observe economic activities agglomeration around the world. The same reasoning is true for economic growth; if a territory experiences growth, its closest neighbors shall too.

Based on this rational, it should be the case that, as distance between territories increases, the benefits between them diminish. Hence, nearby territories should be associated with high externality levels, whereas distant territories should be associated with low externality levels. The last, is the underlying hypothesis to test in the present study, the goal is to determine the distance threshold where externalities from capital are present on output among territories and how the output growth rate affects the output growth rate of their neighbors.

3. The model

Consider a production function where output (Y) in territorial units i and time t depends on capital (K), labor (L) and technology (A):

$$Y_{it} = F(K_{it}, A_{it}L_{it}) \tag{1}$$

Notice that technology is an endogenous variable and interacts with labor. Technology is defined as the set of knowledge and skills that workers have developed during their life; therefore, technology is not associated with capital initially, tough, later it is shown that it depends on this factor as well.

The productive factors interact via a Cobb-Douglas function as follows,

$$Y_{it} = F(K_{it}, A_{it}L_{it}) = K_{it}^{\alpha}A_{it}L_{it}^{1-\alpha} \text{ with } 0 < \alpha < 1 \tag{2}$$

Where K is the stock of capital, A is the technology, L is the Labor, subscripts denote territorial unit i and time t. Parameter α represents the share of each productive factor on output.

The diffusion idea comes from Romer (1986, p. 1003) *"the creation of new knowledge by one firm is assumed to have a positive external effect on the production possibilities of other firms"*. But instead firms, territorial units are considered. Technology, which is available in any territorial unit i, is also available in the nearby territories j, because workers move within a geographical area to reach their jobs. Even when they move from one firm to another, they typically do so within the surrounding area. Workers carry knowledge and skills with them. The model description that follows comes from López-Bazo, et. al. (1998) with modifications adapted for the present study.

For a finite number of territorial units which define a neighborhood delimited by a distance, technology is defined as:

$$A_{it} = \Delta k_{it}^{\alpha}A_{jt}^{\rho} \tag{3}$$

In equation (3), Δ represents an exogenous level of technology that may arise from historical accidents (Krugman, 1991), which shifts the direction of economic activity. A_{jt} refers to the technological level in territorial units j and ρ represents the spatial interdependence between territories, this parameter also reflects the strength with which the ups and downs from territorial units *j* impact on a territorial unit *i*. When there is no spatial interdependence, this means that $\rho=0$, then, technology is only determined by its own capital per worker. In summary, equation (3) reflects how the technology depends on its own capital and the neighbors' technology too.

Technology is dynamic, the knowledge and skills change throughout time, they obey the economic dynamics as they are related to capital flow. The stock of capital corresponds to the set of capital flows held in any territorial unit. Therefore, the set of knowledge and skills are equivalent to the capital flows accumulated over the entire time. It is a function of investment *I,* which depends on saving (*s*):

$$A_t = \int_{-\infty}^{t} I(s)ds = K_t \tag{4}$$

Although workers own the knowledge and skills, they are restricted to learning only the required skills for their specific job, e.g. the arrival of a new machine requires the worker to update his knowledge and skills in order to use the machine efficiently. If the machine never arrives, update is unnecessary, "*learning only takes place through the attempt to solve a problem and therefore only takes place during activity"* (Arrow, 1962, p. 155). Given this set up, it is assumed that the technology growth rate is proportional to the capital growth rate per worker for all territorial units:

$$\dot{A}_t = \dot{k}_t \tag{5}$$

When any territorial unit increases, its stock of capital, the capital for neighboring territories also increase, thus, the knowledge and skills available in any territorial unit are also available for all workers.

$$A_{it} = \Delta k_{it} A_{jt}^{\rho} \tag{6}$$

Where $\gamma = \alpha + \eta$, η represents the share on capital from neighbors, considering that every territory *j* has its own η. When $\eta=\rho=0$, i.e. either neighbors' capital is zero or there is no spatial interdependence, the own capital of unit *i* determines the technology level.

Economic activity is not restricted by administrative delimitations, these boundaries are nonexistent to the flows of knowledge whose vehicle is, mainly, the workers. It is, however, restricted by physical capital flows.

To normalize the production function, given in the equation (2), and make the comparison between territorial units reliable, it is multiplied by $1/L$, and rewrite the equation as:

$$y_{it} = A_{it} k_{it}^{\alpha} \tag{7}$$

Where y_{it} and k_{it} are output and capital per worker respectively in the unit *i* in time *t*. Each territorial unit that belongs to the neighborhood has a similar production function which is determined simultaneously, the territorial unit *j* has a production function equal to

$$y_{jt} = A_{jt} k_{jt}^{\eta} \tag{8}$$

Technology is substituted into the production function of the territorial unit *i* to get the next equation:

$$y_{it} = \Delta k_{it} \left[\frac{y_{jt}}{k_{jt}^{\eta}} \right]^{\rho} \tag{9}$$

If this expression is log-linearized, we obtain the steady state level of output,

$$\ln y_{it} = \ln \Delta + \gamma \ln k_{it} + \rho(\ln y_{jt} - \eta \ln k_{jt}) \tag{10}$$

The last function indicates that output depends on the exogenous level of technology, on the physical capital per worker and on the difference between both output and physical capital per worker of the neighbors. Equation (10) allows for the existence of physical capital externalities on output through spatial interaction.

Equation 10, however, is insufficient to evaluate the output growth diffusion over space. To address this shortcoming a growth equation is introduced. Following Vayá, et.al. (2004) Consider a Solow-Swan's fundamental equation in expression (7) and assume that $\dot{A} = \dot{k}$. The result is equation (11) which is appropriate to estimate the variation of physical capital in territorial unit i

$$\dot{k}_i = s\Delta k_i \, k_j^{\rho} - (d+n)k_i \tag{11}$$

Where d and n are the depreciation and population growth rates respectively. Notice that physical capital variation is a function of capital per worker in territorial unit i and capital per worker in neighboring territorial units j. Thus, the growth rate of capital accumulation in unit i is as follows

$$\frac{\dot{k}_i}{k_i} = s\Delta k_i^{-(1- \;)} k_j^{\rho} - (d+n) \tag{12}$$

To obtain the rate of capital accumulation throughout the economic growth path, consider that, at any point in time, all units that belong to a neighborhood have the same rate, i.e., all territorial units behave at any point in time as one. At this point, all units of the neighborhood share the same growth rate. In the long run, territorial units conform a larger territorial unit, as actually happens on the composition of metropolitan areas where administrative boundaries are irrelevant for interactions. This implies that territorial units adhere to the dynamics where positive and negative exogenous shocks affect all units in the same way, therefore, it is plausible that in the long run all the territorial units accumulate physical capital at the same rate, formally, $k_i^* = k_j^* = k^*$. Moreover,

$$g_k \quad \frac{\dot{k}}{k} = s\Delta k^{-(1-(\gamma+\rho))} - (d+n) \tag{13}$$

The rate of capital accumulation is a decreasing function of capital per worker. The magnitude of the rate depends on how far a given unit is from the steady state. That is, in the territorial units with low capital levels, capital is accumulated at higher rates. Furthermore, it depends positively on the saving rate which in this case is assumed exogenous for simplicity. The accumulation process follows a dynamic that makes sense when territorial units interact across space. In fact, it is expected that territorial units with low capital levels, if they are isolated in space, show low accumulation rates, so that, space and neighborhood matter.

From (13) it is easy to obtain the level of the stock of capital for the neighborhood. As in Sala-i-Martin (2000) it is assumed that in steady state $g_k = 0$. It is substituted the result into the production function to obtain:

$$\ln y_{it} = \left(\frac{1-\rho+\eta}{1-(\gamma+\rho)}\right)\ln\Delta + \left(\frac{\gamma+\eta}{1-(\gamma+\rho)}\right)\ln s - \left(\frac{\gamma+\eta}{1-(\gamma+\rho)}\right)\ln(d+n) + \rho\ln y_{jt} \tag{14}$$

Equation 12 log-linearized around $\ln k_i^*$ leads to the next expression:

$$g_k = (1-\gamma)s\Delta e^{-(1- \;)\ln k^*}(\ln k^* - \ln k_{i0}) \tag{15}$$

In a steady state $s\Delta e^{-(1- \;)\ln k_{i0}} = (d+n)$, such that, equation 15 can be rewritten,

$$g_k = (1-\gamma)(d+n)(\ln k^* - \ln k_{i0}) \tag{16}$$

Then $\beta = -\frac{\partial g_k}{\partial \ln k_i} = (1-\gamma)(d+n)$, which is the classical speed of convergence. In the steady state, if endogenous variables growth at the same rate, then equation (16) can be rewritten as:

$$\ln y_{it} = \left(1 - e^{-\beta t}\right) \ln y^* + e^{-\beta t} \ln y_{i0} \quad (17)$$

From equation (14) and (17) the following expression is defined:

$$\psi = (1 - e^{-\beta t}) \left[\left(\frac{1-\rho+\eta}{1-(\gamma+\rho)} \right) \ln \Delta + \left(\frac{\gamma+\eta}{1-(\gamma+\rho)} \right) \ln s - \left(\frac{\gamma+\eta}{1-(\gamma+\rho)} \right) \ln(d+n) \right] \quad (18)$$

Ertur and Koch (2006, p. 5) assume that all territories have the same steady state and the difference between territories is captured by θ such that,

$$\ln y_{it} - \ln y_{i0} = \theta(\ln y_{jt} - \ln y_{j0}) \quad (19)$$

Where θ is the spatial interdependence between the growth rates on territorial units within a neighborhood. Combining (17), (18) and (19), the next growth equation is obtained,

$$(\ln y_{it} - \ln y_{i0}) = \psi - \left(1 - e^{-\beta t}\right) \ln y_{i0} + \left(1 - e^{-\beta t}\right) \rho \left(\ln y_{jt} - \ln y_{j0}\right) + \left(1 - e^{-\beta t}\right) \theta \ln y_{j0} \quad (20)$$

This expression implies that the average growth rate in the long run on territorial unit i depends on starting level of output, on the growth rate of neighbors and the starting level of output of neighbors.

4. Empirical models

Consider equations (10) and (20) as the base models. The first model captures the externalities diffusion on output and determines a distance threshold where they are significant. The second model is a growth equation used to test the convergence hypothesis.

Both theoretical models are consistent with a Spatial Durbin Model (SDM) structure. The SDM is an extension of the Spatial Autoregressive model (SAR) whose general form is as follows (LeSage & Pace, 2009). The SDM model used is as follows:

$$y = \rho W y + \alpha \iota_n + X\beta + WX\gamma + \varepsilon \quad (21)$$

This model includes spatial lags of the explanatory variables as well as the dependent variable and can be estimated with panel data. This specification solves the bias problem of omitted variables and allows for the inclusion of explanatory variables spatially lagged.

The econometric specification to measure the threshold distance of externalities on output is based on equation (10), which is the production function log linearized. The equation includes factors that reflect the heterogeneity between territorial units and elements associated with time shocks in the territorial units. These shocks may be interpreted as changes in public policy, and economic crises, among others. The econometric model specification is,

$$\ln y_{it} = c_i + \gamma \ln k_{it} + \rho\left(w_{ij}^r \ln y_{jt} - \eta w_{ij}^r \ln k_{jt}\right) + \delta_t + \varepsilon_{it} \quad (22)$$

Where ε_{it} is an idiosyncratic error $N(0, I\sigma^2)$. The equation shows how output in territorial unit *i* depends on its own capital, and on both output and capital on territorial units *j* within a neighborhood. The element w_{ij}^r is the spatial weight matrix, whose composition and role are explained below.

From equation (20) the next regression is specified:

$$g_y \quad \ln\left(\frac{y_{it}}{y_{it-1}}\right) = c_i - \left(1 - e^{-\beta}\right) \ln y_{it-1} + \rho w_{ij}^r \ln\left(\frac{y_{jt}}{y_{jt-1}}\right) + \theta\left(1 - e^{-\beta}\right) w_{ij}^r \ln y_{jt-1} + \varepsilon_{it} \quad (23)$$

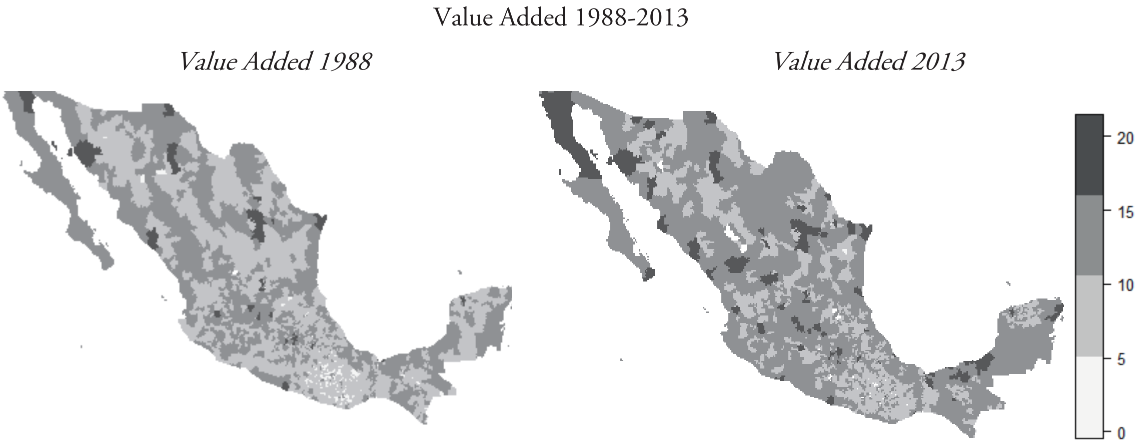
Where, g_y is the output growth rate per worker between year *t* and year *t-1*. In the production function, the terms $w_{ij}^r \ln\left(\frac{y_{jt}}{y_{j0}}\right)$ and $w_{ij}^r \ln y_{j0}$ are spatial lag variables. Notice that, the first two elements on the right side of equation (23) are the same as in the traditional convergence regression. In this study are included two more variables spatially lagged to assess the economic growth not only from the starting level of output but considering the growth rate of neighbors, as well as their starting level of output.

3.1. Data

The analysis considers the municipality level, since the spatial interactions between them ignore the state boundaries and capture accurately the dynamics of regional economies. Ideally, the empirical exercise would include the Gross Domestic Product (GDP) as a measure of output. However, GDP is not calculated at the municipal level. Following the empirical literature for the case of Mexico, Carmeño et al. (2009); Baylis, Garduño-Rivera and Piras (2012), among others, it is used the Gross Value Added (Y) as a proxy of output. Fixed-Capital Gross Formation (K) is used as a measure of capital. Total Employed Population (L) is the variable for population. These three variables are available in the economic census provided by the National Institute of Statistics and Geography (INEGI acronym in Spanish) with a periodicity gap of five years. The oldest economic census that may be compared with the preceding one is from 1989, and the most recent is from 2014. Each one contains information about one year before its publication, thus, the 1989 census contains information from 1988 and so on. The number of municipalities in the last census is 2,457, thus the sample size is 14,742 for the output equation and 12,285 for the growth equation.

The maps in figure 1 show the spatial distribution of the logarithm of the real value added in 1988 (left) and 2013 (right) for 2,457 municipalities. Some territories in the north and in the northwest shifted to a higher value added. Territories in the south, mainly in the state of Oaxaca, show no changes over time. Overall, there are more municipalities with higher value added in the north than in the south. Some outliers in the south like Campeche, Villahermosa, Coatzacoalcos, that belong to the states of Campeche, Tabasco and Veracruz respectively, show a high value added, however, it should be notice that these municipalities/states concentrate activities related to the oil extraction.

Figure 1.
Spatial distribution of Gross Value Added in 1988 and 2013



Source: Author's own elaboration with data from INEGI, 1989, 2014.

Notice, however, that there is a scale effect due to the size of municipalities, northern municipalities are bigger than southern municipalities. In order to more accurately compare municipalities, a relative measure should be used such as output per worker. Graphs in Figure 2 show this variable. In 1988, value added per worker is concentrated in the northwest, in municipalities that belong to the states of Baja California and Sonora, some other municipalities in states like Nuevo León and Tamaulipas. Overall, there are clear differences between northern and southern municipalities. Historically, low income municipalities are primarily located in the south (Chiquiar, 2005). This condition appears to worsen since the signing of the NAFTA, which arguably benefited northbound territories, in 2013 northern municipalities increase their presence with a higher value added per worker, whereas southern municipalities remain in the lower side of the distribution.

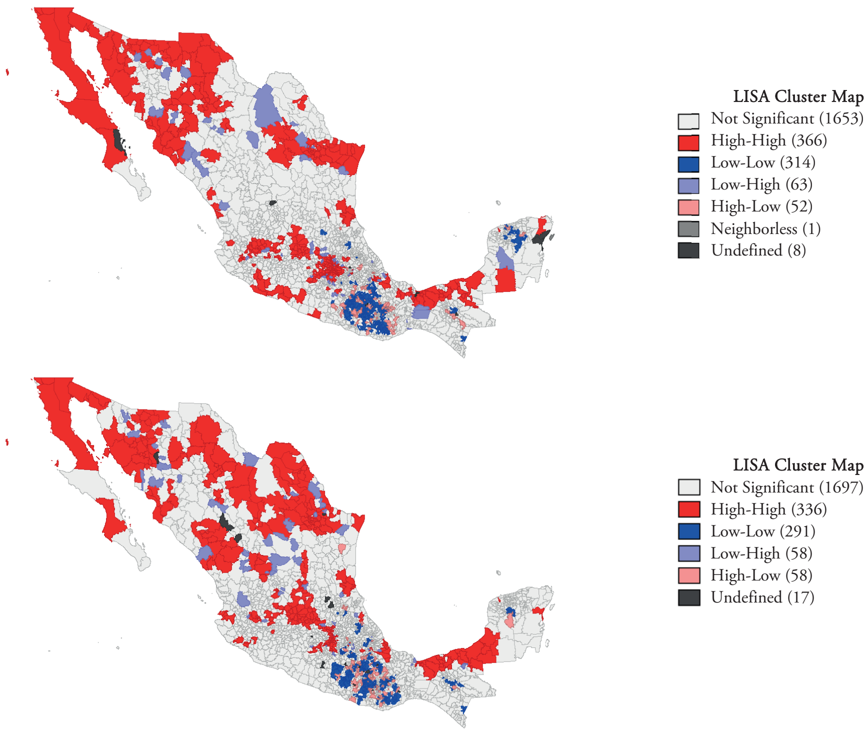
FIGURE 2.
Spatial Distribution of Gross Value Added per worker in 1988 and 2013

Value Added per worker 1988-2013

Value Added per worker 1988 *Value Added per worker2013*

Source: Author's own elaboration with data from INEGI, 1989, 2014.

FIGURE 3.
LISA cluster maps of Value Added per worker, 1988-2013



Note: This analysis is performed with a first order contiguity spatial weight matrix.
Source: Author's own estimation with data from INEGI, 1989, 2014.

In addition, in figure 3 are shown two maps that reflect the cluster formation of the value added per worker in 1988 and 2013. These maps strengthen the statement about the differences between northern and southern municipalities. There is a clear and significant formation of clusters of rich municipalities in the north and in the center of the country, whereas in the south, municipalities that chiefly belong to Guerrero and Oaxaca remain in the Low-Low quadrant, which means that those municipalities have a value added per worker below the average and surrounded by municipalities with value added per worker below the average[2]. It must be addressed that in early 80's the country started a process of economic liberalization where the international trade stand as an engine of the economy. This process benefited the northern territories simply by their geographic location (Aroca, Bosch, & Maloney, 2005).

Regarding output growth, maps in Figure 4 show how the value added (left) and the value added per worker (right) grew between 1988 and 2013. There is no clear pattern on the spatial distribution of the growth rate at levels or per worker, the prompter increased from one period to another along many municipalities, however the growth of output per worker is around zero, just a few municipalities located in the north grew along with some others located in the states of Campeche and Tabasco, perhaps those specialized in the oil industry.

FIGURE 4.
Output growth and output growth per worker between 1988 and 2013

Growth of GVA and GVA per worker 1988-2013

Growth of GVA *Growth of GVA per worker*

Source: Author's own elaboration with data from INEGI, 1989, 2014.

3.2. Spatial Weight Matrix

A key step in spatial econometrics is to determine the spatial weight matrix (Anselin, 1988). As previously indicated, the interest of this work is to find the distance threshold where externalities from capital on output, as well as the output growth rate, are spread out over space. Hence, the model specification must also include a feature that allows to accomplish this purpose.

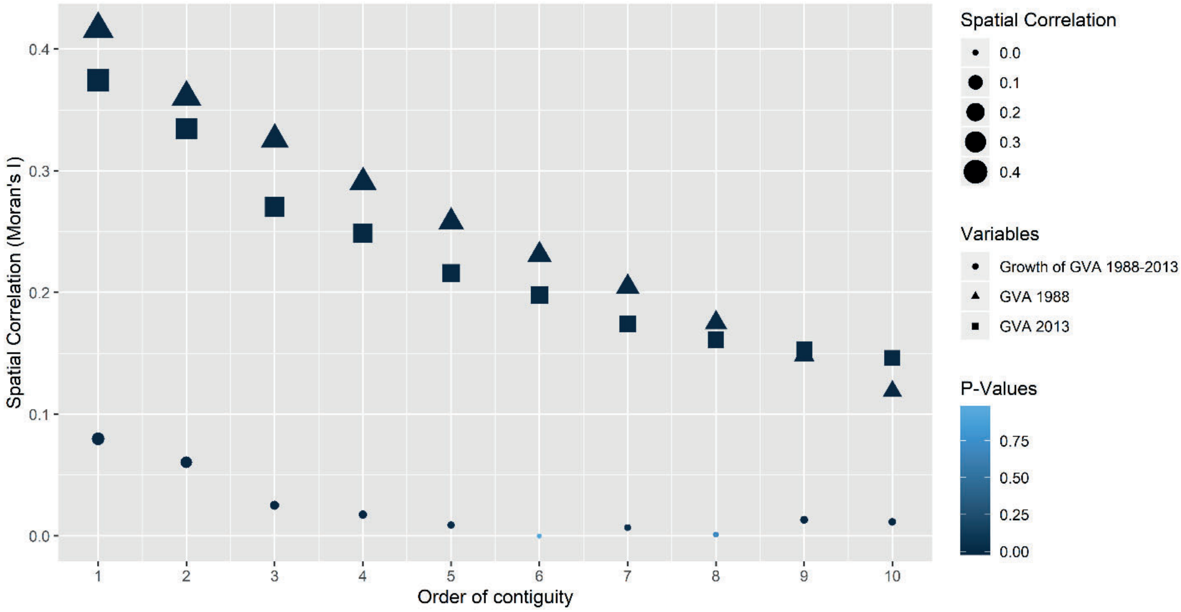
Before to define the spatial weight matrices, the spatial correlation is computed in order to address the spatial behavior of the dependent variables. To accomplish this purpose, it is performed the spatial correlogram through the Moran's Index using high-order contiguity spatial weight matrices.

In figure 5 is shown the spatial correlogram for the GVA per worker in 1988 and 2013, and for the growth of the GVA 1988-2013. The spatial correlation of the GVA in both years decreases as higher order contiguity is considered, however, these are statistically significant at 1% for all order contiguity.

[2] For a wider explanation about the meaning of the quadrants, see Anselin, (1995).

The spatial correlation of the GVA growth rate is below 0.1 for a first order contiguity and decreases from that point to the last. It is statistically insignificant for both sixth and eighth order.

FIGURE 5.
Spatial Correlation of GVA 1988, 2013 and Growth of GVA 1988-2013, for high-order contiguity spatial weight matrices



Source: Author's own estimation with data from INEGI, 1989, 2014.

As spatial correlation persists even for the tenth order of contiguity, there are delimited the distances that captures the spatial structure, let $r = \{20,60,100,140,180,220,260,300\}$ a collection of positive integers that define a distance threshold measured in kilometers[3]. The selection of every distance is arbitrary, however, in table 1 is shown a non-parametric test of spatial correlation considering the distance. Since the southern-central region of the country is highly interconnected, and municipalities are quite close to each other. Considering 20 or 60 km is enough to travel from one place to another; and two or more large or medium cities may be encompassed within that distance. The same cannot be argued for the northern region. Distinctive trends during the development of northern Mexico resulted in differences in the spatial structure. Territories are more spread out as well as distant from each other. Medium and large cities are generally far away as well, 20 or even 60 km is not enough to connect two medium or large cities, therefore a longer distance must be considered. In fact, Arbia (2014) identifies empirically a threshold distance of 380 km where spatial dependence takes place.

Most of the studies that use a spatial weight matrix based on distance, and the municipality is the observation unit, determine the elements of the matrix considering the euclidean distance between centroids of the municipalities, nevertheless, most of the times, these centroids are in the middle of nowhere. For instance, the centroid of Ensenada municipality is 300 km away from the city town (Ensenada) and relies in the middle of the desert. Overall, centroids of municipalities are unmatching with cities, reducing the accurate of the spatial structure represented in the spatial weight matrix. In order to improve the representation of the spatial structure, in this study are taken localities[4] instead of municipalities, only to create the spatial weight matrices. For every municipality, there is a main locality

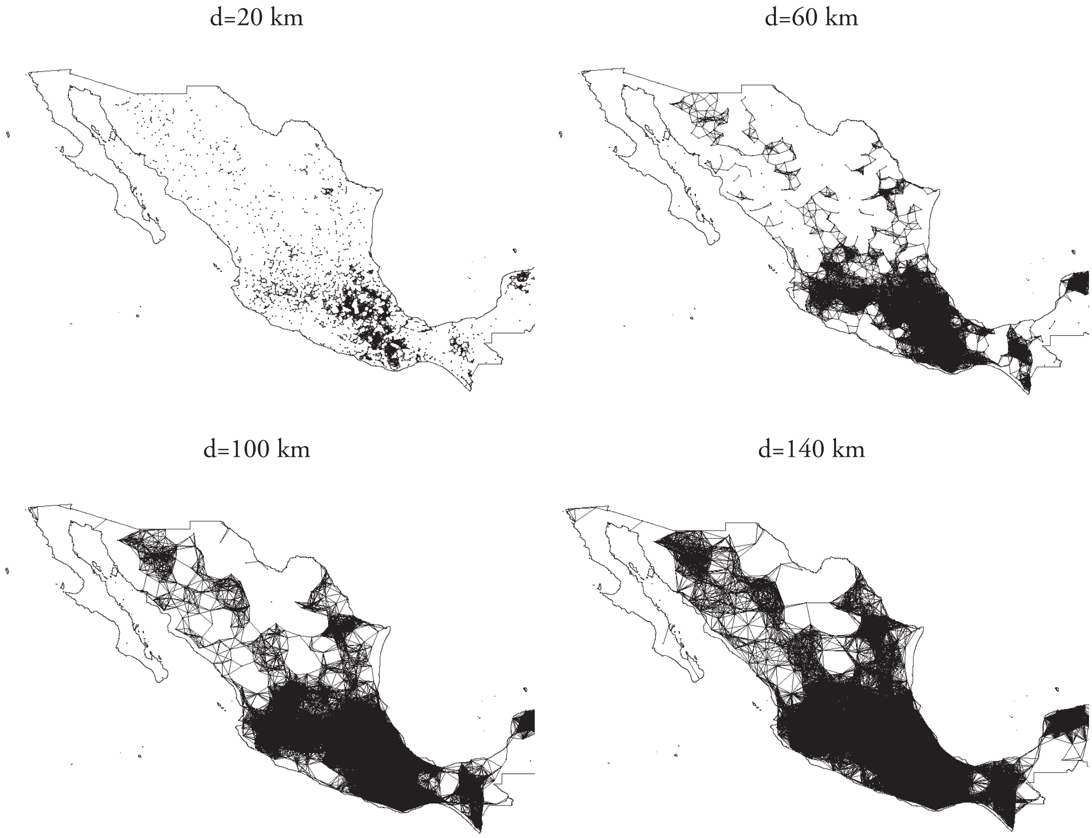
[3] It is used the distance in kilometers, not the euclidean distance.
[4] Localities are more disaggregated than municipality.

that match with the name of the municipality and in the 99% of the cases are urban areas (the main urban area). Choosing localities for creating the spatial weight matrices has two advantages over choosing municipalities 1) increases the accurate in the spatial structure and 2) justifies, *per se,* the using of the distance instead of contiguity as neighboring criteria, due to that localities are not contiguous[5].

Thus, the elements of the spatial weight matrices are defined by $w_{ij} = 1$ if $d_{ij} \leq r$ and $w_{ij} = 0$ if $d_{ij} > r$, Every matrix is row-standardized dividing its element by the row-sum.

The following maps show the spatial weight matrices representation for all distances considered in this work. The first map corresponds to threshold distance of 20 km. The connections between territories is scarce, this matrix just captures interactions between territories in the center of the country, mainly around Mexico City. Also, most of municipalities in Oaxaca are included because they are smaller than those located in other states.[6] The 60 km threshold distance map shows more connections between territories, most municipalities from the southern-central fraction of the country are interacting with each other. Some interrelations in northwestern and northeastern areas are captured with this spatial weight matrix.

FIGURE 6.
Distance-based matrix representations



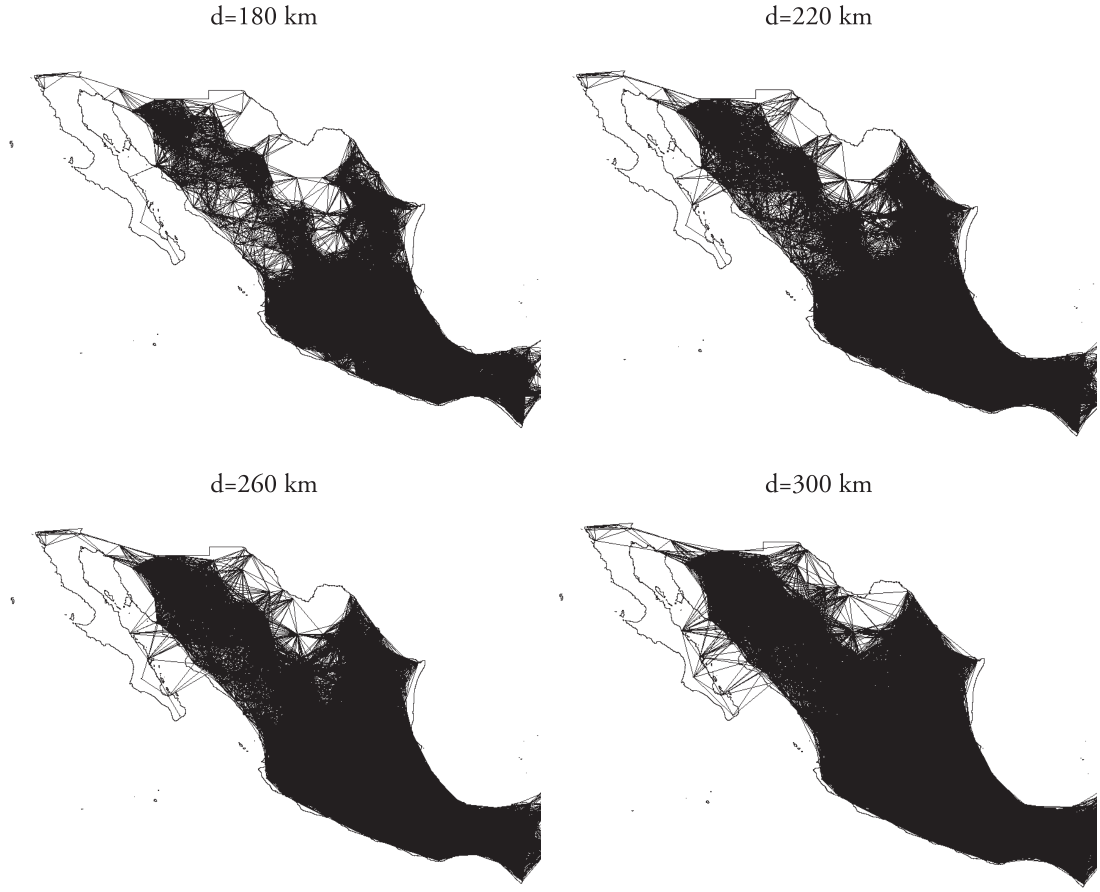
Source: Own elaboration.

The maps in Figure 7 illustrate the spatial weight matrix representations when distance is equal to 180, 220, 260 and 300 km. Notice that most of the municipalities are connected, as distance increases

[5] Data and analysis are still carried out by municipality.
[6] Oaxaca state owns 547 municipalities of 2,457 overall.

the number of interactions does as well. After 220 km, the whole country is connected but the number of links in the north is less than in the southern-central region; while distance increases, municipalities in the north are more connected. Also, after this distance the spatial autocorrelation becomes zero according with the test shown in table 1.

FIGURE 7.
Distance-based matrix representations



Source: Own elaboration.

The distance threshold of 300 km shows municipalities' wide connectivity which is not consistent with empirical evidence, given the number of interactions that each municipality has with others. Nonetheless, it is necessary to use this matrix for empirical work so that results with shorter distances in the matrices may be compared.

5. RESULTS

In a first step, it is performed the Lagrange Multiplier test upon the equations without spatially lagged variables to determine if there is evidence of spatial dependence. The Conditional Lagrange Multiplier (CLM) tests presented in table 1 are developed in Baltagi, Song and Koh (2003). One of these tests performs the null hypothesis that $\lambda = 0$, against the alternative that there is spatial autocorrelation. For all regressions, the null hypothesis is confidently rejected at 1% of significance, which shows evidence in favor of spatial autocorrelation. On the other hand, the second CLM test works under the alternative hypothesis that there are regional random effects (RRE) where the null hypothesis is that μ = 0. In this case, for all regressions the null hypothesis is rejected, thus, the alternative becomes true.

Following these criteria, RRE should be the most efficient assumption to carry out the estimations, however, the Spatial Hausman test (Mutl & Pfaffermayr, 2011) shows a contrary evidence. Following the Spatial Hausman test, alongside the assumption that there is an arbitrary correlation between c_i and the explanatory variables because there is an unobservable heterogeneity for each municipality that makes it unique in the sample, spatial fixed effects are the best option for estimating the equations.

For the output equation, which results are shown in table 1, time dummy variables are included to control for exogenous shocks that affect all municipalities in a similar manner[7]. They capture, for instance, the crisis effect during 2008, the coefficient associated to the dummy variable for 2008 at a distance threshold of 20 km suggests that expected output in this year is 10% less than in 1988, holding constant all other factors. Only for 1998 there is no statistical significance of any coefficient for any distance threshold. A relationship between time and space is found because dummy variables are statistically significant over short distances, beyond 140 km there is no evidence for exogenous shock related to time.

For all regressions, there is evidence of spatial dependence captured by the coefficient associated to the spatially lagged variable W ln y, this coefficient measures the global externalities in the neighborhood. The strength of global externalities from the output increases from 0.122 at 20 km to 0.530 at 300 km, also it is statistically significant at 1%. The spatial dependence coefficient indicates that the global externalities increase along with the distance. As the coefficient is increasing, it implies that production is highly concentrated in a few municipalities because every distance threshold considers more municipalities in the neighborhood, thus, when neighbors increase their production, it is not randomly distributed over space, but it follows a spatial pattern.

The coefficients of the variable $\ln k$ and its spatial lag shown in table 1 must not be interpreted because there are effects that are not part of the spatial interaction. A change in a single observation associated with any explanatory variable will affect the region itself (direct impact) and potentially affect all other regions indirectly (indirect impact) (LeSage & Pace, 2009). Thus, direct impact is a non-spatial effect, while indirect impact is the spatial effect or the spillover effect. These two effects are computed following the method proposed by LeSage and Pace (2009) and presented in Table 2.

In the same table 2 is reported the indirect impact, which represents the spatial diffusion or the spillover effect of capital on output. In contrast with the direct impact, indirect impact increases along with the distance. It is 0.015 for 20 km and it could be considered as weak effect relatively to the total effect. Total effect for 20 km is 0.125, where indirect effect represents 12%. The share of the indirect impact increases along with the distance as well, at 220 km it represents 49% of total effect. Beyond 220 km, indirect impact is higher than direct impact, also it represents more than 50% of the total effect.

The behavior of the indirect impact suggests that distant municipalities generate more externalities than closer ones. However, due to that capital is highly concentrated in a few municipalities, those that are closer compete each other for capital flows instead of mutually benefit, thus, distant municipalities do not represent a hazard for the capital flows on those municipalities located far away.

All impacts are statistically significant at 1%. It must be addressed that for 20, 60 and 180 km there is a very small feedback effect, 0.001, whereas for the rest of distances, there is none. Except for 180 km, it is reasonable that for short distances like 20 and 60 km a feedback effect is found, due to the geographic proximity that increase interaction among municipalities.

The direct impact is the effect of capital on municipality's itself output, it is 0.110 for every distance threshold and it is statistically significant at 1%. This effect is independent on the distance and on the number of neighbors.

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[7] The model also was computed including a trend variable instead of year dummies, however, the last shown a better fit, based on AIC criteria.

Table 1.
Results from output regressions

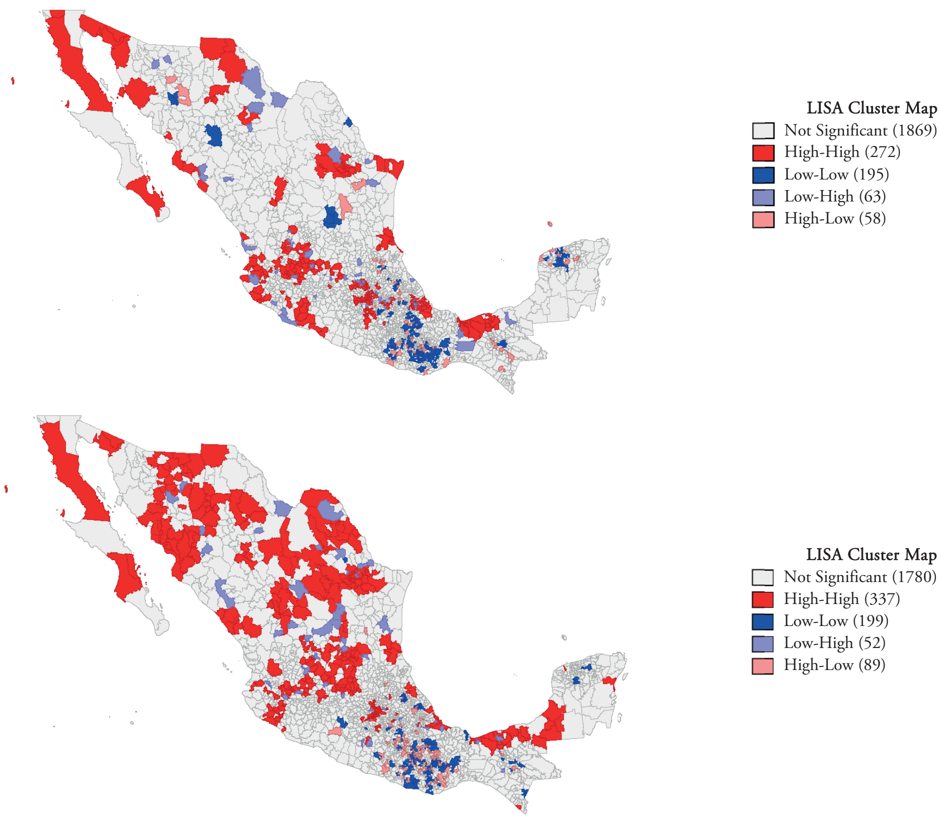
Variable	20km ln y	60km ln y	100km ln y	140km ln y	180km ln y	220km ln y	260km ln y	300km ln y
ln k	0.109***	0.109***	0.110***	0.110***	0.109***	0.110***	0.110***	0.110***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Wln y	0.122***	0.246***	0.339***	0.392***	0.477***	0.495***	0.528***	0.530***
	(0.011)	(0.020)	(0.028)	(0.034)	(0.039)	(0.044)	(0.048)	(0.053)
Wln k	-0.003	-0.006	-0.037**	-0.030	-0.022	-0.036	-0.040	-0.052
	(0.007)	(0.012)	(0.017)	(0.021)	(0.025)	(0.028)	(0.029)	(0.031)
1993	-0.080***	-0.060***	-0.064***	-0.049**	-0.028	-0.034	-0.032	-0.039
	(0.017)	(0.018)	(0.020)	(0.021)	(0.023)	(0.024)	(0.025)	(0.026)
1998	-0.005	0.008	-0.008	0.003	0.020	0.009	0.009	0.000
	(0.017)	(0.019)	(0.022)	(0.024)	(0.027)	(0.028)	(0.030)	(0.031)
2003	0.050***	0.052***	0.032	0.039	0.048	0.036	0.033	0.024
	(0.017)	(0.019)	(0.022)	(0.024)	(0.026)	(0.027)	(0.029)	(0.030)
2008	-0.100***	-0.069***	-0.082***	-0.062**	-0.030	-0.042	-0.038	-0.049
	(0.018)	(0.021)	(0.026)	(0.029)	(0.032)	(0.035)	(0.037)	(0.039)
2013	0.054***	0.060***	0.034	0.044	0.058	0.043	0.041	0.029
	(0.018)	(0.021)	(0.025)	(0.029)	(0.032)	(0.035)	(0.036)	(0.038)
Standard errors in parentheses p<0.01 ***, p<0.05 ***, p<0.1 *								
N	14,742	14,742	14,742	14,742	14,742	14,742	14,742	14,742
AIC	25,051	25,004	25,024	25,039	25,030	25,055	25,065	25,084
Sp Hausman	3989.8	620.97	3164.1	1053.5	1377.1	1487.5	1529.6	1494.3
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CLM test (λ)	11.287	15.485	16.987	17.477	19.621	19.397	19.227	18.494
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CLM test (μ)	53.560	57.743	60.761	59.278	60.502	62.772	64.378	65.590
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 2.
Direct and indirect impacts from output regressions

		20 km	60 km	100 km	140 km	180 km	220 km	260 km	300 km
Direct	ln k	0.110	0.110	0.111	0.110	0.110	0.110	0.110	0.110
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Indirect	ln k	0.015	0.035	0.056	0.070	0.099	0.107	0.122	0.124
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	ln k	0.125	0.145	0.167	0.181	0.209	0.217	0.232	0.234
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

In the next maps are shown the spatial association of capital per worker in 1988 and 2013. Capital per worker in 1988 is scatter over the country, just a few clusters are detected around the main metropolitan areas like Guadalajara, Mexico City, Monterrey, and some others in the north, nevertheless, in 2013, there are no clusters yet in the south of the country, chiefly in municipalities that belong to the states of Chiapas, Guerrero, Michoacán, Oaxaca, whereas there are several cluster identified in the north and in the middle of the country.

FIGURE 8.
LISA cluster maps of capital per worker, 1988-2013



Note: This analysis is performed with a first order contiguity spatial weight matrix.
Source: Author's own estimation with data from INEGI, 1989-2014.

Also, the map shown in figure 8 helps to explain a high indirect impact at long distances; shorten distances are common in the south of the country, spatial weight matrices for 20 and 60 km show high connection among southern, southern-center municipalities. At these distances the externalities from capital on output are weak and the explanation comes from the fact that many municipalities in the south highlight in the spatial structure. On the other hand, externalities from capital on output are higher at long distances because the northern municipalities play a more relevant role in the sample when longer distances are considered, and a higher indirect impact is obtained. Notice that feedback effect is found at 20, 60 and 180 km, even though this effect is very small, shows that southern and southern-center municipalities are more interconnected than northern ones. The northern municipalities should interact each other less than southern ones, due to that they are farther away each other, also, their economic dynamics obey to the U.S. economy more than the national, because main economic activities in northern municipalities are linked to the international trade.

The results of estimating equation (23) are presented in table 4, the dependent variable is the municipalities' output growth rate. Based on CLM test, only for distance threshold of 20, 100 and 140 km, RRE would constitute the best assumption for estimating these equations, however, following Spatial Hausman test, spatial fixed effects become a better option. In the rest of equations, CLM test shows evidence against RRE, such that, the estimation is following spatial fixed effects assumptions.

The coefficient associated with the dependent variable spatially lagged, Wg_y, measures the spatial dependence of the growth rates on municipalities. It also computes the degree to which the growth rate of the municipality *j* impacts the growth rate of neighbors. This coefficient is monotonically increasing with the distance. Its range of values is from 0.139 for 20 km to 0.656 for 300 km and it is significant at 1% in all cases. This means that economic growth is highly concentrated in a few municipalities as well as the production does, when the output growth rate increases, spatially speaking, the increasing is not randomly distributed. As distance increases, a higher dependence between municipalities' growth rate is expected, the ups and downs in the growth rate in *j* impact the ups and downs in the growth rate of *i*. In comparison with the results of table 2, the spatial dependence on output growth rate is stronger than the spatial dependence on output, this is explained by the lack of externalities from capital. Municipalities may depend each other to grow, a municipality with high share of capital and high productivity levels, drags surround municipalities, maybe with complementary activities or secondary activities, however, the lack of externalities from capital implies that it keeps concentrating in the same territories, instead of spread out to others.

Just as for the results in Table 1, there are computed the direct and indirect impacts for the last set of regressions. The results are shown in table 4. Following the same reasoning, direct impact is the effect of the initial level of production of a municipality on its own output growth rate, it is independent on the distance and on the number of neighbors, also it is statistically significant at 1%. Direct impact is the coefficient that reflects the classical speed of convergence. These effects are quite similar to some of the convergence coefficients obtained in Rodríguez-Benavides, López-Herrera and Mendoza-González (2016) through a different methodology than the presented here.

Indirect impact is the spatial effect of starting level of production of neighbors *j* on *i*'s output growth rate. It shows a negative relationship between those variables. The first implication without considering distance, is that municipalities with low production per worker in a previous year caused higher growth rates on neighbors during that period. Conversely, high output per worker in the first period imply low growth rates on neighbors.

Moreover, indirect impact is different for each distance threshold, whereas for 20 km is -0.163, for 300 km is -2.010, this effect is also increasing along with the distance. The implication of this result is that, the negative relationship between starting level of output and output growth rate holds anywhere, however, closer municipalities are likely to have the same output growth rate with respect to those located farther away, in other words, there are higher differences in growth rates among far away municipalities than closer ones. Not only the gap between output levels matters for explaining the difference in growth rates, but spatial location matters as well.

TABLE 3.
Results from growth regressions

Variable	20 km gy	60 km gy	100 km gy	140 km gy	180 km gy	220 km gy	260 km gy	300 km gy
W gy	0.139***	0.281***	0.419***	0.484***	0.563***	0.589***	0.642***	0.656***
	(0.012)	(0.021)	(0.028)	(0.033)	(0.037)	(0.042)	(0.043)	(0.046)
ln y	-1.064***	-1.062***	-1.060***	-1.058***	-1.057***	-1.057***	-1.057***	-1.057***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
W ln y	0.115***	0.230***	0.345***	0.391***	0.481***	0.520***	0.591***	0.594***
	(0.021)	(0.034)	(0.046)	(0.055)	(0.062)	(0.067)	(0.069)	(0.075)
				Standard errors in parentheses				
				p<0.01 ***, p<0.05 ***, p<0.1 *				
N	12,285	12,285	12,285	12,285	12,285	12,285	12,285	12,285
AIC	20,032	19,962	19,919	19,916	19,900	19,920	19,912	19,925
Sp Hausmn	18,076		1,402,385	303,242				
p-value	0.000		0.000	0.000				
CLM test (λ)	23.151	36.306	47.561	57.129	69.027	75.776	81.437	86.487
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CLM test (μ)	2.353	1.552	3.147	2.223	1.731	1.526	1.117	0.567
p-value	0.019	0.121	0.002	0.026	0.084	0.127	0.264	0.571

TABLE 4.
Direct and Indirect impacts of lny0

		20 km	60 km	100 km	140 km	180 km	220 km	260 km	300 km
Direct	ln y0	-1.074	-1.074	-1.073	-1.069	-1.067	-1.065	-1.066	-1.064
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Indirect	ln y0	-0.163	-0.402	-0.752	-0.981	-1.350	-1.506	-1.887	-2.010
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	ln y0	-1.237	-1.476	-1.824	-2.050	-2.417	-2.572	-2.953	-3.075
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

This is evidence in favor of the convergence hypothesis that considers more than just differences in stationary states. In this case, this additional factor considered is the geographical distance between municipalities. Clearly, the indirect impacts show a spatial speed of convergence, at the same time, there is evidence in favor of the existence of increasing returns to scale. This also corroborates the fact that economic activity tends to concentrate instead of spreading out over space.

6. Concluding remarks and further directions

This work corroborates the existence of spatial externalities from physical capital on output in the Mexican municipalities, however, these externalities are weak for municipalities that are close each other. The weak and the lack of externalities is also evidence of a high concentration of capital and output in a few territories.

The lack of externalities from capital at short distances chiefly occurs among southern municipalities, this reflects the possible existence of physical and institutional barriers that avoid those territories to grow. It reflects even the lack of good policies that allow those territories to catch up the most advanced ones, because these municipalities have the disadvantage of be located far from the northbound. There are no changes along 25 years of the analysis, southern municipalities stay in the same relative position when a cluster analysis is performed, these municipalities remain with output levels below the average, surrounded by municipalities with output levels below the average. In this sense, local and regional development policies could help those territories let behind their lack of externalities. These policies could focus on redirect the capital flows through infrastructure development in municipalities with low capital per worker but with high potential for production and distribution of goods and services. These policies also must be focused on local characteristics of the municipalities, it should be able to remove physical and institutional barriers that block the development process, for instance, more spend on railways, roads, airports and seaports are obvious recommendations, however, spend on education and health have positive effects on economic growth (Fonseca, Gómez-Saldívar, & Ventosa-Santaularia, 2019). These policies also should seek the regional integration alongside the trade agreements as attempt to reduce the disparities among municipalities (Baylis, Garduño-Rivera, & Piras, 2012); (Asuad & Quintana, 2010); (Carrion-i-Silvestre & German-Soto, 2009).

In order to remove institutional barriers, more autonomy to the mayoralties would improve the capabilities to take decisions to solve local problems based on local characteristics. From the fiscal policy approach, an effort could be made through preferential taxes in municipalities potentially growing, it generates incentives to the capital to flow to those places instead of traditional ones. Policies in this direction may be aggressive for those municipalities that traditionally receive capital flows, however, it must be considered that externalities arise from other sources rather than physical capital, like human capital, which generates strong spatial externalities, as mentioned by Ertur and Koch (2006); Dall'erba and Llamosas-Rosas (2015).

Redirect flows is a feasible option to allow the capital arrival to the less favored places in the process of increasing openness. At the same time, this issue points to a possible extension of the present work, where human capital could be considered, however, the lack of information may restrict this type of study because this information is not available at disaggregated level such as municipality, hence, a state level approach would be feasible. Evenmore, the physical capital may be split into private and public to determine which one generates more externalities over space, such as Dall'erba and Llamosas-Rosas (2015); Fonseca, Gómez-Zaldívar and Ventosa-Santaularia (2019) point out.

Another growth dimension assessment in this works is the so-called convergence hypothesis which is linked with that described in the last paragraphs, the underlying idea of convergence hypothesis is that differences between *per cápita* output of economies tend to vanish in the long-term. Externalities are by themselves a catalyst for convergence, while territories generate benefits to their neighbors, those trailing in last place could catch up the more advanced ones. Most of the research about convergence just considers steady state distances, ensuring that poor economies grow faster than rich ones, furthermore, the conditional convergence indicates that each economy has an own steady state, and they converge on this steady state. However, in this work the test carried out also considers the physical distance between territories, this may be considered a spatial speed of convergence, because closer territories have similar growth rates to each other, relative to those located farther away, whose rates of growth are different.

The assumptions of decreasing returns on production factors and constant returns to scale, implicitly ensure that the capital factor flows from rich territories toward poor ones, an argument against the last affirmation is that, in the world, agglomerations are observed, in consequence, the statement is not consistent with reality, however, in the present work it is shown under the neoclassical assumptions framework, that the convergence hypothesis holds, along with movement of capital through externalities, from rich toward poor territories. The key issue is to understand the size of the externalities and the spark that generates them, this issue may lead further works in this field.

Municipalities depend each other to improve their growth rate, although the municipalities are not benefiting from the capital flows from neighbors, they are impacted by the economic growth generated in the neighborhood. The benefit comes from the mobility of labor factor and by the complementary markets that surround the most prosperous territories.

Some extensions of this work might consider the irregularity of territory and carry out an analysis for municipalities from the north and another one for municipalities from the southern-central region of the country, also a different collection of spatial weight matrices might be considered.

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Articles

Local government social responsibility: empirical evidence in the region of Extremadura

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Abstract:

This paper serves as a double purpose in the context of local administrations' information on line disclosure of Social Responsibility (SR). First, this study examines how levels of information dissemination of SR are evolving. Second, some fiscal, political, population, and socioeconomic factors were investigated as determinants of this information disclosed. A content analysis of the websites of the local government in a region of Spain was carried out. This region is the first which has a Corporate Social Responsibility Lay. Later, according to literature review, the authors propose a multiple linear regression model based on disclosure index scores calculated previously. On the one hand, the results show an increase in the amount of SR information disclosed between 2013 and 2016. On the other hand, the study concludes that larger municipalities with more resources, progressive party governments, and intense political competition present higher levels of information disclosure of social responsibility.

Keywords: Social Responsibility; Disclosure; Websites; Determinant factors.

JEL classification: H83; H89; M14.

Responsabilidad social en el gobierno local: evidencia empírica en la región de Extremadura

Resumen:

En el contexto de la divulgación de información sobre Responsabilidad Social (RS) por la Administración Local, este trabajo presenta un doble objetivo. En primer lugar, se examina cómo evolucionan los niveles de divulgación de información sobre RS. Para ello, se ha realizado un análisis de contenido de las páginas web de los gobiernos locales en una región de España, pionera en la aprobación de una Ley de Responsabilidad Social Coroporativa. En segundo lugar, se investigan algunos factores poblacionales, socio-económicos, fiscales y políticos determinantes de la divulgación de este tipo de información, planteando un modelo de regresión lineal múltiple en función de un índice de divulgación calculado previamente. Los resultados muestran, por un lado, un aumento en la cantidad de información divulgada entre los años 2013 y 2016. Por otro lado, los municipios de mayor tamaño, con mayores recursos, gobernados por partidos progresistas y con una alta competencia política, muestran mayores niveles de divulgación de información sobre RS.

Palabras clave: Responsabilidad Social; Divulgación de información; Páginas web; Factores determinantes.

Clasificación JEL: H83; H89; M14.

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1. Introduction

In recent years, companies and institutions have devoted significant effort, time, and financial resources to develop social responsibility (SR) policies. Companies' responsible actions are geared towards legitimising the relevant market processes and improving the perceptions of shareholders, customers, employees, and other stakeholders (Server and Capó, 2009; Gallardo-Vázquez, Sánchez-Hernández, and Corchuelo-Martínez-Azúa, 2013; Asgary and Li, 2016). Companies also seek to benefit from the advantages that SR offers in terms of competitiveness (Porter and Kramer, 2006; Server and Capó, 2009; Gallardo-Vázquez *et al.*, 2013; Schramm-Klein, Morschett, and Swoboda, 2015; Shahzad, Rutherford, and Sharfman, 2016). While SR has been linked mainly to businesses' voluntary actions, more and more public institutions are concerned about engaging in socially responsible initiatives, aiming thereby to satisfy the needs of the relevant interest groups and, more specifically, citizens (García-Sánchez, Frías-Aceituno, and Rodríguez-Domínguez, 2013; López *et al.*, 2018). As the public sector's main interest group, citizens need more information to monitor public administration activities (McTavish and Pypper, 2007; Guillamón, Bastida, and Benito, 2011; Araujo and Tejedo, 2016; Meijer *et al.*, 2018). As a result, public entities have decided to play a more active role in promoting sustainability and improving the information provided about these initiatives (Crane, Bastida, and Benito, 2008; Nevado-Gil, Gallardo-Vázquez, and Sánchez-Hernández, 2016).

The study population chosen for analysis in the present research was local governments since they represent the first level of citizen participation in public affairs, thus making municipalities' information disclosure particularly important (Caamaño-Alegre, Lago-Peñas, Reyes-Santias, and Santiago-Boubeta, 2013). Being the public entities closest to citizens, these organisations serve as direct and immediate channels of participation in everyday affairs in citizens' immediate localities (Navarro *et al.*, 2010; Cueto *et al.*, 2014). Local governments are in an advantageous position to know the information demands of the main stakeholders in SR, and municipalities tend to favour disclosure (Díaz, 2009). Notably, the commitment to sustainability that local authorities must communicate to the public could be due to the type of services they provide (Navarro *et al.*, 2011), as well as the importance of these services in terms of local taxes (Guillamón *et al.*, 2011).

A resource that administrations use to establish a direct relationship with citizens is information and communications technology (ICT). The term e-government is used to refer to the use of ICT in areas such as the provision of online services and citizen participation in political affairs and accountability (Heeks and Bailur, 2007; Pina *et al.*, 2009). Through e-government, citizens can monitor administrations' initiatives and the public services provided, which leads to a more responsible management of public resources. In this context – while taking into account the different possible applications of ICT in e-government – the present study focused on the most universal, well-known, and widely used technology: the Internet.

The disclosure of online information facilitates the interaction between citizens and administration, enhancing the communication with the user, at the same time that implies a greater social commitment (Sandoval *et al.*, 2011; Bonsón *et al.*, 2012; Gandía *et al.* Al., 2016). On the other hand, online disclosure will permit that information will be available to everyone, and it will eliminate time and space barriers, offering a better service to citizens (Frías *et al.*, 2014; Cuadrado *et al.*, 2014).

This research sought to serve a dual purpose. First, it investigates the online SR information provided by local governments and, more specifically, on websites in order to calculate an index of information disclosure and to track its evolution between 2013 and 2016. Second, some determinant factors of information disclosure levels were studied. This approach sought to contribute to the generation of knowledge about this area in the Extremadura region since the level of disclosure of socially responsible initiatives by local government is, thus far, a little discussed subject – despite its important impact on citizens. For this reason, authors such as Marcuccio and Steccolini (2005); Pina *et al.* (2007); and Mazzara *et al.* (2010) call for increased research in this field and encourage organisations to adopt sustainable behaviours, which motivated the study presented below.

To achieve the proposed objectives, a sample of 40 municipalities of the Autonomous Community of Extremadura was selected, consisting of those have more than 5,000 inhabitants. This region was chosen because the community approved the first law on corporate social responsibility (Government of Spain, 2010) in Spain, in December 2010, committing Extremadura to promoting the responsible behaviour of both companies and public institutions.

After this introduction, we first examine the previous academic literature on the determinants of information disclosure and discuss research hypotheses. Then we describe the methods used in the statistical treatment of the data supplied by the study sample, analyse the level of information provided by municipality websites, as well as their evolution over time, and identify those factors that have conditioned SR information disclosure. Finally, we detail and discuss the results, offering conclusions, implications, and suggestions for future research.

2. Determinants of online disclosure of sustainability information and research hypotheses

A review of the academic literature on information disclosure at the local level through websites revealed that most studies have focused primarily on economic and political determinants of voluntary financial information (Tejedo-Romero and Araújo, 2018). At the international level, we found research by Laswad *et al.* (2005); Pietrowsky and Van Ryzin (2007); Piotrowski and Bertelli (2010); Jorge *et al.* (2011); Ma and Wu (2011); Frías-Aceituno *et al.* (2013); Bunget *et al.* (2014); and Brusca *et al.* (2016), among others. Focusing on Spain, papers such as Cárcaba and García (2008), Serrano-Cinca *et al.* (2009a), Guillamón *et al.* (2011), Albalate del Sol (2013) and Alcaide and Rodríguez (2015) analyse voluntary information and financial disclosure by local governments. This review identified an increase in research that analyses the factors that lead to greater financial information disclosure by the public sector. Among other studies analysing these disclosure practices, both at the international and national level, we found research by Navarro *et al.* (2010); Navarro *et al.* (2011); Navarro *et al.* (2014); Frías-Aceituno *et al.* (2013); Nevado-Gil *et al.* (2013, 2016); García-Sánchez *et al.* (2013); Moura *et al.* (2014); and Alcaraz-Quiles *et al.* (2015).

According to most studies focusing on the dissemination of information online, population size is a basic factor that determines these practices (Ribeiro, 2007; Pilcher *et al.*, 2008; Cárcaba and García, 2008; Ribeiro and Aibar, 2008; Serrano-Cinca *et al.*, 2009a, 2009b; Joseph, 2010; Navarro *et al.*, 2010; Ribeiro and Aibar, 2010; Jorge *et al.*, 2011; García-Sánchez *et al.*, 2013). Ahmed and Courtis (1999) confirm the significant and positive relationship between the level of disclosure and size, in a meta-analysis performed of 29 outreach studies. According to Ryan *et al.* (2002), size is positively associated with disclosure of annual reports in Australian local governments. Meanwhile, other authors in the literature reviewed, such as Larrán and Giner (2002), reached the same conclusion. Torres *et al.* (2005) argue that the publication of information on the internet has greater possibilities to be disclosed in the largest administrations that in the small. This may be because, as Guillamón *et al.* (2011) argue, the larger municipalities handle larger budgets, so, generally, they have more resources available to allocate to increase the disclosure of information. In addition, Navarro *et al.* (2010) justify this relationship on the grounds that large population municipalities have staff better qualified, which could encourage dissemination practices. However, based on their study of 55 large Spanish local governments, the cited authors concluded that the entities' size does not explain the dissemination of SR information. The same conclusion was reached by Prado-Lorenzo *et al.* (2012) who, based on local Spanish government studies, found no significant relationship between population size and sustainable information disclosure. For García-Sánchez *et al.* (2013), large populations tend to demand more services and have a broader variety of stakeholders, requiring, among other things, more information on sustainability. In this cited study of 102 Spanish local governments, the results indicate that the organisations' size has a positive impact on sustainability reporting. In general, it can be said that the previous literature argues the existence of a positive relationship between the size of the municipality and information disclosure (Cárcaba and García, 2008; García *et al.,* 2013; Nevado and Gallardo, 2016). Therefore, in this study, the following hypothesis was proposed:

H1: A significant and positive relationship exists between entities' size and their level of SR information disclosure.

Another factor that the literature suggests can influence information disclosure is the amount of public resources available (Serrano-Cinca *et al*., 2009a, 2009b; García-Sánchez *et al*., 2013). Laswad *et al.* (2005) and Serrano-Cinca *et al.* (2009a, 2009b) found a positive association between municipal wealth – measured by per capita income – and level of disclosure. Similarly, Navarro *et al.* (2010) assert that municipalities with higher incomes have more means to improve their information systems. However, the cited results provide no empirical evidence to link the volume of budgetary resources managed by local administrations and their level of information dissemination on the Internet. Guillamón *et al.* (2011) found evidence in a sample of the 100 largest Spanish municipalities that budgetary capacity, represented by total spending per capita, is positively related to levels of information disclosure. Along the same lines, García-Sánchez *et al.* (2013) argue that, the higher the level of public spending, the higher the levels of disclosure of sustainability. Based on these findings, the following hypothesis was developed:

H2: A significant and positive relationship exists between institutional capacity and levels of SR information disclosure.

Unemployment rates are also used in the literature as a possible factor explaining levels of disclosure. The higher their unemployment, the greater the municipalities' social needs and, therefore, the greater the pressure on local governments to disseminate information (Navarro *et al*., 2010). Thus, Navarro *et al.* (2011) found a significant and positive relationship between unemployment rates and levels of information about sustainability in 17 Spanish regional governments. In contrast, authors such as Guillamón *et al.* (2011); Albalate del Sol (2013); and Caamaño-Alegre *et al.* (2013) report results indicating that municipalities with higher unemployment rates have lower levels of disclosure. Contrary to the above cited authors, García-Sánchez *et al.* (2013) were unable to confirm any impact of unemployment rates on the disclosure of sustainable practices information. Similarly, Nevado and Gallardo (2016) also did not find any type of impact of unemployment rates on the dissemination of information on sustainable practices. However, in times of crisis this negative relationship could have been like that, but there are recent studies that prove otherwise (Ortiz *et al*., 2018). Based on this literature, the following hypothesis was formulated:

H3: A significant and positive relationship exists between unemployment rates and levels of SR information disclosure.

Internet access is another factor the literature considers related to information disclosure (Caba Pérez *et al*., 2014; Pina *et al*., 2009; Alcaraz-Quiles *et al*., 2015; Saez-Martín *et al*., 2016). Access to broadband could generate an increase in demand for information that could lead to a wider dissemination of information. Debreceny *et al.* (2003) confirmed a positive relationship between these variables, while Caba Pérez *et al.* (2014) found no evidence for this relationship. Therefore, the following hypothesis was proposed:

H4: A significant and positive relationship exists between Internet access and levels of SR information disclosure.

In addition, public administrations are governed by politicians, and they try to attract more votes by meeting the demands of voters and other stakeholders in order to ensure reelection, so political ideas can be reflected in information disclosure (García et al., 2013). Therefore, the literature also considers factors such as political ideology, political competition, and electoral participation as determinants of the degree of disclosure (Cárcaba and García, 2008; Navarro et al., 2011; Jorge et al., 2011; Prado-Lorenzo et al., 2012; Albalate del Sol, 2013; Alcaraz-Quiles et al., 2015). Regarding political ideology, authors such as

Navarro et al. (2010) and Jorge et al. (2011) show that the political orientation of ruling parties is not associated with levels of dissemination of SR information. However, Guillamón et al. (2011) confirmed that municipalities governed by progressive mayors disclose more information than do those governed by conservative mayors. García-Sánchez et al. (2013) also conclude that leftist governments disclose more information. In contrast, Prado-Lorenzo et al. (2012) research shows that parties with conservative tendencies increase their sustainable practices to attract more progressive voters.

Similarly, more political competition, based on the number of political parties participating in elections, can lead to greater information disclosure by government teams (Cárcaba and García, 2008). As political competition grows, the pressure on governing parties increases, which can be reflected in greater information disclosure that seeks to show citizens that these parties offer better services than opposition parties do. In the previous literature, some results, such as Laswad *et al.* (2005), reveal no statistically significant impact of this factor for New Zealand municipalities. However, authors such as Gandia and Archidona (2008), Navarro *et al.* (2011), and Prado-Lorenzo *et al.* (2012) show that levels of disclosure depend on political competition and, moreover, that this influence is positive.

Finally, voter turnout in municipal elections is also considered an indicator of information disclosure as electoral participation demonstrates citizens' interest in government activities (Jorge *et al.*, 2011; Albalate del Sol, 2013). A high voter turnout indicates that citizens have a greater interest in government initiatives (Esteller-Moré and Polo-Otero, 2008; Caamaño-Alegre *et al.*, 2013). Authors such as Esteller-Moré and Polo-Otero (2008) report a positive relationship between electoral participation and fiscal transparency, which is considered an aspect of information dissemination. For Jorge *et al.* (2011), voter abstention also appears to be a positive determinant, while in Albalate del Sol's (2013) research, this does not appear to be statistically significant. The resulting proposed hypotheses were:

H5: Political parties with a progressive ideology show higher levels of disclosure than parties with a conservative ideology do.

H6: A significant and positive relationship exists between political competition and levels of SR information disclosure.

H7: A significant and negative relationship exists between levels of electoral participation and levels of SR information disclosure.

3. Empirical study

3.1. Sample selection, objectives, and methodology

Nevado-Gil *et al.* (2013) analysed the information disclosed about SR, between January and February 2013, by a sample of 40 Extremadura municipalities that represent 64.22% of the autonomous community's total population. Municipalities with a population equal to or more than 5,000 people were chosen, based on a distinction made in Article 20 of Law 7/1985 of 2 April (Government of Spain, 1985) regulating local regimes according to municipalities' organisation. In order to compare disclosure practices over time, the present study used the same sample of Extremadura municipalities' information disclosure in January and February 2016. The Law makes an express mention of the Social Responsibility of the Autonomous Public Administration itself and its dependent public agencies, such as consuming, investing, contracting, employing and providing services entities. Likewise, having an Annual Report on Government Social Responsibility, which systematically includes the policies, measures, actions and actions developed by the different public agencies of its administration, makes the municipalities adopt the same behaviors. This regulation, innovative and pioneering in Spain and in the autonomous community, is one of the agreements included in the Social and Political Reform Pact for Extremadura, approved by the Assembly of Extremadura on April 22, 2010, which aimed to change the production model in the region to achieve sustainable development, based on values such as equal opportunities and social and territorial cohesion. The existence of this Pact and this Law, which are approved in 2010 and set out a very broad plan of actions for companies and institutions, encourages us to check whether the dissemination of social information in this autonomous community is really being undertaken.

To achieve the research objectives, first, we did a temporal study by collecting data from the websites of Extremadura municipalities at two points in time (i.e. 2013 and 2016), to verify whether these institutions are involved in an evolving process that seeks to satisfy users' expressed information needs. In addition, we checked if that evolution is occurring in all the aspects analysed of data collected with a questionnaire. To achieve this goal, content analysis was used, as has been done in numerous studies of this nature (Rodríguez *et al.*, 2006, 2007; Pina *et al.*, 2007; Navarro *et al.*, 2010; Moneva and Martin, 2012; Nevado-Gil *et al.*, 2013; Navarro *et al.*, 2015). This technique allows the systematisation of qualitative information. Content analysis, according to Dumay and Cai (2015), is 'a research technique designed to formulate, from certain data, reproducible and valid inferences that may apply to your context'. Data were collected with the aforementioned questionnaire, which had already been used in previous studies (Nevado-Gil *et al.*, 2013, 2016), consisting of a total of 118 indicators divided into five lines of analysis (see Table 1).

TABLE 1.
Proposed lines of analysis

Lines of Analysis	Definition	Number of Indicators
Line of Analysis 1	Information on municipal corporation	27
Line of Analysis 2	Information on citizens and society	28
Line of Analysis 3	Economic information	22
Line of Analysis 4	Information on services procurement, public works, and urban planning	26
Line of Analysis 5	Environmental information	15
Total Indicators		**118**

Source: Nevado-Gil, Gallardo-Vázquez, and Sánchez-Hernández (2013)[1]

The information gathered enabled the development of an index in order to analyse the degree of SR information disclosure on Extremadura municipalities' websites. To apply this index, the criterion of the presence or absence of each indicator contained in the proposed questionnaire was considered and assigned the value of one if the indicator's information was disclosed and zero otherwise. The use of indices to measure levels of information has been applied in numerous studies, including Gandia and Archidona (2008); Jorge *et al.* (2011); Navarro *et al.* (2010); Joseph and Taplin (2011); Moneva and Martin (2012); Beuren and Angonese (2015), and Navarro *et al.* (2015).

Second, once the disclosure index scores had been calculated, we analysed possible factors affecting the degree of dissemination of SR information. For this, we carried out a multiple linear regression of the disclosure index following the approach used by Laswad *et al.* (2005); Moura *et al.* (2014); Alcaraz-Quiles *et al.* (2015) and Garrido *et al.* (2019), among others. The estimation was done with the EViews software version 6.

[1] In the indicators proposed by Nevado *et al.* (2013) the previously proposed by Navarro *et al.* (2010) with the Global Initiative Reporting (GRI, 2010) to complete both approaches. In particular, the GRI published a pilot guide (GRI, 2005), called Supplement for Public Agencies, revised with the new publication of the sector-specific supplement for the public sector (GRI, 2010).

3.2. Dependent variable: Index disclosure

As noted above, the level of dissemination of SR information was measured with an index consisting of the score each municipality received through a process of review and analysis of municipality web pages. Before calculating the index scores – in order to analyse the level of disclosure by categories of information – a partial index was calculated for each of the lines of analysis into which the questionnaire was divided. These partial indices were determined by the ratio of the sum of the number of items identified on each website and the total number of items that made up each line of analysis. To express this in percentage, the scores were multiplied by 100:

$$IDe_j = \frac{\sum_{i=1}^{c}(m_{ij})}{M} * 100 \quad (1)$$

in which IDe_j = the partial index of information disclosure of line of analysis 'e' in the municipality 'j'; m_{ij} = the number of items identified on the website; c = the total score obtained for each municipality in each line of analysis; M = the number of items that make up each line of analysis 'e'; and e = each of the lines of analysis that make up the disclosure index. In the equation below, C = the line of analysis of each municipal corporation; S = the line of analysis of social information; O = the line of analysis of services and public works contracts; E = the line of analysis of economic information; and M = the line of analysis of environmental information.

The index of full SR disclosure by municipality was calculated with the following equation:

$$ID_j = \left(IDC_j + IDS_j + IDO_j + IDE_j + IDM_j\right) * \frac{1}{5} \quad (2)$$

Having no empirical evidence of the relative importance of the various partial indices that made up the overall index, the same weight was assigned to each of the dimensions or lines of analysis.

3.3. Explanatory variables

The results of the literature review guided the selection of the correct variables to include in the present study (Cárcaba and García, 2008; Pilcher *et al.*, 2008; Serrano-Cinca *et al.*, 2009a, 2009b; Guillamón *et al.*, 2011; Jorge *et al.*, 2011; Cruz *et al.*, 2012; Esteller-Moré and Polo-Otero, 2012; García *et al.*, 2013; Caamaño-Alegre *et al.*, 2013; Albalate del Sol, 2013; Cuadrado, 2014; Alcaraz-Quiles *et al.*, 2015). We thus considered the explanatory variables that are listed in Table 2.

3.4. Model specification

To carry out the contrast of the assumptions detailed in previous sections, multivariate regression techniques were used. Based on multiple linear regression, using the ordinary least squares method, the following model was estimated:

$$ID_j = \beta_0 + \beta_1 S_j + \beta_2 IC_j + \beta_3 UP_j + \beta_4 IA_j + \beta_5 PI_j + \beta_6 PC_j + \beta_7 EP_j + \varepsilon_j \quad (3)$$

In addition, an error term (ε) was also incorporated, which includes the incidents of when the SR information disclosure index is not explained by the independent variables' effects.

TABLE 2.
Definition of explanatory variables

Variable	Measurements/Source	Hypotheses (Expected Sign)
Population Size (S)	Number of municipality residents Data refer to the last census revised in 2015 Source: Institute of Statistics of Extremadura http://estadistica.gobex.es/	H1 (+)
Institutional Capacity (IC)	Budgetary capacity, represented by total spending per capita (2015) Source: Institute of Statistics of Extremadura http://estadistica.gobex.es/	H2 (+)
Unemployed Population (UP)	Unemployment rate (2015) Source: Public Service of National Employment, Government of Spain, Ministry of Employment and Social Security http://www.sepe.es/	H3 (+)
Internet Access (IA)	Number of people with access to the Internet (2015) Source: National Statistics Institute http://www.ine.es/	H4 (+)
Political Ideology* (PI)	Dummy variable that takes the value zero if the party is conservative and one if the party is progressive. Source: Directorate General of Internal Policy of the Government of Spain (information concerning the last municipal elections of 2015) http://www.infoelectoral.interior.es/	H5 (+)
Policy Competition (PC)	Number of parties involved in elections Source: Directorate General of Internal Policy of the Government of Spain (information concerning the last municipal elections of 2015) http://www.infoelectoral.interior.es/	H6 (+)
Electoral Participation (EP)	Voter abstention rate Source: Directorate General of Internal Policy of the Government of Spain (information concerning the last municipal elections of 2015) http://www.infoelectoral.interior.es/	H7 (-)

*In politically conservative parties, we have included the following: Partido Popular (Popular Party) (PP) and Compromiso por Aceuchal (Aceuchal Commitment). In progressive parties, we have included the following: Partido Socialista Obrero Español (Spanish Socialist Workers' Party) and Organización del Pueblo Obrero (Working People's Organization).

4. Analysis of results and discussion

4.1. Evolution of disclosure information index

Table 3 shows the results of the partial indices of SR information disclosure and their evolution in the years considered.

TABLE 3.
Evolution of partial disclosure index

Lines of Analysis	IDe_j	
	2013	2016
Information on Municipal Corporation	23.17%	41.48%
Social Information (Citizens and Society)	32.77%	50.18%
Economic Information	3.18%	14.20%
Information About Services and Works Recruitment	25.48%	45.96%
Environmental Information	11.33%	19.83%

As can be seen, the results reveal a marked increase in the information provided by municipalities through their websites. If, in 2013, the SR information disclosure was quite low, in 2016, there was an increase in the amount of information disclosed. An important fact to note – as a possible reason for this dramatic increase – is the municipal elections held in 2015, which led to changes in government. These data were subsequently analysed to see if this increase may be due to political factors. Another possible reason for this increase in the information disclosed may be that in the public sector, there is greater awareness and conviction about sustainability. As we have already mentioned in this work, citizens are the main agent of interest and demand information and transparency in the performance of municipal management, therefore, increasingly, the administration is becoming aware of the need to improve and streamline the relationship between citizens and the Administration. For example, with the implementation of the e-Administration technology platform (e-Government portal) and its placement at the service of citizens, full and detailed information on social, economic and environmental issues is offered, while raising awareness to the citizen through social and environmental campaigns and allows them an active participation in decision making. On the other hand, the new regulations also affect that increase in the amount of information disclosed. In particular, we consider that one of the influential reasons in the high economic information offered by the local governments of our sample, in relation to previous studies, could be the approval of Law 19/2013, of December 9, of Transparency, Access to Public Information and Good Government[2]. This Law increases and reinforces transparency in public activity and recognizes the right to information to citizens. As can be seen in our study, the information that increases the most is related to economic aspects.

However, some municipalities still do not provide this type of information on the Internet, and, notably, the information in many cases has not been updated. This suggests that, at some point, municipalities decided to provide this information online, but, in subsequent years, they have shown no interest in updating it. In addition, it was also observed that the information provided in many cases is incomplete. Therefore, the Extremadura municipalities still have much to do to improve their information disclosure practices.

4.2. Determinant factors

Descriptive analysis. Having analysed the evolution of the information disclosure index, we examined the factors that determine the relevant disclosure. To this end, we chose to use as a dependent variable the index values for the last year studied (i.e. 2016), since these contain the most current and complete information. Table 4 presents the descriptive statistics of mean, standard deviation, and maximum and minimum values. The continuous variables are presented first, and the dummy variable second. As can be seen from this table, the variables of population size (S) and institutional capacity (IC) have a remarkable degree of dispersion that reflects the diversity of resources among the municipalities studied. The other variables do not show a large dispersion. With respect to the dummy variable (PI), the statistics show that, according to the results of the last municipal elections in 2015, most municipalities are now governed by progressive parties (i.e. 27 municipalities).

[2]See: https://www.boe.es/buscar/act.php?id=BOE-A-2013-12887 . [Consulted 10/06/2019].

TABLE 4.
Descriptive statistics

Continuous Variables					
	N	Minimum	Maximum	Mean	Standard Deviation
ID	40	18.81	63.07	34.33	11.02
S	40	5,001	149,892	17,661.50	27,739.642
IC	40	569.8704	1,189.6129	858.1735	136.1211
UP	40	1.2040	17.8807	12.1597	2.5787
IA	40	.0137	0.2722	0.1511	0.0562
PC	40	2	12	4.53	2.276
EP	40	11.13	38.66	26.3208	5.90531
Dummy Variable					
	N	**1**	**0**		
PI	40	27	13		

Univariate analysis. In order to check whether a correlation exists between the model variables, the Pearson correlation coefficient was applied (see Table 5), as this measures the overall degree of association between two random variables. The correlation matrix shows that most of the independent variables have a moderate or low correlation, except for a few variables that have a strong correlation. However, none of these correlations reached the value of 0.80 considered critical by Cooper and Schindler (2008) and Naser and Hassan (2013). Therefore, multicollinearity does not appear to be a problem in the model, so none of the variables considered for regression analysis had to be removed.

TABLE 5.
Pearson correlation matrix of the study variables

	T	CI	PD	AI	IP	CP	PE
S	1						
IC	-0.326*	1					
UP	-0.048	0.283	1				
IA	0.450**	-0.278	-0.104	1			
PI	-0.312*	0.155	0.041	-0.173	1		
PC	0.797**	-0.408**	-0.191	0.569**	-0.313*	1	
EP	0.567**	-0.330*	-0.079	0.578**	-0.334*	0.617**	1

Notes: (**) correlations are significant at the 1% level; (*) correlations are significant at the 5% level (bilateral)

Multivariate analysis. Prior to regression analysis, we checked the basic assumptions of the general linear model and detected the presence of heteroskedasticity. To solve this problem and get more robust estimations of the regression coefficients, we used the White (1980) test to correct the regression and estimated the model using weighted least squares. The results obtained are presented in Table 6. The R^2 shows that the model has an explanatory power of 64.6%, a considerably higher percentage than for models dealing with cross-sectional data (Gujarati, 2009). Table 6 also shows the F-statistic (8.330640), which measures whether the independent variables included in the model, when considered together, influence the rate of SR information disclosure. Based on the value of the F-sig (0.0000), which is less than 0.01, we concluded that a confidence level of at least 99% exists that the proposed model explains the dependent variable.

Table 6.
Results of multiple linear regression

Variables	Coefficient	T	Probability
(Constant)	0.227697	1.479205	0.1489
S	2.13E-06	3.727266	0.0007(***)
IC	0.000265	2.374211	0.0238(**)
UP	-0.006284	-1.590456	0.1216
IA	0.316067	1.404316	0.1699
PI	0.051172	2.060523	0.0476(**)
PC	0.021855	2.249846	0.0315(**)
EP	-0.003650	-1.415444	0.1666
F-statistic **F-sig**	8.330640 0.00000		
R^2	0.646		

Notes: Dependent variable (ID); regression corrected using the White test (1980) for heteroskedasticity; (***) indicates a significance level at 1%; (**) indicates a significance level at 5%

Regarding the individual significance of each independent variable, as shown in Table IV, the variable representing population size (S) is shown to be extremely significant at a 99% confidence level (t-statistic = 3.72; probability = 0.0007). This variable is positively associated with the dependent variable (ID), as can be seen by the associated coefficient (β_1 = 2.13E-06). The first hypothesis (H1) is, therefore, confirmed, indicating that, the larger the size of the selected Extremadura municipalities, the higher their rate of SR information disclosure. These results are consistent with those of other authors, such as Larrán and Giner (2002); Ryan *et al.* (2002); Cárcaba and García (2008); and García-Sánchez *et al.* (2013).

Regarding institutional capacity (IC), we checked this using statistical measures (t-statistic = 2.37; probability = 0.0238) and found this variable is individually significant at a 95% confidence level and is positively associated with the dependent variable (ID) (β_2 = 0.000265). This confirms the second hypothesis (H2). The present results coincide with those of previous studies (Laswad *et al.*, 2005; Gandía and Archidona, 2008; Guillamón *et al.*, 2011) in which higher levels of information disclosure have been observed in municipalities with more resources.

Regarding the political variables of ideology and political competition (PI and PC) – as was found in most previous studies (Gandía and Archidona, 2008; Guillamón *et al.*, 2011; Navarro *et al.*, 2011; Prado-Lorenzo *et al.*, 2012; García *et al.*, 2013) – a significant influence at a 95% confidence level was confirmed (t-statistic = 2.060523; probability = 0.0476 for PI and t-statistic = 2.249846; probability = 0.0315 for PC). The signs of the coefficients (β_5 = 0.051172 and β_6 = 0.021855, respectively) show a positive relationship with the level of SR information disclosure. These results confirm, therefore, the fifth and sixth hypotheses (H5 and H6), which indicate that municipalities governed by progressive parties and characterised by more intense political competition have higher levels of information disclosure.

The remaining variables (i.e. unemployed population, Internet access, and voter turnout) are not statistically significant in the model, so they have no effect on the dependent variable. This meant that the third, fourth, and seventh hypotheses (H3, H4, and H7) were rejected. A growing unemployed population, greater access to the Internet by municipalities' citizens, and greater or lesser participation of citizens in municipal elections does not appear – according to the results for the present sample – to explain the behaviour of ruling parties in terms of information disclosure.

5. Conclusions, implications, limitations and future research

This research was conducted on a sample of the largest local authorities in Extremadura. The data collected revealed an increase in the amount of SR information disclosed between 2013 and 2016. This study also examined some determinants of the level of this information disclosure based on an analysis of these municipalities' websites.

The results can be divided into two distinct areas. First, the evidence shows that the factors behind the rate of SR information disclosure are municipalities' size, institutional capacity, political ideology of the ruling party, and political competition. Second, contrary to expectations, others factors do not explain the level of information disclosed, among which are a population with higher or lower unemployment rates, Internet access, and greater or lesser electoral participation. Given these results, municipalities can now refocus their practices and policies of SR information disclosure based on the factors that have or do not have an effect on levels of information disclosure.

In order to find a clear explanation that includes the main reason for the increase of information disclosed in 2016, we connected the present results with those of Nevado-Gil *et al.* (2016). In this previous research based on a review of municipalities' websites between 2013 and 2015, no significant differences were found in the level of information disclosure. Given the change of government resulting from municipal elections in May 2015, the present research focused on the presence of political factors, revealing that these are the main cause of most levels of information disclosure. These two studies represent a continuity in the phenomena under study, allowing us to discover in the second study some progress compared to the previous study's results. These results can also be explained with information dissemination theories. In the first place, we can say that, according to the Theory of Legitimacy, it is expected that politicians who want to participate in projects that require significant efforts when undertaking a public investment, will be interested in disseminating this information. Therefore, in election years, in municipal budgets, politicians will encourage the dissemination of information to obtain voter support. Second, the Theory of the Agency is related to the actions of politicians in relation to satisfying the needs of citizens. The rulers must be responsible for their actions and the problem of asymmetry of information is raised. When trying to reduce the problem of asymmetry in information what is achieved is to restore the confidence of the citizen in the politicians, something of vital importance in these moments (Garrido *et al.*, 2019). Finally, the Theory of Stakeholders tries to explain how an entity adopts certain behaviors and issues external information to guarantee its survival. This theory is based on how interdependencies are managed by interest groups that are relevant to the organization. In this sense, interest groups with power are those on which the survival of the entity depends in terms of economic interests, above aspects of moral or legal legitimacy.

We conclude, therefore, that larger municipalities in Extremadura with more resources available, governed by progressive parties, and characterised by more intense political competition, will be more prone to disseminate SR information. At the same time, it appears that unemployment does not motivate governments of Extremadura municipalities to release SR information and neither does having citizens with increasing Internet access. Finally, citizens' participation in elections does not appear to be decisive in Extremadura municipalities' dissemination of SR information.

The above findings clearly have implications for various areas. In terms of academic contributions, some influential and nondecisive factors have been identified by measuring the levels of SR information disclosure for municipalities in Extremadura. This indicates that research can be done to help local administrations by observing which policies encourage and promote some factors and by seeking to eliminate the negative effects of other factors in order to prevent low levels of information disclosure. This can assist municipalities achieve clear public policies and strategies to cover to the maximum level possible citizens' demands. These academic contributions undoubtedly are tied to implications for local governments, achieving a much sought after link between university and local government initiatives and covering an existing gap in previous research.

We would like to emphasize the importance of the online services implementation by the administration. It leads to transforming these organizations, improving efficiency and effectiveness in the internal government administration. At the same time, offering online public services leads to a more open context which improves the image of organizations, increases information transparency and enables citizens to increase their participation in making decisions.

Even if the results obtained for the proposed model are positive, the limitations of this study need to be mentioned. This research has some limiting aspects that restrict the results obtained and, therefore, reduce their usefulness when extrapolated to broader contexts of study. The first is the size of the sample. The municipalities were selected based on current theoretical interests, but a larger sample could yield different results and produce a greater or lesser number of verified hypotheses. The second limitation is that region and country effects must also be considered. In this case, all the municipalities analysed are in Extremadura, Spain. A consideration of entities belonging to other regions and even other countries could produce different results.

In response to these issues, possible future research could include studies with larger sample sizes, with municipalities belonging to other regions of Spain and local governments of other countries. Finally, although not derived from any limitation of the present study, we intend to continue this research by applying other current methodologies that can identify causal relationships between the variables studied and predict future behaviour in municipalities.

Finally, we can offer some recommendations to local governments, among which we rule out the following: an important factor is the direct and explicit commitment of the representative of the government team, in this case the Mayor, as well as the rest of the corporation, on the importance of sustainability, including priorities, strategies and initiatives that are going to be carried out, as well as communicating their successes and achievements in CSR in any of their social, economic and environmental spheres, to the stakeholders, through a strategic CSR plan that culminates with the preparation and publication of a CSR Report. It is also recommended to approve a Code of Good Governance for all political groups or managers and create a commission for reflection and debate with the participation of employees and interest groups.

In addition, you must dispense with information that may be misleading or that incites illegal behavior and thus maintain the quality and safety of the service offered. On the other hand, in order to guarantee and improve the provision of services, it must comply with the legal and regulatory requirements established in current regulations. You can also improve customer service by creating an office and a citizen information platform where municipal information services are offered, information on the city, document confirmation, appointment with councillors and technicians, immediate resolution procedures (registration of mopeds, collection of fines, receipt and delivery of lost objects, modifications of the registers, etc.) and also, establish procedures for the treatment of suggestions, complaints and claims of citizens, obtaining the maximum information about their needs and expectations, as well as the degree of satisfaction towards the services rendered. In this way, it will encourage citizen participation in municipal decisions and will gather opinions, proposals and conclusions that will help support the preparation of municipal budgets.

Another good practice with this interest group could be the adoption of a commitment to reduce road accidents, analyzing and identifying the accident concentration sections, signaling and applying corrective measures in these sections and evaluating the effectiveness of the measures applied.

In terms of society and community, we propose respect and protection of the environment through an Environmental Action Plan that allows actions to be carried out in a sustainable manner aimed at improving the environment such as reducing polluting emissions, improving and conserving of the environmental quality of the Local Entity, the protection and conservation of the natural wealth of the territory, the optimization of the use of natural resources (water, energy or other resources), the reduction of the dependence on non-renewable resources and the promotion of of changes in habits and attitudes on the part of the population in the line of sustainability. Likewise, the possibility of achieving a commitment to energy efficiency and reducing light pollution from public lighting is proposed, establishing conditions to be met by new facilities in terms of efficiency such as replacing traditional street lighting with LED bulbs, analyzing and evaluating economically the corrective measures to be applied on efficient lighting, elaborating and approving new regulations in this matter and assigning an economic endowment for the fulfillment of these purposes, as well as the adoption of a commitment to adhere to the principles of the Agenda 21. Concerning sustainable mobility, we suggest encouraging the use of environmentally-friendly means of transport, as well as the incorporation of non-polluting means of transport.

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Agri-food industry in Extremadura: obstacles to innovation, willingness to innovate, and demanded public actions

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Abstract:
The purpose of this paper is to analyse the barriers perceived by agribusiness companies in Extremadura; how these barriers influence their disposition to innovate and the type of public actions demanded by these companies in order to boost innovation. Data comes from an *ad hoc* survey conducted in 2013. The methodology used combines descriptive analysis with factor analysis and econometric analysis. Main results show that *high costs and risks, lack of human resources* and *difficulties of appropriability* are the barriers that reduce the probability to innovate, and that there are important differences among the perceived factors of obstacles and demands of public actions. This can be a reference to develop government policies specifically geared towards boosting innovation in this kind of industry.

Keywords: Agribusiness, innovation, barriers, innovation policies.
JEL classification: D22; H25; 038.

Industria agroalimentaria en Extremadura: obstáculos a la innovación, disposición a innovar y políticas públicas demandadas

Resumen:
El objetivo de este trabajo es analizar las barreras percibidas por las empresas agroalimentarias en Extremadura; cómo estas barreras influyen en su disposición a innovar y el tipo de acciones públicas que demandan estas empresas para impulsar la innovación. Los datos provienen de una encuesta *ad hoc* realizada en 2013. La metodología utilizada combina el análisis descriptivo con el análisis factorial y econométrico. Los principales resultados muestran que los costes y riesgos elevados, la falta de recursos humanos y las dificultades de apropiabilidad son las barreras que reducen la probabilidad de innovar, y que existen diferencias importantes entre los factores de obstáculos percibidos y las demandas de las acciones públicas. Esto puede ser una referencia para desarrollar políticas gubernamentales orientadas específicamente a impulsar la innovación en este tipo de industria.

Palabras clave: Industria agroalimentaria, innovación, barreras, políticas de innovación.
Clasificación JEL: D22, H25, 038.

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1. Introduction

The agri-food industry occupies a position of great importance within the manufacturing industry (Núñez-Fernandez, 2000), especially in the case of the Autonomous Community of Extremadura where this industry employs 2.7 % of the total amount of industrial workers and accounts for 2.3% of the net sales total (MAGRAMA, 2015b). Here, the weight of the agricultural sector and associated industries are significantly higher than the national average. The agricultural and agri-food sectors have developed activities strongly related to the territory that play a role as important drivers for business activity in rural villages and constitute a key factor for maintaining the population. Noronha *et al.* (2006) highlight the importance of these industries in the rural areas' economy by differentiating various types of companies according to their innovative behaviour. Both sectors are closely linked, being the agri-food industry responsible for transforming and commercializing raw materials and providing a greater added value. In this sense, 6/2015 Law, 24th March, of Land in Extremadura establishes that "any action upon the agricultural sector should also take into account the agri-food production industry, especially quality-differentiated productions". In this way, Agri-food Quality constitutes a fundamental pillar which guarantees the commercialisation of products originating from agriculture and animal husbandry, essential to differentiate the productions in a highly-competitive market. However, in spite of its importance in the regional development, the agribusiness from Extremadura manifests chronic problems caused by an inadequate dimension (86.7% of companies have 10 employees or fewer) such as their local character, the lack of business clusters or the scarce innovation activity registered (Corchuelo & Mesías, 2017). Innovation in all its manifestations plays a key role in the competitiveness for companies and territories in the medium and long term (Porter, 1990; Castillo & Crespo, 2011).

Hence, Public Administrations show a special interest in fostering scientific and technological investigations[1]. Nevertheless, despite all the actions aimed to encourage innovation, there is considerable scope for further improvement, specially making the public administrations aware of the needs and services demanded by businesses to encourage and promote innovation, with the intention to detect and reduce the obstacles perceived by these companies aiming to develop new projects and innovative actions. This is the main objective of this paper: To analyse Extremaduran's agribusiness companies' perceptions of the main obstacles to innovation, to analyse if these barriers influence the probability to innovate as well as the relation with the demanded public actions to increase innovative behaviours. We consider firms belonging to NACE code 10 (Manufacturing of food products). The study differentiates between cooperative and non-cooperative firms, given the special role the first ones play in the regional economy (Corchuelo & Rodríguez, 2017). An essential characteristic of cooperatives is their ability to efficiently exercise the entrepreneurial function. Its role is a key to address not only structural problems of the agri-food sector, but to boost the development of rural areas and contribute to the rationalization of the structures on which the agri-food system is based (Martín de Prado & Llerena, 2004: 200).

This paper is novel in its objective and it has two distinct aspects. On one hand, in Extremadura, the ratio of domestic expenditure in R&D over gross domestic product (GERD/GDP) in 2015 was 0.66%, well below the national total (1.22%) and of UE28 (2.03%). If we consider activity sectors, business expenditure on R&D (BERD) only accounts for 0.3 % of the total expenditure in Spain. This is very low compared to other Spanish Autonomous Communities. Close to 90% of R&D expenditure is made by small to medium a company (SMEs) which is the predominant business size in the region (Economy, Industry and Competitiveness Ministry, 2015). Given the importance of the agri-food industry, it is interesting to analyse both the obstacles perceived and the demanded public actions that could encourage activity in the sector. On the other hand, although there are some papers about innovation at

[1] In this sense, e.g. 14/2011 Law, 1st June, of Science, Technology and Innovation, and Law 5/2016, 7th June (modification of Law 10/2010, 16th November, of Science, Technology and Innovation of Extremadura). In the current VI Regional Plan of Researching, Technological development and Innovation (2017-2020) agribusiness is established as a top priority within the strategic and socioeconomic lines of action in the region. The agri-food industry is also set out as an area of excellence within the priorities of the Community.

regional or national level, as discussed further below, there are only a few studies focusing on this type of industry and even fewer focusing on Extremadura.

This paper is organized as follows: in the next section a review of the studies related to the subject to analyse is carried out; Section 3 presents the data, how it has been obtained and the final sample to perform the study; Next, the methodology used is explained; The results and the discussion are raised in section 5 ending with a final conclusions section.

2. Background

There are numerous studies on innovation related to the regions. In Buesa (1998) the regional allocation of I+D activities and their results are analysed, revealing that the existence of innovative firms is the most influential factor in the relative position occupied by the different regions in Spain and the interregional differences between them. Buesa *et al.* (2002) establishes a typology of the regional innovation systems (RIS), and Badiola and Coto (2012) explain the decisive ones generating innovation in the Spanish regions. At international level, Cooke (2008) makes a brief history of the RIS concept and explains, at the policy level, RIS strategies that have been adopted in recent years by countries such as South Korea, China, Norway and Sweden; Santos and Simoes (2014) analyse the structural barriers and opportunities to promote regional innovation strategies in Portugal; and Niembro (2017) makes a first typology of RIS in Argentina; in a more general way, Zukauskaite (2018) explains the variety of RIS and their institutional characteristics.

Several studies can be found with regard to the analysis of the innovative activity in particular regions and their companies such as Ruiz (2005) and EOI (2011) that analyse the regional innovation and the capacity for innovation of SMEs in Andalucía; González-Pernía *et al.* (2009) and López-Rodríguez *et al.* (2010) focus on the study of the impact of the Basque Country's Regional Innovation System; Corchuelo and Carvalho (2013), and Corchuelo and Mesías (2015 a) assess, from a descriptive perspective, the innovative activity in Extremadura.

Studies are scarce with regard to the agri-food industry; Capitanio *et al* (2010) and Baregheh *et al.* (2012) at an international level, or Alarcón and Sánchez (2012; 2014 a b), Fearne *et al* (2013), and Alarcón *et al.* (2014) in Spain. Among the most recent studies, García-Álvarez-Coque *et al* (2015) analyse the agry-food firms' willingness to participate in R&D projects; Arias *et al.* (2016) make a characterisation of the agri-food firms according to the barriers to innovation. In Corchuelo and Mesías (2017), different typologies of Extremaduran agri-food businesses are analysed according to the willingness to innovate and innovation risk taking, considering innovation a key element in competitiveness.

There are only a few studies focusing on the agri-food cooperatives. The study carried out by Marí-Vidal *et al.* (2014) reveals that innovation and training are external opportunities for the agri-food cooperatives to take advantage of and avoid business failure. Server-Izquierdo and Lajara-Camilleri (2016) analyse innovation as a source of competitiveness in agri-food cooperatives and study the contributing factors.

This study brings new evidence to the studies focused on the analysis of innovation in the regions, with special attention to the region of Extremadura, and to a specific and strategic industry of the region: agri-business. We focus especially on the perceived barriers to innovation and the demands for public actions made by agri-food firms; and how these barriers impinge on the decisions to innovate and on the demand for public actions to foster innovation. In this sense, there are numerous studies that have analysed the influence of obstacles to innovation on the probability to innovate. Some of them highlight the negative relationship between financial obstacles and the probability to innovate (Savignac, 2008; Schneider *et al.*, 2010; Blanchard *et al.*, 2013; Pellegrino & Savona, 2017). Other studies point out the influence of other types of obstacles whether they are knowledge or market conditions (Kamalian *et al.*, 2011; Canales & Álvarez, 2017; Pellegrino & Savona, 2017). In Spain, at regional level, Segarra *et al.*

(2007) show that cost and knowledge barriers seem to be the most important and there are substantial sectoral differences in the way that Catalonian firms react to barriers. Despite the high number of studies focused on the analysis of barriers to innovation, in this aspect of analysis there are not, in our knowledge, studies on barriers to innovation and investment decisions in innovation in the agri-food industry, which is the main novelty of this study.

3. Data and methodology

3.1. Data

Data used in this study comes from a survey conducted among Extremaduran companies in June 2013. The surveying methodology was carried via a personal interview by means of a computer assisted telephone interview (C.A.T.I. system). The design consisted of a stratified sample in proportion to the different activity sectors (manufacturing and knowledge-intensive business services) and business size. The questionnaire includes five blocks of questions (general data, innovative activity implemented, barriers to innovation, public support to R&D received, and demanded public policies)[2]. A final sample of 524 companies is obtained. Different statistical tests were carried out to ensure its robustness compared to the total population found in the General Directory of Spanish Companies (DIRCE-INE)[3].

A subsample of 124 agri-food firms was obtained from the total sample[4] which represents 9% of the total number of agri-food companies in the region this year[5]. Overall, 70% of the companies have fewer than 10 employees and 24.2% have between 10 and 50 employees, so small-sized companies predominate which points out to the high degree of fragmentation within the agri-food industry[6]. With regard to the legal form, 24.2% of the analysed companies (30) are cooperative companies which represents 10.3 % of the total number of cooperatives in the region attending to dates from 2012 (OSCAE, 2013). Comparatively, cooperative companies have a relative size greater than non-cooperative ones. Table 1 shows the sample according to the number of workers.

Table 1.
Agri-food companies by number of workers

No. of workers	Total (%)	Cooperatives (%)	Non-cooperatives (%)
< 10 workers	87 (70.2%)	19 (63.3%)	68 (72.3%)
10-50 workers	30 (24.2%)	7 (23.3%)	23 (24.5%)
> 50 workers	7 (5.6%)	4 (13.4%)	3 (3.2%)
Total companies	124	64	94

3.2. Methodology

Firstly, a descriptive study was conducted to show the main characteristics of the innovative agri-food companies, differentiating between cooperative and non-cooperative firms. The descriptive study focuses on the analysis of the perceived barriers to innovation and the public aids adapted to the needs expressed by the companies (Blocks 3 and 4 in the questionnaire).

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[2] The questionnaire can be made available at the request of those interested.

[3] On 1st January 2013 there were 63.353 companies in the region, representing the 2.01% of the total number of Spanish companies.

[4] We consider firms available in the data set belonging to NACE2009 code 10 (Manufacturing of food products).

[5] A total number of 1383 companies from the agri-food business were registered in the region in 2013. (MAGRAMA, 2015 b). The sample obtained is representative in terms of the size of the total population.

[6] The business size is similar to the industry size in the Spanish economy where 96.3% of companies have fewer than 50 employees and 79.6% fewer than 10 employees (MAGRAMA, 2015 a).

Secondly, the factor analysis is used as a tool to determine the main dimensions of the barriers to innovation perceived by Extremaduran companies. Factor analysis is a multivariable technique based on the elimination of some redundancy in many variables (Bisquerra, 1989). This technique attempts to explain the variability of the variables set, with the fewest number of factors or components, to provide an overview of interrelationships between these variables (Peña, 2002; Hair *et al., 2008*).

Finally, the effects of the perception of barriers on the probability to innovate and on the demand of certain public actions to stimulate innovation were analysed. For each decision, a probit model is used taking the following form:

$$Y_i^* = \beta_i X_i + C_i F_{ki} + \varepsilon_i > 0 \tag{1}$$

The latent variable is not observed. What is observed is the realization of what simply depends on the decision of the firm, so that:

$$Y_i = \begin{cases} 1 & if\ Y_i^* > 0 \\ 0 & otherwhise \end{cases} \tag{2}$$

whereby the decision of the company "*i*" is a function dependent on factors obtained in the previous factor analysis related to innovation barriers (F_k) and a set of explanatory variables (X). The explanatory variables used are binary variables of the companies' characteristics: company size (1: fewer than 10 employees, 0: more than 10 employees) (*size)*; exporting company (1: exporting , 0: not exporting) (*export)*; the size of the locality in which the company is located (1: >15.000 inhabitants; 0: <15.000 inhabitants) (*location)*; company with more work centres located in Spain (1: company with more work centres in Spain; 0: company without) (*C. Spain)*; to be a cooperative (1: the company is a cooperative; 0: the company is not a cooperative) (*coop).*

Using this methodology several decisions are analysed: "probability to be innovative" and "demand for some public actions". In the first case, the latent variable adopts value 1 when the company reported to have performed innovative activities (product, process, organizational or commercial) within the last 2-3 years, and 0 otherwise. This proxy to measure the probability to innovate has been used in some studies as Silva et al. (2008) or Canales and Álvarez (2017). In the second case, the latent variable adopts the value 1 when the company demands for the implementation of those public support actions to encourage innovative activities, and 0 otherwise.

4. Results and discussion

4.1. Descriptive study

Firstly, with regard to the innovative activity, 51.6% of the companies reported to have undertaken some innovation activities in the last 2/3 years. 64 % of them have fewer than 10 employees and 92.2% fewer than 50 employees. The innovative activity is slightly higher in cooperatives (53.3 % of the total of cooperatives) than in non-cooperative companies (51 % of the total of no cooperatives). Furthermore, the main differences detected between cooperative companies compared to non-cooperatives are that the first ones are more export-oriented (68.8% against 38.3%)[7] and comparatively, they develop further product-innovations (62.5% against 60.4% of non-cooperative companies) whilst the percentage of non-cooperative companies that support process innovations is higher (56.2% against 43.8% of cooperatives). Another noteworthy difference between cooperative and non-cooperative companies is the higher level of collaboration for innovation with other companies (43.8% compared to 14.6% of non-cooperative). Overall, the percentage of innovative agri-food companies that collaborate is

[7] In 2015 agri-food cooperatives from Extremadura exported more than 144 million euros which is 17% of the total number of exports in the region.

reduced (31.3%). Cooperative companies use more protective systems of innovation (60% against 49% of non-cooperatives). The higher percentage in terms of public funding in cooperative companies compared to non-cooperative ones is another interesting aspect to emphasize (30% opposite 17% of non- cooperative ones).[8] Table 2 summarizes these aspects.

TABLA 2.
Innovative companies

Characteristics	Total (% total companies)	Cooperatives (% total cooperatives)	Non-cooperatives (% total non-cooperatives)
Innovative companies	64 (51.6%)	16 (53.3%)	48 (51%)
Size:			
< 10 workers	41 (64%)	8 (50%)	33 (68.8%)
10-50 workers	18 (28.2%)	5 (31.2%)	13 (27.1%)
> 50 workers	5 (7.8%)	3 (18.2%)	2 (4.2%)
Innovative exporters companies	29 (46%)	11 (68.8%)	18 (38.3%)
Types of innovation:			
Product	39 (61%)	10 (62.5%)	29 (60.4%)
Process	34 (53.1%)	7 (43.8%)	27 (56.3%)
Organizational	3 (4.7%)	0 (0%)	3 (6.3%)
Commercial	8 (12.5%)	1 (6.3%)	7 (14.6%)
Collaboration with other companies	20 (31.3%)	7 (43.8%)	7 (14.6%)
Protection of innovation	31 (51.7%)	9 (60%)	22 (49%)
Financing with subsidies	25 (20.2%)	9 (30%)	16 (17%)

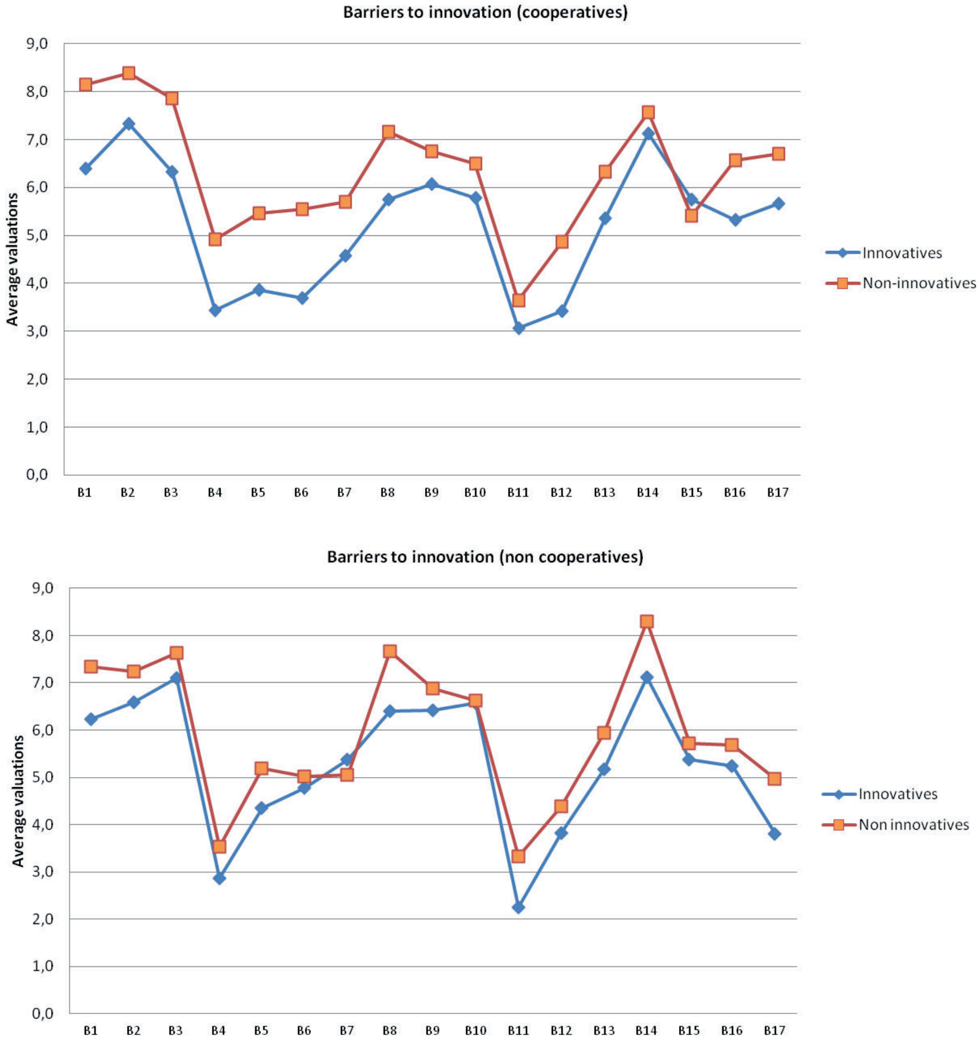
Secondly, a set of questions about the companies' perception on several barriers to innovation has been included in the questionnaire, distinguishing 17 barriers to innovation. Figure 1 differentiates the obstacles perceived by cooperatives and non-cooperative companies, differentiating at the same time innovative from non- innovative companies[9].

In Figure 1, it can be observed for both cooperative and non-cooperative companies, that non-innovative firms perceive relatively greater hindrances to innovation compared to innovative firms, although the differences are fewer in terms of valuations in the case of non-cooperative ones. Segarra and Teruel (2010) conclude that in terms of Spanish businesses, innovative companies perceive more obstacles, especially those related to cost of projects and knowledge access, which reveals that the existing barriers for the Extremaduran agri-food companies are more of the type of the *disincentive* to innovation.

Given the two types of companies, and for both innovative and non-innovative companies, the highest valuation corresponds to the *lack of support from Public Administrations*. Moreover, economic barriers are specially valued: *too-high costs and lack of internal and external funding.* Finally, there is the fact that non-innovative companies perceive more as a barrier the existence of *high economic risk* posed by innovating. Hernández and González de la Fe (2013) show in their study that the lack of support from public administrations is the main obstacle to innovation.

[8] In Corchuelo and Mesías (2015 b) it can be found a more detailed descriptive analysis of the sample.
[9] The valuations are made in a Likert 0-10 scale where the average valuation has been made according to the number of answers.

FIGURE 1.
Average valuation of barriers to innovation



Notes: B1: Lack of internal funding; B2: Lack of external funding; B3: Too-high costs; B4: Lack of qualified personnel; B5: Lack of information technology; B6: Lack of information on markets; B7: Difficulty to find cooperation; B8: High economic risk; B9: Markets dominated by well-established companies; B10: Insufficient flexibility of rules and regulations; B11: Rigidity in organization practices; B12: Difficulty protecting innovations; B13: High risk of imitation; B14: Lack of support from public administrations; B15: Lack of demand for innovation from customers; B16: Lack of mediators for innovation; B17: Market conditions don't imply the need to innovate.
Source: Own elaboration.

The existence of obstacles -specially derived from financial constraints[10], lack of appropriability of results and the existence of high fixed costs- has given rise to *market failures* to the provision of innovation which has traditionally justified from an economical point of view the intervention of governments through *scientific and technology policies.* The aim of these policies is not only to stimulate innovation activities in these companies but also to stimulate and support the whole economic innovation system. There are studies such as Mohnen and Roeller (2005) that provide evidence, based on the barriers to

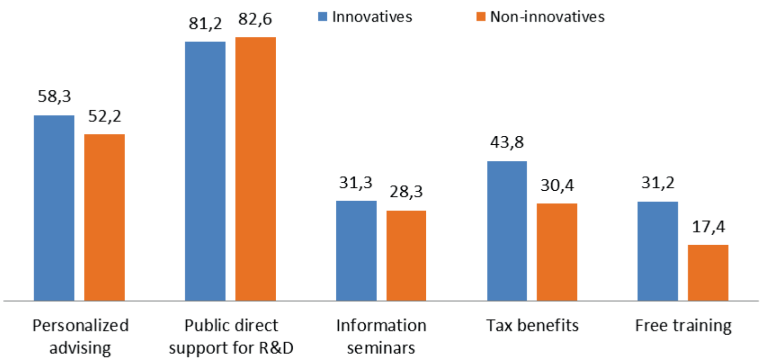
[10] It has been argued that this problem affects specially small and medium sized companies (SMEs) and young innovative companies through credit constraints (Hall, 2002 2005; Hubbard, 1998, or Höfer, 2002).

innovation faced by companies[11], of the necessity to articulate a package of public measures to encourage non-innovative companies to innovate and to make the innovative ones even more so.

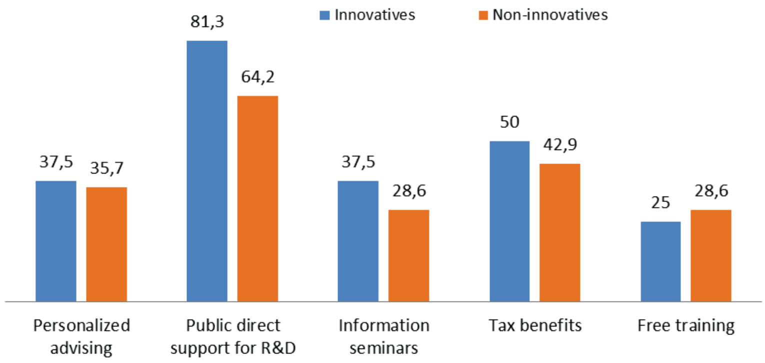
In this sense, the last block of questions in the questionnaire is oriented to asking companies about the kind of public aids companies demand in order to boost innovative activities. Firms are asked about five types of demanded public actions: two of them linked to an increase in public financial support (*subsidies* or *tax benefits*), and the others aimed at offering *personalized advising* to companies, organize specific short *information seminars* on aspects related to innovation, or *free training courses* of longer duration. The results from all the sampled companies are shown in Figure 2. It appears that the main actions demanded from companies are the granting of public subsidies and other types of financial public support. A difference is detected between cooperative and non-cooperative companies on the fact that non-cooperatives demand more personalised advising whereas cooperatives demand, especially innovative ones, more tax benefits.

FIGURE 2.
Demanded Public actions (% companies)

Non-cooperatives (%)



Cooperatives (%)



Source: Own elaboration.

[11] Without trying to be too exhaustive for space reasons, we highlight that there are studies which have analysed in an international/national level the effectiveness of public funding support to innovation (subsidies and tax benefits) are very numerous. Focusing on Spain, there are several studies which have analysed the effectiveness of subsidies to innovation (Busom, 2000; González *et al.*, 2005; González & Pazó, 2008) and tax benefits separately (Marra, 2004; Corchuelo, 2006; Corchuelo & Martínez-Ros, 2010) whereas studies by Marra (2008); Busom *et al* (2010, 2011) analyse them together. A recent study made by Busom *et al.* (2014) shows the relationship between market failures (appropriability and financial constraints, which are barriers to innovation) and the use of public support (national subsidies and tax benefits) for a representative sample of Spanish manufacturing companies with more than 10 employees taken from PITEC (FECYT and INE) database. The study concludes that, in average, for small and medium size companies, subsidies are more beneficial to reduce the barriers which produce under-investment in R&D activities than tax benefits.

4.2. Factor analysis of barriers to innovation

Once the data was analysed in a descriptive way, and as stated in the methodology, a factor analysis (FA) is applied to all companies in the sample (innovative and non-innovative firms) to reduce the number of variables needed to categorize companies linked to the perception of obstacles to innovation. Bartlett's sphericity test and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were applied to test the validity of the sampling. The former is used to check that the correlation matrix is close to an identity matrix, i.e., one with all the diagonal elements unity and the off-diagonal elements null (Visauta 1998). The KMO measure is used to compare the observed correlation coefficients with the partial correlation coefficients. Results for both tests (KMO = 0.794; and Bartlett's sphericity test=357.917; sig.= 0.000) indicate that the sample is adequate for FA.

From the FA six factors/components have been obtained whose definition is obtained from the rotated component matrix (Table 3), which allows a better explanation of the generated factors.

Table 3.
Rotated Component Matrix

	Factor					
	1	**2**	**3**	**4**	**5**	**6**
B1: Lack of internal funding					0.739	
B2: Lack of external funding					0.846	
B3: High costs			0.680			
B4: Lack of qualified personnel		0.608				
B5: Lack of information on technology	0.883					
B6: Lack of information on markets	0.890					
B7: Difficulty to find innovation's partners	0.444					
B8: Economical risks			0.887			
B9: Markets dominated by established companies			0.556			
B10: Insufficient flexibility in rules and regulations						0.590
B11: Rigidity in organisational practices		0.677				
B12: Difficulty to protect innovations		0.736				
B13: High risk of imitations		0.706				
B14: Lack of public support						0.759
B15: Lack of demand for innovation				0.788		
B16: Lack of innovation mediators		0.539				
B17: No need for innovation in the market				0.851		

The next factors have been found:

Factor 1: Explains 32.5% of the variance and shows high scores in "lack of information on technology", "lack of information on markets", and "difficulties to find partners and cooperation". This is a factor related to "*obstacles to innovation due to non-cooperation and lack of information*".

Factor 2: This factor explains 9.7% of variance and it is mainly related with the barriers "rigidity in organisation practices", "lack of qualified personnel", "difficulty to protect innovation", "high risks of imitation" and "lack of mediators for innovation". Therefore, this is a factor related to intrinsic aspects of the companies and, in consequence, it has been defined as "*Obstacles to innovation due to the lack of human resources and appropriability*".

Factor 3: The third component explains 8.7% of the variance and it is related to “too high costs”, “high economic risk” and “markets dominated by well-established companies” variables. It has been defined as “*obstacles to innovation due to high costs and risks”.*

Factor 4: The fourth component, with a 7.2% of variance, is linked to “lack of demand for innovation” and “no need for innovation in markets” variables. It has been defined as “*obstacles to innovation due to no need for innovation".*

Factor 5: The fifth component explains 5.7% of variance and it is related with the barriers “lack of internal funding” and “lack of external funding” variables. This is a factor related to “*Obstacles to innovation motivated by financial constraints”.*

Factor 6: Finally, the last factor, with a 5.5% of variance, is linked to “insufficient flexibility of rules and regulations” and “lack of support from public administrations” variables. It is defined as *"obstacles to innovation due to institutional reasons".*

In Arias *et al.* (2016), a factor analysis of obstacles to innovation was conducted to analyse the differences in innovation among agri-food companies. For that purpose, innovating companies’ data was taken from PITEC (2010-2012). The factor analysis revealed the existence of two factors linked to “*technical capacity to innovate”* and “*economic/financial capacity*”. Also, in Corchuelo and Mesías (2015 c) an analysis applied to companies from Extremadura, using the complete sample that includes both manufacturing companies and knowledge-intensive businesses services sectors, revealed the existence of four factors of obstacles to innovation related to “*lack of internal resources and sustainability”, “costs and financial constraints”, “risks and market conditions”* and “*lack of demand for innovation*”.

4.3. Agri-food companies decisions

Finally, the decisions made by the agri-food companies are analysed in order to evaluate the influence of the factors obtained as obstacles to innovation, other variables related to the companies’ characteristics in regard to the probability to innovate, and the demands required by agri-food companies in order to encourage the innovation. Table 4 shows the mean of the marginal effects for each observation (calculated for each value of the independent variables_*dy/dx*) and significances which underline the influence these different variables have on the probability.

With regard to the probability for innovation it can be observed (Table 4, column 2, model 1) that Factor 3 (*obstacles to innovation due high costs and risks*) has a negative and significant effect on the probability of innovation in the agri-food companies. The existence of obstacles to innovation due to these reasons has been revealed by several studies. With regard to the *high costs*, studies such as Baldwing and Lin (2002) and Tourigny and Le (2004), both of them focused on Canada; Silva *et al.* (2008) focused on Portugal; Kamalian *et al.* (2011) on Iran; and D’Este *et al* (2012) on United Kingdom. The latest study also points to *market conditions* as an important barrier to innovation. In Spain, there are studies carried out by Madrid-Guijarro *et al.* (2009), Segarra and Teruel (2010), Hernández and González de la Fé (2013), and Corchuelo and Mesías (2015 c). The study conducted by Necadová and Schoelleová (2011) in Czech Republic also reveals that besides the existence of costs, a *high economic risk* is also an obstacle to innovation.

TABLE 4.
Companies' decision: innovation and demanded public performances

Variable	Innov.(1) *dy/dx* (s.e.)	Demand 1 (2) *dy/dx*	Demand 2 (3) *dy/dx*	Demand 3 (4) *dy/dx*	Demand 4 (5) *dy/dx*	Demand 5 (6) *dy/dx*
Factor 1	-.027 (n.s.)	.004 (n.s.)	.024 (n.s.)	.006 (n.s.)	.037 (n.s.)	**.083 (**)**
Factor 2	**-.087 (*)**	.070 (n.s.)	-.055 (n.s.)	-.021 (n.s.)	.030 (n.s.)	-.061 (n.s.)
Factor 3	**-.131 (**.)**	.079 (n.s.)	-.024 (n.s.)	**-.008 (**)**	-.040 (n.s.)	-.051 (n.s.)
Factor 4	-.019 (n.s.)	**.081 (*)**	.020 (n.s.)	.005 (n.s.)	**.140 (**)**	.002 (n.s.)
Factor 5	-.045 (n.s.)	-.031 (n.s.)	**.031 (**)**	.030 (n.s.)	-.025 (n.s.)	.004 (n.s.)
Factor 6	-.052 (n.s.)	-.009 (n.s.)	.057 (n.s.)	.012 (n.s.)	.031 (n.s.)	.035 (n.s.)
Size	-.148 (n.s.)	-.036 (n.s.)	-.197 (n.s.)	.083 (n.s.)	.173 (n.s.)	.156 (n.s.)
Export	**.310 (***)**	.084 (n.s.)	.137 (n.s.)	.116 (n.s.)	.045 (n.s.)	.110 (n.s.)
Location	-.062 (n.s.)	.127 (n.s.)	-.044 (n.s.)	.000 (n.s.)	-.079 (n.s.)	-.016 (n.s.)
C Spain	**.289 (**)**	-.099 (n.s.)	**0.299 (**)**	.186 (n.s.)	.102 (n.s.)	.126 (n.s.)
Coop	-.064 (n.s.)	**-.225 (**)**	-.135 (n.s.)	.012 (n.s.)	.073 (n.s.)	.050 (n.s.)
Nº Observ.	122	122	122	122	122	122
Log-likelihood	-73.402	-77.303	-68.962	-73.362	-75.319	-63.430

Notes: (1): the dependent variable takes on value 1 if the company has carried out innovation activities in the last 2/3 years and 0 otherwise; (2) the dependent variable takes on value 1 if the company requests personal advising and 0 otherwise; (3) the dependent variable takes on value 1 if the company requests subsidies and direct public support and 0 otherwise; (4) the dependent variable takes on value 1 if the company requests information seminars and 0 otherwise; (5) the dependent variable takes on value 1 if the company requests tax benefits and 0 otherwise; (6) the dependent variable takes on value 1 if the company demands free training and 0 otherwise.
Each column shows the mean of the estimated marginal effect of the covariates in each joint probability. dy/dx for factor levels is the discrete change from the base level.
*** P<0,01; ** P<0,05; * P<0,1; n.s. not significant.

Moreover, it is found that the obstacle factor linked to the *lack of human resources and appropriability* (Factor 2) also shows a negative and statistically significant effect on the probability of innovation in agri-food companies. Several studies underline these factors as barriers to innovation. In particular, the *lack of qualified personnel* becomes apparent in studies by Silva *et al.* (2008), McCann (2010), Necadová and Scholleová (2011) and Hernández and González de la Fe (2013). Kamali *et al.* (2011) in Iran, indicate as an obstacle the lack of skilled labour, especially in small and medium-sized companies (SMEs). Piatier (1984), in a research applied to eight European countries highlights, as barriers to innovations, the education system and the skilled workforce. The level of education: human capital limitations, lack of entrepreneurial mindset and absence of adequate tools to innovate in education, are also identified in the research by Comtesse *et al.* (2002). Canales and Álvarez (2017) analyse the impact of knowledge-obstacles such as availability of human resources on the probability of introducing innovations resulting that these type of barriers reduce in approximately 26% the innovation probability in the Chilean firms. It is interesting to highlight that, to our knowledge, there are no studies that reveal the lack of appropriability as an important barrier to innovation. This is caused because, in general, the national innovation surveys do not contemplate this type of barriers, that have been taken into account in our questionnaire. The result shows the importance of these types of barriers (difficulty protecting innovations and high risk of imitation) as deterrent factor of firms' innovation.

The remaining factors motivated by *non-cooperation and lack of information, no need for innovation, funding restrictions* and *institutional reasons* are not significant therefore they do not affect the probability to innovate in the case of the agri-food companies in Extremadura.

With regard to the characteristics of the companies, if a firm exports goods as well as has additional locations in Spain has a positive and significant effect on the probability to be innovative. The relationship between internationalization and innovation has been analysed in several theoretical and empirical researches (Cavusgil & Knight, 2014; Katsikeas *et al.,* 2000). In Server-Izquierdo and Lajara-Camilleri (2016) the existence of a relationship between the degree of innovation and the degree of internationalization can be observed in the agri-food Spanish cooperatives, considering the volume of exports on the company's total turnover. The company size has no bearing on the probability to innovate. Similarly, no empirical evidence is obtained on the existence of a relationship between the size of the company and innovation in agri-food companies in Arias *et al.* (2016) research. However, an evidence is obtained from the research by Server-Izquierdo and Lajara-Camilleri (2016) regarding Spanish citrus cooperatives, and in García-Álvarez-Coque *et al.* (2015) regarding agri-food firms in the region of Valencia. In our case the companies size is primarily small, as mentioned in the descriptive study, and this can influence the fact that this variable proved to be not significant. No difference is observed in the probability to innovate based on whether the company is cooperative or non-cooperative. On the contrary, there are evidences about the effect of legal form of the company in R&D activities in the studies of Fearne *et al.* (2013) and García-Álvarez-Coque *et al.* (2015).

In terms of the public actions demanded by companies (Table 4 columns 3 to 7), by analyzing their requirements to ease these obstacles and the companies' characteristics it is observed that regarding *personal advising* (Demand 1) there is a negative and significant effect by the cooperatives (Table 4, column 3, model 2). Previously analysed and as it is shown in Figure 2, non-cooperative companies demand this type of actions to a greater extent. This is the only difference perceived between cooperative and non-cooperative agri-food companies as the coefficient of this variable in the remaining regressions is no significant. Regarding obstacles to innovation, it can be seen that Factor 4 (*obstacles to innovation due to no need for innovations*) has a positive and significant impact on the probability to demand for *personalized advising*. The need to be innovative and differentiate from competitors leads companies to demand this type of public action in order to develop innovative products that generate demand in small markets.

With regard to the demand for *subsidies* (Demand 2)*,* the probability to be demanded by agri-food companies which have other work centers in Spain has a positive and significant effect. Factor 5 (*obstacles to innovation due to financial constraints*) also has a positive and significant effect on the likelihood of demand for greater direct public financial support (Table 4, column 4, model 3).

It is interesting to highlight that Factor 3 (*obstacles to innovation due to high costs and risks*), as an important factor that reduces the probability to innovate, has a positive and significant effect on the probability of requesting information seminars (Demand 3) (Table 4, column 5, model 4).

Neither the existence others barriers to innovation nor the company's characteristics affect the demand for *information seminars* (Demand 3), so there are no differences between the firms in this type of demanded action from the public administration (Table 4, column 5, model 4).

Again, the existence of obstacles due to *no need for innovations* (Factor 4) has a positive and significant influence on the probability to demand more *tax benefits* (Demand 4) (Table 4 column 6, model 5). The research by Hernández and González de la Fe (2013) points out that the lack of demand for innovative products is an obstacle to innovation. This result is interesting in the sense that tax benefits could motivate businesses to generate the need to create innovation demands in this market through, for example, improvements in the product's quality according to Law 6/2015, 24th March, Agrarian of Extremadura. This reason could influence the fact that agri-food companies consider these obstacles in the demands of *personalized advising* and *tax benefits*.

Finally, with regard to the demand for *free training* (Demand 5)*,* it must be highlighted that the perception of obstacles in view of the *non-cooperation and lack of information* has a positive and significant effect (Table 4, column 7, model 6). The *lack of cooperation between companies* is underlined as a barrier to innovation in researches by Tiwari and Buse (2007) and Buse *et al.* (2010). Likewise, the *lack* *of information on technology* is considered in researches by Mc Cann (2010) and Necadová and Scholleová (2011). D'Este et al. (2012) also highlight the *lack of knowledge* as an important barrier. Thus, the demand for more free training is revealed as a need for small companies that suffer from lack of information. Greater cooperation could be fostered for companies to reduce their size-issue in order to access to more training schemes.

5. Conclusion

The agri-food industry occupies a position of great importance within the manufacturing industry both in the case of Spain as well as in some regions like Extremadura where the weight of the agrarian sector and allied industries is substantially higher than the national average. Despite its importance, the agribusiness in Extremadura suffers several chronic problems, some of them related to the lack of developed innovative activity which is still significantly low. In this sense, public administrations have a special interest in encouraging scientific and technological research. However, despite the actions already carried out there remains scope for improvement, especially sharing their knowledge and communicating with the main actors of innovation (the companies), with the objective to ascertain which public actions are specially demanded attending to the obstacles perceived in order to increase the innovative activity.

Within this framework, the main objective of this study has been to analyse the perceptions of the Extremaduran agri-food companies of the main obstacles to innovation and to analyse if these have an influence in the probability to innovate, as well as the relation with the demanded public actions in order to increase the innovative behaviour.

Results show that, on one hand, the existence of *high costs and risks* and *lack of human resources and difficulties of appropriability* are the factors that have a negative effect on the probability to innovate in Extremaduran agri-food companies; on the other hand, there are important differences among factors of obstacles and demands of public actions. The factor due to *no need of innovations* has a positive effect on the probability to demand *personalized advice* and *fiscal benefits*. *Financial constraints* positively influence the demand for *direct public financial support*. The factor that has the higher negative effect on the probability to innovate (*high costs and risks*) positively influences the demand for *information seminars*. Finally, the obstacle factor due to *no-cooperation and lack of information* has a positive effect on the demand for *free training*.

The consideration of these obstacles and the demanded public actions can be used as a reference to design public policies from the point of view of recommendations oriented to encourage innovation in these type of industries given the importance that have in the regional development. As public recommendations, firstly, it should be taken into account the public actions demanded to reduce the perception of the different barriers to innovation; secondly, it would be interesting to study the demand of additional actions that diminish the perception of, especially, the lack of appropriability of the results of innovation in this industry.

However, the obtained conclusions must be interpreted with caution due to the fact that the data comes from a voluntary survey, yet it is justified given the lack of information concerning of agri-food companies in Extremadura. In addition, conclusive results cannot be drawn comparing them to other researches of other Spanish regions or other countries given the inexistence of such studies. It would have been interesting to make a comparison having had similar data. Despite these limitations, it is considered that this research provides a good approximation to the relationship between the perceived obstacles to innovation and demanded public policies that could be applied to develop public policies and encourage these type of activities in other regions of Spain.

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Vulnerabilidad territorial y demográfica en España. Posibilidades del análisis multicriterio y la lógica difusa para la definición de patrones espaciales

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Resumen:

Este trabajo analiza la relación entre los patrones espaciales de la vulnerabilidad territorial y de la vulnerabilidad demográfica en España. Se desarrolla, con este fin, un modelo SIG basado en la lógica difusa y la evaluación multicriterio, que pone de relieve las distintas gradaciones espaciales existentes en relación a estos dos tipos de vulnerabilidad. El artículo, de marcado enfoque geodemográfico y técnico, se aborda en un momento estratégico en el que la componente demo-espacial gana importancia progresivamente como objeto de estudio, dada la profundidad y trascendencia de los cambios experimentados por la población a cualquier escala a la que éstos se aborden, hecho al que se suma en España la preocupación por la sostenibilidad económica y ambiental de los territorios afectados por el proceso de despoblación. De otra parte, el artículo pretende ofrecer una alternativa metodológica que dé respuesta a la simplificadora y común propuesta de analizar el tema de los desequilibrios territoriales a partir tan solo de la población y de la superficie geográfica.

Palabras clave: Sistemas de Información Geográfica, Evaluación Multicriterio, Lógica difusa, Vulnerabilidad.
Clasificación JEL: C21, J11, R23.

Territorial and demographic vulnerability in Spain. The opportunities of the multicriteria method in the definition of spatial patterns

Abstract:

This paper is focused on the relations between the spatial patterns of territorial and demographic vulnerabilities in Spain. To aim this goal, the study is based on a GIS model of fuzzy logic and multicriteria evaluation, which highlights the spatial gradation of vulnerabilities. The article shows a strategic geodemographic approach, which is addressed at the importance of studying the population, because of the transcendence and implications of the changes experienced by the demo-spatial component at any scale. Furthermore, the study aims a research contribution in the concern that exists in Spain related to the sustainability of certain territories. On the other hand, the article proposes a methodological alternative to analyze the issue of territorial imbalances based not only on the population, but also on the geographical area.

Keywords: Geographic Information Systems, Multicriteria evaluation, Fuzzy logic, Vulnerability.
Clasificación JEL: C21, J11, R23.

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1. Introducción

La dimensión demográfico-territorial gana progresivamente relevancia en los estudios prospectivos y de planificación estratégica. La población, que es el elemento básico de las estructuras territoriales, de la organización social y de la estructura económica, históricamente ha presentado un marcado carácter de variable dependiente en relación a los cambios económico-territoriales (industrialización, crecimiento urbano y metropolitano…) y a las decisiones de política territorial relacionadas con las grandes infraestructuras de transporte, grandes embalses, trasvases, repoblaciones forestales, etc. Estos cambios económicos y estas decisiones de política territorial han generado profundos desequilibrios espaciales que, cual fractal, se reproducen en el territorio español a todas las escalas, determinando tanto la dinámica y la distribución espacial de la población como las características estructurales de ésta. Sin embargo, en las últimas décadas las trasformaciones experimentadas por la población en el territorio han sido de tal magnitud y profundidad que podría afirmarse que están convirtiendo a la variable demográfica en causa o factor más que en consecuencia o efecto, siendo esta afirmación especialmente válida y significativa en relación a las áreas más vulnerables demográfica y territorialmente, como son los espacios rurales y, singularmente, los espacios de montaña.

De otra parte, es bien conocido que actualmente existe un destacado interés por detectar y analizar áreas vulnerables en distintos ámbitos y a distintas escalas (Comisión Europea, 2008; Méndez, 2015 y Rodríguez-Domenech, 2016) y desde diferentes dimensiones: socio-demográfica, socio-económica, residencial, percibida o subjetiva (Alguacil *et. al*, 2014). Si bien las áreas de elevada concentración de habitantes, esto es urbanas, han sido un foco de atención recurrente en los estudios de vulnerabilidad (De Cos y Usobiaga, 2016), recientemente asistimos a una creciente preocupación por las situaciones de vulnerabilidad derivadas de niveles de ocupación tan bajos que hacen de ciertas zonas claros ejemplos de territorios que entran en una trayectoria crítica desde el punto de vista de la sostenibilidad presente y futura tanto en términos demográficos como territoriales (Recaño, 2017). Para ello, resulta clave desentrañar la relación entre territorio y población, incorporando los criterios característicos propios de estos dos elementos desde la perspectiva teórica de la vulnerabilidad.

Sobre esta base teórica, en el presente trabajo se aborda la configuración espacial de la vulnerabilidad territorial y la vulnerabilidad demográfica, a través de los Sistemas de Información Geográfica (SIG) como herramienta técnico-metodológica de análisis. Y es que el territorio se comporta de forma gradual en la mayor parte de los procesos que en él tienen lugar. En este sentido, el patrón espacial de la vulnerabilidad también responde a la *lógica difusa* o *borrosa* (Pászto et. al., 2015) que evita las rupturas categóricas en favor de grados de transición que van marcando el paso de lo más a lo menos vulnerable.

Sobre esta base, el potencial analítico y de gestión de los SIG se pone al servicio de la aplicación de todas las fases que implica el *método multicriterio* con un fin concreto, cual es el de analizar del grado de vulnerabilidad territorial y demográfica en España, a partir de múltiples criterios que se solapan espacialmente evocando a la división vertical propia de la información geográfica.

Esta aportación metodológica parte de la incorporación de una técnica ampliamente desarrollada para la toma de decisiones espaciales (Gómez y Barredo, 2005), que normalmente se ha enfocado hacia la búsqueda de la ubicación idónea para un determinado uso, actividad o servicio. Si bien, en este caso las bases de la evaluación multicriterio se adaptan tanto al fin específico señalado con anterioridad como a los requerimientos metodológicos propios de los SIG, que a través del componente de procedimientos computerizados y de su relación con los otros elementos del sistema (Olaya, 2014) hacen posible su desarrollo empírico.

2. Marco teórico. Despoblación rural y envejecimiento: un enfoque multicausal

El envejecimiento de la población y la despoblación, fenómenos que en la mayor parte del mundo rural se superponen, se han convertido en uno de los temas emergentes en las agendas políticas de los países desarrollados y, singularmente, en España. Sin embargo, las variables demográficas no deberían de ser analizadas aisladamente porque aparecen relacionadas intrínsecamente con factores territoriales (Molina, 2019), económicos, sociales o políticos, entre otros. Si bien, de los citados, en este estudio nos centraremos en los geográficos, priorizando la visión comparativa cruzada entre la vulnerabilidad demográfica y la vulnerabilidad territorial.

En relación a la despoblación, junto a las causas demográficas (caída de la natalidad, incremento de la mortalidad por envejecimiento, aumento de la emigración), el peso de los factores económicos es determinante para explicarla (Ayuda *et al.*, 2010). Estos factores caben ser explicados en el contexto de la modernización económica del sector primario, traducida en una disminución de la población ocupada en el sector, que la mecanización hizo posible y a la que se suma la integración vertical de la agricultura (Langreo, 1987) o la integración vertical para la cadena de valor en los agro-negocios (Victoria, 2011).

A estas causas de carácter general, en los países desarrollados se sumaron en el caso de la España de la Dictadura otros factores como la crisis de la minería en diferentes áreas rurales del país, la construcción de embalses de grandes dimensiones (Swyngedouw, 2014[1]), las repoblaciones forestales (Gómez y Mata, 1992), que se calcula afectaron a lo largo de la etapa de la Dictadura a casi un 10% de la superficie del territorio nacional, el desarrollo de infraestructuras de transporte (Pérez, 1988) así como líneas eléctricas, agua potable u otros más intangibles -pero no menos condicionantes- como la mayor presión fiscal que históricamente han soportado los espacios rurales (Del Romero, 2018).

La especificidad del espacio rural español es que el proceso de cambio y modernización de las estructuras agrarias –y por tanto la emigración rural– se ha desarrollado más tardíamente que en el resto de Europa, pero se ha producido de forma más intensa y en un periodo más corto: en tan solo dos o tres décadas, desde el Plan de Estabilización de 1959 hasta la Gran Crisis energética y económica de los 70´ del pasado siglo XX (De Cos y Reques, 2005; 2006), mientras que en los otros países del continente se prolongó a lo largo de más de una centuria. Estas transformaciones, que han continuado en las últimas décadas, se han traducido en una masiva pérdida de población, esto es, en una despoblación progresiva, que ha impedido asegurar el reemplazo generacional en un cada vez más alto porcentaje de explotaciones agropecuarias, y en consecuencia en la dificultad de mantener la continuidad de éstas como efecto del déficit de población en la llamada generación soporte: 30-49 años (Camarero, 2009). A este hecho se suman el alto grado de envejecimiento del empresariado en el sector primario y densidades por debajo del umbral crítico, cifrable en 8 hab./Km^2 según Gómez Orea y Gómez Villarino (2013) o en 12,5 hab./Km^2 según la Comisión Europea (2016).

Todos estos hechos se desarrollan en el contexto de una fuerte dispersión de la población en el territorio y en un débil, frágil y desequilibrado sistema de asentamientos, lo que supone un nuevo problema estructural. Por todas estas razones la despoblación rural (y ligada a ella la sostenibilidad económica y ambiental en una buena parte de la España rural, singularmente en la mayor parte de áreas de montaña) se ha convertido en uno de los temas emergentes, tanto en las preocupaciones políticas y sociales de los países europeos, y singularmente en España, como en la investigación en Ciencias Sociales (Collantes y Pinilla, 2011; Collantes *et al.*, 2014; Del Romero, 2018; CES, 2018, entre otros).

Con ello, la despoblación rural y la vulnerabilidad demográfica y territorial, en su más amplio sentido, son temas relevantes en la actualidad. Tanto es así, que a nivel nacional se ha organizado la Comisión de Despoblación en el marco de la Federación Española de Municipios y Provincias que va

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[1] En Del Romero, 2018, p. 147.

avanzando en los rasgos de la España despoblada y en sus condiciones de vulnerabilidad frente al resto del territorio. En este sentido, la Comisión de Despoblación simplifica los rasgos de la España demográficamente vulnerable a partir de los siguientes aspectos, algunos de ellos ya mencionados con anterioridad: densidad, envejecimiento, natalidad y pérdida de población (FEMP, 2017: 10). Sobre esta base, la densidad se puede medir en modelos de densidad focal que superan las variaciones vinculadas al tamaño superficial de la unidad administrativa; el envejecimiento se vincula al índice de envejecimiento y se complementa con un enfoque estructural a través de la proporción de la generación soporte y la TBM; la natalidad se mide directamente según la TBN y, finalmente, la pérdida continuada de población se mide a partir de la tasa de crecimiento medio anual. Estos rasgos resultan claves, como se argumentará posteriormente, en el desarrollo metodológico del presente estudio. Por otro lado, el condicionante territorial tradicionalmente se vincula a condiciones de altitud, pendiente y accesibilidad (CES, 2018), a las que podrían añadirse otras variables como las relativas a las coberturas (Jonard *et al.*, 2009; Reig *et al.*, 2016). En este sentido, hay que tener en cuenta que un aspecto muy ligado a la dinámica de las áreas vulnerables es la presencia de equipamientos y servicios, variable difícil de abordar por la ausencia de fuentes universales en la materia, pero fácilmente inducible a través del poblamiento, y más exactamente de la existencia de núcleos con un tamaño demográfico que garantice la presencia de tales instalaciones.

En este contexto, es precisamente la aceleración del proceso de despoblación lo que hace necesario analizar en profundidad en nuestro país la relación entre vulnerabilidad territorial y vulnerabilidad demográfica, porque serán los espacios más vulnerables territorialmente los que inicien antes y profundicen en mayor medida su proceso de despoblación y de despoblamiento, esto es, lo que explique su vulnerabilidad demográfica, factor éste que condicionará su futuro muy negativamente. En este sentido, la configuración espacial de los patrones de vulnerabilidad territorial y demográfica aportados en el presente artículo se postula como un punto de partida para análisis comparativos e integrados que en un futuro se pudieran derivar a escalas de detalle, sobre cómo la vulnerabilidad territorial y demográfica se relacionan en las distintas áreas del país. En esta fase, sin embargo, se aporta una tabulación cruzada de ambos tipos de vulnerabilidad a nivel municipal que sin servir de análisis causal sí nos permite avanzar en el conocimiento de la vulnerabilidad con la doble perspectiva incorporada.

3. Materiales y métodos: la evaluación multicriterio como alternativa metodológica para determinar los patrones espaciales de vulnerabilidad

El trabajo se apoya fundamentalmente en un variado conjunto de análisis y modelos SIG ampliamente demandantes de datos homogéneos para el conjunto del país, tanto modelados en raster a resolución de 30 metros, como en vectorial referidos a entidades diversas. Así, se trata de un estudio en el que los materiales –entendidos éstos como fuentes de entrada en soporte digital– y los métodos estadísticos avanzados (Ábalos y Paredes, 2014), –implementados mediante SIG– cobran un protagonismo especial.

3.1. La importancia de fuentes cartográficas digitales para la modelización de la vulnerabilidad

Solo se pueden llevar a cabo estudios geodemográficos si se cuenta con una sólida base de fuentes estadísticas. Sin embargo, los cambios en los proyectos censales, las restricciones derivadas de la *Ley de protección de datos* y la menor disponibilidad de información estadística cuanto mayor detalle tenga la entidad espacial de referencia, son factores que con frecuencia ejercen un efecto disuasorio en el planteamiento de estudios aplicados a escalas de detalle.

Así, se puede considerar que en España la mayor limitación de las fuentes para el estudio de la despoblación rural radica en la ausencia de información estadística para el análisis geodemográfico a microescala (incluida la escala municipal) para periodos anteriores a 1991 y posteriores al *Censo de Población* *de 2001*, así como la fiabilidad de las fuentes y la insuficiencia de éstas para el cálculo de las poblaciones flotantes y/o estacionales, en definitiva, para analizar el uso temporal del territorio (García y Sánchez, 2001; Goerlich & Mas, 2008; Franch *et al.*, 2013).

Frente a esta situación, en el presente estudio se apuesta por el uso en profundidad de las fuentes cartográficas, disponibles en formato SIG, que cuentan con elevado potencial para trabajos como el que nos ocupa. Así, debemos aprovechar las oportunidades derivadas de la Directiva Europea Inspire (*Directive*, 2007) y las órdenes ministeriales de Fomento 956/2008 y 2807/2015 por la apertura que han supuesto estos hitos normativos para el acceso a bases cartográficas oficiales en soporte digital.

Tanto es así, que el estudio de la vulnerabilidad territorial se aborda íntegramente a partir de la consideración de fuentes cartográficas. Estas fuentes son claves para analizar aspectos relacionados con la orografía y la accesibilidad, que son las dos esferas fundamentales consideradas por su vinculación a las diferentes circunstancias de vulnerabilidad territorial.

La orografía se analiza a partir del *Modelo Digital del Terreno* producido por la NASA (USA), a partir de datos del Satélite Aster, con una resolución de 30 metros. Los datos originales en ocho cuadrantes son sometidos a un proceso de combinación raster y a una reproyección del EPSG 4326 al 25830.

Por su parte, la accesibilidad se analiza a partir de modelos de distancias euclídeas a los distintos elementos de intercomunicación del territorio, como son, autopistas y autovías, carreteras nacionales y estaciones de ferrocarril. La fuente principal para identificar la ubicación de estas infraestructuras es la *Base Cartográfica Numérica 1/200.000* producida por el Instituto Geográfico Nacional (IGN) y distribuida a través del Centro Nacional de Información Geográfica (CNIG). Las capas originales han sido sometidas a filtros y operaciones de unión. Del mencionado servidor procede también el *Nomenclátor*, ligado al *Padrón Continuo* por unidad poblacional –que permite aislar los núcleos a partir de cierto umbral, en este caso los 10.000 habitantes– como referencia clave para garantizar la concentración potencial de actividades, equipamientos y servicios a la población residente en las proximidades. Asimismo, se incorporan datos procedentes de *Padrones Municipales de Habitantes* y *Movimiento Natural de Población*, producidos por el Instituto Nacional de Estadística (INE).

3.2. El método multicriterio y la lógica difusa para la superación de rupturas categóricas en el estudio de la vulnerabilidad

La evaluación multicriterio, como método orientado inicial y genéricamente a la toma de decisiones espaciales (Gómez y Barredo, 2005), se incorpora a este trabajo con adaptaciones puntuales metodológicas por el cambio de finalidad, donde los factores no son condicionantes sino rasgos de vulnerabilidad y las restricciones tan sólo se materializan en el límite del ámbito de estudio. La implementación del método multicriterio y la lógica difusa mediante SIG presentan un elevado potencial para el fin que nos ocupa, en cuanto que permiten modelizar la vulnerabilidad tanto de forma genérica como específica -teniendo en consideración la dualidad de enfoques de vulnerabilidad referidos en el presente estudio-; así la apuesta metodológica contribuye a acotar espacialmente y profundizar cuantitativamente en los distintos grados de vulnerabilidad.

3.2.1. Posibilidades y procedimientos del método multicriterio para el estudio de la vulnerabilidad

La modelización de la vulnerabilidad a través de la modalidad multicriterio de combinación lineal ponderada *(WLC- Weighted Linear Combination)* contribuye decisivamente a poner de relieve el modelo espacial graduado de vulnerabilidad territorial y demográfica a nivel nacional, sobre la base de los principios de una ausencia de límites categóricos y de la necesaria combinación y compensación de factores mediante el establecimiento de un sistema de pesos expresados en tantos por uno.

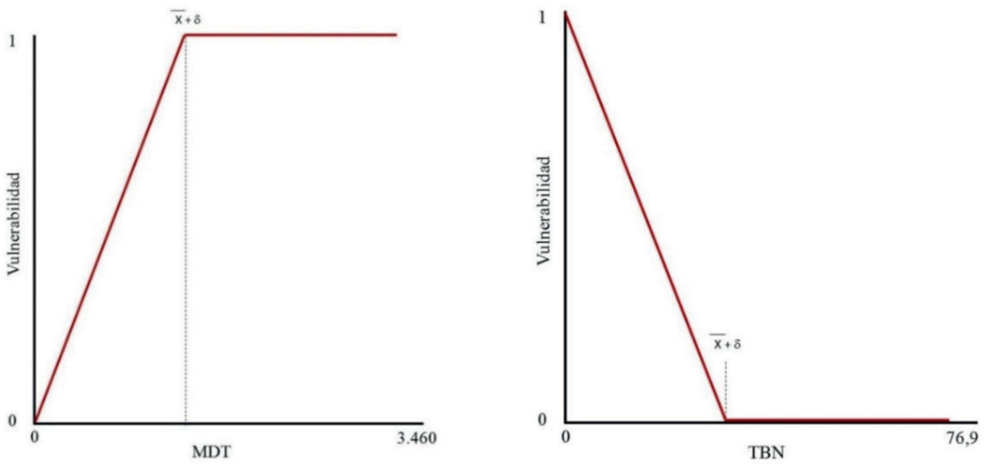
Esta modalidad multicriterio es una de las más extendidas y en ella cobra especial importancia el proceso de compensación de criterios, a través del cual un elevado peso de un factor implicaría una mayor influencia de ese rasgo en el modelo de vulnerabilidad final. Además, hay que precisar que a través de la compensación, los píxeles no vulnerables en alguno de los factores (valor estandarizado 0) no quedan excluidos si tienen nivel de vulnerabilidad importante en otros factores de elevado peso relativo, lo que supone una ventaja adicional importante para evitar la pérdida de matices e información.

Por otro lado, en esta presentación metodológica inicial hay que precisar que una de las fases claves de la evaluación multicriterio –directamente ligada a la ausencia de rupturas bruscas en el territorio- es la adaptación y estandarización de cada variable en función de los principios de la lógica difusa. El principio básico subyacente en la lógica difusa presenta una realidad gradual donde el comportamiento de las variables no es binario (0 ó 1) sino que es difuso, borroso o gradual; esto es, aporta valores numéricos reales intermedios entre un nivel de vulnerabilidad nulo (0) que irán ganando intensidad hasta un valor de vulnerabilidad máximo (1). Así, con independencia de los rangos de partida de las capas incorporadas al modelo multicriterio, todos los factores son estandarizados en capas de pertenencia difusa, escalados entre 0 (no vulnerable) y 1 (vulnerabilidad máxima).

Para la preparación de conjuntos difusos a partir de los factores originales se incorpora la herramienta *Fuzzify*, desarrollada en el entorno del programa SIG libre QGIS[2], con la cual se toman como referencia funciones de pertenencia difusa de tipo lineal y puntos de control variables basados en criterios homogéneos, estimados a partir de las estadísticas de capa (valores medios y desviaciones típicas), siendo la mayor parte de las funciones crecientes (esto es, a mayor valor de la variable mayor vulnerabilidad), excepción hecha de los factores de vulnerabilidad demográfica correspondientes a ocupación del territorio, potencial demográfico, natalidad y evolución de la población.

FIGURA 1.
Esquemas ilustrativos de las funciones de pertenencia difusa empleadas en la estandarización de los factores

Función lineal creciente de preparación de lógica difusa del factor territorial altitudinal | *Función lineal decreciente de preparación de lógica difusa del factor demográfico de natalidad*



Fuente: Elaboración propia.

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[2] A pesar de que este método está disponible en distintos programas SIG, se ha optado por el software libre QGIS y por el complemento denominado *Easy AHP (Analytic Hierarchy Process),* que permite la comparación por pares para la estimación de pesos y la combinación lineal ponderada (WLC).

Con esta aplicación de funciones de pertenencia difusa se consigue establecer un sistema de estandarización basado en criterios homogéneos, dado que las variables originales se expresan en unidades de medida diferentes, con rangos bien distintos y con una amplia gama de posibilidades de interpretación en función de la representatividad o adecuación para un objetivo concreto (Eastman, 1999).

3.2.2. Elección de factores y establecimiento de pesos relativos

Como en todo análisis multivariante la fase de elección de factores resulta clave y ésta debe apoyarse necesariamente en los correspondientes análisis estadísticos exploratorios previos, a partir de la matriz de correlaciones, índices de autocorrelación espacial y representación de patrones espaciales, para posteriormente sobre esa base proceder a la exploración factorial y modelización de dos tipos de vulnerabilidad: por un lado, la *vulnerabilidad territorial* (Cuadro 1), sustentada en seis factores vinculados a la orografía y la accesibilidad y, por otro, la *vulnerabilidad demográfica* (Cuadro 2) apoyada en seis criterios sobre estructura y dinámica de la población.

Cuadro 1.
Factores de vulnerabilidad territorial

Temática	Factor	Variable
Orografía	Altitud	Modelo Digital de Elevaciones (m)
	Pendiente	Modelo Digital de Pendientes (grados)
Accesibilidad	Por autopista y autovía	Modelo de distancia euclídea a los tramos de autopistas y autovías (m)
	Por carretera nacional	Modelo de distancia euclídea a los tramos de carreteras nacionales (m)
	Por ferrocarril	Modelo de distancia euclídea a las estaciones de ferrocarril (m)
	A equipamientos y servicios	Modelo de distancia euclídea a los núcleos >10.000 habitantes (m)

Fuente: Elaboración propia.

Cuadro 2.
Factores de vulnerabilidad demográfica

Temática	Factor	Variable
Estructura demográfica	Envejecimiento	Índice de Envejecimiento (%)
	Ocupación del territorio	Densidad Bruta de Población (hab./Km^2)
	Potencial demográfico	Proporción de población soporte 30-49 años (%)
Dinámica demográfica	Natalidad	Tasa Bruta de Natalidad (‰)
	Mortalidad	Tasa Bruta de Mortalidad (‰)
	Evolución	Tasa de Crecimiento Acumulativo 2001-2017 (%)

Fuente: Elaboración propia.

A todos estos criterios podría haberse añadido el poblamiento, esto es, el grado de dispersión de la población en el territorio. Sin embargo, esta variable, aunque fue inicialmente contemplada, se descartó de la propuesta metodológica final ya que los elevados valores observados en Galicia y Asturias, con sus 30.139 y 6.944 entidades de población respectivamente, invalidaba el análisis multicriterio de conjunto, derivando una subestimación general de los niveles de vulnerabilidad territorial para el conjunto del país.

Tras la selección y preparación de los factores se establece un sistema de pesos de los factores en tantos por uno, basado en la consideración de importancias relativas desiguales en los criterios que intervienen en el modelo. De hecho, se puede llegar a plantear que la ponderación es una de las ventajas claves de la evaluación multicriterio en cuanto que permite establecer unos pesos desiguales estimados en tantos por uno, que participan decisivamente en el proceso de compensación de unos factores con otros (De Cos, 2007).

En esta fase, con la finalidad de evitar subjetividades del equipo investigador que repercutan en etapas posteriores, se establecen los pesos de los factores a partir de una matriz simétrica de comparación por pares. Concretamente, para el desarrollo de este estudio se cuenta con la participación de un panel de expertos integrado por gestores de distintas Reservas de la Biosfera de España, que tuvo lugar en el contexto del Seminario "*Proceso de despoblación en la Red Española de Reservas de la Biosfera*"[3]. El grupo de gestores de las Reservas de la Biosfera de España cuenta con un amplio conocimiento del territorio de las distintas reservas, las cuales nos permiten muestrear el conjunto del país a partir de 49 recintos, en los que se representan cerca de 600 municipios y en los que se dan interesantes condiciones territoriales y demográficas para ser analizadas bajo el prisma de la vulnerabilidad. En la sesión celebrada, se organizaron sendos paneles orientados a la comparación de cada factor con el resto y en un formato posterior conjunto se planteó la puesta en común y la unificación de matrices (cuadros 3 y 4). En función de las argumentaciones de los distintos expertos, se consensuaron las importancias relativas en una matriz simétrica tanto para los factores de vulnerabilidad territorial como demográfica.

CUADRO 3.
Matriz simétrica y pesos derivados en los factores del modelo multicriterio de vulnerabilidad territorial

Factores	Factores comparados						Peso
	1	2	3	4	5	6	
1-Altitud	1						0,033
2-Pendiente	3	1					0,240
3-Accesibilidad por autopista y autovía	5	1	1				0,060
4-Accesibilidad por carretera nacional	7	1	3	1			0,160
5-Accesibilidad por ferrocarril	1	1/3	1/5	1/3	1		0,070
6-Accesibilidad a equipamientos y servicios	5	3	3	3	7	1	0,438

Nota: en la matriz se compara la importancia relativa de cada factor situado en las filas con los ubicados en las columnas. La igualdad de importancia se expresa mediante el valor 1; si es más importante el factor de la fila que el de la columna la importancia va desde 2 hasta un máximo de 9 y si, por el contrario, es menos importante el valor de la fila que el comparado de la columna, su importancia relativa va desde 1/2 hasta 1/9.
Fuente: Elaboración propia.

[3] Ministerio para la Transición Ecológica. Centro Nacional de Educación Ambiental (CENEAM). Valsaín/Segovia 11-13/09/2018.

CUADRO 4.
Matriz simétrica y pesos derivados en los factores del modelo multicriterio de vulnerabilidad demográfica

Factores	Factores comparados						Peso
	1	2	3	4	5	6	
1-Envejecimiento	1						0,175
2-Ocupación del territorio	1/5	1					0,122
3-Potencial demográfico	1/5	1	1				0,087
4-Natalidad	3	1	5	1			0,182
5-Mortalidad	1/3	1/3	1/3	5	1		0,074
6-Evolución	4	3	3	1	7	1	0,361

Nota: en la matriz se compara la importancia relativa de cada factor situado en las filas con los ubicados en las columnas. La igualdad de importancia se expresa mediante el valor 1; si es más importante el factor de la fila que el de la columna la importancia va desde 2 hasta un máximo de 9 y si, por el contrario, es menos importante el valor de la fila que el comparado de la columna, su importancia relativa va desde 1/2 hasta 1/9.
Fuente: Elaboración propia.

4. Análisis y discusión de resultados

En el presente apartado se incorporan los modelos multicriterio de vulnerabilidad territorial y demográfica, los cuales son abordados individualmente para poner de relieve los distintos patrones espaciales resultantes. Asimismo, se incorpora una interpretación conjunta de las similitudes y diferencias que sendos modelos presentan.

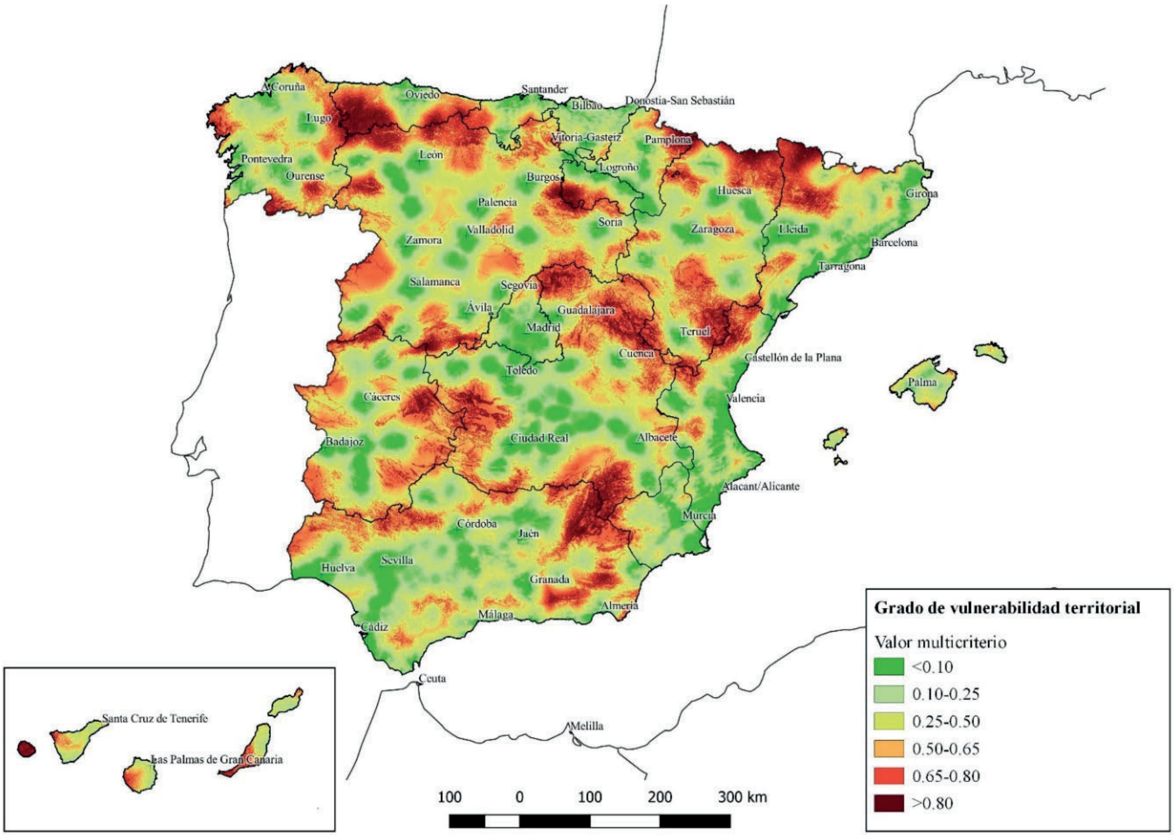
4.1. El modelo multicriterio de vulnerabilidad territorial en España

El modelo de vulnerabilidad territorial resultante del presente estudio (Mapa 1) refleja el peso de los factores geográficos físicos (cual son la altitud y las pendientes) y los humanos (esencialmente los ligados a la accesibilidad por diferentes medios de transporte y la distancia potencial a los equipamientos y a los servicios) y expresa el diferente grado que presentan unas áreas y otras del territorio español en relación a este concepto.

Sin duda la España de montaña y la España interior son las que muestran los valores más críticos. De norte a sur, en función de su mayor grado así como por la extensión e intensidad del territorio afectado, la máxima vulnerabilidad territorial corresponde a la Montaña Cantábrica occidental (la cual aparece fragmentada en dos áreas separadas por la autovía A-66 y autopista AP-66 Asturias-León: al Este de la misma las comarcas de la Cantabria occidental, del valle del Nansa y Liébana, la Montaña Palentina y Picos de Europa; al Oeste, el Occidente de Asturias y Ancares leoneses y gallegos); a ellas se suman el Pirineo y Prepirineo central y occidental, el Sistema Ibérico, Sierra de Gredos y Sierra de Francia, una gran extensión en la Submeseta sur (la que corresponde a las comarcas de la Serena, la Siberia, Jara-Los Ibores y las Villercas en tierras extremeñas y La Jara y la Sierra de San Vicente en Ciudad Real) y, en Andalucía, la Bética y la Penibética oriental. De esta tipología forma parte, asimismo, otro elevado número de áreas de menos extensión y grado de vulnerabilidad territorial, cual son el Finisterre gallego, el Macizo galaico y comarca zamorana de Sanabria, el norte de Burgos y valles pasiegos de Cantabria, la comarca del Cerrato castellano, Sierra Morena -casi en su totalidad-, así como la mayor parte de las comarcas de la Raya de

Portugal, la Penibética occidental y en Canarias las islas menores y el sur y oeste de las dos islas mayores: Gran Canaria y Tenerife.

MAPA 1.
La vulnerabilidad territorial en España definida a partir de un modelo multicriterio



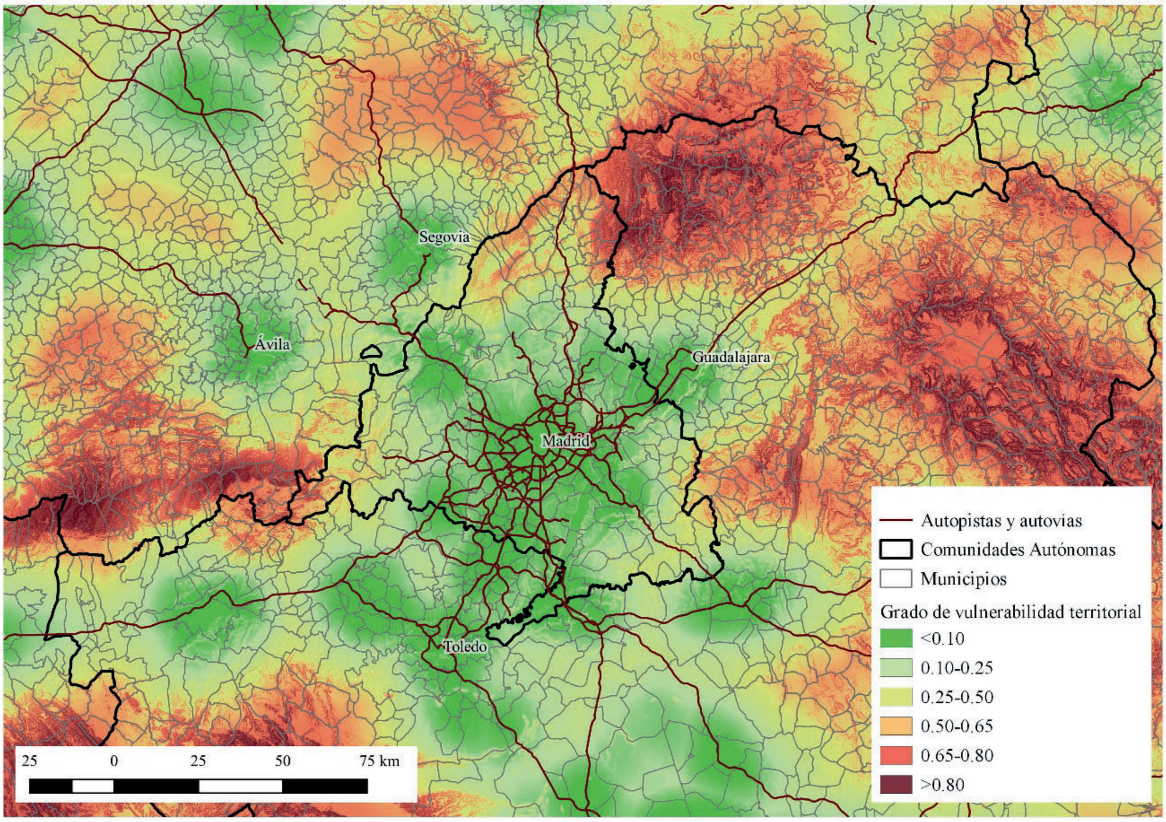
Fuentes: IGN, Líneas límite y recintos municipales 1/25.000 y Base Cartográfica Nacional 1/200.000. Elaboración propia.

Por el contrario, los espacios menos vulnerables territorialmente corresponden, en consonancia con los factores que se han utilizado, a la España costera y en mayor medida la España mediterránea, que exhibe una marcada continuidad espacial, frente a la España cantábrica, que presenta más discontinuidades (costa vasca desde la frontera de Francia hasta Santander-Torrelavega, ruptura en la Cantabria costera occidental y Asturias oriental, conglomerado urbano-metropolitano Oviedo - Gijón - Avilés, la llamada Ciudad Astur, de nuevo discontinuidad en la Asturias occidental y costa norte gallega). Otra de las grandes áreas caracterizadas por presentar grados de vulnerabilidad territorial bajos, al margen de las orlas costeras señaladas, es Madrid y su área metropolitana (Mapa 2) en su sentido más amplio (esto es, desbordando los límites administrativos de su propia comunidad: hacia Guadalajara al Este, hacia Segovia al Norte, hasta Ávila al Oeste y hacia Toledo al Sur).

Los otros espacios a considerar con baja vulnerabilidad territorial son el valle del Guadalquivir (singularmente Sevilla y su área metropolitana), el valle del Ebro y todas las ciudades y sus entornos periurbanos de la sub-meseta norte y sur no mencionados anteriormente. En Canarias, como se apuntó, los espacios más urbanizados, que corresponden a las áreas norte y este de las islas, presentan asimismo los menores grados de vulnerabilidad territorial.

Como aproximación numérica, siendo conscientes de lo escasamente representativo de la entidad de comunidad autónoma, se ofrece un resumen con los principales resultados de este ambicioso análisis de vulnerabilidad territorial, tanto en valores absolutos (Cuadro 5) como en valores relativos a partir de sendos diagramas ternarios (figuras 2.a y 2.b). Consideramos en las mismas la extensión geográfica que suman y la población que reside en los distintos municipios españoles según su vulnerabilidad media territorial.

Mapa 2.
Detalle del grado de vulnerabilidad territorial en Madrid y su área metropolitana



Fuentes: IGN, Líneas límite y recintos municipales 1/25.000 y Base Cartográfica Nacional 1/200.000. Elaboración propia.

CUADRO 5.
Superficie y población de las comunidades autónomas según grado de vulnerabilidad territorial

	Superficie que suman los municipios, según su grado de vulnerabilidad territorial				Población residente que suman los municipios, según su grado de vulnerabilidad territorial			
CCAA	Alto	Medio	Bajo	Total	Alto	Medio	Bajo	Total
Andalucía	26.155	35.963	25.483	87.600	397.550	1.566.502	6.407.362	8.371.414
Aragón	21.073	17.963	8.695	47.731	87.160	200.986	1.020.577	1.308.723
Canarias	2.882	4.827	23	7.732	197.246	1.851.104	59.771	2.108.121
Cantabria	1.262	1.574	2.489	5.325	9.414	25.286	545.595	580.295
Castilla La Mancha	36.437	19.968	23.007	79.411	217.723	271.716	1.542.040	2.031.479
Castilla y León	34.936	39.749	19.545	94.229	268.140	402.569	1.755.092	2.425.801
Cataluña	8.817	11.042	12.344	32.202	108.179	540.162	6.907.489	7.555.830
Com.Valenciana	5.317	5.734	12.215	23.266	33.678	183.600	4.724.231	4.941.509
Extremadura	19.997	12.698	8.984	41.679	213919	277461	584239	1.075.619
Galicia	7.037	14.630	8.014	29.681	201.545	693.379	1.802.175	2.697.099
Islas Baleares	615	3.770	634	5.019	53.440	490.514	572.045	1.115.999
La Rioja	1.827	1.075	2.139	5.041	6.490	10.471	298.420	315.381
Madrid	518	2.403	5.105	8.025	8.718	103.068	6.395.398	6.507.184
Murcia	1.813	4.197	5.303	11.312	33.681	264.138	1.172.454	1.470.273
Navarra	1.925	4.202	3.579	9.706	15.819	95.686	531.729	643.234
País Vasco	362	2.149	4.721	7.231	2.276	129.960	2.061.922	2.194.158
Princ. de Asturias	5.463	3.171	1.975	10.609	66.350	146.527	822.083	1.034.960
Ceuta	0	0	20	20	0	0	84.959	84.959
Melilla	0	14	0	14	0	86.120	0	86.120
Total España	176.433	185.126	144.274	505.833	1.921.328	7.339.249	37.287.581	46.548.158
Valores relativos España	*34,9*	*36,6*	*28,5*	*100,0*	*4,1*	*15,8*	*80,1*	*100,0*

Nota: La discretización de los valores de vulnerabilidad en los niveles alto, medio y bajo se realiza a través del criterio desviacional, considerando nivel medio los casos que se encuentran en torno a la media +/- media desviación típica, con nivel alto los que tienen vulnerabilidad superior a la media + media desviación típica y, finalmente, con nivel bajo los que tienen una vulnerabilidad inferior al valor de la media – media desviación típica.
Fuentes: IGN, Líneas límite y recintos municipales 1/25.000 e INE, Padrón Municipal de Habitantes (2017). Elaboración propia.

La realización de los cálculos descritos en el cuadro anterior supone una destacada aportación derivada de la metodología propuesta en el artículo. Así, se elabora una estadística detallada y estandarizada del grado de vulnerabilidad territorial por comunidades autónomas que puede constituir una base importante para la toma de decisiones a nivel nacional; incluso, para perfilar la vulnerabilidad en base a la superficie que está afectada, así como según la población que reside en esos ámbitos. En este sentido, hay que destacar que la obtención de resultados estandarizados y acotados entre 0 (vulnerabilidad nula) y 1 (máximo nivel de vulnerabilidad) hace que las situaciones en las que se encuentran las distintas partes del territorio español sean plenamente comparables, a la vez que independientes de los rangos y escalas de medida de las variables que originan el resultado final.

FIGURA 2.
Agrupaciones de comunidades autónomas según superficie y población residiendo en municipios con diferente grado de vulnerabilidad territorial

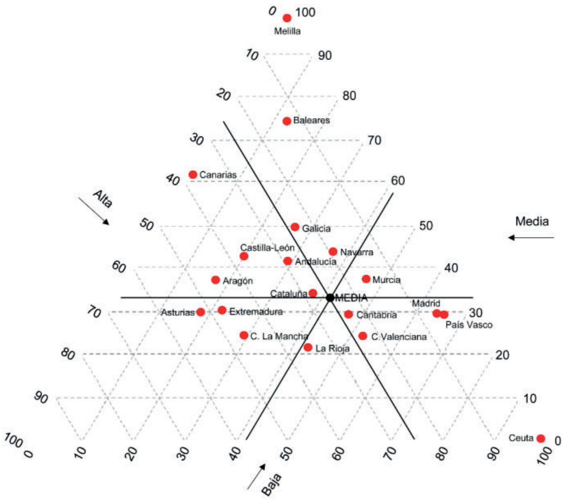


Figura 2.a. Porcentaje de superficie

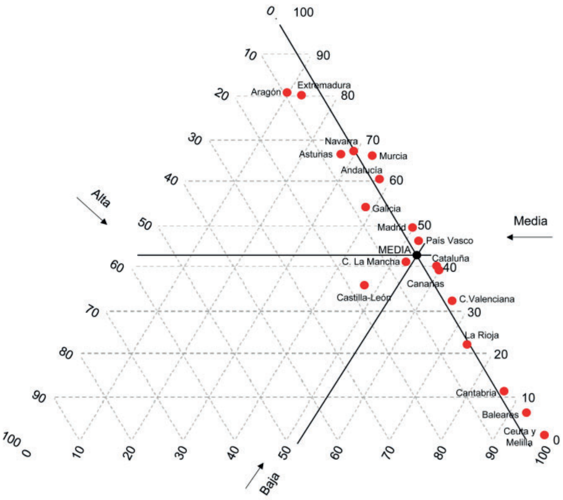


Figura 2.b. Porcentaje de población

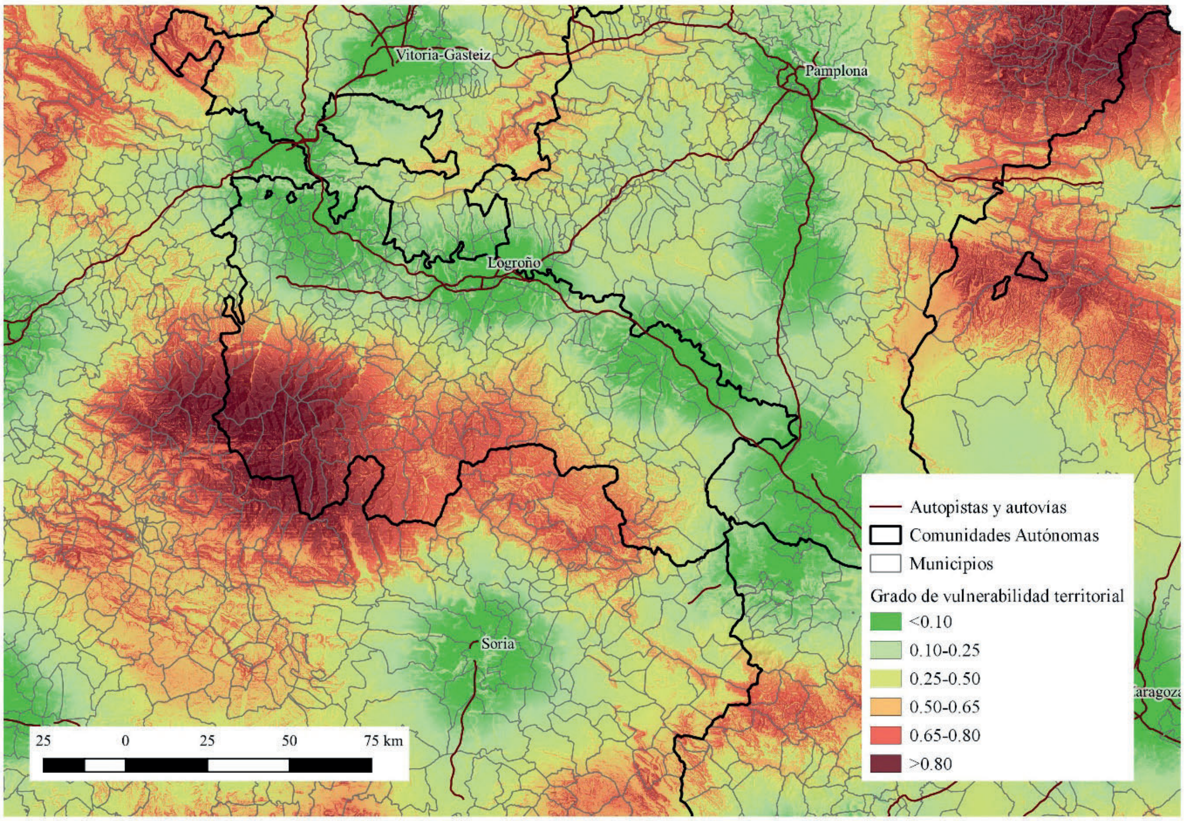
Nota: los diagramas triangulares representan la posición de las comunidades autónomas en relación al valor medio nacional, estadístico descriptivo que ha sido estimado a partir de los valores de vulnerabilidad extrapolados del modelo raster a los recintos municipales del conjunto del país.
Fuente: Elaboración propia.

Más de la mitad de las comunidades autónomas españolas presentan porcentajes de su superficie con alto grado de vulnerabilidad territorial, entendiendo por tales aquellas que tienen valores por encima de la media nacional (35% del territorio del país). Casos especialmente significativos son los de Asturias (52%), Extremadura (48%) y Castilla La Mancha (46%); agrupadas en otro clúster: Aragón (44%), Canarias (37%), Castilla y León (37%), Andalucía (30%) y Cataluña (27%) y, caso aparte, La Rioja (36%). Todas ellas son eminentemente rurales, al menos en términos geográficos o territoriales y la mayor parte de ellas son regiones interiores.

Si se tiene en cuenta la población residiendo en territorios vulnerables el orden cambia, pero las regiones son las mismas: Extremadura (20%), Castila y León y Castilla La Mancha (11%) y Galicia y Aragón, que en el plano del peso demográfico de territorios vulnerables cobran importancia con un 7,5% y 6,7% respectivamente. Asturias desciende hasta el 6,4% de su población, presentado valores inferiores a las anteriores, hecho que se explica por tratarse de una región más urbanizada y por el peso de la llamada *Ciudad Astur* (Oviedo-Gijón-Avilés).

Por el contario, las que presentan la situación más favorable (Figura 2.b), con valores más bajos, han resultado corresponder, además de Ceuta y Melilla, por razones ligadas a su singular carácter de enclave urbano en el Norte de África, al País Vasco y Madrid (ambas con tan solo un 0,1%), Comunidad Valenciana (0,7%), Cataluña (1,4%) y Cantabria (1,6%). Son regiones casi todas ellas altamente urbanizadas, bien comunicadas, contando la mayor parte de su población con buen acceso a los servicios de primer orden. A estas regiones se suma La Rioja (2,1%). El bajo valor porcentual que presenta su población en esta desfavorable situación y su adscripción a este grupo se explica por su contrastada estructura territorial dual valle-montaña (Mapa 3) y la fortísima concentración de su población en este primer tipo de entorno geográfico, a lo que se suma la propia macrocefalia de esta comunidad autónoma uniprovincial.

Mapa 3.
Detalle del grado de vulnerabilidad territorial en La Rioja y su entorno geográfico



Fuentes: IGN, Líneas límite y recintos municipales 1/25.000 y Base Cartográfica Nacional 1/200.000. Elaboración propia.

La cartografía de detalle muestra la expresividad del método desarrollado no solo a nivel nacional sino, especialmente, a escala de comunidad autónoma. Así, pone perfectamente de relieve la variación espacial de la vulnerabilidad en el territorio autonómico, diferenciando incluso las zonas dentro de los propios límites municipales que tendrían que ser objeto de políticas específicas para hacer frente a la situación de vulnerabilidad estimada. Asimismo, la obtención de una realidad graduada permitiría abordar los cronogramas de acción en base a las limitaciones presupuestarias según el grado de vulnerabilidad multicriterio y atendiendo, también, a la población a la que esas inversiones beneficiarían.

Finalmente, el modelo de vulnerabilidad territorial en España puede ser interpretado en base a su zonificación sin hacerse alusión expresa a las delimitaciones administrativas; esto es, considerando en primer plano la configuración territorial según la presencia de zonas urbanas y metropolitanas frente a las áreas de predominio rural, así como a la adscripción a las áreas de proximidad a la costa frente a la España interior. Este análisis aporta resultados de interés que contribuyen a la explicación de los patrones espaciales de la vulnerabilidad territorial (Cuadro 6), entre los cuales destaca un mayor nivel de vulnerabilidad en las zonas rurales e interiores frente a las urbanas y cercanas a la costa. Tanto es así, que por término medio el territorio externo a zonas urbanas o costeras tiene un nivel de vulnerabilidad que supera el doble que el presentado por las zonas incluidas en algún sistema urbano o en zonas ubicadas a menos de 10Km de la costa.

Cuadro 6.
Estadísticas de vulnerabilidad territorial por unidades de referencia con carácter no administrativo

	Nº municipios	Vulnerabilidad territorial			
		Media	Mediana	Cuartil 3	Desviación típica
Valores generales España	8.198	0,434	0,424	0,622	0,240
Según pertenencia a las áreas urbanas funcionales definidas a nivel europeo (FUAs)					
En zonas urbanas	985	0,199	0,156	0,271	0,137
Fuera de zonas urbanas	7.213	0,466	0,461	0,648	0,233
Según distancia a la costa					
A menos de 10 Km	756	0,256	0,177	0,389	0,214
A más de 10 Km	7.442	0,452	0,445	0,637	0,235
A menos de 20 Km	1.293	0,264	0,204	0,385	0,201
A más de 20 Km	6.905	0,466	0,461	0,648	0,233
Según combinación de los criterios de pertenencia a áreas urbanas funcionales y distancia a la costa					
En zonas urbanas o a menos de 10 Km de distancia a la costa	1.469	0,264	0,204	0,385	0,201
Fuera de zonas urbanas o a más de 10 Km de distancia a la costa	6.729	0,478	0,476	0,655	0,228

Nota: Los estadísticos descriptivos muestran valores de vulnerabilidad basados en el modelo multicriterio, por lo que su rango está acotado entre un valor mínimo de 0 (no vulnerable) y 1 (vulnerabilidad máxima).
Fuente: Elaboración propia.

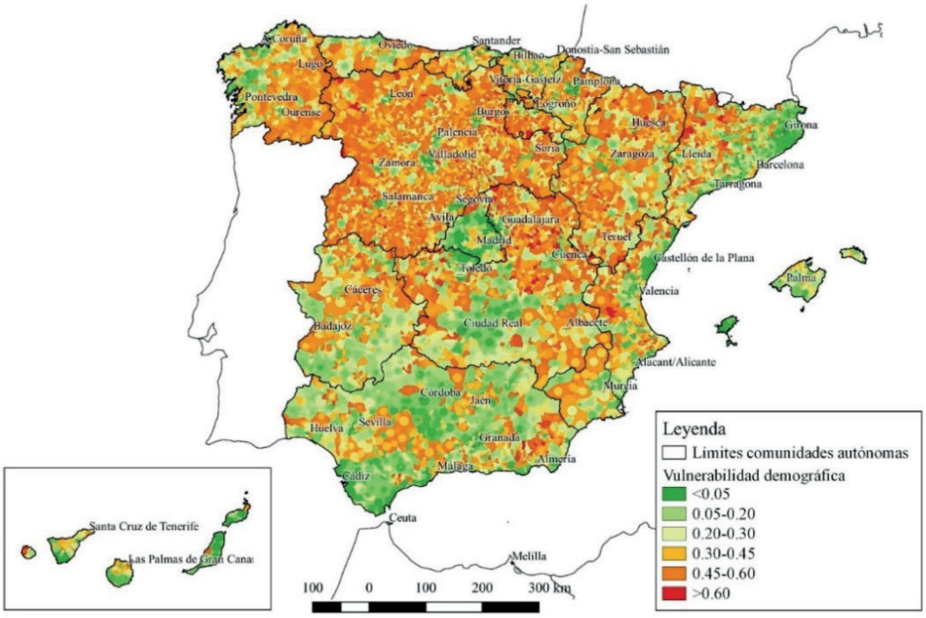
4.2. El modelo multicriterio de vulnerabilidad demográfica en España

En relación a la vulnerabilidad demográfica el territorio español ofrece unas estructuras peor definidas que en el enfoque territorial, como consecuencia de que la unidad de análisis de la que partimos en la mayor parte de factores es el municipio. Sobre el mismo cabe apuntar un hecho bien conocido: su heterogénea distribución en cuanto a la dimensión física de estas unidades administrativas. En el análisis de la vulnerabilidad demográfica ya no podemos operar con el pixel de 900 m^2, que fue el utilizado para el análisis de la vulnerabilidad territorial, por la entidad de referencia municipal a la que se obtiene desagregada la información estadística necesaria para desarrollar el presente modelo.

No obstante lo cual, la cartografía multicriterio (Mapa 4) permite resaltar importantes fenómenos y destacados contrastes en relación al grado de vulnerabilidad demográfica en España.

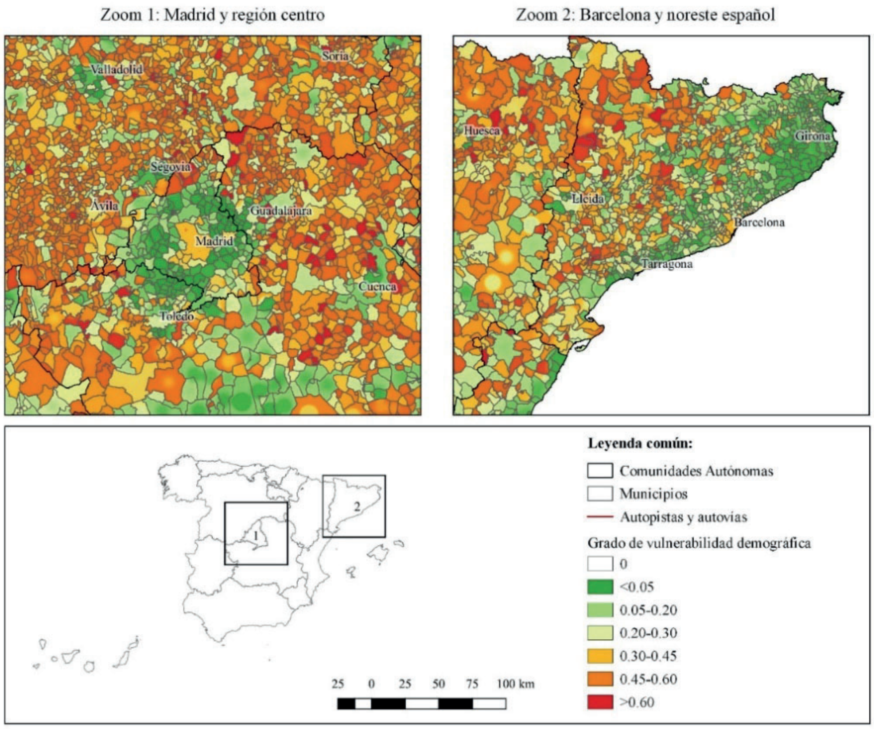
En primer lugar, hay que apuntar la contraposición existente entre una España costera que exhibe una estructura demográfica más sólida y una España interior que soporta estructuras demográficas más debilitadas. La segunda asimetría se produce entre la mitad norte más vulnerable demográficamente y un sur que lo es en menor medida, salvo en sus áreas de montaña. La tercera desigualdad está relacionada con la componente rural y urbana en España: a la fortaleza de la España urbana, esto es, ciudades y sus entornos periurbanos cada vez más desarrollados (Reques y De Cos, 2013; Azcárate et al., 2014; Rubiera et al., 2016), se contraponen los marginados y marginales espacios rurales y singularmente de montaña. El cuarto plano de asimetría, a otra escala, se da en el seno de las grandes áreas metropolitanas (Mapa 5) -singularmente Madrid y Barcelona- entre sus espacios centrales más envejecidos y vulnerables demográficamente y sus muy desarrollados territorialmente anillos metropolitanos, más rejuvenecidos y dinámicos (Rubiera, 2006).

MAPA 4.
La vulnerabilidad demográfica en España definida a partir de un modelo multicriterio



Fuentes: IGN, Líneas límite y recintos municipales 1/25.000 y Base Cartográfica Nacional 1/200.000. INE, Padrón Municipal de Habitantes (2017), Censo de Población (2001 y 2011) y Movimientos Naturales de Población. Elaboración propia.

MAPA 5.
Detalle del modelo de vulnerabilidad demográfica en el área de Madrid y Barcelona



Fuentes: IGN, Líneas límite y recintos municipales 1/25.000 y Base Cartográfica Nacional 1/200.000. INE, Padrón Municipal de Habitantes (2017), Censo de Población (2001 y 2011) y Movimientos Naturales de Población. Elaboración propia.

El análisis pormenorizado a escala intrarregional desvela estos mismos planos a mayor nivel de detalle. Puede señalase, no obstante, el fuerte contraste entre los espacios organizados en torno al llamado Eje Atlántico (La Coruña – Santiago – Pontevedra – Vigo) *versus* la Galicia interior; el conglomerado urbano-metropolitano Oviedo-Gijón-Avilés *versus* el resto de Asturias, la Cantabria costera *versus* la interior; la orla costera mediterránea *versus* los espacios interiores de montaña.

En suma, el análisis presentado muestra los matices territoriales de unas estructuras demográficas y de unos potenciales de población para un país, España, que presenta los más altos desequilibrios demo-espaciales del continente europeo (European Parliament, 2006).

Los resultados generales, a nivel de comunidad autónoma, tanto en valores absolutos como relativos se presentan a continuación en el Cuadro 7 y en las figuras 3.a y 3.b.

Cuadro 7.
Población y superficie totales según grado de vulnerabilidad demográfica por comunidades autónomas

	Población residente en municipios, según su grado de vulnerabilidad demográfica				**Superficie que suman los municipios, según su grado de vulnerabilidad demográfica**			
CCAA	Alto	Medio	Bajo	Total	Alto	Medio	Bajo	Total
Andalucía	68.814	5.067.079	3.235.521	8.371.414	6.686	52.263	28.651	876
Aragón	120.194	1.059.323	129.206	1.308.723	21.135	24.674	1.922	47.731
Canarias	3.698	832.172	1.272.251	2.108.121	221	2.153	5.358	7.732
Cantabria	12.410	65.164	502.721	580.295	1.771	2.161	1.393	5.325
Castilla La Mancha	158.762	796.307	1.076.410	2.031.479	28.912	38.728	11.771	79.411
Castilla y León	420.538	869.987	1.135.276	2.425.801	59.094	31.340	3.796	94.229
Cataluña	72.619	2.960.325	4.522.886	7.555.830	6.682	13.828	11.693	32.202
Com. Valenciana	34.693	1.530.749	3.376.067	4.941.509	4.399	10.477	8.390	23.266
Extremadura	78.100	860.861	136.658	1.075.619	9.725	29.120	2.834	41.679
Galicia	181.600	1.471.974	1.043.525	2.697.099	13.182	11.686	4.813	29.681
Islas Baleares	0	70.424	1.045.575	1.115.999	0	1.085	3.934	5.019
La Rioja	14.018	70.329	231.034	315.381	2.407	2.030	605	5.041
Madrid	8.990	3.206.667	3.291.527	6.507.184	817	1.462	5.746	8.025
Murcia	0	984.136	486.137	1.470.273	0	8.652	2.661	11.312
Navarra	24.889	431.696	186.649	643.234	2.619	5.634	1.453	9.706
País Vasco	3.952	1.030.101	1.160.105	2.194.158	713	4.163	2.356	7.231
Princ. de Asturias	51.632	696.314	287.014	1.034.960	3.803	5.574	1.233	10.609
Ceuta	0	0	84.959	84.959	0	0	20	20
Melilla	0	0	86.120	86.120	0	0	14	14
Total España	1.254.909	22.003.608	23.289.641	46.548.158	162.163	245.028	98.641	505.833
Valores relativos España	*2,7*	*47,3*	*50,0*	*100,0*	*32,1*	*48,4*	*19,5*	*100,0*

Nota: la discretización de los valores de vulnerabilidad en los niveles alto, medio y bajo se realiza a través del criterio desviacional, considerando nivel medio los casos que se encuentran en torno a la media +/- media desviación típica, con nivel alto los que tienen vulnerabilidad superior a la media + media desviación típica y, finalmente, con nivel bajo los que tienen una vulnerabilidad inferior al valor de la media – media desviación típica.
Fuentes: IGN, Líneas límite y recintos municipales 1/25.000 y Base Cartográfica Nacional 1/200.000. INE, Padrón Municipal de Habitantes (2017), Censo de Población (2001 y 2011) y Movimientos Naturales de Población. Elaboración propia.

Por su parte, los diagramas ternarios adjuntos, en los que se presenta el peso relativo en cada comunidad autónoma de los grados alto, medio o bajo de vulnerabilidad demográfica, nos permite agrupar éstas según sus características estructurales. Tanto si se analiza la superficie que suma cada nivel o grado de grado de vulnerabilidad demográfica (Figura 3.a) como si se analiza la población en estos distintos grados (Figura 3.b) se llega a la misma conclusión: los marcadísimos contrastes entre las regiones más rurales o ruralizadas y las más urbanas o urbanizadas. Así, en relación a la vulnerabilidad demográfica la mayor superficie afectada corresponde a Castilla y León (62% de su territorio, junto a un alto 17% de su población), seguida de Castilla La Mancha (36% de su territorio y solo el 8% de su población), Galicia (44% y 7%) y Aragón (44% y 9%, respectivamente). Estas regiones confrontan con otras como la Comunidad de Madrid, País Vasco, Cataluña, Comunidad Valenciana o Canarias, que presentan valores muy bajos en superficie (siempre por debajo del 10%) y marginales en cuanto a la población afectada por grados de vulnerabilidad demográfica alta.

FIGURA 3.
Agrupaciones de comunidades autónomas según la superficie y población residiendo en municipios con diferente grado de vulnerabilidad demográfica

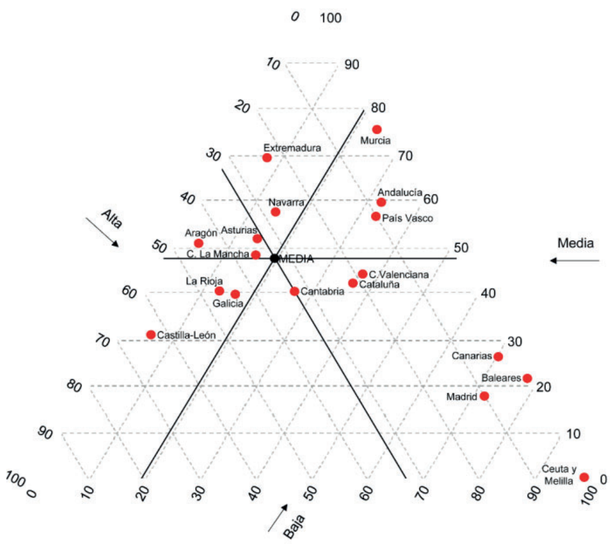


Figura 3.a. Porcentaje de superficie

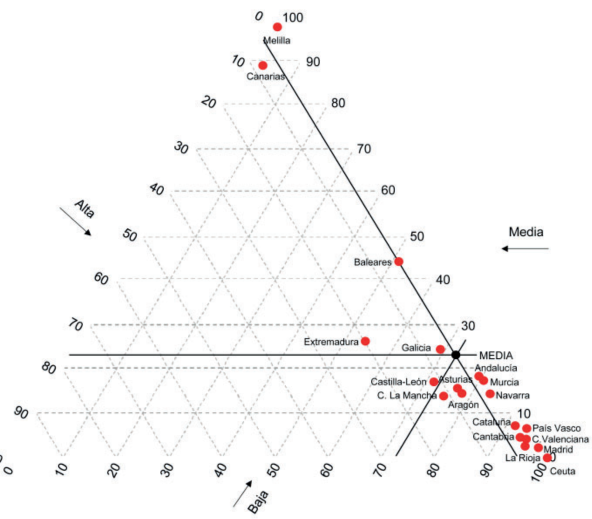


Figura 3.b. Porcentaje de población

Nota: los diagramas triangulares representan la posición de las comunidades autónomas en relación al valor medio nacional, estadístico descriptivo que ha sido estimado a partir de los valores de vulnerabilidad extrapolados del modelo raster a los recintos municipales del conjunto del país.
Fuente: Elaboración propia.

Por otro lado, con una lectura de los patrones en base a criterios no administrativos, debemos reafirmar que la vulnerabilidad demográfica de mayor nivel se configura en las zonas no urbanas y en la España interior (Cuadro 8); así, mientras que el valor medio de vulnerabilidad demográfica es de 0,383 sobre 1 hay que destacar que este valor en áreas urbanas se reduce hasta 0,185 y deja las tres cuartas partes del territorio con vulnerabilidades inferiores a 0,266. Frente a esto, en áreas no urbanas la vulnerabilidad media asciende a 0,410 y muestra una cuarta parte del territorio con valores de vulnerabilidad demográfica superiores a 0,523.

Cuadro 8.
Estadísticas de vulnerabilidad demográfica por unidades de referencia con carácter no administrativo

	Nº municipios	Vulnerabilidad demográfica			
		Media	Mediana	Cuartil 3	Desviación típica
Valores generales España	8.198	0,383	0,408	0,512	0,171
Según pertenencia a las áreas urbanas funcionales definidas a nivel europeo (FUAs)					
En zonas urbanas	985	0,185	0,174	0,266	0,133
Fuera de zonas urbanas	7.213	0,410	0,435	0,523	0,158
Según distancia a la costa					
A menos de 10 Km	756	0,184	0,185	0,261	0,111
A más de 10 Km	7.442	0,403	0,430	0,521	0,163
A menos de 20 Km	1.293	0,210	0,207	0,291	0,129
A más de 20 Km	6.905	0,415	0,443	0,526	0,159
Según combinación de los criterios de pertenencia a áreas urbanas funcionales y distancia a la costa					
En zonas urbanas o a menos de 10 Km de distancia a la costa	1.469	0,210	0,207	0,291	0,129
Fuera de zonas urbanas o a más de 10 Km de distancia a la costa	6.729	0,425	0,448	0,529	0,148

Nota: Los estadísticos descriptivos muestran valores de vulnerabilidad basados en el modelo multicriterio, por lo que su rango está acotado entre un valor mínimo de 0 (no vulnerable) y 1 (vulnerabilidad máxima).
Fuente: Elaboración propia.

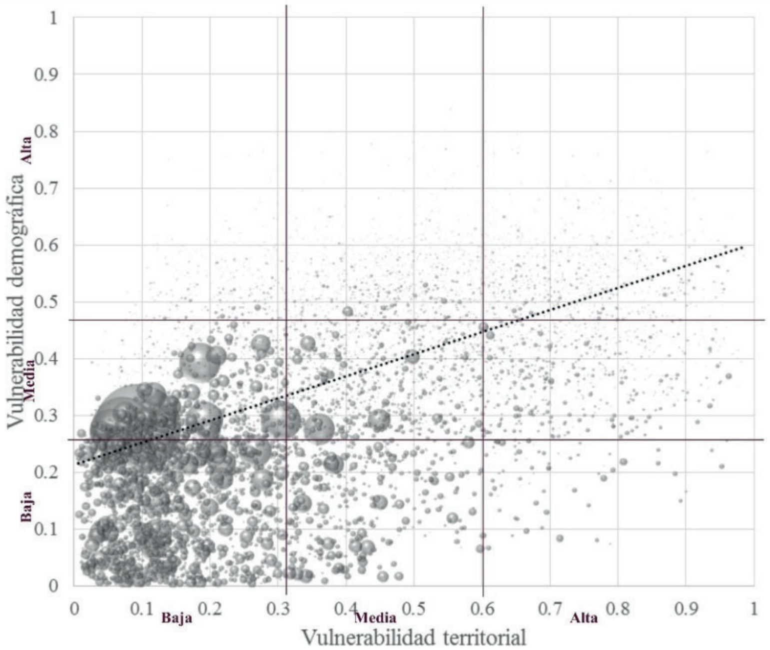
4.3. El análisis conjunto de la vulnerabilidad territorial y la vulnerabilidad demográfica

En el diagrama binario correspondiente a la Figura 4 se presentan conjuntamente los resultados de cada municipio español respecto a la vulnerabilidad territorial y demográfica. En términos estadísticos presentan un índice de correlación lineal de 0,56, que con su valor positivo medio avala los planteamientos posibilistas frente a los deterministas, con lo que interpretamos que no existe un condicionamiento pleno de las condiciones del medio físico sobre el componente demográfico; así, entendemos que existe cierta tendencia a que los valores de vulnerabilidad territorial se relacionen linealmente con los de vulnerabilidad demográfica, no pudiendo explicarse plenamente la varianza de los segundos en función de los primeros. A partir de esta premisa, en el eje de abscisas se presenta el índice vulnerabilidad territorial y en el eje de ordenadas el índice de vulnerabilidad demográfica. Los valores se mueven en un rango acotado entre 0 y 1, representando 0 la ausencia de vulnerabilidad y 1 el nivel más alto posible.

En puridad podría establecerse un índice de vulnerabilidad demográfico-territorial conjunto que quedaría expresado por la combinación de los tres grados de vulnerabilidad posibles cruzados en términos territoriales (X) y demográficos (Y). Así, los municipios más cercanos al origen 0,0 corresponden con una mejor situación en relación a la vulnerabilidad (esto es, baja en los dos ejes) mientras que a medida que nos alejamos de esa situación hacia el umbral 1,1 aparecen situaciones de vulnerabilidad más destacadas, desde los niveles medios a los altos.

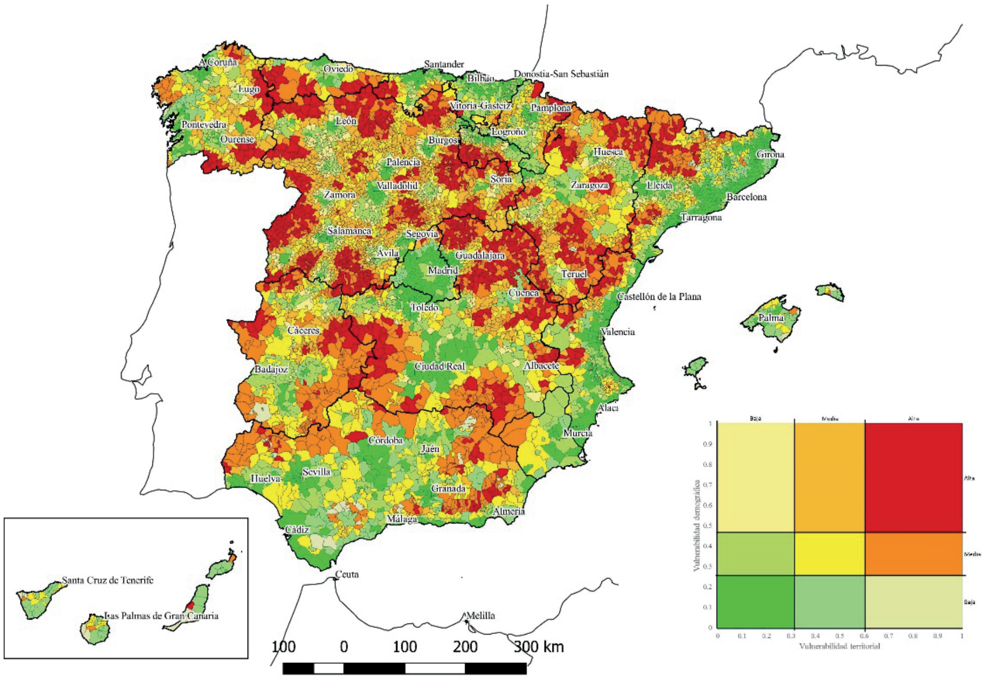
Por su parte, en el Mapa 6, que cabe ser considerado como la síntesis de resultados del presente estudio, se representan los valores cruzados de la vulnerabilidad territorial y demográfica, lo que permite a partir de un número de nueve categorías sintéticas, corroborar las afirmaciones parciales anteriores.

FIGURA 4.
Análisis bivariado del modelo de vulnerabilidad territorial y demográfica



Nota: el tamaño de los símbolos es proporcional al volumen de población de cada municipio de España.
Fuentes: IGN, Líneas límite y recintos municipales 1/25.000 e INE, Padrón Municipal de Habitantes (2017). Elaboración propia.

MAPA 6.
Patrón espacial de la vulnerabilidad demográfico-territorial en España



Fuentes: IGN, Líneas límite y recintos municipales 1/25.000 y Base Cartográfica Nacional 1/200.000. INE, Padrón Municipal de Habitantes (2017), Censo de Población (2001 y 2011) y Movimientos Naturales de Población. Elaboración propia.

Los resultados cartográficos se confirman con las estadísticas aportadas en el Cuadro 9, donde se observa que la población urbana y de las áreas litorales muestra bajos niveles de vulnerabilidad demográfico-territorial. Este dato contrasta con la importante proporción de superficie afectada por alta vulnerabilidad demográfico-territorial (16%), presente en algo más de 1.300 municipios.

Cuadro 9.
Población y territorio en España según su grado de vulnerabilidad territorial y demográfica

Grado de vulnerabilidad territorial	Grado de vulnerabilidad demográfica	Superficie		Población		Nº municipios
		Valor absolutos (km^2)	Valores relativos (%)	Valor absolutos (habitantes)	Valores relativos (%)	
Alto	Alto	82.760	16,3	479.302	1	1.310
Alto	Medio	87.529	17,3	1.082.085	2,3	905
Alto	Bajo	6.145	1,2	359.941	0,8	69
Medio	Alto	63.689	12,6	566.172	1,2	1.266
Medio	Medio	90.495	17,9	3.000.920	6,4	1.261
Medio	Bajo	31.621	6,2	3.772.157	8,1	405
Bajo	Alto	16.393	3,2	209.435	0,4	444
Bajo	Medio	67.005	13,2	16.089.045	34,6	1.079
Bajo	Bajo	60.875	12,0	20.989.101	45,1	1.459
Total España		506.513	100,0	46.548.158	100,0	8.198

Fuentes: IGN, Líneas límite y recintos municipales 1/25.000 e INE, Padrón Municipal de Habitantes (2017). Elaboración propia.

Los datos son contundentes y prueban la solidez del método propuesto: los espacios con alto grado de vulnerabilidad territorial representan más de un tercio (35%) del territorio español y tan solo suman el 5% de la población. Un dato aún más significativo: en los 87.760 km^2, que es la superficie que suma el territorio que presenta un mayor grado de vulnerabilidad demográfica y territorial, reside tan solo el 1% de la población, lo que supone una densidad de 6 habitantes por km^2. Por el contrario, los espacios con bajo grado de vulnerabilidad demográfica y territorial, que afecta a poco más de la cuarta parte del territorio nacional (28%), presentan un peso demográfico del 80%. Un último dato significativo: la densidad del territorio con vulnerabilidad territorial y demográfica baja es de 344 hab./Km^2. Las cifras expresan con total rotundidad los marcados desequilibrios demográfico-territoriales en España.

Por otro lado, la generación de una tabulación cruzada de la componente territorial y demográfica de la vulnerabilidad a nivel municipal supone un punto de partida fundamental para matizar la situación de vulnerabilidad en la que se encuentran los municipios españoles; con ello, se plantea un avance respecto a trabajos previos en cuanto a que se pueden dirigir las políticas específicas en función de si un determinado municipio adolece de una situación de vulnerabilidad por su situación territorial (condiciones orográficas, accesibilidad y proximidad a servicios) o bien por sus rasgos demográficos (envejecimiento, dinámica y evolución negativas), o incluso por la combinación de ambas circunstancias.

5. Conclusiones

Los análisis que se hacen frecuentemente comparando territorio y población en términos absolutos presentan metodológicamente fuertes limitaciones. La incorporación del concepto de vulnerabilidad territorial y vulnerabilidad demográfica permite analizar el binomio "territorio" y "población" en términos cualitativos: el territorio, según se ha demostrado en este trabajo a través del análisis multicriterio, es "rugoso" (orografía, pendiente, altitud, accesibilidad) y la población presenta características (tanto ligadas a su estructura como a su dinámica) que la diferencian e impiden considerarla como un simple agregado estadístico sin atributos, hecho que explica la necesidad de abordar ambos aspectos conjuntamente.

El análisis de la vulnerabilidad desde la perspectiva metodológica que proporciona la lógica difusa y la aplicación del método multicriterio ha permitido constatar unos fortísimos desequilibrios demo-espaciales: los diferentes grados identificables en cuanto a vulnerabilidad demográfico-territorial evocan distintos planos de asimetría territorial que se muestran a partir de realidades contrastadas con grados de transición difusos entre los extremos. En nuestro país la vulnerabilidad se muestra muy polarizada en el plano demográfico y muy graduada en el territorial y, a partir de ambas perspectivas, se han configurado los patrones demo-espaciales de la España actual y se han puesto de relieve los rasgos en relación a la menor vulnerabilidad de la España costera frente a la mayor vulnerabilidad del interior, así como de los sistemas urbano-metropolitanos frente a los espacios rurales y de montaña. A otra escala, contrasta en el seno de las grandes áreas metropolitanas la contraposición entre las estructuras demográficas más regresivas y envejecidas de sus espacios centrales y las rejuvenecidas y dinámicas de sus anillos periurbanos.

Una de las fundamentales aportaciones de la propuesta metodológica no es tanto confirmar las grandes pautas de distribución de la vulnerabilidad, como poner de relieve los matices y los niveles intermedios, esto es, la diferencia de situación de áreas que en las próximas décadas pueden ser objetivos sensibles de los procesos de vulnerabilidad demográfico-territorial. En relación con ello, la expresividad de los resultados nacionales se hace patente también a escala intra-regional, constituyendo un destacado punto de partida para la toma de decisiones en materia de despoblación en nuestro país.

En suma, los desequilibrios territoriales han de ser medidos a partir de métodos que vayan más allá de la simple superficie geográfica y el número de habitantes, porque entendemos que este procedimiento conlleva fuertes limitaciones metodológicas. En esta investigación los parámetros población y territorio se han articulado en torno a la vulnerabilidad como concepto-eje y al análisis multicriterio como vía metodológica. Esta vulnerabilidad ha sido definida en el plano teórico, medida en el plano estadístico y determinada cartográficamente a fin de diagnosticar con rigor la actual realidad demo-espacial española y pretende servir de base a las respuestas que se deben plantear para afrontar su futuro.

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Mortalidad y estatus socioeconómico en la España de principios del siglo XXI

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Resumen:

Este artículo analiza las desigualdades socioeconómicas en mortalidad en España desde una perspectiva regional y teniendo en cuenta los efectos de la trayectoria laboral sobre la tasa de mortalidad. Del análisis geográfico se obtiene una distribución que agrupa las provincias en cinco grupos en función de su tasa de mortalidad y características poblacionales, reflejando un modelo concéntrico con menores tasas de mortalidad en el centro de la península, que van creciendo conforme se abandona dicha centralidad. Los resultados muestran una relación inversa entre la probabilidad de defunción y las variables socioeconómicas nivel educativo y ocupación. Estos resultados ponen de manifiesto la relación de las variables geográficas, económicas y laborales con las tasas de mortalidad y la necesidad de considerarlas a la hora de elaborar políticas sanitarias, como por ejemplo las relacionadas con la edad de jubilación.

Palabras clave: Economía Regional; Economía Demográfica; Salud y Mortalidad; Empleo y Capital Humano.

Clasificación JEL: R11, J10, I12, J24.

Mortality and socioeconomic status in early 21st century Spain

Abstract:

This paper analyzes socioeconomic inequalities in mortality in Spain considering geographical and labor market effects on the mortality rate. From the geographical analysis, a distribution obtained that groups provinces into five groups according to their mortality rate and population characteristics. The map presents a concentric model with lower mortality rates in the center of the peninsula, increasing as we move away from it. On the other hand, the results show an inverse relationship between the probability of death and the socioeconomic variables, educational level and occupation, confirming that they reflect two different aspects of human capital. These results indicate the importance of geographical, economic and labor disparities in the mortality rate and the need to consider them when preparing policies, such as policies related to retirement age.

Keywords: Regional Economy; Demography; Health and Mortality; Human Capital and Employment.

JEL Classification: R11, J10, I12, J24.

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1. Introducción

El estudio empírico de las desigualdades socioeconómicas en salud en España es relativamente reciente e insuficientemente abordado. La razón principal radica en la ausencia de bases de datos que permitan integrar adecuadamente la información sobre la salud y las diferentes dimensiones que pueden englobarse en el concepto de status socioeconómico.

Lo habitual en la literatura sobre desigualdades en mortalidad en España ha sido combinar la información de población de los censos o de los registros del padrón municipal con los registros de mortalidad del INE, pero la ausencia de información ha condicionado la elección del instrumento representativo del status socioeconómico que se ha limitado a dos variables: la educación y la ocupación.

Centrándose en el nivel educativo puede destacarse el trabajo de Reques et al. (2014) que aborda, por vez primera a nivel nacional, el estudio de la desigualdad en mortalidad en relación con la educación usando datos del Censo de 2001 y realiza un seguimiento de las muertes producidas en los siete años siguientes. En Reques et al. (2015) se analizan las diferencias en mortalidad según el nivel de estudios en cada una de las provincias españolas. Otros trabajos analizan las desigualdades en la mortalidad en países europeos e incluyen entre ellos algunas regiones españolas, generalmente Barcelona, la Comunidad de Madrid o el País Vasco (Huisman et al, 2004; Mackenbach et al, 2008; Mackenbach et al, 2015). Estos trabajos relacionan mortalidad con nivel educativo y se establecen vínculos entre salud autopercibida, diversos factores de riesgo con la educación y los ingresos.

Entre los estudios de carácter local o regional, se encuentra Martínez et al (2009) que se limita a las mujeres de la Comunidad de Madrid. Borrell et al (2008) y Puigpinós et al (2009) analizan la mortalidad en la ciudad de Barcelona (1992-2003) usando datos censales. En el primero, por diversas causas de muerte y en el segundo focalizando en la mortalidad por cáncer. Borrell et al (1999) abarcan la mortalidad en 1993-94 en las ciudades de Madrid y Barcelona. Regidor et al (2003) analiza la Comunidad de Madrid, con datos censales de 1996, añadiendo controles sobre la situación laboral, el estado civil, el número de miembros del hogar y una categoría de privación del área de residencia.

El uso de la ocupación como variable representativa del status es más limitado. En el artículo de Regidor et al (2012) se sigue a una cohorte de 4000 personas mayor de 60 años desde el 2001 al 2008 y se controlan según clase social (empleador/empleado), ocupación y nivel educativo. Regidor et al (2005) estudian la mortalidad en relación con la ocupación para los hombres económicamente activos de la Comunidad de Madrid, controlando por la situación laboral y nivel educativo. Borrell et al (2003) siguen a trabajadores funcionarios del ayuntamiento de Barcelona en el periodo 1984-93 y comparando ocupaciones manuales y no manuales, encontrando desigualdad en hombres, pero no en mujeres. El análisis de Regidor et al (1996) se ocupa de ocho provincias españolas y agrupan las diferentes ocupaciones en tres niveles o categorías.

Otro enfoque seguido para el análisis de la desigualdad socioeconómica en la mortalidad es el geográfico. El análisis de la distribución espacial de la mortalidad en el caso español ha usado dos tipos de lentes. Una, que se fija en grandes agregados, ha estudiado la desigualdad en mortalidad entre las diferentes comunidades autónomas y provincias. En este campo, Goerlich y Pinilla (2005) presentan la esperanza de vida por CCAA, así como su evolución temporal y encontrando escasa dispersión alrededor de la media, y ninguna relación entre esperanza de vida y renta per cápita. Goerlich y Pinilla (2009) presentan una visión más detallada a nivel provincial y encuentran que la desigualdad aumenta al reducir el nivel de análisis y una clara diferenciación norte-sur de la mortalidad, que lleva a altas tasas de mortalidad en las provincias del sur (Andalucía, Extremadura y Murcia), mientras que las mayores esperanzas de vida se concentran en el centro del país. El hecho de que la organización de los sistemas de salud sea de base regional induce a un análisis a dicho nivel.

Mapas provinciales referidos a causas concretas de muerte aparecen en Boix, Aragonés, y Medrano (2003) o en López-Abente et-al (2001). Una fotografía muy sugerente puede obtenerse de la elaboración de atlas de mortalidad por todas las causas y causas específicas, a partir de áreas geográficas de pequeño tamaño (Benach 2007; Benach y Martínez, 2013) que presenta mapas de mortalidad de este tipo para el conjunto de España, incluyendo el detalle del interior de las mayores ciudades. El estudio de Regidor et al. (2015) ofrece mapas que muestran la desigualdad en mortalidad provincial según el nivel educativo y para distintas causas. Circunscrito a la Comunidad Valenciana se encuentra el trabajo de Martínez-Beneito et al (2005) y centrado en la mortalidad por cáncer está el atlas municipal de López-Abente et al. (2006). Los estudios muestran perfiles geográficos marcados detrás de los que puede intuirse la distribución sectorial de la actividad económica, la distribución de la riqueza, factores socioculturales o ambientales.

A partir de los trabajos previos, el objetivo de este artículo es ampliar el análisis en una doble dirección. La primera se refiere a la cuestión geográfica y la segunda a los efectos del mercado laboral sobre la tasa de mortalidad. En cuanto al aspecto geográfico, no cabe duda que las características físicas, climáticas, naturales del lugar de residencia inciden en la mortalidad, con lo que a la hora de evaluar diferencias en dicha tasa y la influencia de variables socio-económicas lo primero que hay que hacer es corregir el sesgo geográfico, puesto que si no se eliminan los resultados o influencia de dichas variables no son interpretables.

El segundo objetivo es valorar los efectos de la trayectoria laboral en la tasa de mortalidad, considerando en la medida de lo posible la influencia del puesto de trabajo. Este análisis podría constituir un primer paso para evaluar los efectos de un incremento de la edad de jubilación.

2. Método y estimación

2.1. Los datos

Se utilizan los datos de la muestra continua de vidas laborales de 2007 a 2009 (MCVL) cuya utilidad en el campo de la salud ha sido apuntada por López et al (2014). La muestra se construye a partir de todos aquellos individuos que han tenido algún tipo de relación con la Seguridad Social en el año de referencia, bien sea por estar en alta o por recibir algún tipo de prestación. No están incluidos los demandantes de empleo que no reciben ningún tipo de prestación y tampoco los cotizantes a otros sistemas de previsión como MUFACE (funcionarios), ISFA (militares) y MUGEJU (administración de justicia) y cuya exclusión creemos que es la causa de una infrarrepresentación de las personas de alto nivel educativo. Sobre dicho conjunto de individuos se realiza un muestreo aleatorio simple, no estratificado, de un 4% de la población de referencia que incluye a algo más de un millón de personas.

Los datos son de tipo panel y se actualizan cada año. Algunos individuos desaparecen de la muestra y son reemplazados por otros. Una de las razones del abandono de la muestra es la defunción. El seguimiento de los individuos en las olas de los años siguientes permite comprobar los que mueren cada año. Así, por ejemplo, en 2007 hay 1.200.076 personas distintas, de las que en 2008 se encuentra información sobre 1.149.287 y desaparecen de la muestra 50.789 (de los que 12.082, son muertos a lo largo del 2007). En el 2009, se enlaza con 1.106.061, por lo que faltan 94.105 del fichero del 2007. Entre esos se encuentran los 12.635 que figuran como muertos en 2008. Por último, se contabilizan 12.763 muertes en 2009 (los porcentajes de muertes sobre la muestra de 2007, son un 1,01%, en 1,05% y 1,06% en 2007, 2008 y 2009, respectivamente).

A la hora de medir el status socioeconómico mediante la ocupación hay que tener presente que ésta no ha tenido que ser la misma en toda la vida laboral de un individuo. Lo habitual es utilizar la ocupación en el momento de realizar el estudio o la última ocupación. Pero al hacerlo de ese modo se menosprecia el historial de vida laboral del individuo. La base de datos incluye un registro para cada año natural de cada distinta relación laboral de un individuo en donde figura el grupo de cotización y doce campos con la base cotización de cada mes del año, de modo que para cada individuo se ha obtenido un indicador de su cualificación laboral mediante el promedio de su grupo de cotización ponderado por el número de meses que lo ha ocupado y redondeado al entero más cercano. El promedio resultante vendrá a ser un resumen del historial laboral de las personas.

2.2. Análisis

Una variable como la mortalidad depende de gran cantidad de factores y muchos de estos factores tienen que ver con la situación geográfica de las personas. Por ello, se va a tratar de determinar de manera previa la influencia de estos elementos y tenerlos en cuenta en la segunda fase cuando se estudie el efecto de la trayectoria laboral en las tasas de mortalidad. Lo que se ha hecho es agrupar las provincias en 5 realizando dos estimaciones logit de la variable indicativa de mortalidad. Una controlando por edad, sexo y la otra controlando también por provincia de residencia (donde se incluyen las 50 provincias y las dos ciudades autónomas de Ceuta y Melilla). Con el primer modelo se calcula la probabilidad de muerte estandarizada para el conjunto del país y con la segunda la de cada una de las provincias (utilizando los pesos de cada grupo poblacional, edad y sexo, del padrón de 2007).

El cociente de la probabilidad de muerte de cada provincia por la del conjunto del país constituye la ratio de mortalidad estandarizada. Un análisis cluster sobre dichos ratios permite agrupar las provincias en cinco grupos. Los motivos para incluir la edad y el sexo en estas estimaciones es que son elementos que determinan en gran medida la tasa de mortalidad por lo que hay que depurarlos a la hora de aislar el componente regional.

Cuadro 1.
Variables incluidas en el análisis

Edad	Continua
Sexo	Dicotómica
Grupo de cotización	
Grupo cotización 1	Alta dirección
Grupo cotización 2	Media dirección, jefes administrativos y de talles
Grupo cotización 3	Administrativos y subalternos
Grupo cotización 4	Oficiales de primera y segunda
Grupo cotización 5	Oficiales de tercera
Grupo cotización 6	Peones y asimilados
Educación	
Nivel educativo 0	Universitarios
Nivel educativo 1	Bachiller y formación profesional
Nivel educativo 2	Graduado escolar
Nivel educativo 3	Titulación inferior a graduado escolar
Nivel educativo 4	No sabe leer ni escribir
Variables geográficas	
Capital de provincia	Dicotómica
Municipio grande	Dicotómica
Grupo regional	
Grupo provincial 1	Dicotómica
Grupo provincial 2	Dicotómica
Grupo provincial 3	Dicotómica
Grupo provincial 4	Dicotómica
Grupo provincial 5	Dicotómica

Fuente: Elaboración propia.

Una vez considerado el componente provincial, en una segunda etapa se ha incorporado a las estimaciones individuales, junto con las variables habituales. Este segundo paso analiza la desigualdad en mortalidad en relación con el status socioeconómico utilizando el nivel educativo y la ocupación como aproximación al mismo. Para ello, se realizan estimaciones logit de la variable indicativa de mortalidad controlando por variables de interés, el sexo, la edad, el nivel educativo, la ocupación y las variables regionales. En concreto se estiman cuatro modelos logit donde la variable dependiente toma el valor uno en caso de muerte y cero en caso contrario y las variables explicativas se van incluyendo de manera secuencial.

3. Resultados

3.1. El componente regional

Los resultados referidos a los ratios correspondientes entre las tasas de mortalidad provinciales y la nacional se presentan en el Cuadro 2. El rango del ratio oscila entre 0,8 y 1,2, con lo que encontramos provincias con una tasa de mortalidad un 20% por debajo de la media nacional y otras un 20% por encima, una diferencia de hasta un 40%. Este resultado es ciertamente elevado, considerando que las tasas han sido corregidas por la estructura de edad.

Cuadro 2.
Ratios tasa mortalidad provincial/nacional

Grupo	Provincia	Ratio	Provincia	Ratio
Grupo 1	Segovia	0,80	Soria	0,89
	Ávila	0,81	Cuenca	0,89
	Guadalajara	0,81	Madrid	0,90
	Ourense	0,87	Palencia	0,91
	Teruel	0,88	Salamanca	0,91
Grupo 2	Zamora	0,93	Pontevedra	0,94
	León	0,93	Burgos	0,94
	Lleida	0,93	Rioja	0,95
	Álava	0,93	Navarra	0,96
Grupo 3	Valladolid	0,97	Lugo	0,99
	Tarragona	0,97	Alicante	0,99
	Albacete	0,97	Coruña	0,99
	Toledo	0,97	Santander	1,00
	Zaragoza	0,98	Guipúzcoa	1,00
	Barcelona	0,98		
Grupo 4	Vizcaya	1,01	Granada	1,04
	Asturias	1,02	Huesca	1,04
	Castellón	1,02	Huelva	1,05
	Gerona	1,02	Baleares	1,05
	Córdoba	1,03	Jaén	1,06
	Cáceres	1,03	Valencia	1,06
	Ciudad Real	1,03		
Grupo 5	Murcia	1,09	Santa Cruz	1,15
	Almería	1,09	Cádiz	1,16
	Las Palmas	1,09	Sevilla	1,17
	Badajoz	1,11	Melilla	1,21
	Málaga	1,14	Ceuta	1,20

Fuente: Elaboración propia con datos de la MCVL y Padrón.

La distribución de la mortalidad en relación con la zona de residencia permite concluir que nos encontramos ante un modelo concéntrico, las provincias al norte de Madrid presentan las menores tasas de mortalidad y estas tasas van creciendo conforme se abandona dicha centralidad, especialmente cuando la mirada se dirige hacia el sur, siendo especialmente altas en Sevilla, Huelva y Cádiz, continuando por el litoral mediterráneo y en algunos lugares del norte del país, dado que estas provincias se concentran sobre todo en los grupos 4 y 5.

3.2. Estimación individualizada de la probabilidad de fallecimiento

En el cuadro 3 se presenta el odd ratio de los distintos modelos estimados. La influencia de la edad y sexo en la probabilidad de muerte son las habituales en los cuatro modelos estimados y estadísticamente diferente de uno en todos los casos: la tasa de mortalidad aumenta con la edad y las mujeres presentan tasas de mortalidad inferiores a las de los hombres.

Existe una relación inversa entre la probabilidad de defunción y las variables socioeconómicas, tanto el nivel educativo como la ocupación. En el modelo uno que únicamente incluye los grupos de cotización, todas las variables son significativas. Los odd ratios son mayores que uno al comparar con el grupo de cotizantes de mayor nivel, los altos directivos. También el efecto del nivel educativo, incluido en el modelo 2, es el habitual. Educación y grupo de cotización están correlacionados, al introducir las dos se reduce la desigualdad explicada por cada una de ellas, pero son complementarias y tienen efectos diferentes, sobre todo al diferenciar por sexo, como se verá más adelante.

Las variables geográficas, incluidas en el modelo 3, indican que el hecho de que la residencia del individuo sea una capital de provincia o un municipio grande supone una menor probabilidad de muerte. La significatividad de los grupos provinciales refleja la necesidad de incorporar este componente en las estimaciones individuales, puesto que en caso contrario se estarían obteniendo resultados sesgados. La diferencia en entre el primer y segundo grupo de provincias no es significativa, pero las provincias del quinto grupo presentan una probabilidad de muerte un 40% superior a la del grupo base, valor que es completamente coherente con el obtenido en el apartado anterior.

3.3. Segmentación por sexo y edad

Se ha realizado un análisis segmentado de la influencia tanto del grupo de cotización como de la educación por sexo y edad. Las probabilidades estimadas muestran pautas similares según sexo en la relación de la mortalidad con el grupo de cotización. En la Figura 1 se observa que los perfiles parecen idénticos para todos los grupos de edad, aunque difieren en los niveles. Se observa, por ejemplo, que para trabajadores entre 25 y 35 años los asalariados masculinos del grupo 1 tienen el doble de probabilidades de muerte que las asalariadas, mientras que el ratio es más de 2,5 para el grupo de menor salario. Esto indica que además de tener un efecto positivo sobre la tasa de mortalidad masculina, este efecto es mayor para los grupos de menor nivel de cotización, es decir para aquéllas profesiones que requieren una menor cualificación.

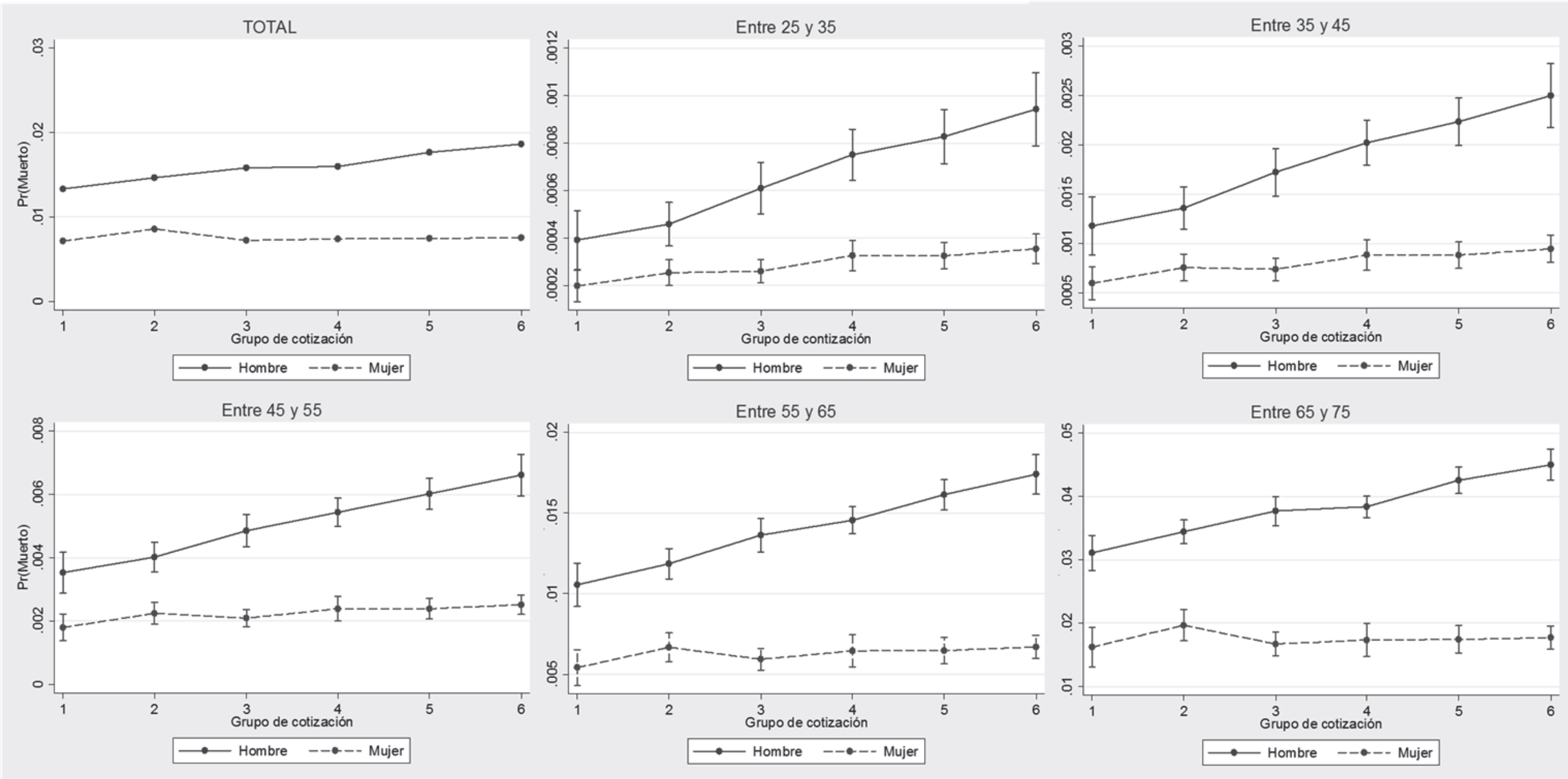
Este esquema de comportamiento se mantiene al considerar a los trabajadores de mayor edad, con lo que se detecta claramente una regularidad que no depende de la edad, ni del espacio geográfico, ni de la educación, ni del tamaño de la ciudad, puesto que son elementos que han sido descontados a la hora de realizar las estimaciones.

Cuadro 3.
Estimación logit de la probabilidad de muerte

	Modelo 1	Modelo 2	Modelo 3	Modelo 4
Edad	1,111***	1,110***	1,110***	1,131***
Mujer	0,448***	0,456***	0,461***	0,745**
Grupo de cotización				
Grupo cotización 2	1,118***	1,061	1,067	1,567*
Grupo cotización 3	1,227***	1,124**	1,128**	2,014***
Grupo cotización 4	1,274***	1,155***	1,142***	2,839***
Grupo cotización 5	1,403***	1,260***	1,242***	3,388***
Grupo cotización 6	1,471***	1,302***	1,250***	3,827***
Educación				
Nivel educativo 2		1,119*	1,081	1,680*
Nivel educativo 3		1,175***	1,120*	2,292***
Nivel educativo 4		1,207***	1,135**	1,959**
Nivel educativo 5		1,454***	1,333***	1,479
Variables geográficas				
Capital de provincia			0,844***	0,843***
Municipio grande			0,796***	0,798***
Grupo regional				
Grupo 2			1,138	1,137
Grupo 3			1,263***	1,261***
Grupo 4			1,246***	1,243**
Grupo 5			1,413***	1,404***
Interacciones				
Mujer Nivel educativo 1				0,732**
Mujer Nivel educativo 2				0,626***
Mujer Nivel educativo 3				0,757*
Mujer Nivel educativo 4				1,01
Mujer Grupo cotización 2				1,052
Mujer Grupo cotización 3				0,859
Mujer Grupo cotización 4				0,89
Mujer Grupo cotización 5				0,764**
Mujer Grupo cotización 6				0,742**
Edad Nivel educativo 2				0,994
Edad Nivel educativo 3				0,990**
Edad Nivel educativo 4				0,993*
Edad Nivel educativo 5				0,998
Edad Grupo cotización 2				0,995
Edad Grupo cotización 3				0,992**
Edad Grupo cotización 4				0,987***
Edad Grupo cotización 5				0,986***
Edad Grupo cotización 6				0,985***
Constante	Sí	Sí	Sí	Sí
N	876042	847768	847768	847768
chi2	39124,762***	35633,795***	35794,854***	35896,041***
Pseudo R2	0,2657	0,2612	0,2624	0,2632

Fuente: Elaboración propia con datos de la MCVL.

FIGURA 1.
Efecto del historial laboral sobre la probabilidad de muerte por sexo y edad



Fuente: Elaboración propia con datos de la MCVL.

Una manera de medir la desigualdad es el ratio relativo, calculado como el cociente de la probabilidad de muerte con respecto al grupo de referencia, que en nuestro caso es el grupo de cotización más alto (Grupo de cotización 1). Una segunda medida es la diferencia en probabilidades con respecto a este grupo de referencia. Estos valores se presentan en el Cuadro 4.

En las mujeres las diferencias por grupos de cotización son mucho menores que para los hombres. En los hombres, en los tres primeros grupos de cotización los efectos marginales no son significativamente distintos de cero (es decir, que pasar del 1 al 2 y de este al 3 no cambia significativamente la probabilidad de muerte). Con el gráfico se ve que el aumento en la probabilidad de muerte es más intenso en lo grupos 5 y 6, es decir, en los trabajos manuales de menor cualificación. En el caso de la mujer, la cualificación laboral introduce menos diferencias en la probabilidad de muerte.

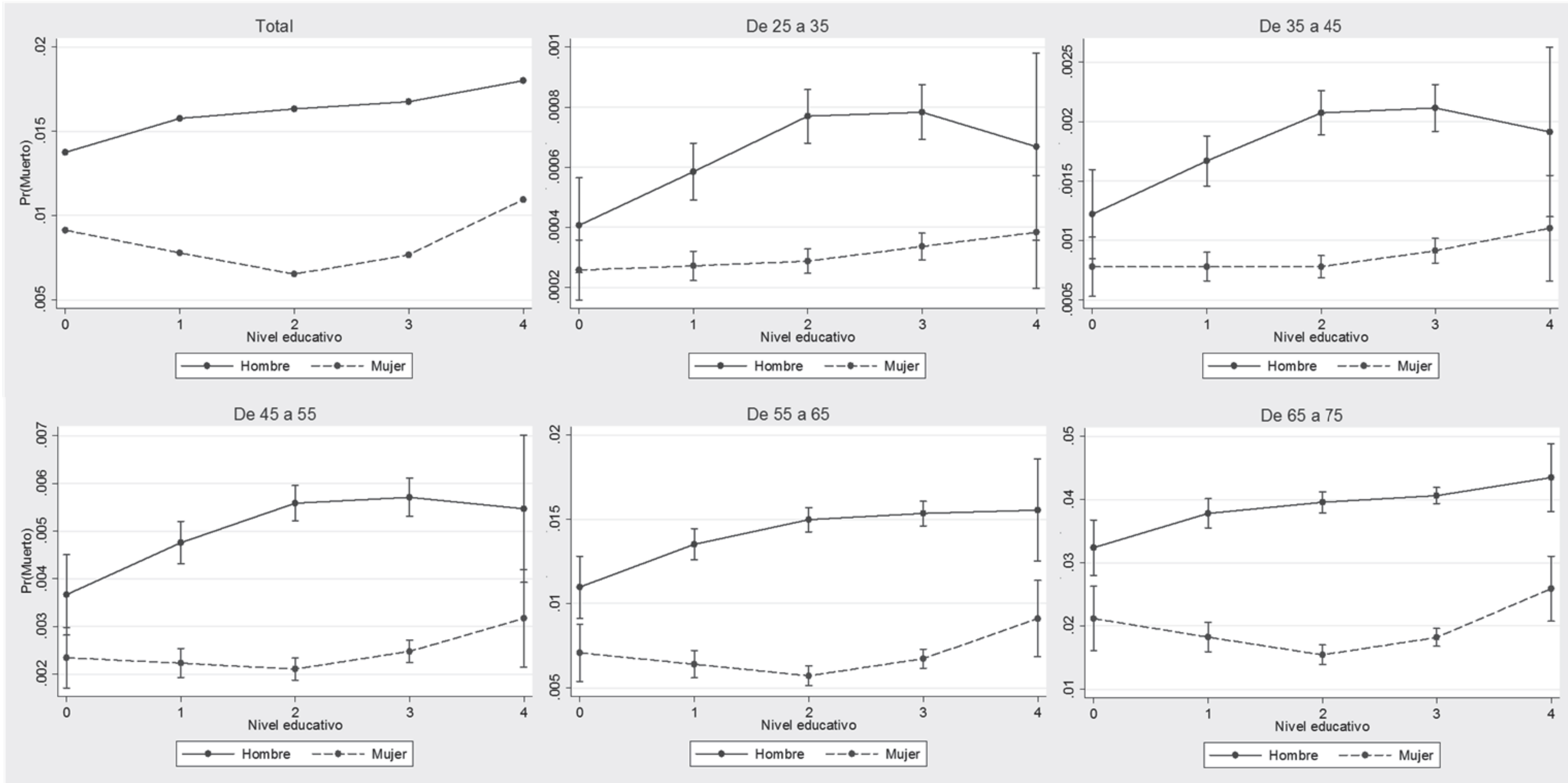
Cuadro 4.
Ratios relativos y diferencias en probabilidad según grupo de cotización y sexo

Grupo	Hombres			Mujeres		
	Probabilidad	Ratio	Diferencia	Probabilidad	Ratio	Diferencia
1	1,54%	1.00	-	0,90%	1,00	-
2	1,65%	1,07	0,10%	1,01%	1,12	0,10%
3	1,79%	1,16	0,24%	0,90%	1,00	0,00%
4	1,80%	1,16	0,25%	0,94%	1,04	0,03%
5	1,97%	1,27	0,42%	0,89%	0,99	-0,01%
6	2,03%	1,32	0,49%	0,89%	0,99	-0,01%

Fuente: Elaboración propia con datos de la MCVL

Los resultados relativos a la educación son similares. Las probabilidades estimadas muestran pautas muy diferentes según sexo en la relación de la mortalidad con el nivel educativo (Figura 2). Parece haber relación clara en el caso del hombre, conforme se reduce el nivel educativo aumenta también la probabilidad de muerte. No así en el de la mujer, donde la desigualdad aparece esencialmente para el nivel educativo más bajo. Mientras que en los varones toda reducción del nivel educativo lleva aparejada un aumento de la probabilidad de muerte, en las mujeres, no ocurre lo mismo, la probabilidad de muerte es menor en la educación y sólo aumenta cuando se reduce el nivel educativo al nivel más bajo. Por tanto, la diferencia en el total entre hombres y mujeres viene marcada especialmente por el nivel de estudios menor.

FIGURA 2.
Efecto de la educación sobre la probabilidad de muerte por sexo



Fuente: Elaboración propia con datos de la MCVL.

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En el caso de los hombres la desigualdad introducida por el nivel educativo se hace más patente, especialmente conforme aumenta la edad. En el caso de las mujeres hay una cierta igualdad en la probabilidad de muerte según sea el nivel educativo, sólo rota por el nivel educativo 4, especialmente para los grupos de edad más elevados. En el Cuadro 5 se presentan los valores de la figura, así como el ratio intergrupo. Como puede comprobarse, la probabilidad de muerte aumenta un 35 % en los hombres al pasar del nivel educativo mayor al menor, mientras que ese incremento en las mujeres es del 25%, sin embargo, el ratio es mayor que uno para todos los niveles educativos en el caso de los hombres y únicamente para las mujeres con un nivel educativo menor.

Cuadro 5.
Ratios relativos y diferencias en probabilidad según nivel educativo y sexo

Educación	Hombres			Mujeres		
	Probabilidad	Ratio	Diferencia	Probabilidad	Ratio	Diferencia
0	1,60%	1,00		1,07%	1,00	
1	1,79%	1,11	0,18%	0,89%	0,83	-0,18%
2	1,83%	1,14	0,23%	0,78%	0,73	-0,28%
3	1,84%	1,15	0,23%	0,94%	0,88	-0,12%
4	1,95%	1,22	0,35%	1,32%	1,24	0,25%

Fuente: Elaboración propia con datos de la MCVL.

4. Discusión

Una variable como la mortalidad depende de gran cantidad de factores, como puede verse en Grigoriev et al. (2013). Muchos de estos factores tienen que ver con la situación geográfica de las personas, puesto que la residencia en una región determina unas condiciones físicas (clima, humedad, altura, calidad y acceso al agua), sociales (tasas de criminalidad) y económicas (estructura productiva, legislación sobre la seguridad en el trabajo). Un análisis como el que se realiza en este trabajo debe tener en cuenta estos efectos y cabe una doble estrategia. La primera consiste en incluir en las estimaciones variables que recojan estos factores, con lo que las correlaciones entre las variables explicativas se incrementarían notablemente. La segunda posibilidad, que ha sido la adoptada en este trabajo, es tratar de determinar de manera previa la influencia de estos elementos y tenerlos en cuenta en la segunda fase cuando se determina la influencia de las variables socioeconómicas en la mortalidad.

Los resultados han mostrado claras diferencias regionales, provincias con una tasa de mortalidad un 20% por debajo de la media nacional y otras un 20% por encima, una diferencia de hasta un 40%. Este resultado es ciertamente elevado, considerando que las tasas han sido corregidas por la estructura de edad, y muestra la necesidad de un análisis más profundo a nivel regional, tanto desde el punto de vista de condicionantes físicos como los referidos a política sanitaria. La distribución espacial de la mortalidad obtenida ofrece un patrón similar (aunque no idéntico) al observado en otros trabajos (Benach y Martínez, 2013; Benach, 2007; Reques et al, 2015; Regidor et al, 2015) ya que es preciso recordar que la muestra que se analiza no es completamente representativa de la población. En la MCVL no están incluidos los cotizantes de determinados sistemas de previsión como MUFACE (funcionarios), ISFA (militares) y MUGEJU (administración de justicia) y cuya exclusión puede llevar a una infrarrepresentación de las personas de alto nivel educativo. En todo caso, se repite el patrón geográfico encontrado en esos trabajos, con mayores tasas de mortalidad en provincias de la periferia española (Andalucía, Murcia, Canarias, Asturias…) y menores a medida que nos acercamos al centro de la península. Lo que sin duda muestra la necesidad de un análisis más profundo a nivel provincial, tanto desde el punto de vista de condicionantes físicos como los referidos a política sanitaria.

En cuanto al segundo objetivo del análisis, que es el efecto de la trayectoria laboral en la tasa de mortalidad, los resultados indican que la tasa de mortalidad aumenta con la edad y las mujeres presentan tasas de mortalidad inferiores a las de los hombres. Son muchos los estudios que sugieren que las diferencias regionales en las tasas de mortalidad pueden tener su origen en desigualdades socioeconómicas. En esta línea, el efecto del nivel educativo es el habitual en este tipo de literatura, observándose un gradiente inverso en las tasas de mortalidad en función del nivel educativo (Reques et al, 2015; Huisman et al, 2004; Mackenbach et al, 2008). Además, el efecto no es el mismo para hombres y mujeres y cambia por grupos de edad. Mientras que en los varones toda reducción del nivel educativo lleva aparejada un leve aumento de la probabilidad de muerte, en las mujeres, no ocurre lo mismo, la probabilidad de muerte sólo aumenta de manera significativa cuando nos encontramos en el grupo de menor educación. Por tanto, la diferencia en el total entre hombres y mujeres viene marcada especialmente por el nivel de estudios menor. Por otro lado, residir en una capital de provincia o un municipio grande supone una menor probabilidad de muerte. Sin duda el acceso a los servicios sanitarios juega un papel importante en este aspecto.

La inclusión de la trayectoria laboral del trabajador como determinante de la tasa de mortalidad es un aspecto más novedoso. Los resultados indican que el grupo de cotización es un elemento significativo, incluso cuando se controla por el nivel educativo, con lo que se confirma que están recogiendo dos aspectos distintos de lo que puede denominarse capital humano. Del mismo modo que ocurre con el nivel educativo, la influencia del grupo de cotización tiene que ser matizada por el sexo de los trabajadores. Los asalariados masculinos del grupo de cotización 1 tienen el doble de probabilidades de muerte que las asalariadas, mientras que el ratio se eleva a 2,5 para el grupo de menor salario. Esto indica que, el grupo de cotización, además de tener un efecto positivo sobre la tasa de mortalidad masculina, este efecto es mayor para los grupos de menor nivel de cotización, es decir, para aquéllas profesiones que requieren una menor cualificación.

Estos resultados nos indican la importancia que tienen las variables geográficas, económicas y laborales en la tasa de mortalidad de los trabajadores y la relevancia que tenerlas en consideración a la hora de elaborar políticas, como por ejemplo políticas relacionadas con la edad de jubilación, ya que no es lo mismo aumentar la edad de jubilación en dos años a un grupo de trabajadores con una esperanza de vida de 2 años puesto, que lo que se hace es eliminar la jubilación, que a otro cuya esperanza de vida sea 10 años.

5. Conclusiones

El análisis de las tasas de mortalidad no es sencillo, puesto que en su determinación intervienen variables de muy distinta naturaleza. En este trabajo se pretenden aislar dos de estas variables. La primera tiene que ver con el componente geográfico y la segunda con el mercado de trabajo y el capital humano de los asalariados españoles. Sin duda las características físicas, climáticas, naturales del lugar de residencia inciden en la mortalidad, con lo que a la hora de evaluar la influencia de variables socio-económicas lo primero que hay que hacer es corregir el sesgo geográfico. El segundo aspecto considerado es el efecto de la trayectoria laboral en la tasa de mortalidad, aspecto que puede arrojar luz sobre los efectos de un incremento de la edad de jubilación en la tasa de mortalidad de los trabajadores.

El análisis geográfico confirma la importancia de incluir el componente regional en el estudio de la mortalidad en España. Como resultado se ha obtenido una distribución de la mortalidad que agrupa las provincias españolas en cinco grandes grupos en función de sus similitudes en cuanto la tasa de mortalidad y características poblacionales, nos encontramos ante un modelo concéntrico, puesto que las provincias al norte de Madrid presentan las menores tasas de mortalidad, y estas tasas van creciendo conforme se abandona dicha centralidad, especialmente cuando la mirada se dirige hacia el sur.

En cuanto al segundo objetivo del análisis, que es el efecto de la trayectoria laboral en la tasa de mortalidad, los resultados indican que hay una clara relación inversa entre la probabilidad de defunción y las variables socioeconómicas, tanto el nivel educativo como la ocupación. El grupo de cotización es un elemento significativo, incluso cuando se controla por el nivel educativo, con lo que se confirma que están recogiendo dos aspectos distintos de lo que puede denominarse capital humano.

Estos resultados nos indican la importancia que tienen las variables geográficas, económicas y laborales en la tasa de mortalidad de los trabajadores y la relevancia que tenerlas en consideración a la hora de elaborar políticas, como por ejemplo políticas relacionadas con la edad de jubilación.

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Efectos de las alternativas para la participación de los tributos del sistema de financiación autonómica en la nivelación horizontal

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Resumen

A lo largo de la vigencia del actual modelo de financiación autonómica se ha puesto de manifiesto la necesidad de su modificación tanto en numerosos trabajos académicos como por parte de los gobiernos autonómicos. Uno de los parámetros para el que se ha propuesto un cambio consiste en cómo han de participar en la nivelación horizontal los diferentes tributos integrados en el sistema de financiación autonómica. Este trabajo analiza las implicaciones que tendrían las principales alternativas que existen al respecto tanto en el grado de variabilidad de la financiación como en los resultados para las distintas comunidades autónomas.

Palabras clave: financiación autonómica, recursos tributarios, nivelación horizontal y vertical.
Clasificación JEL: H71, H77.

Effects of the alternatives for the participation of the regional financing system taxes in the horizontal equalization

Abstract

The need for modifying the current system of regional finance has been argued in numerous academic works and by the different autonomous governments. One of the parameters for which a change has been proposed is how the different taxes integrated in the regional financing system should participate in horizontal equalisation. This paper analyzes the implications of the main alternatives that exist in this regard, both in the degree of variability of funding and in the results for the different autonomous communities.

Keywords: regional finance, tax revenue, horizontal and vertical transfers.
JEL classification: H71, H77.

1. Introducción

Existe un alto grado de consenso sobre la necesidad de reforma del vigente Sistema de Financiación Autonómico (SFA), como se ha puesto de manifiesto tanto en numerosos trabajos de carácter académico como en los documentos remitidos por las comunidades autónomas (CCAA) en el seno del Comité

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Técnico Permanente de Evaluación integrado en el Consejo de Política Fiscal y Financiera (MINHAP, 2016), aduciéndose para ello a diversos motivos. Así, son varios los estudios que argumentan la necesidad de incrementar sus recursos, debido a la posible existencia de un desequilibrio vertical (*e.g.*, Vilalta, 2016; Pérez y Cucarella, 2015). Así mismo, también se ha hecho referencia en estos trabajos a la evolución dinámica del conjunto de los recursos integrados en el SFA (Hierro y Atienza, 2016; Zabalza, 2016; Zabalza, 2017), de los aportados por el Estado (De la Fuente, 2015a; Vilalta, 2016) y de la operativa de las entregas a cuenta (Cuenca, 2015). Otra de las cuestiones objeto de análisis consiste en su estructura, proponiendo todos los trabajos una simplificación. En este sentido, las propuestas consisten básicamente en contar con un único fondo de nivelación, donde se integrarían los recursos tributarios y los aportados por el Estado (Vilalta, 2016; Zubiri, 2016) o distinguir dos fondos de nivelación, de los cuales uno tendría como fin principalmente la nivelación horizontal; el otro, financiado con aportaciones del Estado, trataría de resolver en algún grado las diferencias de financiación que persistiesen tras la aplicación del primero de los fondos (Comité de Expertos, 2017; De la Fuente, 2016a). Otro aspecto para el que se plantea su modificación consiste en el criterio que se emplea para medir las necesidades de gasto y distribuir los recursos nivelados (e.g., De la Fuente, 2015b, 2015c, 2016a; Hierro y Atienza, 2016; Pérez y Cucarella, 2015; Vilalta, 2016; Zabalza, 2016). También ha sido objeto de análisis el modo de determinación del valor normativo de ciertos tributos cedidos (*e.g.*, De la Fuente, 2016b; López Laborda y Zabalza, 2015; López Laborda, 2016), la valoración y distribución de los recursos para competencias singulares (Hierro y Atienza, 2016), la consideración de los recursos tributarios del REF en el SFA (Clavijo, Galván y Sánchez, 2018; De la Fuente, 2016a), el tratamiento de las CCAA forales en relación al SFA (*e.g.*, Monasterio, 2010; RIFDE, 2017) o cómo abordar la cláusula de *statu quo* en el próximo SFA (De la Fuente, 2016a; Lago y Martínez Vázquez, 2015).

Otra de las modificaciones propuestas gira en torno a cómo ha de financiarse el fondo dedicado a la nivelación horizontal, esto es, aquel que tiene como fin corregir, mediante transferencias de recursos entre CCAA, las diferencias de capacidad fiscal en relación a los tributos integrados en el SFA, así como de necesidades de gasto. A este respecto existen básicamente dos propuestas: una participación en igual proporción de todos los recursos tributarios cedidos en este fondo, de modo similar a cómo se ha realizado hasta este momento (*e.g.*, Hierro y Atienza, 2016; Vilalta, 2016), frente a otro planteamiento en el que el IVA y los impuestos especiales cedidos (IIEE) se incluyan en su totalidad en el mismo y el resto de tributos se integre sólo en una proporción (De la Fuente, 2016a; Zubiri, 2016). Esta última propuesta ha sido finalmente la reflejada en el informe de la Comisión de Expertos para la revisión del modelo de financiación autonómica (Comisión de Expertos, 2017). Así mismo, Zabalza (2016) y Zabalza (2018) proponen la sustitución de los tramos autonómicos del IVA e IIEE por transferencias desde la Administración Central, dado que las CCAA no tienen competencias normativas sobre estos tributos. Estas transferencias, junto con las que deba aportar la Administración Central para completar la diferencia entre necesidades de gasto y los recursos tributarios del SFA, se repartirían de forma proporcional a la población ajustada, por lo que, a los efectos del presente trabajo, podría considerarse como una propuesta similar a esta última.

El presente trabajo tiene como objetivo analizar cómo inciden estas dos opciones, sobre cómo integrar los tributos del SFA en el fondo de nivelación horizontal (FNH), en la variabilidad de la financiación por unidad de necesidad y los resultados que generan para las diferentes CCAA. Con esta finalidad se establecen los supuestos necesarios para realizar esta comparación en términos homogéneos, ofreciéndose la misma tanto a través de los correspondientes desarrollos analíticos como sus resultados a partir de los importes de la liquidación del SFA para 2016.

Para ello, en el siguiente epígrafe se exponen brevemente las diferencias de capacidad fiscal entre CCAA para los tributos del SFA y se describen las dos alternativas ya señaladas para la financiación del FNH. Por su parte, el tercer apartado analiza la incidencia de ambas opciones en la dispersión de la financiación por unidad de necesidad, así como los resultados que tienen para las distintas CCAA. Finalmente, en el último epígrafe se recogen las principales conclusiones.

2. La financiación del fondo de nivelación horizontal

Cómo se configura la nivelación entre las CCAA en España es una cuestión relevante, dadas las diferencias en bases imponibles y necesidades de gasto de las CCAA (Lago Peña y Martínez, Vázquez, 2015), así como por el creciente peso de los recursos tributarios en los sucesivos modelos de SFA (92,2% de la financiación total en términos normativos y a competencias homogéneas en 2016). La tabla 1 recoge el coeficiente de variación de Pearson (CV) de la recaudación en términos normativos por habitante ajustado de cada uno de los recursos tributarios del SFA para 2016. Así, las diferencias entre CCAA en recaudación normativa por habitante ajustado para el conjunto de los tributos integrados en el SFA son en promedio del 28,4%[1].

Tabla 1.
Grado de dispersión entre CCAA de régimen común de la recaudación normativa por habitante ajustado (2016)

Tributo integrado en el SF	CV	CV sin considerar Canarias (*)	Peso en la capacidad tributaria
IVA	27,9%	16,6%	32,7%
Impuestos especiales sobre alcohol y bebidas alcohólicas	9,6%		0,7%
Impuesto sobre las labores del tabaco	27,6%	16,1%	4,0%
Impuesto sobre hidrocarburos	28,7%	17,8%	6,8%
Impuesto sobre electricidad	20,1%		1,3%
Subtotal	**25,0%**	**12,8%**	**45,6%**
IRPF	41,4%		40,5%
Cedidos tradicionales tras ajuste (**)	31,2%		14,7%
IEDMT	62,7%		0,4%
Subtotal	**37,5%**		**54,4%**
Total capacidad tributaria	**28,4%**		**100,0%**

(*) Se ha calculado sólo para aquellos tributos que no son exigibles en Canarias en virtud del REF. (**) Para los cedidos tradicionales se ha tomado la recaudación en términos normativos tras aplicar los ajustes propuestos por De la Fuente (2018) para estimar una alternativa (recaudación *homogénea*) a los valores normativos según la Ley 22/2009.
Fuente: Elaboración propia a partir de MINHAP (2018) y De la Fuente (2018).

Atendiendo a las diversas propuestas para la reforma del SFA ya indicadas, se partirá de una estructura de SFA que integra (i) un fondo dedicado a la nivelación horizontal (FNH), cuyo fin consiste en reducir las diferencias de capacidad fiscal entre CCAA en el grado que se considere adecuado mediante transferencias entre las mismas; y (ii) un fondo para la nivelación vertical (FNV), en el que se integrarían recursos aportados por el Estado, también en una cuantía que deberá ser decidida en la próxima reforma del SFA, con el objetivo principalmente de reducir las diferencias de financiación entre CCAA tras la aplicación del FNH.

Para esta estructura de SFA se contemplarán dos posibilidades sobre los recursos que nutren el FNH: en una de ellas (alternativa 1) todos los recursos tributarios integrados en el SFA se nivelan en la misma proporción, mientras que en la otra alternativa (alternativa 2) la recaudación de los tramos autonómicos correspondientes al IVA y a los IIEE sujetos actualmente a liquidación se integran en su totalidad en el

[1] Calculado considerando la propuesta de De la Fuente (2018) para determinar la recaudación normativa (homogénea) de los tributos cedidos tradicionales integrados en el SFA.

FNH, frente al resto de tributos que podrían integrarse de forma parcial en éste. La primera de las propuestas sería similar a la estructura del SFA vigente, que integra en el Fondo de Garantía el 75% de la recaudación normativa de todos los tributos del SFA. La segunda alternativa se correspondería con la contenida en Comisión de Expertos (2017).

Para cualquiera de las dos alternativas que se analizan en este trabajo, la financiación que obtendría una CA, sin considerar la que pudiera corresponderle por sus competencias singulares, vendrá dada por su participación en el FNH, la parte de sus recursos tributarios no integradas en el fondo anterior y la cuantía que le corresponda en el FNV. Permaneciendo todo lo demás constante, cuanto más elevado sea el peso del FNH, mayores serán las transferencias entre CCAA dedicadas a la nivelación, y mayor será, por tanto, su aportación a esta nivelación con cargo a los recursos tributarios que le han sido cedidos.

Uno de los argumentos a favor de la nivelación total del IVA y de los IIEE (alternativa 2) consistiría en que se trata de recursos tributarios con una menor elasticidad en relación al ciclo, siendo esta una de las características deseables de los tributos asignados a los niveles subcentrales (e.g., Bird, 2009). Así, atendiendo a Mourre, Astarita y Princen (2014), la elasticidad de los impuestos indirectos en relación a la brecha de producción es próxima a 1, mientras que la del IRPF ascendería a 1,84 en España, lo que les otorgaría a los primeros una mayor estabilidad y, por tanto, serían más apropiados para constituir la financiación que con carácter de mínimo y uniforme se establezca para el conjunto de las CCAA. La integración de la totalidad de la recaudación cedida por estos impuestos tendría como ventaja añadida que, ante un hecho de carácter estructural que generase una necesidad adicional de recursos, un incremento de tipos, dadas las exigencias de uniformidad que impone la UE, se traduciría en un aumento de recursos por unidad de necesidad uniforme para todas las CCAA, sin que ello supusiera un aumento de las diferencias de financiación, por lo que constituiría un mecanismo de reequilibrio vertical adecuado. Por otra parte, la integración en la misma proporción de todos los tributos en el FNH (alternativa 1) tiende, como se verá posteriormente, a generar un menor grado de variabilidad de la financiación entre CCAA. Además, esta opción aportaría una mayor facilidad de comprensión del modelo, siendo esto último uno de los atributos deseables del SFA al que se ha hecho referencia frecuentemente (*e.g.*, Lago y Martínez Vázquez, 2015; Zabalza, 2018).

3. La financiación del fondo de nivelación horizontal: impacto en los recursos percibidos por las CCAA

El análisis comparativo de las dos alternativas, relativas a la financiación del FNH, se llevará a cabo bajo unos supuestos que permitan que este se realice en términos homogéneos: (a) idénticos recursos totales integrados en el SFA, (b) igual importe total de recursos sujetos a nivelación horizontal (FNH) y (c) un mismo importe de transferencias aportadas por el Estado (FNV).

A continuación, se expone la incidencia de estas dos alternativas en el grado de dispersión de la financiación por habitante ajustado entre CCAA, así como sus resultados para las distintas CCAA. Ello se llevará a cabo en tres etapas, analizando en un primer momento su efecto en la financiación de las CCAA antes de la distribución del FNV. Posteriormente se examinará el impacto que ambas alternativas tienen en el reparto del FNV y, finalmente, en la financiación total.

3.1. Incidencia de la financiación del fondo de nivelación horizontal en la financiación básica de las Comunidades Autónomas

Las ecuaciones (1) y (2) expresan la financiación correspondiente a una CA antes de su participación en el FNV para las alternativas 1 y 2, respectivamente, y que, haciendo uso de la terminología empleada en De la Fuente (2012), denominamos financiación básica.

$$FB_i^1 = (\overline{ic} + \overline{rt}) * h^1 * pa_i + (ic_i + rt_i) * (1 - h^1) * pa_i \quad (1)$$

$$FB_i^2 = (\overline{ic} + \overline{rt} * h^2) * pa_i + (rt_i) * (1 - h^2) * pa_i \quad (2)$$

Donde:

FB_i^1 y FB_i^2 son la financiación básica total de la CA_i para las alternativas 1 y 2, respectivamente.

$\overline{ic}$ y $\overline{rt}$ son la recaudación promedio por habitante ajustado en términos normativos por impuestos sobre el consumo (IVA e impuestos especiales) y por el resto de tributos del SFA, respectivamente.

ic_i y rt_i son los ingresos normativos por impuestos sobre el consumo (IVA e impuestos especiales) y por el resto de tributos del SFA por habitante ajustado para la CA_i, respectivamente.

h^1 es la proporción en que se integran en el FNH todos los recursos tributarios en la alternativa 1, mientras que h^2 es la proporción en que se integran los rt en el FNH en la alternativa 2.

pa_i es la población ajustada de la CA_i.

Un componente de la financiación básica de una CA son las transferencias de nivelación horizontal (TNH). Partiendo de lo antes indicado, el importe total de las TNH en las alternativas 1 y 2 se corresponde con las ecuaciones (3) y (4), respectivamente:

$$\sum_{i=1}^{n} |TNH_i^1| = \sum_{i=1}^{n} [|(ic_i - \overline{ic}) * h^1 + (rt_i - \overline{rt}) * h^1|] * pa_i \quad (3)$$

$$\sum_{i=1}^{n} |TNH_i^2| = \sum_{i=1}^{n} [|(ic_i - \overline{ic}) + (rt_i - \overline{rt}) * h^2|] * pa_i \quad (4)$$

Los impuestos sobre el consumo (ic_i), considerando los porcentajes de cesión actuales y atendiendo a los puntos de conexión utilizados en el SFA, muestran una dispersión entre CCAA, en su recaudación por unidad de necesidad, inferior a la que corresponde al resto de tributos del SFA (rt_i) (tabla 1). Ello conduce a que, para un mismo importe de recursos totales incluidos en el FNH, las diferencias en fb_i entre las distintas CCAA serán superiores en la alternativa 2, dado que el mismo importe total del FNH se está obteniendo en mayor medida con los recursos que presentan menores diferencias entre CCAA y se integrarán en el mismo en menor proporción los recursos tributarios para los que las distancias entre éstas son más altas. Es decir, las transferencias de nivelación horizontal serán siempre superiores en la alternativa 1.

Entre los requisitos señalados al inicio del apartado 3 para lograr un análisis homogéneo de las dos alternativas, se encuentra que en ambas la dimensión total del FNH sea idéntica, lo que se da cuando, para un mismo volumen de recursos tributarios cedidos de cada uno de los tributos, la relación entre h^1 y h^2 es la que aparece en la expresión (5) (ver apéndice). Con base en ello, h^2 será inferior a h^1 y la distancia entre ambos será mayor cuanto más elevada sea la importancia de los impuestos sobre el consumo en el conjunto de los recursos tributarios del SFA.

$$h^2 = \frac{(h^1 - 1) * \overline{ic}}{\overline{rt}} + h^1 \quad (5)$$

Si en la ecuación (4) se sustituye h^2 por la expresión mostrada en (5), el total, en términos absolutos, de las transferencias de nivelación horizontal en la alternativa (2) será igual a:

$$\sum_{i=1}^{n} |TNH_i^2| = \sum_{i=1}^{n} \left|(ic_i - \overline{ic}) + (rt_i - \overline{rt}) * h^1 + (h^1 - 1) * \frac{\overline{ic}}{\overline{rt}} * (rt_i - \overline{rt})\right| * pa_i \quad (6)$$

La diferencia entre (3) y (6) proporciona la distancia entre el total de las TNH, en términos absolutos, para las alternativas (1) y (2), lo cual queda recogido en la igualdad (7).

$$\sum_{i=1}^{n} |(rt_i - \overline{rt})| * (1 - h^1) * \frac{\overline{ic}}{\overline{rt}} * pa_i - \sum_{i=1}^{n} |(ic_i - \overline{ic})| * (1 - h^1) * pa_i \quad (7)$$

Teniendo en cuenta que en la liquidación del SFA para 2016 la razón $\frac{\overline{\iota c}}{rt}$ es 0,84 y las diferencias de dispersión entre CCAA para ambos grupos de tributos (véase tabla 1), la suma total de las TNH en valores absolutos de las distintas CCAA serán, para un mismo volumen de FNH en ambos modelos y permaneciendo todo lo demás constante, superiores en la alternativa 1 que en la 2 (véase tabla 2). Esta distancia disminuye cuando se incrementa el grado de integración de los tributos en el *FNH*. Por otra parte, cuanto menor sea la importancia en el SFA de la recaudación de los impuestos sobre el consumo en relación a la correspondiente al resto de tributos, menores tenderán a ser las distancias entre el total de las TNH de las dos alternativas.

Tabla 2.

Diferencias en las transferencias de nivelación total (TNH) correspondientes a las alternativas 1 y 2 (2016)

h^1	55,00%	65,00%	75,00%	85,00%	95,00%
h^2	17,34%	35,71%	54,08%	72,45%	90,82%
	TNH^1-TNH^2	TNH^1-TNH^2	TNH^1-TNH^2	TNH^1-TNH^2	TNH^1-TNH^2
Cataluña	-356.527.895,83	-277.299.474,53	-198.071.053,24	-118.842.631,94	-39.614.210,65
Galicia	277.502.935,83	215.835.616,76	154.168.297,69	92.500.978,61	30.833.659,54
Andalucía	803.823.832,82	625.196.314,41	446.568.796,01	267.941.277,61	89.313.759,20
Principado de Asturias	44.464.140,24	34.583.220,19	24.702.300,13	14.821.380,08	4.940.460,03
Cantabria	45.203.094,48	35.157.962,38	25.112.830,27	15.067.698,16	5.022.566,05
La Rioja	17.274.356,16	13.435.610,34	9.596.864,53	5.758.118,72	1.919.372,91
Región de Murcia	182.160.349,59	141.680.271,90	101.200.194,21	60.720.116,53	20.240.038,84
C. Valenciana	384.429.016,24	299.000.345,97	213.571.675,69	128.143.005,41	42.714.335,14
Aragón	58.149.568,25	45.227.441,97	32.305.315,70	19.383.189,42	6.461.063,14
Castilla-La Mancha	286.079.116,37	222.505.979,40	158.932.842,43	95.359.705,46	31.786.568,49
Canarias	-642.895.701,67	-500.029.990,18	-357.164.278,70	-214.298.567,22	-71.432.855,74
Extremadura	175.310.820,94	136.352.860,73	97.394.900,52	58.436.940,31	19.478.980,10
Illes Balears	33.807.868,09	26.295.008,52	18.782.148,94	11.269.289,36	3.756.429,79
Madrid	-1.576.926.643,69	-1.226.498.500,65	-876.070.357,61	-525.642.214,56	-175.214.071,52
Castilla y León	268.145.142,17	208.557.332,80	148.969.523,43	89.381.714,06	29.793.904,69
Total	**3.360.331.823,33**	**2.613.591.418,14**	**1.866.851.012,96**	**1.120.110.607,78**	**373.370.202,59**

Nota. Para la fila **total,** se ha calculado utilizando la expresión (7), es decir, empleando valores absolutos para las TNH de cada alternativa, y estimar así las distancias entre las dos opciones en volumen total de TNH. Sin embargo, la distancia individual para cada CA se ha determinado utilizando el signo que corresponde a cada CA: negativo, si en la alternativa 1 la CA debería aportar más al FNH que en la alternativa 2 si es una CA contribuyente a este fondo, o porque recibe con la alternativa 1 una menor transferencia en el caso de ser una CA beneficiaria de estas transferencias. Los valores de h^2 son los equivalentes al h^1 según la expresión (5).
Fuente: elaboración propia a partir de MINHAP (2018) y De la Fuente (2018).

Por todo lo anterior, permaneciendo todo lo demás igual, fb_i presentará una mayor dispersión en su conjunto en la alternativa 2. Así, los CV de la financiación básica por habitante ajustado (fb_i) para ambas alternativas quedan recogidos en las igualdades 8 y 9 (véase apéndice), siendo este estadístico siempre superior en la alternativa 2 al reproducir la dispersión observada para los rt, mientras que en la primera queda en función de la relativa al conjunto de los tributos del SF (ct), la cual es inferior. Los resultados incluidos en la tabla 3 muestran que, tomando como base los datos relativos a 2016, la dispersión de la fb_i obtenida por las distintas CCAA sería siempre un 31,8% superior en la alternativa 2.

$$CV_{fb}^{1} = (1-h^1) * CV_{ct} \tag{8}$$

$$CV_{fb}^{2} = (1-h^1) * CV_{rt} \tag{9}$$

TABLA 3.
Coeficientes de variación de Pearson de la financiación básica por habitante ajustado en las alternativas 1 y 2 (2016)

h^1	h^2	CV_{fb}^1	CV_{fb}^2
50,0%	8,16%	14,2%	18,7%
60,0%	26,53%	11,4%	15,0%
70,0%	44,89%	8,5%	11,2%
75,0%	54,08%	7,1%	9,4%
80,0%	63,26%	5,7%	7,5%
90,0%	81,63%	2,8%	3,7%
100,0%	100,00%	0,0%	0,0%

Fuente: Elaboración propia a partir de MINHAP (2018) y De la Fuente (2018).

La elección de una de las dos alternativas examinadas no tiene consecuencias idénticas para todas las CCAA. La diferencia que se registraría en la TNH de cada CA vendrá dada por la expresión (10) (véase también apéndice).

$$TNH_i^2 - TNH_i^1 = \left[\left(\frac{rt_i}{\overline{rt}} - \frac{ic_i}{\overline{ic}}\right) * (1 - h^1) * \overline{ic}\right] * pa_i \quad (10)$$

Tomando los importes correspondientes a 2016, las CCAA que verían mejorar su transferencia de nivelación horizontal (incrementando su cuantía si son perceptoras o reduciendo la misma si son contribuyentes) con la adopción de la opción 2 son Canarias, Madrid y Cataluña, ya que son las únicas CCAA que presentan una mayor distancia en relación al promedio en rt_i que en ic_i (véase tabla 4). Las dos últimas son las CCAA de régimen común con mayor PIB per cápita, por lo que un impuesto directo progresivo como el IRPF tiene especial relevancia para las mismas. El caso particular de Canarias se debe a que, a pesar de ser una CA con una recaudación normativa por IRPF inferior al promedio, presenta un significativo desfase en impuestos al consumo en relación, como consecuencia del REF.

Salvo Madrid y Cataluña, el resto de CCAA con capacidad tributaria por habitante ajustado superior al promedio no resultarían beneficiadas por la alternativa 2 en cuanto a TNH se refiere, dado que la distancia que presentan en relación al promedio es superior en el caso de los ic_i. Este es el caso de Baleares, Aragón y Cantabria. Finalmente, todas las CCAA con capacidad fiscal por habitante ajustado inferior al promedio obtienen una menor TNH en la alternativa 2, salvo Canarias por los motivos ya indicados. Si se toma como base los datos relativos a 2016, las CCAA más perjudicadas en la alternativa 2 frente a la 1 serían Extremadura, Castilla La Mancha y Murcia (reduciendo su percepción).

Así mismo, las CCAA para las que, por ejemplo, el sector turístico tiene una mayor importancia tenderán a mostrar una proporción más elevada del consumo final de los hogares interior sobre su PIB, por lo que en principio resultarían perjudicadas por este rasgo de su economía en el caso de la alternativa 2. En la tabla 5 se muestra una estimación del importe del PIB per cápita ligado al turismo para aquellas CCAA de las que se dispone de esta información según Exceltur (2018), así como el importe correspondiente al consumo final de los hogares interior per cápita de las mismas. Existe una fuerte correlación positiva entre estas dos magnitudes (coeficiente de correlación del 89% para 2013), así como entre la primera y la recaudación normativa de los impuestos ligados al consumo integrados en el SFA per cápita (84,2%)[2].

[2] Existe una alta correlación entre el gasto en consumo final de los hogares interior y la recaudación por IVA debido también a la metodología seguida para calcular el indicador de consumo que se emplea para la distribución territorial de este impuesto, dado que este indicador está basado en gran medida en el gasto en consumo final de los hogares interior.

TABLA 4.
Diferencias entre las dos alternativas en transferencia de nivelación horizontal por habitante ajustado (2016) ($h^1 = 75\%$)

	$\frac{ic_i}{\overline{ic}}$	$\frac{rt_i}{\overline{rt}}$	$(\frac{rt_i}{\overline{rt}} - \frac{ic_i}{\overline{ic}})$	$\frac{ct_i}{\overline{ct}}$	tnh^2	tnh^1	$tnh^2 - tnh^1$
Cataluña	116,48%	127,14%	10,66%	122,28%	-341,79	-368,56	26,77
Galicia	94,13%	73,06%	-21,07%	82,66%	233,95	286,87	-52,92
Andalucía	90,56%	68,83%	-21,74%	78,73%	297,20	351,79	-54,59
Principado de Asturias	100,44%	91,47%	-8,96%	95,56%	50,95	73,46	-22,51
Cantabria	111,10%	94,09%	-17,01%	101,84%	-73,10	-30,37	-42,73
La Rioja	105,30%	93,54%	-11,76%	98,90%	-11,28	18,26	-29,54
Región de Murcia	98,04%	69,94%	-28,11%	82,74%	214,84	285,44	-70,60
C. Valenciana	103,88%	86,24%	-17,65%	94,28%	50,32	94,64	-44,32
Aragón	109,12%	99,90%	-9,22%	104,10%	-91,03	-67,87	-23,16
Castilla-La Mancha	94,74%	64,99%	-29,75%	78,54%	280,15	354,88	-74,72
Canarias	3,41%	70,08%	66,67%	39,71%	1.164,64	997,19	167,45
Extremadura	86,91%	52,86%	-34,05%	68,37%	437,60	523,13	-85,53
Illes Balears	143,29%	136,48%	-6,81%	139,58%	-671,78	-654,68	-17,10
Madrid	117,75%	173,46%	55,70%	148,08%	-655,26	-795,17	139,91
Castilla y León	103,16%	80,77%	-22,40%	90,97%	93,08	149,33	-56,25

Nota. tnh^2 y tnh^1 toman valores positivos cuando la CA es perceptora de TNH y negativos cuando participa como contribuyente en FNH.
Fuente: Elaboración propia a partir de MINHAP (2018) y De la Fuente (2018).

TABLA 5.
PIB turístico per cápita y consumo final de los hogares interior per cápita (2013)

	PIB turístico per cápita	Consumo final de los hogares interior (per cápita)	Impuestos sobre consumo SF per cápita
Galicia	2.165,39	12.097,71	922,02
Andalucía	2.043,23	11.600,67	885,62
Principado de Asturias	2.119,51	13.150,37	983,79
La Rioja	2.323,26	12.837,27	1.023,75
Región de Murcia	1.769,02	11.578,79	956,11
C. Valenciana	2.533,30	13.564,40	1.008,18
Illes Balears	10.269,95	20.271,12	1.375,60
Madrid	1.903,27	14.656,54	1.145,76
Canarias	6.435,02	14.468,02	(a)

(a) No se ha considerado Canarias, dado que en esta no se aplican los impuestos estatales sobre el consumo integrados en el SFA de mayor importancia.
Nota. El PIB turístico per cápita se ha obtenido a partir de la estimación de la importancia relativa del sector turístico en el PIB en Exceltur (2018), que ofrece esta información para 10 CCAA, si bien para distintos ejercicios que van desde 2011 a 2016; se tomó la proporción del último ejercicio del que se disponen datos y se aplicaron al PIB per cápita correspondiente a 2013 según INE, dado que éste es el último ejercicio para el que se dispone de los datos de consumo de los hogares de CCAA.
Fuente: Elaboración propia a partir de Exceltur (2018), INE (2018) y MINHAP (2017).

Las diferencias entre las dos alternativas estudiadas en cuanto a TNH por habitante ajustado se traducen en su integridad en diferencias entre CCAA en cuanto a fb_i, por lo que lo antes señalado en relación a la primera magnitud es extensible a esta última (véase ecuación 11).

$$fb_i^2 - fb_i^1 = tnh_i^2 - tnh_i^1 = \left(\frac{rt_i}{\overline{rt}} - \frac{ic_i}{\overline{ic}}\right) * (1 - h^1) * \overline{ic} \quad (11)$$

3.2. La financiación del fondo de nivelación horizontal y su impacto en la aplicación del fondo de nivelación vertical

Para las dos alternativas analizadas, la aportación estatal al SFA, una vez fijados los porcentajes de cesión de los recursos tributarios cedidos, se concretaría en transferencias integradas en el *FNV* a distribuir con criterios que traten de reducir las disparidades de financiación entre CCAA, originadas por sus diferentes capacidades fiscales, y que quedaran tras la aplicación del FNH. En el Informe de la Comisión de Expertos se proponen dos posibles criterios en relación a la distribución de este FNV. Uno de ellos consiste en el reparto de estos recursos de forma proporcional a la distancia con la CA mejor financiada (también propuesto en De la Fuente, 2016a), mientras que la otra alternativa consiste en que estos recursos se apliquen, en primer lugar, a la eliminación de la distancia entre la CA peor financiada con la segunda con menor financiación, y así sucesivamente[3]. Finalmente, otra opción consistiría en el reparto de estos recursos siempre de forma directamente proporcional a las necesidades de gasto (Vilalta, 2016; Zubiri, 2016), siendo esta la vía que en menor medida reduce las distancias de financiación entre CCAA.

Con el objeto de describir la incidencia de las dos alternativas para la financiación del FNH analizadas en este trabajo, se ha tomado el primero de los dos criterios propuestos por el Informe de la Comisión de Expertos. Dado que las diferencias entre CCAA en financiación por habitante ajustado antes del reparto del FNV son superiores en la alternativa 2, un mismo importe de recursos integrados en el FNV conseguirá resolver una proporción inferior de estas diferencias (k^2) frente a la proporción que se reduciría en la alternativa 1 (k^1) (véase expresiones 12, 13, 14 y 15). La razón para ello es que la proporción de diferencias con la mejor financiada que se podría resolver con un determinado FNV en la opción 2 queda nuevamente en función de las distancias entre CCAA, en este caso en relación al valor máximo, para los que aquí hemos denominado *resto de tributos* ($\sum_{i=1}^{n}(rt_{max} - rt_i) * pa_i$), mientras que para la alternativa 1 depende de las distancias relativas a la totalidad de los recursos tributarios del SFA ($\sum_{i=1}^{n}(ct_{max} - ct_i) * pa_i$), siendo estas últimas inferiores, todo ello considerando también la importancia que tienen en la actualidad los rt en los recursos tributarios del SF.

$$k^1 = \frac{FNV}{\sum_{i=1}^{n}(ct_{max} - ct_i) * pa_i * (1 - h^1)} \quad (12)$$

$$k^2 = \frac{FNV}{\sum_{i=1}^{n}(rt_{max} - rt_i) * pa_i * (1 - h^2)} = \frac{FNV * \overline{rt}}{\sum_{i=1}^{n}(rt_{max} - rt_i) * pa_i * (1 - h^1) * \overline{ct}} \quad (13)$$

$$k^1 - k^2 = \frac{FNV}{(1 - h^1)} * \left[\sum_{i=1}^{n}(rt_{max} - rt_i) * pa_i - \sum_{i=1}^{n}(ct_{max} - ct_i) * pa_i * \frac{\overline{rt}}{\overline{ct}}\right] / (\sum_{i=1}^{n}(ct_{max} - ct_i) * pa_i * \sum_{i=1}^{n}(rt_{max} - rt_i) * pa_i) \quad (14)$$

[3] Para ambos criterios, en el caso de conseguirse eliminar todas las diferencias, el resto de recursos del FNV se repartiría de forma proporcional a la población ajustada de cada CA.

Como se observa en la tabla 6, un mismo importe total de FNV en la alternativa 1 resolvería una proporción superior de distancias con la CA mejor financiada que en la alternativa 2, siendo esta proporción constante e independiente del grado de integración de los tributos en el FNH, siempre que en ninguna de las dos alternativas se hayan eliminado todas las diferencias. Esta mayor proporción de distancias con la mejor financiada resueltas vía FNV (52,8% si se toman los importes de la liquidación del SFA en 2016) está en función de las diferencias que se registran con la CA mejor financiada para, por un lado, rt y, por otro, para el conjunto de tributos del SFA (ct) (véase ecuación 15). Como consecuencia de todo ello, en la alternativa 1 se alcanza la nivelación total con un grado de integración de los recursos tributarios (h^1) en el FNH inferior al equivalente al que se precisaría en la alternativa 2 (h^2).

$$(k^1 - k^2)/k^2 = \frac{\overline{ct}}{\overline{rt}} * \sum_{i=1}^{n}(rt_{max} - rt_i) * pa_i / \sum_{i=1}^{n}(ct_{max} - ct_i) * pa_i - 1 \quad (15)$$

Tabla 6.

Proporción de diferencias con la CA mejor financiada cubiertas a través del FNV en las dos alternativas

h^1	h^2	k^1	k^2	$(k^1 - k^2)/k^2$
50,00%	8,16%	35,60%	23,30%	52,8%
60,00%	26,53%	44,50%	29,12%	52,8%
70,00%	44,89%	59,33%	38,83%	52,8%
75,00%	54,08%	71,19%	46,60%	52,8%
80,00%	63,26%	88,99%	58,25%	52,8%
82,20%	67,31%	100,00%	65,45%	52,8%
85,00%	72,45%	100,00%	77,66%	28,8%

Fuente: Elaboración propia a partir de MINHAP (2018) y De la Fuente (2018).

Las diferencias que originan ambas alternativas en cuanto a percepción de transferencias de nivelación vertical para cada CA responden a la distancia entre la recaudación por habitante ajustado para rt y ct de cada CA con el valor máximo de ambas variables (véase expresión 16 y apéndice)[4]. Así, aquellas CCAA que presenten una mayor distancia con el valor máximo por habitante ajustado para rt que para el conjunto de los recursos tributarios (ct) percibirán una transferencia de nivelación vertical más elevada con la alternativa 2 que con la 1, de modo contrario a lo señalado en el caso de las transferencias de nivelación horizontal, para las que las CCAA con rt_i inferior al promedio tienden a obtener transferencias de nivelación horizontal en la opción 2 inferiores a las que percibirían en la opción 1.

$$tnv_i^2 - tnv_i^1 = \left[\frac{dmaxrt_i}{\overline{dmaxrt}} - \frac{dmaxct_i}{\overline{dmaxct}}\right] * \overline{fnv} \quad (16)$$

Donde:

$dmaxrt_i$ y $dmaxct_i$ representan la distancia entre la recaudación normativa para rt y ct de la CA_i por habitante ajustado en relación a las de la CA que presenta para estas variables el importe máximo.

$\overline{dmaxrt}$ y $\overline{dmaxct}$ son el promedio de las dos variables antes descritas, respectivamente.

$\overline{fnv}$ es el importe promedio por habitante ajustado para el conjunto de las CCAA.

[4] Estas diferencias en tnv_i se darán siempre que en ninguna de las dos alternativas se haya alcanzado un grado de nivelación completo.

La mayoría de las CCAA presentan una distancia más elevada con el valor máximo de rt_i (Madrid) que la que presentan para el conjunto de los recursos tributarios del SFA (Madrid), lo cual tiene su origen fundamentalmente en el mayor peso relativo del IRPF en rt_i que en ct_i y el carácter progresivo de este impuesto. Todo lo anterior lleva a que la mayoría de las CCAA obtendrían una *TNV* más alta en la alternativa 2 que en la 1 (véase tabla 7). Una excepción es Canarias, que, debido a su peculiar REF, registra diferencias en relación al máximo más altas en ct_i que en rt_i.

Tabla 7.

Transferencias de nivelación vertical por habitante ajustado para las alternativas 1 y 2 (2016)

CCAA	$(rt_{max}\text{-}rt_i)/\overline{dmaxrt}$ (5)	$(ct_{max}\text{-}ct_i)$ / $\overline{dmaxct}$ (6)	(5)-(6) =(7)	$tnv_i^2 - tnv_i^1$= (7)* fnv= (8)
Cataluña	63,1%	53,7%	9,4%	17,75
Galicia	136,7%	136,1%	0,6%	1,14
Andalucía	142,4%	144,2%	-1,8%	-3,40
Principado de Asturias	111,6%	109,2%	2,4%	4,47
Cantabria	108,1%	96,2%	11,9%	22,40
La Rioja	108,8%	102,3%	6,5%	12,27
Región de Murcia	140,9%	135,9%	5,0%	9,50
C. Valenciana	118,7%	111,9%	6,8%	12,89
Aragón	100,1%	91,5%	8,7%	16,36
Castilla-La Mancha	147,7%	144,6%	3,0%	5,72
Canarias	140,7%	225,4%	-84,7%	-159,79
Extremadura	164,2%	165,8%	-1,6%	-3,04
Illes Balears	50,3%	17,7%	32,7%	61,65
Madrid	0,0%	0,0%	0,0%	0,00
Castilla y León	126,2%	118,8%	7,4%	13,97

Nota. Los importes reflejados en la tabla de diferencias de tnv son lo que se obtienen para un h^1 del 75%, si bien estos no cambiarán al variar h^1, salvo que en una de las dos alternativas se llegue a la nivelación total y el resto de FNV que en su caso quedara se repartiera en proporción a la población ajustada.

Fuente: Elaboración propia a partir de MINHAP (2018) y De la Fuente (2018).

3.3. La financiación total por habitante ajustado y la participación de los recursos tributarios en la nivelación horizontal

El grado de dispersión de la financiación total por habitante ajustado (ft_i), medido a través de su desviación típica, resulta de aplicar al correspondiente a la financiación antes de la nivelación vertical de cada una de las dos alternativas la proporción en que el FNV logra reducir las distancias con la CA mejor financiada (k^1, k^2), (ver ecuaciones 17 y 18). A su vez, como ya se ha indicado, la dispersión en la financiación antes de la nivelación vertical en las alternativas 1 y 2 responden tanto al grado de integración de los tributos en el FNH como a la dispersión correspondiente al conjunto de los tributos del SFA por habitante ajustado (ct) y al resto de los tributos (rt), respectivamente. Todo ello resulta en una mayor dispersión de la financiación total por habitante ajustado en la alternativa 2 que en la alternativa 1, siendo superior la distancia relativa del nivel de dispersión observado entre las dos alternativas que la que corresponde a la financiación básica (véase tabla 8). O lo que es lo mismo, para obtener un mismo nivel de dispersión entre las CCAA en cuanto a financiación total por habitante ajustado, y manteniendo constantes los recursos tributarios cedidos y el total del FNH –es decir, el grado de integración de los recursos tributarios cedidos en este fondo-, la alternativa 2 requeriría un mayor FNV.

$$CV_{ft}^{1} = (1 - k^{1}) * CV_{fb}^{1} * \frac{\overline{ct}}{\overline{ft}} = (1 - k^{1}) * (1 - h^{1}) * \frac{\overline{ct}}{\overline{ft}} * CV_{ct} \quad (17)$$

$$CV_{ft}^{2} = (1 - k^{2}) * CV_{fb}^{2} * \frac{\overline{ct}}{\overline{ft}} = (1 - k^{2}) * (1 - h^{1}) * \frac{\overline{ct}}{\overline{ft}} * CV_{rt} \quad (18)$$

$$CV_{ft}^{2} - CV_{ft}^{1} = (1 - h^{1}) * \frac{\overline{ct}}{\overline{ft}} * (CV_{rt} * (1 - k^{2}) - CV_{ct} * (1 - k^{1})) \quad (19)$$

Tabla 8.

Grado de dispersión de la financiación total por habitante ajustado en las alternativas 1 y 2 (2016)

h^1	h^2	cv_{ct}	cv_{rt}	cv^1_{fb}	cv^2_{fb}	k^1	k^2	cv^1_{ft}	Cv^2_{ft}
50,00%	8,16%	28,4%	37,5%	14,21%	18,73%	35,60%	23,30%	8,54%	13,40%
60,00%	26,53%	28,4%	37,5%	11,37%	14,98%	44,50%	29,12%	5,88%	9,91%
70,00%	44,89%	28,4%	37,5%	8,52%	11,24%	59,33%	38,83%	3,23%	6,41%
75,00%	54,08%	28,4%	37,5%	7,10%	9,36%	71,19%	46,60%	1,91%	4,66%
80,00%	63,26%	28,4%	37,5%	5,68%	7,49%	88,99%	58,25%	0,58%	2,92%
82,20%	67,31%	28,4%	37,5%	5,06%	6,67%	100,0%	65,45%	0,00%	2,15%
85,00%	72,45%	28,4%	37,5%	4,26%	5,62%	100,0%	77,66%	0,00%	1,17%
90,00%	81,57%	26,5%	34,3%	2,65%	3,43%	100,0%	100,0%	0,00%	0,00%

Fuente: Elaboración propia a partir de MINHAP (2018) y De la Fuente (2018).

La diferencia entre las dos alternativas en cuanto a ft_ipara cada CA viene dada por la expresión (20). Si, del mismo modo que se ha efectuado para tnh_i, fb_i y tnv_i, se analiza la incidencia de las dos alternativas en la ft_i de las distintas CCAA, se observa que el efecto final para cada CA dependerá del efecto combinado que las dos alternativas tienen, por un lado, en la TNH y, por otro, en la TNV. Así, en la alternativa 2, en lo que a la nivelación horizontal se refiere, las CCAA con mayores rt_i frente a ic_i tenderían a resultar beneficiadas. Sin embargo, en la nivelación vertical, las CCAA con mayores distancias en relación al máximo en rt_i, frente a las que presentan para el conjunto de los recursos tributarios del SFA (ct_i), obtienen mayores recursos en el FNV en la alternativa 2. Observando la expresión (20), el signo del efecto neto de estos dos elementos dependerá fundamentalmente, por un lado, del grado de integración de los recursos tributarios en el FNH y, por otro, de la dimensión del FNV.

$$ft_i^2 - ft_i^1 = \left(\frac{rt_i}{\overline{rt}} - \frac{ic_i}{\overline{ic}}\right) * (1 - h^1) * \overline{ic} + \left[\frac{dmaxrt_i}{\overline{dmaxrt}} - \frac{dmaxct_i}{\overline{dmaxct}}\right] * \overline{fnv} \quad (20)$$

Si se parte del importe de transferencias del Estado en la liquidación del SFA para 2016 a competencias homogéneas y para un h^1 del 75%, la mayoría de las CCAA obtendría en la alternativa 2 una mayor transferencia de nivelación vertical que en la opción 1, pero sin compensar el menor importe de transferencia por nivelación horizontal que obtendrían en aquella alternativa, excepto en el caso de Baleares (véase tabla 9). Todo ello es consecuencia, entre otros factores, de que las distancias de cada CA entre, por un lado, el resto de los tributos y los impuestos sobre el consumo tienden a ser superiores a las que se observan, por otro lado, entre los primeros (rt_i) y el conjunto de éstos (ct_i). Con todo, el efecto final depende también de h^1, de modo que cuanto mayor sea este parámetro, menores serán las diferencias entre las dos alternativas en cuanto a transferencias de nivelación horizontal y por tanto también inferiores las diferencias a nivel de ft_i que se generan con estas dos alternativas.

En la tabla 10 se observa que las tres CCAA con mayor capacidad tributaria por habitante ajustado (Madrid, Cataluña y Baleares) son las que obtendrían una mayor financiación en la alternativa 2, todo ello si se parte de los importes recogidos en la liquidación del SFA para 2016, mientras que el resto tendría

TABLA 9.

Diferencias de financiación total en términos normativos y a competencias homogéneas por habitante ajustado entre las alternativas 1 y 2 (2016; h^1 =75%)

	$\frac{rt_i}{\overline{rt}}$ (1)	$\frac{ic_i}{\overline{ic}}$ (2)	(1)-(2)=(3)	(3)*(1-h1)*$\overline{ic}$ = fb^2_i-fb^1_i (4)	(rt_{max}-rt_i)/$\overline{dmaxrt}$ (5)	(ct_{max}-ct_i)/$\overline{dmaxct}$ (6)	(5)-(6) = (7)	tnv^2_i-tnv^1_i =(7)* $\overline{fnv}$= (8)	ft^2_i-ft^1_i = (4)+(8) = (9)	Orden (9)
Cataluña	127,1%	116,5%	10,7%	26,77	63%	54%	9,4%	17,75	44,51	3
Galicia	73,1%	94,1%	-21,1%	-52,92	137%	136%	0,6%	1,14	-51,78	11
Andalucía	68,8%	90,6%	-21,7%	-54,59	142%	144%	-1,8%	-3,40	-58,00	12
Principado de Asturias	91,5%	100,4%	-9,0%	-22,51	112%	109%	2,4%	4,47	-18,05	7
Cantabria	94,1%	111,1%	-17,0%	-42,73	108%	96%	11,9%	22,40	-20,33	8
La Rioja	93,5%	105,3%	-11,8%	-29,54	109%	102%	6,5%	12,27	-17,27	6
Región de Murcia	69,9%	98,0%	-28,1%	-70,60	141%	136%	5,0%	9,50	-61,11	13
C. Valenciana	86,2%	103,9%	-17,6%	-44,32	119%	112%	6,8%	12,89	-31,43	9
Aragón	99,9%	109,1%	-9,2%	-23,16	100%	91%	8,7%	16,36	-6,80	5
Castilla-La Mancha	65,0%	94,7%	-29,7%	-74,72	148%	145%	3,0%	5,72	-69,00	14
Canarias	70,1%	3,4%	66,7%	167,45	141%	225%	-84,7%	-159,79	7,67	4
Extremadura	52,9%	86,9%	-34,1%	-85,53	164%	166%	-1,6%	-3,04	-88,57	15
Illes Balears	136,5%	143,3%	-6,8%	-17,10	50%	18%	32,7%	61,65	44,54	2
Madrid	173,5%	117,8%	55,7%	139,91	0%	0%	0,0%	0,00	139,91	1
Castilla y León	80,8%	103,2%	-22,4%	-56,25	126%	119%	7,4%	13,97	-42,28	10

Fuente: Elaboración propia a partir de MINHAP (2018) y De la Fuente (2018).

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generalmente una financiación menor con esta opción. No obstante, con un grado de integración de los tributos en el FNH del 90% (h^1), otras tres CCAA pasarían a obtener mejores resultados con la alternativa 2 (CCAA que tienen un rt_i ligeramente superior al promedio o próximo a éste). En el caso de Canarias la situación es inversa, de modo que, a partir de un determinado importe de h^1, la alternativa 2 le ofrecería peores resultados. Cataluña sería la única CA que, habiendo obtenido una mayor financiación básica en la alternativa 2, también obtendría una tnv superior en esta opción.

De todo ello se deduce que la cuantía de las diferencias entre ambas opciones para cada CA, además del grado de integración de los recursos tributarios en el *FNH*, depende de la importancia de los impuestos sobre el consumo en el SFA y de la dimensión del *FNV*, pero para un mismo importe de estos parámetros, las CCAA con menor rt_i tenderán a obtener peores resultados en financiación total en la alternativa 2. Obviamente, ambas alternativas generarán los mismos resultados en financiación total por unidad de necesidad cuando, dados h^1 y el *FNV*, en ambas alternativas se produzca la nivelación total.

Tabla 10.
Diferencias de financiación total en términos normativos y a competencias homogéneas por habitante ajustado atendiendo a diferentes grados de integración de los tributos en el FNH (2016)

CCAA	h^1				
	50%	60%	70%	80%	90%
	$ft^2 - ft^1$				
Cataluña	71,28	60,57	49,86	39,16	28,45
Galicia	-104,70	-83,53	-62,37	-41,20	-20,03
Andalucía	-112,59	-90,75	-68,92	-47,08	-25,24
Principado de Asturias	-40,56	-31,55	-22,55	-13,54	-4,54
Cantabria	-63,05	-45,96	-28,87	-11,78	5,31
La Rioja	-46,81	-34,99	-23,18	-11,36	0,45
Región de Murcia	-131,71	-103,47	-75,23	-46,99	-18,74
C. Valenciana	-75,75	-58,02	-40,29	-22,56	-4,84
Aragón	-29,97	-20,70	-11,44	-2,17	7,09
Castilla-La Mancha	-143,72	-113,83	-83,95	-54,06	-24,17
Canarias	175,12	108,14	41,16	-25,82	-92,81
Extremadura	-174,09	-139,88	-105,67	-71,46	-37,25
Illes Balears	27,44	34,28	41,12	47,96	54,80
Madrid	279,83	223,86	167,90	111,93	55,97
Castilla y León	-98,54	-76,04	-53,54	-31,03	-8,53

Fuente: Elaboración propia a partir de MINHAP (2018) y De la Fuente (2018).

4. Conclusiones

El SFA ha sido objeto en los últimos años de diversas propuestas de modificación. Una de las cuestiones para las que se ha planteado un cambio es sobre cómo han de participar los distintos tributos que se integran en el SFA en el FNH, el cual resulta esencial para la materialización de los principios de suficiencia, solidaridad y equidad. Así, frente a la participación en el FNH de todos los tributos cedidos a las CCAA en un mismo grado (alternativa 1), otra alternativa consiste en la integración completa de los tramos autonómicos del IVA y de los IIEE en este fondo, mientras que el resto de los tributos podría integrarse de forma parcial (alternativa 2). Este trabajo examina cuáles serían las consecuencias de cada alternativa en el grado de dispersión en la financiación que recibirían las CCAA por unidad de necesidad y cómo se posicionan las distintas CCAA en cada una en lo que a financiación se refiere. Los análisis y resultados expuestos muestran que, manteniéndose todo lo demás constante, la alternativa 2 generaría mayores diferencias entre CCAA en financiación percibida por habitante ajustado.

Analizadas las diferencias entre estas dos alternativas de forma secuencial, se observa que, en la alternativa 2, el grado de dispersión entre las CCAA en la financiación por habitante ajustado, antes del reparto de los recursos aportados por el Estado para la conformación del FNV, está directamente en función de la dispersión observada para la recaudación normativa por habitante ajustado de los que se ha denominado en este trabajo rt_i, entre los que destaca el IRPF. Por su parte, en la alternativa 1 es una función de la dispersión de la recaudación normativa del conjunto de los recursos tributarios cedidos e integrados en el SFA, lo que resulta en una menor variabilidad frente a la alternativa 2. Debido a ello, para un mismo importe total de recursos integrados en el FNH las transferencias de nivelación horizontal entre CCAA son inferiores en la alternativa 2. Estas mayores diferencias en financiación por habitante ajustado en la alternativa 2 traen como consecuencia que, un mismo importe de recursos aportados por el Estado para el FNV, repartidos entre las CCAA con la finalidad de reducir las diferencias que persistieran en su caso tras la nivelación horizontal, tendrá menor eficacia que en la alternativa 1. Partiendo de los importes relativos a la liquidación del SFA para 2016 y de un grado de integración de los recursos tributarios en el FNH del 75%, para obtener la igualdad plena en financiación tras el FNV, con la alternativa 1 sería preciso una aportación del Estado al FNV de 11,54 miles de millones de euros, mientras que con la alternativa 2 serían necesarios 17,64 miles de millones de euros (un 53% más).

Por otro lado, las CCAA favorecidas por la alternativa consistente en que los tramos autonómicos del IVA y de los IIEE asuman el protagonismo en la nivelación horizontal serían aquellas que muestran los importes más elevados en rt_i, que coinciden fundamentalmente con las CCAA con mayor recaudación normativa por habitante ajustado en IRPF, consecuencia, principalmente, de su mayor PIB per cápita. Por el contrario, las CCAA que tienden a obtener menor financiación que en la alternativa 1 serían aquellas que tienen una mayor recaudación normativa por habitante ajustado para los impuestos sobre el consumo, rasgo que presentan generalmente las CCAA en las que sector turístico tiene mayor importancia relativa en su producto interior bruto, excepto para Canarias por las peculiaridades derivadas de su Régimen Económico y Fiscal.

Una de las ventajas de la alternativa 2 radica en que constituye un mecanismo de reequilibrio vertical consistente en la utilización de variaciones en los tipos del IVA y de los IIEE para lograr el ajuste de los recursos frente a cambios en las necesidades de gasto de las CCAA que de forma conjunta puedan surgir a lo largo del tiempo. Ahora bien, la adopción de esta alternativa, propuesta en el Informe de la Comisión de Expertos, deberá tener en cuenta, especialmente tanto en la fijación del grado de integración del resto de tributos del SFA en el FNH como en la elección del criterio de reparto del FNV, que la misma generaría un mayor grado de desigualdad en la financiación por habitante ajustado.

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Apéndice

Ecuación (5)

$$FNH^1 = \sum_{i=1}^{n} (\overline{ic} + \overline{rt}) * h^1 * \ pa_i; \ FNH^2 = \sum_{i=1}^{n} (\overline{ic} + \overline{rt} * h^2) * \ pa_i$$

Para que $FNH^1 = FNH^2$, $\sum_{i=1}^{n} (\overline{ic} + \overline{rt}) * h^1 * \ pa_i = \sum_{i=1}^{n} (\overline{ic} + \overline{rt} * h^2) * \ pa_i$,

$\sum_{i=1}^{n} (\overline{ic} + \overline{rt}) * h^1 * \ pa_i - \sum_{i=1}^{n} \overline{ic} * pa_i = \sum_{i=1}^{n} \overline{rt} * h^2 * pa_i$,

$$h^2 = \frac{(h^1 - 1) * \overline{ic}}{\overline{rt}} + h^1$$

Ecuación (8)

Partiendo de que $fb_i^1 = (\overline{ic} + \overline{rt}) * h^1 + (ic_i + rt_i) * (1 - h^1)$

$$CV_{fb}^1 = \frac{\sqrt{\sum_{i=1}^{n} (\overline{ct} * h^1 + (1 - h^1) * ct_i - \overline{ct} * h^1 - (1 - h^1) * \overline{ct})^2 * \frac{pa_i}{pa}}}{\overline{ct} * h^1 + \overline{ct} * (1 - h^1)} = \frac{(1 - h^1)}{\overline{ct}} * S_{ct}$$

$$= (1 - h^1) * CV_{ct}$$

Ecuación (9)

Partiendo de que $fb_i^2 = (\overline{ic} + \ \overline{rt} * h^2) + (rt_i) * (1 - h^2)$

$$CV_{fb}^2 = \frac{\sqrt{\sum_{i=1}^{n} (\overline{ic} + \overline{rt} * h^2 + (1 - h^2) * rt_i - \overline{ic} - \overline{rt} * h^2 - (1 - h^2) * \overline{rt})^2 * \frac{pa_i}{pa}}}{\overline{ic} + \overline{rt} * h^2 + (1 - h^2) * \overline{rt}}$$

$$= \frac{(1 - h^2)}{\overline{ct}} * S_{rt} = \left(1 - h^1 - (h^1 - 1) * \frac{\overline{ic}}{\overline{rt}}\right) * CV_{rt} * \frac{\overline{rt}}{\overline{ct}} = (1 - h^1) * CV_{rt}$$

Ecuación (10)

$$TNH_i^1 - TNH_i^2 = \ (ic_i + rt_i - \overline{ic} - \overline{rt}) * h^1 * pa_i - (ic_i + rt_i * h^2 - \overline{ic} - \overline{rt} * h^2) * pa_i$$

Sustituyendo h^2 por la expresión (5)

$$TNH_i^1 - TNH_i^2 = (ic_i - \overline{ic}) * (1 - h^1) * pa_i + (rt_i - \overline{rt})(h^1 - 1) * pa_i * \frac{\overline{ic}}{\overline{rt}}$$

$$= \left[ic_i * (1 - h^1) + \frac{\overline{ic}}{\overline{rt}} * rt_i * (h^1 - 1)\right] * pa_i = \left(\frac{ic_i}{\overline{ic}} - \frac{rt_i}{\overline{rt}}\right) * (1 - h^1) * \overline{ic} * pa_i$$

Ecuación (16)

En la medida en que la dimensión del *FNV* no elimine la totalidad de las diferencias de financiación con la CA mejor financiada, las $\boldsymbol{tnv_i}$ vendrán dadas por las siguientes fórmulas.

$$tnv_i^1 = (ct_{max} - ct_i) * (1 - h^1) * k^1$$

$$tnv_i^2 = (rt_{max} - rt_i) * (1 - h^2) * k^2$$

Sustituyendo en tnv_i^2 h2 por la expresión (5):

$$tnv_i^2 = (rt_{max} - rt_i) * \frac{\overline{ct}}{\overline{rt}} * (1 - h^1) * k^2 = \frac{(rt_{max} - rt_i) * FNV}{\sum_{i=1}^{n}(rt_{max} - rt_i) * pa_i}$$

$$tnv_i^2 - tnv_i^1 = \left[(rt_{max} - rt_i)/\sum_{i=1}^{n}(rt_{max} - rt_i) * pa_i - (ct_{max} - ct_i)/\sum_{i=1}^{n}(ct_{max} - ct_i) * pa_i\right] * FNV = \left[\frac{dmaxrt_i}{\overline{\overline{dmaxrt}}} - \frac{dmaxct_i}{\overline{\overline{dmaxct}}}\right] * \overline{fnv}$$

Si el volumen de recursos integrado en el *FNV* diera para alcanzar la igualdad de financiación por unidad de necesidad de todas las CCAA, en cualquiera de las dos alternativas para las que se diera este hecho y a partir de ese umbral, la tnv_i de todas las CCAA será igual a la suma de la que proporcionen las expresiones anteriores para cada alternativa correspondiente a ese umbral y el importe resultante del cociente entre el *remanente* de recursos del *FNV* y la población ajustada de todas las CCAA.

Methodological and Research notes

Local taxation in the EU: A convergence study

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Abstract:

In this note we study the convergence of local taxation in the EU-15 for 1975-2015 and two sub-periods, 1975-1994 and 1995-2015. Through a sigma convergence analysis, we find evidence of convergence for 1975-2015 and 1995-2015 but divergence for 1975-1994. In a club convergence approach, the countries are clustered into two clubs in the overall sample, while in the sub-periods we identify two and three clubs and divergent countries.

Keywords: local taxation; European Union; sigma convergence; club convergence.
JEL classification: E62; H20.

Imposición local en la UE: un estudio de convergencia

Resumen

En esta nota estudiamos la convergencia de la imposición local en la UE-15 en 1975-2015 y dos subperiodos, 1975-1994 y 1995-2015. Mediante un análisis de sigma convergencia, encontramos evidencia de convergencia para 1975-2015 y 1995-2015 pero divergencia para 1975-1994. En una aproximación de clubs de convergencia, los países son agrupados en dos clubs en el periodo completo, mientras que en los subperiodos identificamos dos y tres clubs respectivamente junto a países divergentes.

Palabras clave: Imposición local; Unión Europea; convergencia sigma; club de convergencia.
Clasificación JEL : E62; H20.

1. Introduction

The analysis of fiscal convergence has received increasing attention in the literature in recent decades, especially in the context of the European Union integration process. We focus on local taxation[1] due to the relevance of the non-central levels of government in most EU countries, where non-central revenue represented an (unweighted) average of 17.45% of total tax revenue for the EU-15 in 2015. And specifically for the local level, this average was 4.70% in 2015, with a minimum of 0.60% in Ireland and

[1] The local taxation in the EU relies both on income & profits and property, with two models clearly differentiated. For example, in 2015, the taxes on income & profits represented the 97.6% of total local tax revenues in Sweden, concretely on individuals, whereas in Luxembourg the 90.3% of the income & profits taxation relies on corporates. The cases of Finland and Denmark are similar to Sweden, with shares of 92.6% and 88.7% respectively. On the other extreme, the property tax represented the 100% of total local taxation in the United Kingdom. Ireland, with 91.4%, and Greece, with 93.8%, have also property-based local tax systems.

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a maximum of 15.80% in Sweden. In addition, the local taxation represented the 11.21% of the total tax revenue, again with great differences across countries, between the 2.40% of Ireland and the 36.40% of Sweden.

Due to data availability and the length required for time series analysis, we study local taxation in the EU-15 for the period 1975-2015. To the best of our knowledge, this is the first attempt to study tax convergence at the local level of government, with previous studies on tax convergence in the EU having focused on the central government tax burden or its components[2] (Table 1).

The paper is organized as follows. Section 2 describes the methodology and data. The main results are presented in Section 3. Section 4 contains the conclusions.

TABLE 1.
Papers on tax convergence in EU

Paper	Data	Approach	Results
Esteve, Sosvilla-Rivero and Tamarit (2000)	EU-15 1967-1994	Sigma and time series	Catch-up to Germany for several countries
Delgado (2009)	Tax burden (total and three main components) EU-15 1965-2005	Beta, sigma and gamma	Convergence due to taxation on goods and services
Delgado and Presno (2011)	Tax burden EU-15 1965-2004	Time series	United Kingdom and Germany long-run convergence; few countries converge
Regis, Cuestas and Chen (2015)	Corporate tax (statutory rates) EU-19 (1980-2014) and 25 (1993-2014)	Club	Four clubs
Delgado and Presno (2017)	Tax burden, tax mix (total and five components) EU-15 1975-2011	Club	Sigma convergence Several clubs in each component

Source: Own elaboration.

[2] Bertarelli, Censolo and Colombo (2014) study convergence of total revenue.

2. Methodology and data

Sigma convergence

This is based on the evolution of the dispersion of the tax indicator, using the coefficient of variation (CV):

$$CV_t = \frac{\left(\frac{1}{N}\sum_{i=1}^{N}(y_{it}-\overline{y_t})^2\right)^{1/2}}{\overline{y_t}} \tag{1}$$

where y_{it} is the tax value in the country i (i=1,…,N) in year t (t=1,…,T); and $\bar{y}_t$ is average tax in year t.

In addition, we compute the annual rate of sigma convergence and we test the (unconditional) sigma convergence hypothesis by estimating:

$$CV_t = \alpha' + \beta' t + \varepsilon_t \tag{2}$$

where $\beta'<0$ denotes σ-convergence and $\beta'>0$ σ-divergence.

Club convergence

Phillips and Sul (2007) propose the *logt* test in order to analyze convergence in panel data.

Panel data are traditionally decomposed as:

$$y_{it} = g_{it} + a_{it} \tag{3}$$

where g_{it} and a_{it} represent systematic components (such as permanent common components) and transitory components respectively. In order to separate common components from idiosyncratic components, (3) can be transformed in the following dynamic model:

$$y_{it} = \left(\frac{g_{it}+a_{it}}{\mu_t}\right)\mu_t = \delta_{it}\mu_t \tag{4}$$

where μ_t (or *common growth component*) is a common component which captures some deterministic or stochastically trending behavior. δ_{it} (or *transition parameter*) is a time varying factor-loading coeficient which measures the idiosyncratic distance between μ_t and y_{it}.

In estimating δ_{it}, Phillips and Sul (2007) focus on the relative transition path:

$$h_{it} = \frac{y_{it}}{N^{-1}\sum_{i=1}^{N} y_{it}} = \frac{it}{N^{-1}\sum_{i=1}^{N} \; it} \tag{5}$$

which traces out an individual transition path over time for economy i in relation to the panel average, where the common growth path is removed.

The *logt* test is based on the time series regression model:

$$\log\left(\frac{H_1}{H_t}\right) - 2\log(\log(t)) = \mathrm{c} + b\log(t) + \varepsilon_t \tag{6}$$

where t=[rT], [rT]+1, …, T, for some fraction r>0 normally in the range [0.2, 0.3], and [rT] is the integer part of rT. Specifically, it is suggested to set r=0.3 for small/moderate sample size (T≤50). On the other hand, H_t is the variance of the relative transition coefficients in period t:

$$H_t = N^{-1}\sum_{i=1}^{N}(h_{it}-1)^2 \tag{7}$$

Under convergence, $h_{it} \underset{p}{\rightarrow} 1$ for all i as $t \rightarrow \infty$, and H_t converges to zero asymptotically. Also, b converges in probability to the scaled speed of the convergence parameter 2α. Thus, the null hypothesis of convergence is tested by a one-sided t test of $\alpha \geq 0$ (using the estimate $\hat{b}$ and HAC standard errors), and is rejected at the 5% significance level if $t_{\hat{b}} < 1.65$.

When the null is rejected, Phillips and Sul (2007) propose a four-step clustering algorithm (based on the iterative application of the *logt* test) which allows the endogenous identification of all possible subgroups or clubs which converge in the panel. Phillips and Sul (2009) state that their initial algorithm tends to over-estimate the number of clubs, and propose merging them into larger clubs using the *logt* convergence test.

Not only is the sign of b of interest, but also its magnitude since this measures the speed of convergence. $0 \leq \hat{b} < 2$ $(0 \leq \hat{\alpha} < 1)$ implies convergence in a relative sense, indicating that differentials tend to decrease over time within each club (convergence in growth rates), and $\hat{b} \geq 2$ $(\hat{\alpha} \geq 1)$ indicates absolute convergence within the panel to a club-specific tax burden level over the period (convergence in levels).

Data

We study local taxation in EU-15 from two perspectives: the percentages of GDP (%GDP) and of total tax revenue (%Revenue). The data are from the OECD[3] and for the period 1975-2015. Table 2 contains the descriptive statistics and the Annex incorporates the data for all countries in 1975, 1995 and 2015.

Table 2.
Descriptive statistics

	%GDP			%Revenue		
	1975	**1995**	**2015**	**1975**	**1995**	**2015**
Mean	3.53	4.11	4.70	10.06	9.87	11.21
St. Dev.	3.63	4.58	4.55	9.50	9.64	9.95
Min.	0.0	0.3	0.6	0.0	0.9	2.4
Max.	11.4	14.6	15.8	30.0	31.3	36.4

Source: OECD and own elaboration.

3. Results

Sigma convergence

The results for σ-convergence are summarized in Table 3 and represented in Figure 1 (including the test). For local taxation both as a percentage of GDP and of total revenue, the results confirm the existence of σ-convergence in the overall period. However, we can differentiate two sub-periods, with 1995 as the turning point. Note that in 1993 the euro convergence (Maastricht) criteria were approved with the consequent effects on taxes and public expenditures, with 1996 as the target to satisfy the criteria. The annual rate of convergence for 1975-2015 is -0.17% for %GDP and -0.15% for %Revenue. However, if we look at 1975-1994, the conclusion is σ-divergence, with annual rates of 0.36% and 0.17% respectively. σ-convergence occurs in 1995-2015, with annual rates of -0.66% and -0.45% respectively[4]. These

[3] Concretely, data have been extracted at the OECD Fiscal Decentralization Database, available at: http://www.oecd.org/tax/fiscal-decentralisation-database.htm

[4] Local tax convergence in the EU may be the result of several forces: i) the decision on the role of the local public sector in the economy –see Lago-Peñas, Martínez-Vázquez and Sacchi (2016) for a recent survey on decentralization and Blanco, Delgado and Presno (2019) for a study on convergence of fiscal decentralization in the EU-; ii) tax competition and tax mimicry among local

relatively high annual rates of sigma convergence in the second period support the conclusion of a strong approximation of the burden derived from the local taxation in the EU.

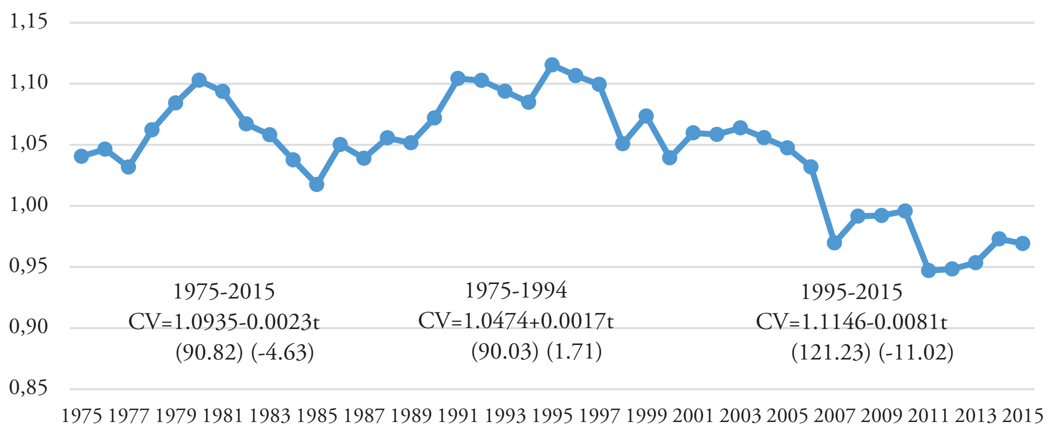
TABLE 3.
σ-convergence

	%GDP	%Revenue
CV1975	1.0406	0.9438
CV2015	0.9692	0.8876
Annual rate (%) of convergence(-)/divergence(+)		
1975-2015	-0.17	-0.15
1975-1994	0.36	0.17
1995-2015	-0.66	-0.45

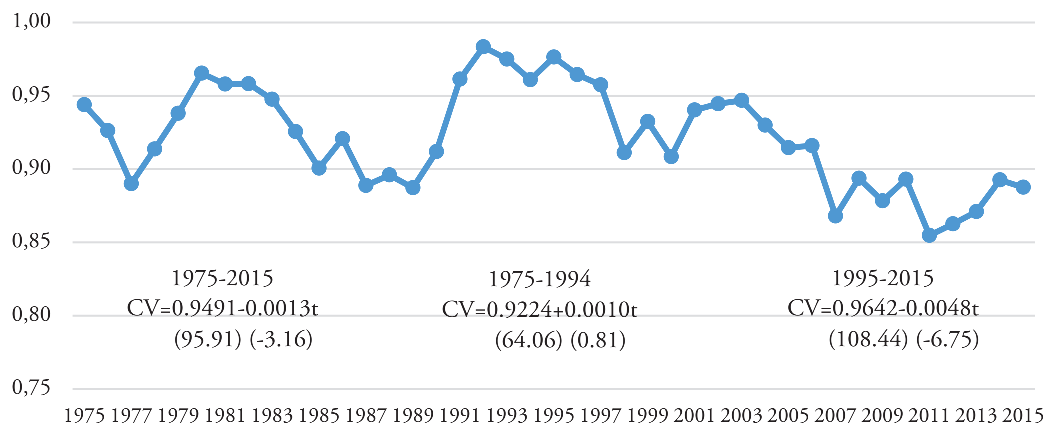
Source: Own elaboration.

FIGURE 1.
σ-convergence

a) %GDP



b) % Revenue



Source: Own elaboration.

governments; iii) the integration process in general. The outcome is almost certainly due to a combination of at least these three factors.

Club convergence

The results of the club convergence analysis are reported in Table 4 (initial, merged and transition). We analyze convergence for the 1975-2015 period and two sub-periods considering 1995 as a turning year based on the σ-convergence results. In all cases the *logt* test leads to rejection of the hypothesis of overall convergence at the 5% significance level: countries did not converge to the same steady state equilibrium in terms of local taxation.

For 1975-2015, two clubs are identified for %GDP and two plus a divergent country (Sweden) for %Revenue. Club 1 includes high local taxation countries. Meanwhile, Sweden presents an increasing share of local taxation, 36.4% in 2015, far from Denmark with 26.9%. In all the cases the convergence is relative, with high speed of convergence (0.628) in club 2 of low taxation. As stated above, this relative convergence implies that the differentials tend to decrease over time within each club, but countries are not converging to the same tax burden level. The clubs cannot be merged in this period.

In 1975-1994, with the %GDP approach, three clubs are formed, plus two divergent countries, and the merging process only move one of these countries (Greece) to a club. It should be noted the absolute convergence in club 1, formed by Sweden and Denmark, with the highest local taxation, and a speed of convergence of 1.016. This result implies that Sweden and Denmark are converging in levels of local taxation. The analysis of %Revenue also reveals two clubs –with relative convergence derived from low speeds of convergence- plus five divergent countries, reduced to three with the merging step.

In the period 1995-2015, in both cases the initial four clubs are merged into two, characterized by high and low local taxation, with two divergent countries which are then reduced to one, Sweden. The clubs are similar to the achieved for the overall period.

The average relative transition curve for each club is represented in Figure 2.

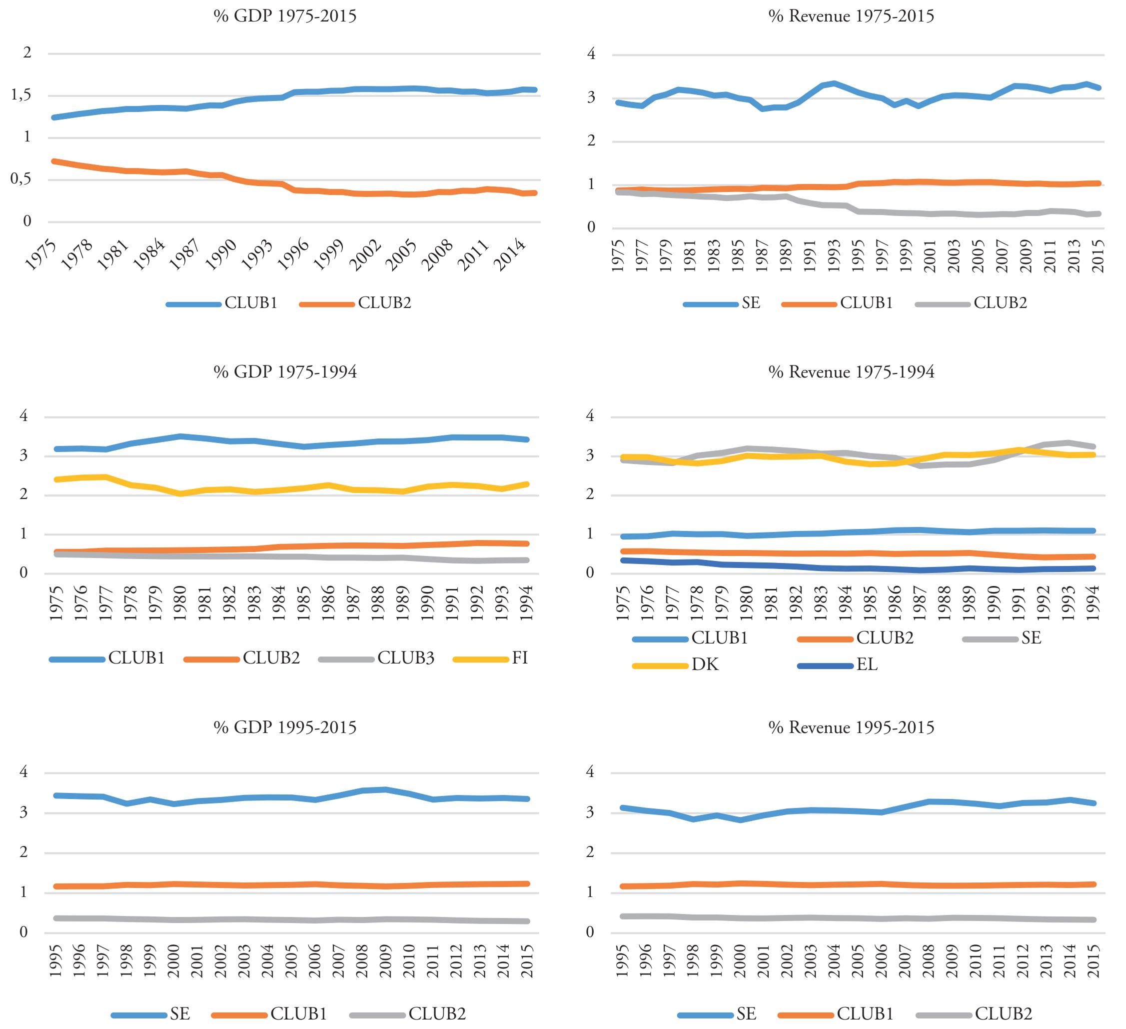
In addition, the clustering procedure allows us to study evidence of convergence between neighboring members of different clubs (Table 4, last columns). Following Phillips and Sul (2009), we performed this test by running the *logt* test including 50% of the lowest local taxation members (in terms of %GDP or %Revenue) in the upper club together with 50% of the highest local taxation members of the lower local taxation club. Except for %GDP in 1975-2015, in all cases the findings indicate strong evidence of transitioning across clusters (in particular, conditional convergence). These groups can be understood as being in a state of transition, with some countries showing a tendency towards a higher or lower club, joining the new club in the future.

TABLE 4.
Club convergence

Club	Countries-Initial	$t_{\hat{b}}$	$\hat{b}$	$\hat{\alpha}$	Club	Countries-Merged	$t_{\hat{b}}$	$\hat{b}$	$\hat{\alpha}$	Transition-between-clubs	$t_{\hat{b}}$	$\hat{b}$
1975-2015												
%GDP	Full sample	-4.521*	-0.381	-0.190	(Same)							
Club_1	SE-DK-FI-IT-FR-ES-PT-NL	2.739	0.119	0.058						Club 1_(FR-ES-PT-NL) + Club 2_(DE-BE-UK)	-6.397*	-0.775
Club_2	AT-BE-DE-IE-EL-LU-UK	1.235	0.288	0.144								
%Rev	Full sample	-5.524*	-0.490	-0.245								
Club_1	DK-FI-IT-FR-ES-DE-PT-BE-NL-IE	1.803	0.137	0.068						Club 1_(DE-PT-BE-NL-IE) + Club 2_(UK-EL)	1.728	0.410
Club_2	UK-EL-LU-AT	2.498	1.357	0.628								
Divergence	SE											
1975-1994												
%GDP	Full sample	-17.351*	-0.775	-0.387								
Club_1	SE-DK	1.779	2.033	1.016	Club_1	SE-DK	1.779	2.033	1.016	Club 1_(DK) + Club 2_(AT-FR)	-13.010*	-0.626
Club_2	AT-FR-ES-PT	2.213	0.173	0.086	Club_2	AT-FR-ES-PT	2.213	0.173	0.086			
Club_3	LU-BE-IT-DE-UK-NL-IE	0.889	0.211	0.105	Club_3	LU-BE-IT-DE-UK-NL-IE-EL	-0.188	-0.039	-0.019	Club 2_(ES-PT) + Club 3_(DE-LU-BE-IT)	1.764	0.756
Divergence	FI-EL				Divergence	FI						
%Rev	Full sample	-10.648*	-0.740	-0.370								
Club_1	AT-FR-ES-PT	3.604	0.386	0.193	Club_1	AT-FR-ES-PT-FI	0.138	0.005	0.002	Club 1_(ES-PT) + Club 2_(DE-LU-IT-BE)	0.627	0.250
Club_2	LU-IT-DE-BE-UK-IE	0.774	0.258	0.129	Club_2	LU-IT-DE-BE-UK-IE-NL	0.614	0.181	0.090			
Divergence	SE-DK-FI-NL-EL				Divergence	SE-DK-EL						
1995-2015												
%GDP	Full sample	-12.976*	-0.485	-0.242								
Club_1	DK-FI-IT-FR	3.390	0.368	0.184	Club_1	DK-FI-IT-FR-ES-DE-EL-PT	-0.957	-0.072	-0.036	Club 1_(ES-DE-PT-EL) + Club 2_(BE-UK-NL)	0.894	0.202
Club_2	ES-DE-EL	2.234	1.200	0.600	Club_2	NL-AT-LU-IE-BE-UK	-0.793	-0.158	-0.079			
Club_3	NL-AT-LU-IE	2.676	0.791	0.395	Divergence	SE						
Club_4	BE-UK	-0.931	-0.142	-0.071								
Divergence	SE-PT											
%Rev	Full sample	-18.742*	-0.539	-0.269								
Club_1	DK-FI-IT-FR	2.839	0.247	0.123	Club_1	DK-FI-IT-FR-ES-DE-EL-PT	-0.176	-0.014	-0.007	Club 1_(ES-DE-PT-EL) + Club 2_(BE-UK-NL)	0.111	0.019
Club_2	ES-DE-EL	2.177	1.024	0.512	Club_2	UK-BE-IE-NL-LU-AT	0.761	0.190	0.095			
Club_3	UK-BE-IE	0.544	0.213	0.106	Divergence	SE						
Club_4	NL-LU-AT	6.163	1.704	0.852								
Divergence	SE-PT											

Source: Own elaboration. * Indicates rejection of the null hypothesis of convergence at the 5% level. Note: Abbreviations: AT:Austria, BE:Belgium, DK:Denmark, DE:Germany, IE:Ireland, EL:Greece, ES:Spain, FR:France, IT:Italy, LU:Luxembourg, NL:Netherlands, PT:Portugal, FI:Finland, SE:Sweden, UK:United Kingdom.

FIGURE 2.
Average relative transition curves. Merged



Source: Own elaboration.

4. CONCLUDING REMARKS

We have studied convergence of local taxation as a percentage of GDP and total tax revenue in the EU-15 for the period 1975-2015. We find evidence of σ-convergence for the period as a whole, with an annual rate of convergence of 0.17% for local taxation as a percentage of GDP and 0.15% as a percentage of total revenue. However, we can distinguish two differentiated patterns: σ-divergence in 1975-1994, with annual rates of 0.36% and 0.17%, and σ-convergence in 1995-2015, with annual rates of 0.66% and 0.45%. Regarding club convergence, we find two clubs in 1975-2015, but the analysis of the two sub-periods reveals different results. After the merging procedure of the initial clubs, for local taxation as a percentage of GDP three and two clubs (plus divergent countries) are formed in each sub-period respectively. For local taxation as a percentage of total tax revenue, the results indicate two clubs with several divergent countries.

In terms of fiscal federalism and concretely fiscal decentralization, these results support the assumption of different views of the role of the public sector, and specifically the local level, in the economy. In addition, the data exhibit the resistance of the central (and regional) levels of government to move tax capacity to the local level, shifting the local taxes from 10.06% to 11.21% of total tax revenue between 1975 and 2015, and with two differentiated models of local taxation, based on taxes on income and profits (the Nordic case) or on property (UK, Ireland and Greece).

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Annex – Data

Table A.1.
Local taxation as %GDP and %Total Tax Revenue in EU 1975, 1995 and 2015

	%GDP			%Revenue		
	1975	1995	2015	1975	1995	2015
Austria	4.5	1.7	1.3	12.4	4.1	3.1
Belgium	1.7	2.0	2.2	4.4	4.8	4.8
Denmark	11.1	14.6	12.5	30.0	31.3	26.9
Finland	8.5	9.9	10.5	23.5	22.3	23.8
France	2.6	4.6	6.0	7.6	11.0	13.3
Germany	3.1	2.7	3.1	9.0	7.4	8.3
Greece	0.6	0.3	1.4	3.4	0.9	3.8
Ireland	2.0	0.8	0.6	7.3	2.7	2.4
Italy	0.2	2.1	7.0	0.9	5.4	16.2
Luxembourg	2.1	2.3	1.3	6.7	6.5	3.5
Netherlands	0.4	1.2	1.4	1.2	3.1	3.7
Portugal	0.0	1.6	2.5	0.0	5.4	7.3
Spain	0.8	2.7	3.3	4.3	8.5	9.8
Sweden	11.4	14.1	15.8	29.2	30.9	36.4
United Kingdom	3.8	1.1	1.6	11.1	3.7	4.9

Source: OECD.

Análisis de los sectores de Bioeconomía a través de matrices de contabilidad social específicas (BioSAMs): el caso de España

*Alfredo J. Mainar-Causapé**

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Resumen:

La economía de base biológica (Bioeconomía), será fundamental para alcanzar un desarrollo sostenible, siendo necesario analizar los vínculos entre los sectores de la bioeconomía y el resto de actividades y determinar su impacto en el crecimiento económico. Una interesante herramienta para este análisis son las BioSAMs, matrices de contabilidad social con gran desagregación de sectores bio-económicos, estimadas para los 28 Estados miembros de la Unión Europea (UE). Con ellas se ha realizado un análisis de tipo lineal para cuantificar la capacidad de estos sectores para contribuir al impulso del desarrollo económico, tanto en España, como en comparación con la UE.

Palabras Clave: Bioeconomía; Matrices de Contabilidad Social; Economía Española; Unión Europea; Modelos multisectoriales.

Clasificación JEL: D57; C67; Q10; Q20.

Analysis of the Bioeconomy sectors using specific Social Accounting Matrices (BioSAMs): the case of Spain

Abstract:

The biobased economy (Bioeconomy) will be key to achieve sustainable development, and it is essential to analyse the links between the sectors of the bioeconomy and the rest of activities, determining their impact on economic growth. An interesting tool for this analysis is the BioSAMs dataset, social accounting matrices with high disaggregation of bio-economic sectors, for the European Union (EU) 28 Member States. Using these matrices, a linear analysis has been carried out to quantify the capacity of bio-based sectors to contribute to the promotion of economic development, both in Spain and in comparison with the EU.

Keywords: Bioeconomy; Social Accounting Matrices; Spanish Economy; European Union; Multisectoral models.

JEL classification: D57; C67; Q10; Q20.

Nota: Las opiniones expresadas son exclusivamente las del autor y no pueden en ningún caso ser consideradas como una postura oficial de la Comisión Europea.

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1. Introducción

La bioeconomía comprende varios sectores económicos, disciplinas académicas y áreas de política. Incluye la producción de recursos biológicos renovables y la transformación de estos recursos y flujos de residuos en productos con valor añadido, tales como alimentos, piensos, productos biológicos y bioenergía. De esta forma, en la bioeconomía se agrupan diferentes sectores de la economía que producen, procesan y reutilizan los recursos biológicos renovables (agricultura, silvicultura, pesca, alimentos, productos químicos y materiales de base biológica y bioenergía). Además, la relación entre la bioeconomía y el principio del flujo económico circular es clara, por cuanto ésta se define por un sistema de producción orientado hacia la transformación de los recursos biológicos renovables y de los flujos de residuos en valor añadido: alimentos, piensos, aplicaciones industriales y energéticas, etc. Por lo tanto, resulta necesario analizar los posibles impactos de las políticas sectoriales, a escala nacional y/o regional, así como políticas intersectoriales relacionadas (medio ambiente, cambio climático, economía circular, residuos, políticas industriales y regionales, innovación, etc.), políticas esenciales para tratar los nuevos retos sociales como la creciente demanda de alimentos o el cambio climático[1]. De ahí el creciente interés por el análisis de la bioeconomía, tanto a nivel político en las instituciones (por ejemplo en la Unión Europea,UE, ver Comisión Europea, 2012 y 2014), como en el ámbito académico (McCormick y Kautto, 2013; Fritsche e Iriarte, 2014; M'barek et al., 2014; Philippidis et al., 2014; Fuentes-Saguar et al., 2017; Ferreira et al., 2018; entre otros). En cualquier caso, entre los estudios empíricos existentes no hay un análisis específico de los bio-sectores en la economía española, estando los realizados hasta le fecha comprendidos en análisis más amplios a nivel europeo (Fuentes-Saguar et al., 2017; Philippidis y Sanjuán, 2018). Esta nota metodológica pretende dar un primer análisis de la bioeconomía en España desde una perspectiva multisectorial, poniéndola en comparación con el resto de la UE.

2. Metodología. BioSAMs y análisis de multiplicadores

Una cuestión fundamental en el análisis de la Bioeconomía es la disponibilidad de bases de datos adecuadas. Los primeros intentos en este sentido, se encuentran en las llamadas "AgroSAMS", matrices de contabilidad social (SAMs)[2] con especial desagregación del sector primario, para los años 2000 y 2007 (Müller et al., 2009; Philippidis et al., 2014; respectivamente). Sin embargo, sólo recientemente, con la estimación de las BioSAMs (Mainar y Philippidis, 2018), se dispone de una completa desagregación de los sectores de bioeconomía, recogiendo no sólo las actividades agrícolas y primarias, sino también las de bioindustria y bioenergía, integrando la información económica de estos sectores en el flujo circular de la renta[3].

La elaboración de las BioSAMs (Mainar y Philippidis, 2018) se basa en la elaboración de sendas SAMs estándar previas, distinguiendo las actividades y productos según la clasificación de actividades y productos en Eurostat NACE2 Rev. 2 (Nomenclature statistique des Activités économiques dans la

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[1] Existe en la literatura un claro consenso sobre la relación entre la Bioeconomía y la calidad medioambiental. Buenos ejemplos son McCormick y Kautto (2013), De Besi y McCormick, (2015), Philippidis et al. (2015), Ramcilovik-Suominen y Pülzl (2016), o Haddad et al. (2019), entre otros.

[2] Una Matriz de Contabilidad Social (más conocida por su acrónimo inglés, SAM - *Social Accounting Matrix*-) es una base de datos que recoge y organiza los datos económicos y sociales para todas las transacciones entre agentes económicos en una economía en un momento dado. Cada celda *i,j* describe simultáneamente un gasto de la cuenta representada en la columna j y un ingreso en la cuenta representada en la fila i, siendo los totales de filas y columnas iguales por el principio de la contabilidad de doble entrada. Una SAM integra las estadísticas sociales en el tradicional modelo Input-output, recogiendo la interdependencia de los sectores productivos y sus relaciones con las instituciones y la demanda final, así como los flujos de renta entre los factores de producción y dichas instituciones responsables de la demanda final, completando así el flujo circular de la renta representado en forma matricial (ver Stone, 1955, o Pyatt y Round, 1979, entre otros).

[3] Las BioSAMs de los 28 Estados Miembros de la Unión Europea pueden consultarse y descargarse libremente en https://datam.jrc.ec.europa.eu.

Communauté Européenne rev. 2)[4] y la CPA (Clasificación de Productos por Actividad), respectivamente (Eurostat, 2008). Posteriormente, se desagregan las ramas de agricultura, sector primario e industrias de la alimentación, así como de los sectores de la bioenergía y las bioindustrias. La división de los productos agrícolas primarios y las industrias de la alimentación se llevó a cabo utilizando como fuente principal la base de datos del modelo CAPRI (Common Agricultural Policy Regionalised Impacts) (Britz y Witzke, 2014), en combinación con las Cuentas Económicas de la Agricultura (Economic Agriculture Accounts, EAA) de Eurostat (Eurostat, 2016a). La base para la desagregación de sectores de biomasa, bioenergía y bioindustria se obtiene a partir de la base de datos del modelo MAGNET[5], para las relaciones interindustriales, y de las bases de datos disponibles en la Comisión Europea (Joint Research Centre, 2017) y Eurostat sobre empleo y volumen de negocios[6]. El resultado final es un conjunto de 29 BioSAMs para 2010 (una por estado miembro de la UE y una para el agregado UE28), que incluye cuentas para 80 actividades y productos. Hay 21 cuentas para actividades de cultivo, 6 de ganadería, 14 para la transformación de alimentos, 5 para la bioenergía (que recogen los biocombustibles, de primera y de segunda generación, y bioelectricidad), 3 cuentas de suministro de biomasa (silvicultura, cultivos energéticos y «pellets»), otras 3 cuentas de sectores bio-industriales (textil, madera y bioquímica) y una cuenta para la pesca. Las restantes 27 cuentas cubren sectores como los combustibles fósiles (2), construcción, resto de la industria (13) y los servicios (11). Además, las BioSAMs contienen dos factores de producción (capital y trabajo), una cuenta de márgenes (comercio y transporte) y tres cuentas fiscales (impuestos y subvenciones sobre la producción y el consumo y los impuestos directos). Por último, hay una sola cuenta respectivamente para hogares, empresas o corporaciones empresariales, administración pública, ahorro-inversión y resto del mundo. El Cuadro 1 muestra la desagregación de las cuentas de bioeconomía y la agregación de ramas de las BioSAMs utilizada en los posteriores análisis.

Una forma de sencilla de aplicar las BioSAMs en un primer análisis de la Bioeconomía es obtener los correspondientes multiplicadores de producción y empleo. Aunque se aplican técnicas ya bien conocidas en el análisis Input-output, como son los multiplicadores contables (Pyatt y Round, 1979), la ventaja de disponer de matrices de contabilidad social en lugar de las tradicionales tablas Input-output es que se tiene en cuenta ahora el flujo circular de la renta al completo, lo que confiere a los resultados una significatividad superior.

El punto de partida para el análisis es la siguiente ecuación de equilibrio:

$$\mathbf{x} = \mathbf{A}\,\mathbf{x} + \mathbf{y} \Leftrightarrow \mathbf{x} = (\mathbf{I}\text{-}\mathbf{A})^{-1}\mathbf{y} = \mathbf{M}\,\mathbf{y} \qquad (1)$$

donde $\mathbf{x}$ es el vector de la producción bruta total de las cuentas endógenas, siendo $\mathbf{y}$ el vector de valores de las variables exógenas (en esta aplicación se consideran exógenas las cuentas de Sector Publico, Ahorro-Inversión y Resto del Mundo) respecto a las cuentas endógenas. $\mathbf{A}$ es la habitual matriz de coeficientes técnicos (sus elementos a_{ij} muestran la participación del sector i en cada unidad producida por el sector j). La suma por columnas de los elementos de $\mathbf{M}$ da como resultado los multiplicadores de la producción, que muestran el aumento de la producción en la economía generado por un *shock* exógeno en valores (por

[4] Nomenclatura estadística de actividades económicas de la Comunidad Europea, versión revisada 2.

[5] MAGNET (Modular Applied GeNeral Equilibrium Tool) es un modelo de equilibrio general global neoclásico avanzado. MAGNET se ha utilizado para simular los impactos de las políticas agrícolas, comerciales y de biocombustibles, así como temas de gran alcance como el uso de la tierra, la nutrición, la distribución del ingreso, en los países en desarrollo y la seguridad alimentaria. El consorcio MAGNET, liderado por Wageningen Economic Research (WEcR), incluye el Centro Común de Investigación de la Comisión Europea (Joint Research Centre, JRC).

[6] El uso de estas bases de datos complementarias (aunque fundamentales) para la desagregación de los sectores de bioeconomía, implica la conciliación de las diferentes nomenclaturas de sectores y productos que estas utilizan. Para ello se ha utilizado una transformación auxiliar de los sectores a la clasificación GTAP -*Global Trade Analysis Project*- (Aguiar et al., 2016).y se han seguido las correspondencias existentes entre ésta y MAGNET y CAPRI. No obstante, aunque dichas correspondencias están, en general, bien delimitadas, en los casos de ambigüedad o solapamiento se ha seguido el criterio de seguir la asignación a la cuenta de mayor relevancia, lo que puede implicar algunas discrepancias que, en cualquier caso, no resultan cuantitativamente relevantes.

Cuadro 1.
Descripción de los Sectores de Bioeconomía

Grandes sectores	Sectores agregados	Descripción (sectores incluidos en las BioSAMs)
Sector primario	Cereales	Arroz, trigo, cebada, maíz, otros cereales
	Vegetales	Tomates, patatas, otras hortalizas
	Frutas	Otros frutos, uvas, frutas
	Semillas oleaginosas	Colza, girasol, soja y semillas
	Plantas oleaginosas	Aceitunas, otras plantas oleaginosas
	Cultivos industriales	Remolacha azucarera, plantas textiles, tabaco
	Otros cultivos	Plantas vivas, otros cultivos
	Ganadería extensiva	Bovinos vivos; ovinos, caprinos, caballos, asnos, mulos...
	Ganadería intensiva	Animales vivos de la especie porcina, aves de corral
	Otra ganadería	Otros animales vivos y productos de origen animal
	Leche cruda	Leche cruda
	Pesca	Pesca
Industria agroalimentaria	Alimentación animal	Piensos, forraje subproducto tortas (subproducto de biodiesel)
	Carnes rojas	Carne de vacuno; carne de especies ovina y caprina
	Carnes blancas	Carne de animales de la especie porcina, aves de corral
	Aceites vegetales	Aceites vegetales
	Productos lácteos	Productos lácteos
	Arroz	Arroz
	Azúcar	Azúcar transformado
	Aceites vegetales	Aceites vegetales
	Vino	Vino
	Aceites vegetales	Aceites vegetales
	Otros prod.aliment.	Otros productos alimenticios
Biomasa	Cultivos energéticos	Cultivos energéticos
	Pellets	Pellets
	Silvicultura	Silvicultura, explotación forestal y actividades de los servicios relacionados con las mismas
Bioenergía	Bioelectricidad	Bioelectricidad
	Biofuel1	Biocarburantes de 1ª generación (bioetanol, biodiésel)
	Biofuel2	Biocarburantes de 2ª generación térmica y tecnología bioquímica (biocarburantes)
Bioindustrias	Madera	Productos de la madera
	Textiles	Productos textiles, prendas de vestir y artículos de cuero y calzado
	Bio-químicos	Productos bio-químicos
Actividades no bio-económicas	Recursos naturales	Extracción de carbón, petróleo y minerales en bruto
	Energía	Electricidad y gas
	Manufacturas	Productos manufacturados (10 sectores desagregados), construcción y agua
	Servicios	Servicios (11 sectores desagregados)

Fuente: Elaboración propia, adaptado de Mainar et al. (2017).

ejemplo, exportaciones) para un producto determinado. Los multiplicadores de empleo se obtienen usando un vector **e** con la ratio del número de puestos de trabajo por millón de euros de valor de la producción (estimado aquí a partir de los datos de empleo de la *Labour Force Survey* -Eurostat, 2016b-, y datos procedentes de las cuentas económicas de la agricultura -Eurostat, 2016a-. En los sectores no agrícolas se utilizan las estimaciones del Joint Research Centre (2017). Multiplicando este vector (en forma de matriz diagonal, **E**) por **M**, se obtiene la matriz de multiplicadores de empleo, **Me**

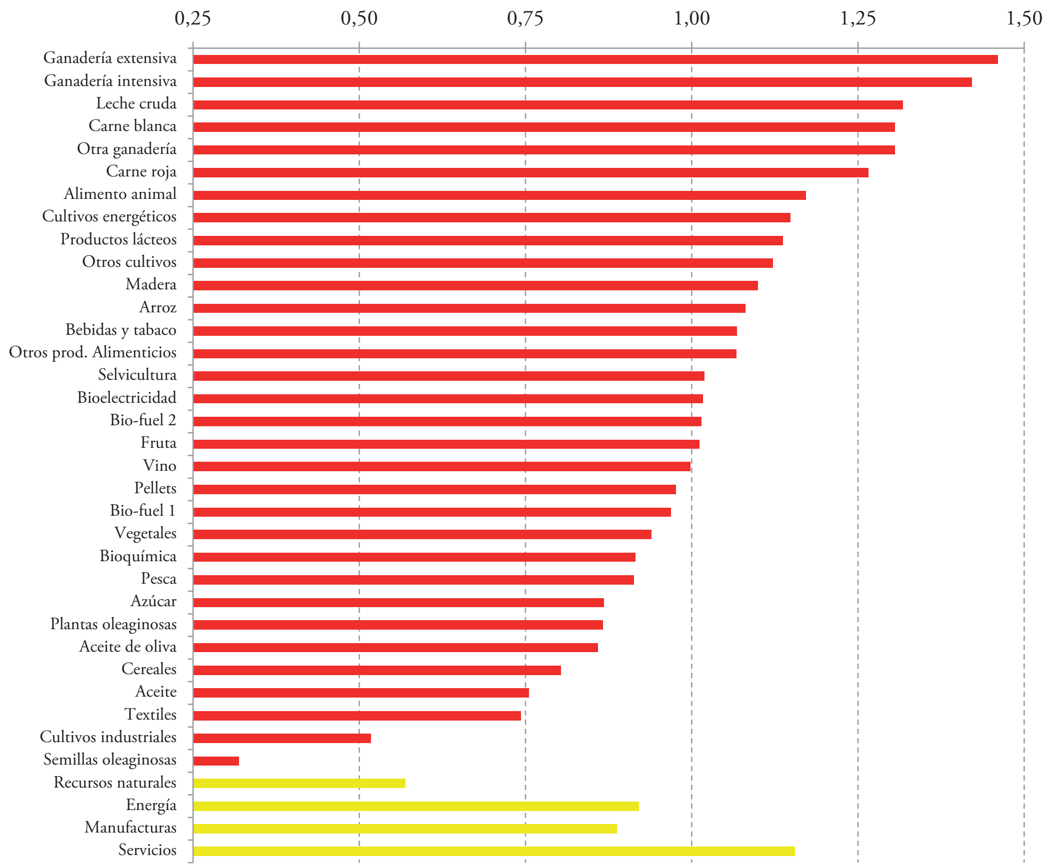
$$\mathbf{Me} = \mathbf{E\ M} \tag{2}$$

Cada elemento de Me es el incremento en el número de empleos de la cuenta i cuando la cuenta j recibe una inyección exógena unitaria (millones de euros en este caso).

3. Resultados: los sectores de bioeconomía en España y en la Unión Europea

Se muestra a continuación un primer análisis de la bioeconomía en España, comparando sus principales valores con los correspondientes a los del resto de países miembros de la Unión Europea, obteniendo para ello los multiplicadores de producción y empleo descritos previamente.

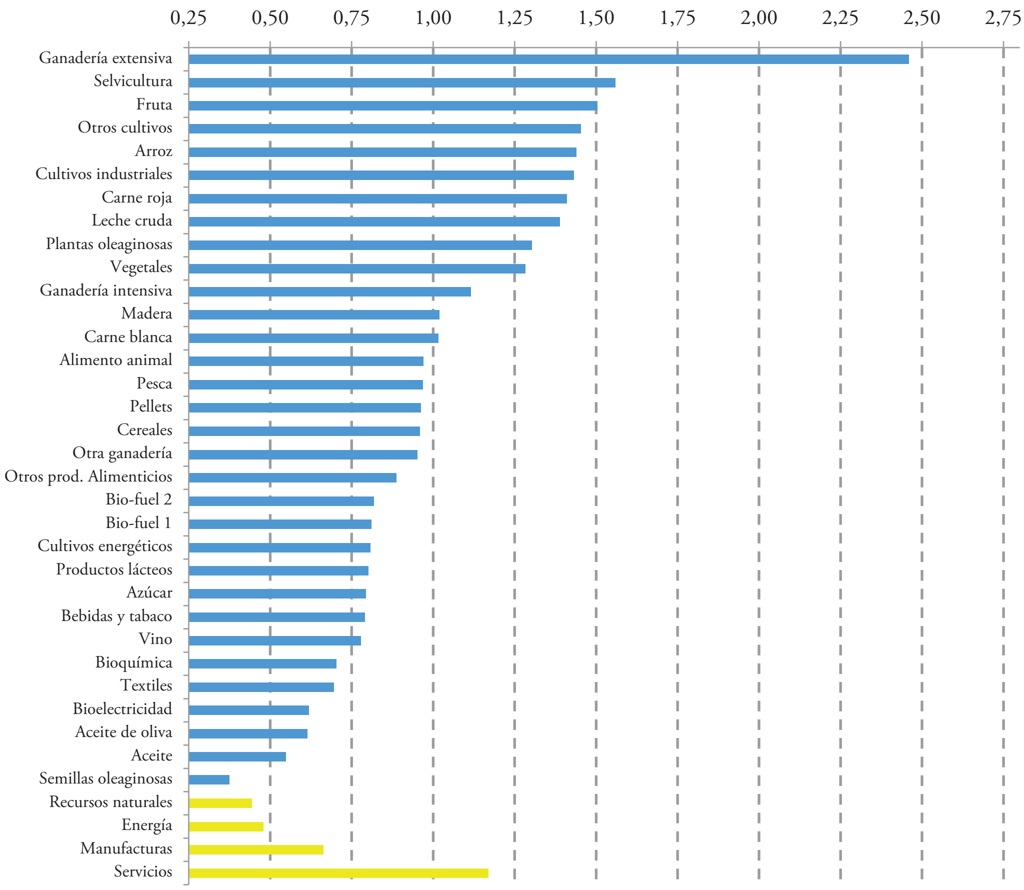
Gráfico 1.
Backward linkage del output (valor de su multiplicador respecto a la media) de los sectores de la Bioeconomía. España, 2010



Fuente: Elaboración propia.

Comenzando por el análisis en España, los Gráficos 1 y 2 resumen los principales resultados desagregados para la economía española. Así, los multiplicadores de la producción muestran que las actividades que se consideran más innovadoras y con mayor valor añadido todavía no son capaces de producir mayor riqueza que la media, siendo todavía la agricultura y la ganadería sectores importantes para el proceso de creación de riqueza. En España, en general, como se observa en el Gráfico 1, los sectores económicos de base biológica con mayores valores de su multiplicador del output están vinculados a la ganadería y a la explotación de productos relacionados: *Ganadería* (propiamente dicha), *leche*, *productos lácteos*, *carne* y *alimentación animal*. Los *cultivos energéticos*, la *madera* y *selvicultura* aparecen con valores inferiores pero todavía superiores a la media, mientras que entre los cultivos de alimentación únicamente el *arroz* y la *fruta* superan el multiplicador promedio. *Bioelectricidad* y *bio-fuel 2* se encuentran también entre los sectores que superan la media, pero no de forma significativa. En cualquier caso, y como puede comprobarse también en la Tabla 1, se observa la mayor capacidad de incrementar el output que tienen en España las actividades primarias y de industria agroalimentaria.

GRÁFICO 2.
Backward linkage del empleo (valor de su multiplicador respecto a la media) de los sectores de la Bioeconomía. España, 2010



Fuente: Elaboración propia.

Sin embargo, al hablar de los multiplicadores de empleo, la ordenación de los sectores cambia de forma significativa, si bien la *ganadería* (extensiva) se mantiene como el sector con mayor valor de dicho multiplicador, casi 2.5 veces el valor medio. Los otros productos que mantienen su posición en el ranking son *carne* (roja) y, en menor medida, *leche*. No obstante, sectores como *azúcar*, *bio-fuel 1*, *aceite*, *textiles* o *bioquímica*, mantienen unos valores relativos claramente más bajos, al igual que en el caso del multiplicador del output. Además, tan sólo el *Sector primario* (y ahora también *Biomasa*) mantiene unos valores del multiplicador claramente superiores a la media, siendo relativamente inferior ahora la capacidad creadora de empleo de la *Industria agroalimentaria* (Tabla 1).

Estas diferencias entre los multiplicadores de output y empleo, se basan en las diferentes intensidades de uso del factor trabajo. Los productos agrícolas y otros sectores primarios, con mayor intensidad de mano de obra, generarán más empleo que la media. Por otra parte, y como es normal en este tipo de análisis estático, a corto plazo los sectores industriales más intensivos en capital generan relativamente menos puestos de trabajo. Así, en general, muchos sectores agrarios (*cereales*, *ganadería extensiva*, *vegetales*, etc.) presentan ratios empleo/output elevados, mientras que en la industria agroalimentaria y algunos sectores primarios específicos (*ganadería intensiva*, *azúcar*, *leche*, etc.) las ratios son mucho menores e incluso inferiores a la de sectores no bioeconómicos. Esto hace que la importancia relativa de los sectores cambie sustancialmente al considerar multiplicadores del output o del empleo.

Para la comparación entre la bioeconomía en España y en el conjunto de la Unión Europea, se han considerado los grandes sectores agregados. La Tabla 1 presenta la comparación de los grandes sectores (ver Cuadro 1) de bioeconomía en España con los del resto de la Unión Europea y con dos subconjuntos de la misma de interés especial para la comparación: los países de la UE del Este de Europa y aquellos que son relativamente especializados en el sector agrario y la industria agroalimentaria[7].

Tabla 1.
Multiplicadores del output y del empleo de los grandes sectores de la Bioeconomía. España y países de la Unión Europea, 2010

	Multiplicadores del output			
	España	**UE (Sin España)**	**UE Países del Este**	**UE Especializados (agri+alim)**
Sector Primario	2.43	2.07	2.08	2.12
Ind. Agroalimentaria	2.43	1.87	1.91	1.99
Biomasa	2.24	2.15	2.41	2.39
Bioenergía	2.16	1.82	1.92	1.98
Bioindustria	1.88	1.66	1.68	1.56
Bioeconomía	2.33	1.87	1.93	1.95
No Bioeconomía	2.38	2.06	2.08	2.06

	Multiplicadores de empleo (empleos x millón de euro)			
	España	**UE (Sin España)**	**UE Países del Este**	**UE Especializados (agri+alim)**
Sector Primario	25.49	26.61	57.51	30.70
Ind. Agroalimentaria	17.38	17.07	40.77	20.00
Biomasa	29.81	24.11	47.77	35.24
Bioenergía	14.79	12.46	27.11	15.83
Bioindustria	14.71	14.50	32.88	18.02
Bioeconomía	18.66	18.56	43.80	22.53
No Bioeconomía	19.68	18.13	37.11	20.08

Fuente: Elaboración propia.

[7] Se han considerado aquellos países miembros de la UE cuyo porcentaje de producción de las ramas Sector Primario + Industria Agroalimentaria sobre el total supera la media comunitaria en 2010 (5,6%): Bulgaria, Chipre, Croacia, Dinamarca, España, Estonia, Francia, Grecia, Holanda, Hungría, Irlanda, Letonia, Lituania, Polonia, Portugal y Rumanía.

Los resultados muestran que el conjunto de sectores de bioeconomía en España presenta un multiplicador del output claramente superior al del resto de la Unión Europea (2.33 frente al 1.87), diferencia más acusada en el caso de los sectores de *sector primario* (2.43 – 2.07) y, muy especialmente, de la *industria agroalimentaria* (2.43 – 1.87). La diferencia es también significativa en cuanto a la *Bioenergía* (2.16 frente a 1.82), y menos relevante en *Biomasa* (2.24-2.15) y *Bioindustrias* (1.88-1.66). Este resultado podría achacarse al mayor peso relativo que los sectores agroalimentarios tienen en España frente al resto de la UE, pero al realizar la comparación con los aquellos países con especialización superior a la media en estos sectores, se mantiene, (aunque con menores diferencias) esta superioridad (con la excepción de *Biomasa*). Las razones para estos resultados pueden estar en la coexistencia en España de un sector primario modernizado y bien ligado con una industria agroalimentaria en expansión, junto con las relaciones con el resto sectores de base biológica, bien como producción secundaria o como inputs.

Sin embargo, en los multiplicadores de empleo se observan prácticamente los mismos valores del multiplicador de la bioeconomía, tanto para España, como para el resto de la UE (18.66 y 18.56, respectivamente), siendo incluso superior el del resto de la UE en el sector primario, aunque el de la economía española es claramente más alto para *Biomasa*. Si, debido a la preponderancia del sector primario y la industria agroalimentaria dentro de la producción de la bioeconomía, se considera el conjunto de países especializados en los mismos, los resultados en términos de multiplicadores de empleo para estos países son superiores en todos los casos a los presentados por la bioeconomía española, si bien se da el suceso contrario en los multiplicadores de output. Esto parece indicar que tanto el conjunto de la UE, como los países especializados en el sector agrario y agroalimentario, requieren de una mayor ratio de empleo por output, lo cual es lógico considerando la inclusión en ambos agregados de países del Este recientemente asociados, que presentan grandes necesidades de factor trabajo para su producción primaria (ver Fuentes-Saguar et al, 2017). Así, como se observa en la Tabla 1, los multiplicadores para los países del Este son significativamente más altos debido a su mayor intensidad en el factor trabajo (sobre todo en los sectores primarios).

4. Conclusiones

La bioeconomía será esencial para lograr un desarrollo económico sostenible, siendo necesario analizar los actuales vínculos económicos entre los sectores de la bioeconomía y el resto de la economía. A través del uso de la nueva base de datos de BioSAMs para la UE y sus Estados miembros, se ha hecho un primer análisis de los principales impactos y la relevancia de estos sectores en el desarrollo de la economía española, poniéndolos en comparación con los valores del conjunto de la Unión Europea. Los resultados muestran que los sectores de bioeconomía en España todavía no han alcanzado su desarrollo potencial en la generación de producción y empleo, si bien presentan una capacidad superior al resto de la Unión Europea. Esta capacidad para generar output y empleo, unida a sus características favorables al sostenimiento del medioambiente, debe ser tenida en cuenta a la hora de plantear diferentes políticas relacionadas con la bioeconomía que permitan explotar sus posibilidades de desarrollo. Herramientas como las BioSAMs permiten la aplicación de numerosas técnicas de análisis que contribuyan a este análisis y a la evaluación de potenciales políticas. En este sentido, se plantean como futuras líneas de trabajo la actualización temporal de las mismas, la ampliación de la desagregación a sectores de especial interés (selvicultura, por ejemplo) y la extensión del análisis a aspectos tales como repercusiones medioambientales y sostenibilidad.

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Books reviews

Geografía de Europa. Estructuras, Procesos y Dinámicas Territoriales

López Palomeque, F. & Plaza Gutiérrez, J.I. (Eds. y Coords.) (2019).
Valencia: Tirant Humanidades y Publicacions Universitat de València.
589 pp. ISBN: 978-84-17508-33-3. Incluye e-book.

En España, la publicación de manuales universitarios en el campo de la Geografía atravesó una etapa de crisis durante la primera década del siglo XXI. El escaso número de estudiantes de la disciplina en nuestro país y la consolidación de los criterios de evaluación de la investigación, que primaban los artículos sobre los libros, en particular los orientados a la docencia, confluyeron para reducir el número anual de novedades. Afortunadamente, la entrada en vigor del Espacio Europeo de Educación Superior a partir de 2010, que incide más en la labor autónoma de aprendizaje de los estudiantes, y el reconocimiento que de las publicaciones docentes hacen los nuevos criterios de acreditación publicados en 2015, explican la revitalización reciente de este tipo de obras, tan mal tratadas en España como prestigiadas en otros contextos académicos y universitarios.

El caso que nos ocupa aquí, el manual titulado *«Geografía de Europa. Estructuras, Procesos y Dinámicas Territoriales»* (2019), es una buena prueba de este proceso. Tiene su antecedente en una primera edición del año 2000, publicada por Ariel y coordinada también por el profesor López Palomeque (Universidad de Barcelona), a quien se añade ahora el profesor Plaza Gutiérrez (Universidad de Salamanca). Estamos, pues, ante una edición totalmente nueva de la obra de referencia en lengua española sobre esta materia, que ha requerido la ampliación de la nómina de autores desde los seis de la primera entrega hasta los catorce de la segunda, todos ellos colegas de probada solvencia. La editorial Tirant, en su colección de Humanidades, junto con Publicaciones de la Universidad de Valencia, han apoyado un trabajo que se suma a otros manuales (*«Geografía de Humana de España»* y *«Geografía Regional de España»*, ambos aparecidos en 2017) para perfilar una colección de textos imprescindible para la enseñanza universitaria de la Geografía y, por qué no, de otras ciencias humanas y sociales. Esperemos que se consolide esta línea editorial con nuevas aportaciones en un futuro cercano.

De momento, la oportunidad y pertinencia de una segunda edición de esta *«Geografía de Europa»* está fuera de toda duda. Las dificultades objetivas que atraviesa ese gran proyecto colectivo que es Europa, más allá de su materialidad territorial, son objeto de debate cotidiano dentro y fuera del mundo universitario: el Brexit, la difusión de los populismos de todo signo político, la nunca cerrada cuestión de la ampliación de la Unión Europea (ahora centrada en la región balcánica), la redefinición de las fronteras políticas mediante el uso de la fuerza militar (Crimea, Ucrania oriental), la gestión y asimilación de la inmigración, el papel del continente en la escena geopolítica y económica mundial o su liderazgo en el complejísimo proceso de transición ecológica -civilizatoria, me atrevo a decir- son otros tantos motivos para escribir y leer un libro que pone de relieve las bases territoriales de estos y otros procesos de incumbencia general debido a su influencia directa sobre el presente y el futuro de todos los habitantes del continente.

Es necesario, por cierto, subrayar el término *continente* porque no se trata, como podría pensarse apresuradamente, de un estudio geográfico de la Unión Europea, sino de una auténtica geografía del continente europeo, con sus 49 estados, incluyendo las partes europeas de Rusia y Turquía.

El esquema de la obra es clásico en apariencia. Consta de ocho capítulos: *Europa, aproximación geográfica; Estructura física y paisajes naturales; La población europea: dinámicas y problemas actuales; Las transformaciones de los sistemas y de los espacios urbanos europeos; Espacios rurales: cambios y permanencias; Cambios geoeconómicos: hacia una economía terciarizada y postindustrial; Retos ambientales; y La Europa política: realidades y retos de futuro.*

Es decir, la obra reúne los requisitos exigibles a un manual de Geografía regional. Justifica la delimitación del objeto de estudio (capítulo 1) y parte de la descripción del medio físico (capítulo 2) para tratar después el factor humano (capítulo 3), los tipos de espacios (urbano-capítulo 4 y rural-capítulo 5) y las formas de coordinación colectiva que aseguran la supervivencia material (economía-capítulo 6) y la convivencia social (política-capítulo 8, con especial atención a la Unión Europea como actor determinante). El capítulo 7 es más novedoso dentro de los enfoques regionales y encaja perfectamente con la inquietud sobre las perniciosas implicaciones del modelo de desarrollo urbano-industrial sobre la naturaleza que lo sustenta.

Ahora bien, dentro de ese clasicismo, que es también una manera eficaz de construir una obra destinada a estudiantes de Grado, sobre todo, se pueden encontrar apartados específicos dedicados a conceptos y procesos que han cobrado una notable relevancia desde la aparición de la primera edición: el debate sobre el Antropoceno (página 121), los servicios ecosistémicos de los paisajes naturales (página 121ss), las migraciones y sus impactos (página 174ss), la ciudad neoliberal, la gobernanza, los megaproyectos y la gentrificación (página 249ss), la PAC y el desarrollo rural (página 324ss), la financiarización (página 363ss), las aerolíneas de bajo coste (página 428ss), el metabolismo y la huella ecológica (página 445ss), o la revitalización -desafortunada- de los conflictos políticos en Europa (páginas 563ss).

Todos los capítulos vienen acompañados de tablas estadísticas, figuras, mapas y fotografías, concentrados algunos de ellos en un cuadernillo central en color. Se aportan además recuadros específicos que desgranan estudios de caso que ilustran los contenidos generales discutidos en el texto. A ese material se suma una más que notable relación de recursos adicionales, sean atlas, enciclopedias, direcciones electrónicas y recomendaciones anotadas de lectura. En el capítulo cinco se invita a la consulta de documentación complementaria alojada en un servidor digital, un recurso cada vez más frecuente en la edición académica.

Todo este amplísimo material adicional es imprescindible en una obra de esta naturaleza, máxime cuando hablamos de Geografía. Por ello, es cuestionable la calidad de muchas de las ilustraciones que contiene la obra. Los condicionantes de coste de edición y de tamaño físico del volumen afectan a la resolución de las imágenes, sobre todo en la edición de papel. La edición electrónica corrige parcialmente estas deficiencias, lo que lleva a pensar que el recurso a un repositorio digital de imágenes de apoyo debería utilizarse de forma general en el texto y no sólo en algunos capítulos. La cartografía, el lenguaje geográfico por excelencia, se resiente en su expresividad por estas limitaciones. También se observa un empleo excesivo de mapas de escala nacional que enmascaran la diversidad -o disparidad- de los datos regionales que ofrecen EUROSTAT y GISCO. Es, de nuevo, un problema derivado de las dimensiones de un libro que no es un atlas, y que impide mostrar, o percibir, los contornos de los fenómenos representados. También se deberían armonizar los estilos de cita de la abundante bibliografía que citan los ocho capítulos; incluso podría haberse considerado la conveniencia de una única relación bibliográfica final, para evitar redundancias y facilitar la consulta a los lectores.

Estos detalles técnicos no desmerecen, por supuesto, las virtudes y fortalezas académicas de esta *Geografía de Europa* que aúna contenidos fundamentales con perspectivas de máxima actualidad. Sólo me cabe una duda de fondo: ¿habría sido más atractiva una organización interna del texto basada en problemas, procesos y desafíos, y no en los grandes apartados o divisiones canónicas de la Geografía?

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