Spatial productivity spillovers across Spanish municipalities

Martin-Barroso, David and Nuñez Serrano, Juan Andres and Velazquez, Francisco J.

Universidad Complutense de Madrid, Universidad Autonoma de Madrid, GRIPICO

2010

MICRO-DYN Working Paper no. 21/10

Spacial productivity spillovers across Spanish municipalities

by

David Martín-Barroso, Juan Andrés Núñez-Serrano, Francisco J. Velásquez-Angona

This paper was produced in the framework of MICRO-DYN (www.micro-dyn.eu), an international research project funded by the EU Sixth Framework Programme (www.cordis.lu) with socio-economic sciences and humanities (http://ec.europa.eu/research/social-sciences/index_en.html). This publication reflects only the author's views, the European Community is not liable for any use that may be made of the information contained therein.

Spatial productivity spillovers across Spanish municipalities☆

David Martín-Barroso*,[a], Juan Andrés Núñez-Serrano[a], Francisco J. Velázquez-Angona[a]

[a] *Departamento de Economía Aplicada II, Universidad Complutense de Madrid, Facultad de Ciencias Económicas y Empresariales, Campus de Somosaguas s/n, 28223 Pozuelo de Alarcón, Madrid, Spain. Tel. +34 913 942 635. Fax +34 913 942 457*

Abstract

Whilst a great deal of effort has been dedicated to identification of agglomeration effects on labour productivity, the measurement of spatial productivity spillovers is a question that has been addressed only occasionally along the New Economic Geography literature. We estimate agglomeration effects, nonetheless conditioned to the possible existence of spatial productivity spillovers across Spanish municipalities in year 2001. To this respect, we find that agglomeration effects are in the same order of magnitude than those

☆This paper was produced in the framework of MICRO-DYN (www.micro-dyn.eu), an international research project funded by the EU Sixth Framework Programme (www.cordis.lu) with socio-economic sciences and humanities (http://ec.europa.eu/research/social-sciences/index_en.html). This publication reflects only the author's views, the European Community is not liable for any use that may be made of the information contained therein.

*Corresponding author.

Email addresses: `dmartin@ccee.ucm.es` (David Martín-Barroso), `janunezs@ccee.ucm.es` (Juan Andrés Núñez-Serrano), `javel@ccee.ucm.es` (Francisco J. Velázquez-Angona)

encountered when measured in the standard way. Further, these agglomeration effects coexist with very strong spatial productivity spillovers in a close neighbourhood of 10 km. Finally, these spatial effects are shown to quickly diminish as distance increases.
Key words:

IV estimation, elevation, spatial externalities.

JEL: R10

---

1. Introduction

Many recent New Economic Geography papers have measured the positive relationship between productivity and the density of economic activity, at different levels of geographical disaggregation and across a large number of economies (Brülhart and Mathys, 2008; Rosenthal and Strange, 2004). Significantly lower amounts of effort have been dedicated to identification of the geographical amplitude and extent of these agglomeration forces and the measurement of spatial productivity spillovers across regions.

The majority of papers assign these effects solely to agglomeration forces and treatment of productivity spillovers is much scarcer. To this respect Dekle and Eaton (1999) measure the range of agglomeration effects in distance terms, Rice et al. (2006) identify proximity by travel time, whilst Baldwin et al. (2008) introduce two concentric rings of 10 and 50 kilometres and shows that industry establishments' density within the first 10 kilometres of a plant has strong positive effects on Canadian firms' performance. Jaffe et al. (1993) analyses US knowledge spillovers through patent citations finding out that they are in general, geographically localised to the same state where patents were originally generated. Carrington (2003) highlights the existence and importance of spillover effects across neighbouring regions in the European Union, and how these effects determine the capacity of these regions to converge in per capita income. Moretti (2004) surveys thoroughly theoretical models and estimation issues on the identification of human capital spillovers across cities. Parent and Riou (2005) point out the relevance of knowledge spillovers across European regions.

Whilst Ciccone (2002) identifies neighbouring agglomeration forces for five European countries in the mid-1980s, Martín-Barroso et al. (2009) show that these forces could be discarded in the Spanish economy when measured at the municipality level and once institutional differences across regions have been taken into account, highlighting the relevance of regional administrative units in Spain, which seem to have confined agglomeration forces to their geographical borders.

However, neighbours may not just influence labour productivity through agglomeration. There exists the possibility that geographical proximity leads to productivity spillovers amongst close firms and hence, amongst close regions. The existence of agglomeration economies will tend to enhance productivity levels in larger cities. As shown by Table 1, average labour productivity increases substantially with the size of municipalities, presenting largest cities (those with at least 100,000 inhabitants) an almost 30 per cent higher productivity level with respect to smallest municipalities, i.e. those registered under the size class of less than 5,000 inhabitants.

[Insert Table 1 around here]

Additionally, those higher productivity municipalities may have some area of influence over a close neighbourhood, positively affecting neighbours' productivity levels. In fact, regressing average labour productivity across neighbourhood areas of large municipalities, i.e. those with at least 15,000 inhabitants, and radius d kilometres, on the productivity level of the reference municipality, results in a statistically significant and positive effect which vanishes off when distance d increases. Figure 1 shows the results of the mentioned relationship for the two considered and later described datasets, with the elasticity and associated confidence intervals at the 95 per cent significance level (dashed lines) in the y-axis, and the radius of the neighbourhood area in kilometres along the x-axis. The area of influence of these large municipalities goes up to 25 and 30 kilometres depending on the nature of the analysed data, resembling the dimension of average metropolitan areas in Spain.

[Insert Figure 1 around here]

In this sense, Baldwin et al. (2008) point out that close proximity of firms is thought to enhance the flow of knowledge and thereby have a positive impact on productivity. To this respect, the concept of distance must be considered in relative terms. For some activities, distance may refer to tens of kilometres, however, for some others, distances can be identified with more than a hundred kilometres. Further, consideration of spatial productivity spillovers may modify the importance of agglomeration forces across the firms placed under certain locations.

The aim of this paper is to measure the existence and importance of spatial productivity spillovers, taking into account agglomeration effects between Spanish cities and municipalities for year 2001.

The paper is organised as follows. Next section presents the proposed empirical model to capture productivity spillovers. We then very briefly describe the municipal database used for the analysis. Results are presented and discussed just before finishing the article off with conclusions and final remarks.

2. Modelling productivity spillovers across regions

The initial theoretical model we depart from is the one proposed by Ciccone (2002): 215-218. The resulting most basic regression has the following form,

$$\ln y_i = \sum_j \gamma_j + \theta \ln d_i + \sum_{l=1}^{5} \delta_l \ln \left(H_{l,i} \right) + u_i \tag{1}$$

where y_i denotes labour productivity in municipality i, γ are regional indicators to control for differences in exogenous total factor productivity and rental prices of capital across provinces or *Comunidades Autónomas*, and d_i is municipality's employment density. H_l accounts for the fraction of workers with human capital level l. The disturbance term u_i, captures differences in exogenous total factor productivity in municipality i and the region that contains it.

However, municipal productivity levels may, at some extent, being also affected by their proximity to other high level productivity municipalities.

Thus labour efficient cities could have some neighbouring area of influence and therefore affect regional levels of productivity. Proximity to certain cities where most efficient enterprises are located may generate imitation effects across neighbouring firms. Additionally, access to relatively cheaper or technologically intense intermediate goods, proximity to large cities' labour markets, technological externalities across close firms..., they all constitute important sources of spatial productivity and technological spillovers.

Measuring proximity in distance terms, denoting total factor productivity in municipality i by Ω_i and assuming that Ω_i is affected by surrounding productivity levels, we get expression (2),

$$\Omega_i = \Phi \left(y_n^*\right)^{\omega} \tag{2}$$

where Φ denotes regional exogenous total factor productivity, and subindex n indicates that the variable is observed along a given neighbouring area of diameter $2n$ kilometres. We believe that productivity spillovers must be taking place from those most efficient municipalities to those surrounding locations with lower productivity levels, and hence, an appropriated way to capture these effects could be via the maximum value for labour productivity, y^*, observed in the area formed by the complete set of municipalities at a certain distance from municipality i no greater than n. To this respect, we adopt a spillover specification similar to that proposed by Nelson and Phelps (1966), which is also used by Benhabib and Spiegel (1994). We determine one area for each different municipality, and a set of distances $n = 10, \ldots, 500$, in 10 km intervals. Incorporating the log-linearised version of (2) into (1), we can formulate the corresponding empirical regression model, which goes a step further and includes the maximum productivity realisation of any of the municipalities encountered in a given area of reference n, which is introduced in (3) once at a time, resulting in 50 different regressions. The maximum considered distance of 500 km corresponds to the distance between the two largest Spanish cities (Madrid and Barcelona).

$$\ln y_i = \gamma + \omega_d \ln(y_n^*) + \theta \ln d_i + \sum_{l=1}^{5} \delta_l \ln \left(H_{l,i}\right) + u_i \tag{3}$$

This model is extended to the inclusion of regional indicators at NUTs-2 level, *Comunidades Autónomas*, in one hand, and NUTs-3 level, *provincias*, in the other. By allowing the constant term γ in (3) to vary across regions we intend to capture differences in average total factor productivity between regions. These regional indicators could also be denoting differences in institutional settings due to the existence of a high degree of economic and political autonomy at the regional level, especially at NUTs-2 level.

To control for endogeneity problems associated to the ordinary least squares (OLS) estimation of (3), we use instrumental variable estimation methods (IV), particularly the two-stage least squares estimator (2SLS) of θ, using municipal elevation measured in meters as a valid instrument for labour density following Combes et al. (2008) recommendations. In fact, Combes et al. (2008) propose soil fertility as a fundamental determinant of original settlements and hence city localisations. Altitude plays a very similar role to this respect, as it is negatively related to soil fertility and undoubtedly, it has influenced human settlement paths. This altitude variable is correlated with employment density, and it should not be correlated with total factor productivity.

Next section describes the dataset used for the analysis.

3. Data

Spain has very rich statistical regional information. Main economic variables are available by *Comunidades Autónomas* (NUTs-2), and in some cases, the statistics are also published at provinces level (NUTs-3). Unfortunately there is no such datasets at the municipality level, there is only data for large cities (more than 15,000 inhabitants) and not all regions are complete, hence we have to estimate some data for this level of regional disaggregation[1]. For this we use SABI dataset, the Spanish branch of AMADEUS family of databases, generated by the private firms INFORMA and Bureau Van Dyck. This database, which constitutes neither a census nor a representative sample of Spanish firms, contains balance sheets and useful information for more than 525,000 enterprises in 2001, of a total of 2,645,000 (although only 1,409,000 have employees) according to the National Institute of Statistics (INE), and it covers more than 50 per cent of total employment. The sample is thus elevated to the universe by means of expansion coefficients constructed through the mentioned regional accounts provided by INE. The elevation procedure aims to eliminate main sources of biasness associated to SABI dataset representativeness (see Martín-Barroso et al. (2009) for details on this elevation mechanism).

Data on human capital comes from 2001 Spanish Population Census.

[1]Viladecans (2004) uses this same level of geographical disaggregation nonetheless considering just municipalities of more than 15,000 inhabitants for only 14 of the 17 different Spanish NUTs-2 regions and including just manufacturing firms for year 1994. This information comes from the reports of the official fiscal database for VAT, wage taxes and customs revenues, which it used to be elaborated by the Institute for Fiscal Studies. It is nowadays produced since mid 1990s by the State Agency for Tax Administration and unfortunately is only available at NUTs-3 level. Whilst this dataset only covered 4.1 per cent of total number of municipalities (331 out of 8110), it represented 62 per cent of total Spanish population in 1994.

These statistics have information at municipality level and are available for five different education levels, nonetheless they are based on resident population and not on workers. However, this Population Census offers information on workers' geographical mobility, i.e. those living in a given municipality but working in a different one, allowing approximation of employees' qualification levels working in a given municipality.

Total area is obtained from INE through the 1999 Agricultural Census, and the municipal elevation variable required for IV estimation of agglomeration effects comes from the Spanish National Geographical Institute (IGN).

We build three different databases, (i) one which considers total area and non agricultural economic activities, (ii) a more appropriate adjustment where non agricultural economic activities are solely associated to non agricultural area and, (iii) total area and the whole of the economic activity. Usage of these three different datasets is justified by the fact that agriculture and forestry are not subject to the same agglomeration forces of remaining economic activities. For these two activities to occur land must be appropriately available and present adequate soil fertility. Conversely, choosing the area, either total or non agricultural, can be controversial. Although the inclusion of agriculture and forestry suggests consideration of the agricultural area, it is also true that this agricultural land may in fact constitute an important space reserve for the rest of the economic and urban activities. With the exception of environmentally protected areas and high ecological value areas, land is subject to land use changes oriented towards urban and economic developments.

We now turn to presentation and analysis of results on the influence of agglomeration effects and spatial productivity spillovers over municipality productivity.

4. Productivity spillovers across regions

Results to estimations of the set of regressions associated to empirical model in (3) are presented in Table 2 for the without agriculture dataset, and Table A1 in the Appendix, for remaining two datasets. Figure 2 illustrates along the y-axis the magnitude of spatial productivity spillovers, captured through the ω_d parameter in (3), and associated confidence intervals at the 95 per cent significance level (dashed lines), as well as the agglomeration θ elasticities. The radius in km of influential neighbourhood area is registered along the x-axis.

[Insert Table 2 around here]

The elasticity of labour productivity with respect to labour density seems not to be affected when conditioned to the presence of productivity spillovers across neighbours. Values are very close to those obtained in previous literature, around the 5 per cent level, although here these elasticities are measured at the municipality level (Ciccone, 2002; Martínez-Galarraga et al., 2007; Martín-Barroso et al., 2009). Extremes are both found in 2SLS estimations, elevation being the instrument for the agglomeration variable, and range from 3.11 (.87) to 6.81 (.82) per cent. OLS results are more centred on the 5 per cent level, oscillating between 4.84 (.46) and 6.03 (.53). With respect to spatial productivity spillovers, strong positive externalities occur along a close neighbourhood of at most 10 km radius, with elasticities that range from 35.30 to 36.77 per cent. These effects decrease rapidly with distance, although they persist significatively up to a 30 kilometre radius. Thus municipal productivity benefits substantially from high level productivity close neighbours. Here we are probably capturing the influence of metropolitan areas.

Some negative and relatively small externalities appear along the different neighbourhood areas of radius 90 to 140 km, with elasticities ranging from -2.59 to -1.66. These negative externalities nonetheless disappear as soon as regional indicators are included in regressions. In fact, the average area of *Comunidades Autónomas* (NUTs-2) corresponds to circles of an approximate 100 km radius, so this result may well be related to the existence of these regional administrative units and associated regional policies oriented to enhance linkages amongst the firms located within these regional boundaries. For instance, the design of road networks between different locations of a given *Comunidad Autónoma* is due to regional and provincial governments. By year 2001, only 15 per cent of the Spanish road network was under the central government responsibility, in contrast to the high capacity network, which is basically managed by the central government who controls 72 per cent of this network.

Positive externalities emerge when total factor productivity regional differences are captured with regional indicators, for distances as far as 350 km when NUTs-3 indicators, and 500 km if NUTs-2, with elasticities that wonder around the neighbourhood of corresponding θ values, see Figure 2. In fact, these distances are somehow representative of the distances between main metropolitan areas in Spain[2]. This result shows the existence of an

[2]Some examples of these distances in kilometres, calculated by the Great Circle Distance formula, are: Madrid-Barcelona: 504, Madrid-Málaga: 419, Barcelona-Alicante: 408, Madrid-Sevilla: 394, Madrid-Alicante: 360, Madrid-Bilbao: 321, Barcelona-Valencia: 304, Madrid-Valencia: 304.

additional type of spatial productivity spillovers taking place over long distances amongst most important cities. Thus one can think of different distance concepts depending on the nature of the economic activity in mind, where long-distance spillovers may come up as a result of productive specialisation patterns across service sectors where geographical interconnections are especially strong, justifying for instance, the nature and design of actual communication networks between main cities.

[Insert Figure 2 around here]

Regional indicators are always and jointly statistically significant at the 99.9 per cent significance level and R^2 coefficients range from 9.25 to 23.32 per cent.

The same general patterns are observed for remaining two datasets, where the conditional elasticities of labour productivity with respect to agglomeration are slightly lower in both cases as expected, being the agriculture dataset the one with lowest elasticity values.

5. Conclusions

Results corroborate the existence of spatial productivity spillovers operating jointly with agglomeration effects —agglomeration being measured by labour density— on labour productivity at the municipality level, with elasticities slightly over 5 per cent, in consonance with previous results. Spatial productivity spillovers occur at different geographical distances. In one hand, along a very close neighbourhood of each municipality, with distances being under the 30 kilometres level—most probably indicating the strong economic links amongst those local towns that integrate large metropolitan areas— and in the other, some positive externalities arise across large distances, suggesting that spatial productivity spillovers are at least, a national wide phenomena although only between large agglomerated cities.

References

Baldwin, J., Beckstead, D., Brown, W., Rigby, D., 2008. Agglomeration and the geography of localization economies in Canada. Regional Studies 42 (1), 117 – 132.

Benhabib, J., Spiegel, M., 1994. The role of human capital in economic development: Evidence from aggregate cross-country data. Journal of Monetary Economics 34 (2), 143 – 173.

Brülhart, M., Mathys, N., 2008. Sectoral agglomeration economies in a panel of European regions. Regional Science and Urban Economics 38 (4), 348–362.

Carrington, A., 2003. A divided Europe? regional convergence and neighbourhood spillover effects. Kyklos 56 (3), 381 – 394.

Ciccone, A., 2002. Agglomeration effects in Europe. European Economic Review 46 (2), 213–227.

Combes, P., Duranton, G., Gobillon, L., Roux, S., 2008. Estimating agglomeration economies with history, geology, and worker effects. C.E.P.R. Discussion Papers 6728.

Dekle, R., Eaton, J., 1999. Agglomeration and land rents evidence from the prefectures. Journal of Urban Economics 46 (2), 200–214.

Jaffe, A., Trajtenberg, M., Henderson, R., 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. The Quarterly Journal of Economics 108 (3), 577–598.

Martín-Barroso, D., Núñez-Serrano, J., Velázquez-Angona, F., 2009. A different look at agglomeration effects in Spain. Mimeo, Universidad Complutense de Madrid.

Martínez-Galarraga, J., Paluzie-Hernández, E., Pons-Novell, J., Tirado-Fabregat, D., 2007. Agglomeration and labour productivity in Spanish industry: a long-term analysis. Working Papers in Economics 175, Universitat de Barcelona. Espai de Recerca en Economia.

Moretti, E., 2004. Human capital externalities in cities. In: Henderson, J. V., Thisse, J. F. (Eds.), Handbook of Regional and Urban Economics. Vol. 4 of Handbook of Regional and Urban Economics. Elsevier, Ch. 51, pp. 2243–2291.

Nelson, R., Phelps, E., 1966. Investment in humans, technological diffusion, and economic growth. The American Economic Review 56 (1/2), 69–75.

Parent, O., Riou, S., 2005. Bayesian analysis of knowledge spillovers in european regions. Journal of Regional Science 45 (4), 747 – 775.

Rice, P., Venables, A., Patacchini, E., 2006. Spatial determinants of productivity: Analysis for the regions of Great Britain. Regional Science and Urban Economics 36 (6), 727–752.

Rosenthal, S., Strange, W., 2004. Evidence on the nature and sources of agglomeration economies. In: Henderson, J. V., Thisse, J. F. (Eds.), Handbook of Regional and Urban Economics. Elsevier, Amsterdam, pp. 2119–2171.

Viladecans, E., 2004. Agglomeration economies and industrial location: city-level evidence. Journal of Economic Geography 4 (5), 565–582.

A. Appendix

[Insert Table A.1 around here]

B. Figure Captions

Figure 1. The elasticities of average neighbouring productivities with respect to the productivity of large municipalities (population $\geq$ 15,000 inhabitants). 95 per cent significance level.

Figure 2. Spatial productivity spillovers. Without agriculture dataset.

Tables

Table 1. Average productivity in Euros per worker and size of municipalities

Size Classes x = Population	**Average Productivity (a)**	**Average Productivity (b)**	**Frequency**	**Percentage**
$x < 5,000$	29,324.25	28,737.77	6,950	85.7
$5000 \leq x < 15,000$	28,781.21	28,785.59	725	8.94
$15,000 \leq x < 100,000$	32,755.45	32,011.98	379	4.67
$x \geq 100,000$	37,758.75	36,498.54	56	.69
Total			**8,110**	**100**

(a) Without agriculture dataset and **(b)** with agriculture dataset

Table 2. Spatial productivity spillover effects of neighbours. Without agriculture dataset

	Regional Indicator	**OLS**	**Elevation 2SLS**
Agglomeration (%)	*NO*	5.06*** to 5.78***	4.74*** to 6.81***
Standard error (%)		.45 to .48	.85 to .82
+ve SPS‡		3.08* to 35.45***	3.19* to 35.30***
-ve SPS		-2.46** to -1.66†	-2.59** to -1.77*
R^2 (%)		9.25 to 20.37	9.23 to 20.27
Agglomeration (%)	*NUTs-2*	4.84*** to 5.50***	3.11*** to 4.03***
Standard error (%)		.46 to .50	.87 to .92
+ve SPS		3.08† to 36.53***	2.84† to 36.77***
-ve SPS			
R^2 (%)		10.44 to 21.64	10.22 to 21.38
Wald test	*ccaa = 0*	7.02*** to 9.22***	7.4*** to 9.53***
Wald test	*ccaa != pro = 0*	6.55*** to 10.78***	7.08*** to 11.44***
Agglomeration (%)	*NUTs-3*	5.25*** to 6.03***	4.92*** to 6.27***
Standard error (%)		.48 to .53	.90 to .99
+ve SPS		4.93* to 36.54***	4.93* to 36.60***
-ve SPS			
R^2 (%)		12.62 to 23.32	12.62 to 23.31
Wald test	*pro = 0*	21.87*** to 92.15***	19.93*** to 92.33***

*** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .10$.
‡ SPS stands for spatial productivity spillovers.

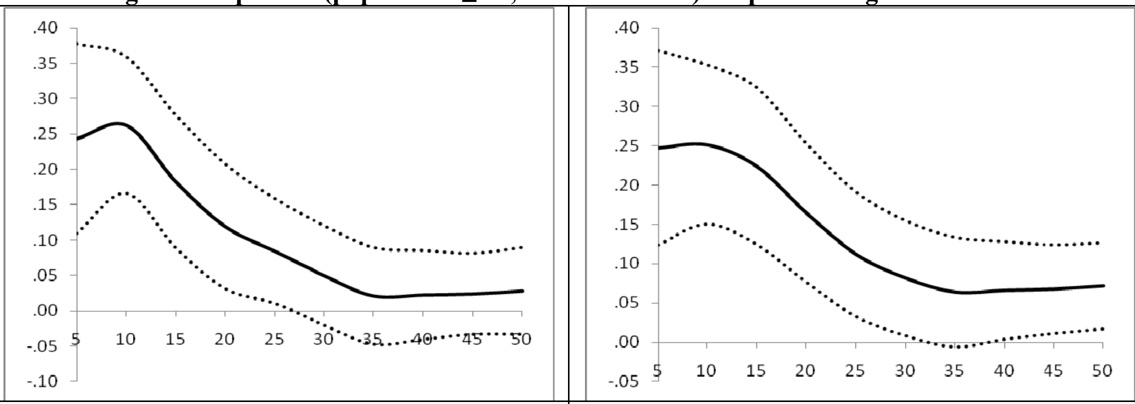
Table A1. Spillover effects of neighbours

	Regional Indicator	OLS	Elevation 2SLS
Without agriculture and total area dataset			
Parameter (%)	*NO*	4.65*** to 5.26***	3.73*** to 5.32***
Standard error (%)		.42 to .45	.67 to .65
+ve externalities		1.6† to 35.6***	1.67† to 35.59***
-ve externalities		-2.25* to -1.52†	-2.54** to -1.58†
R^2 (%)		8.94 to 20.19	8.84 to 20.19
Parameter (%)	*NUTs-2*	4.57*** to 5.3***	2.75*** to 3.56***
Standard error (%)		.45 to .50	.77 to .81
+ve externalities		3.23* to 36.49***	2.89† to 36.78***
-ve externalities			
R^2 (%)		10.32 to 21.49	10.02 to 21.2
Wald test	*ccaa = 0*	7.01*** to 8.09***	7.44*** to 8.65***
Wald test	*ccaa != pro = 0*	5.14*** to 7.91***	5.79*** to 8.78***
Parameter (%)	*NUTs-3*	5.22*** to 6.09***	4.46*** to 5.7***
Standard error (%)		.47 to .52	.81 to .90
+ve externalities		3.54† to 36.45***	3.57† to 36.6***
-ve externalities			
R^2 (%)		12.68 to 23.33	12.65 to 23.28
Wald test	*pro = 0*	10.86*** to 85.06***	10.12*** to 81.81***
With agriculture and total area dataset			
Parameter (%)	*NO*	3.79*** to 4.33***	4.31*** to 5.45***
Standard error (%)		.43 to .46	.72 to .67
+ve externalities		3.91** to 33.92***	4.08** to 33.86***
-ve externalities		-1.96† to -1.96†	-1.87† to -1.87†
R^2 (%)		7.29 to 17.72	7.28 to 17.69
Parameter (%)	*NUTs-2*	3.47*** to 4.00***	1.61* to 3.24***
Standard error (%)		.45 to .49	.77 to .82
+ve externalities		2.53† to 34.84***	2.52† to 35.08***
-ve externalities			
R^2 (%)		8.37 to 18.67	8.29 to 18.38
Wald test	*ccaa = 0*	6.47*** to 7.97***	6.7*** to 7.94***
Wald test	*ccaa != pro = 0*	5.09*** to 7.94***	5.27*** to 7.81***
Parameter (%)	*NUTs-3*	3.86*** to 4.44***	2.92*** to 4.16***
Standard error (%)		.48 to .52	.80 to .84
+ve externalities		3.07† to 35.39***	3.05† to 35.52***
-ve externalities			
R^2 (%)		10.23 to 20.26	10.22 to 20.19
Wald test	*pro = 0*	8.19*** to 69.51***	7.4*** to 66.75***

*** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .10$.

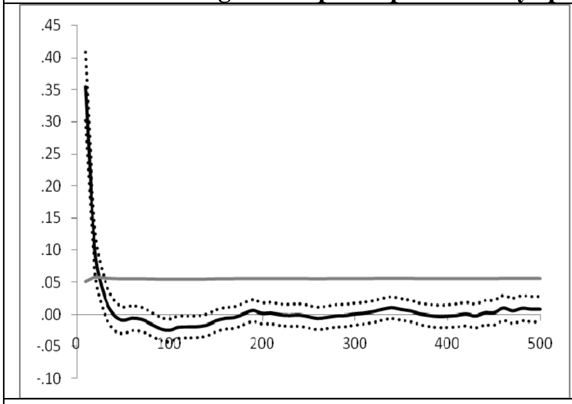
Figures

Figure 1. The elasticities of average neighbouring productivities with respect to the productivity of large municipalities (population ≥ 15,000 inhabitants). 95 per cent significance level.

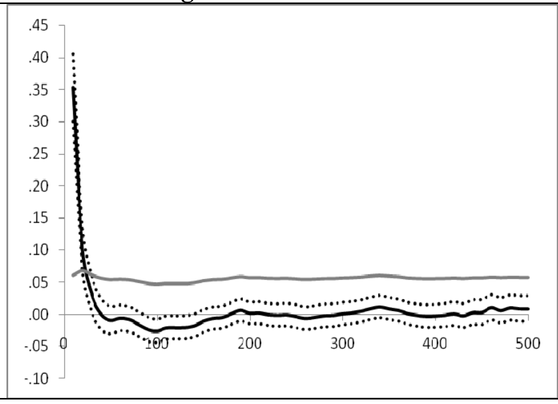


Without agriculture dataset	With agriculture dataset

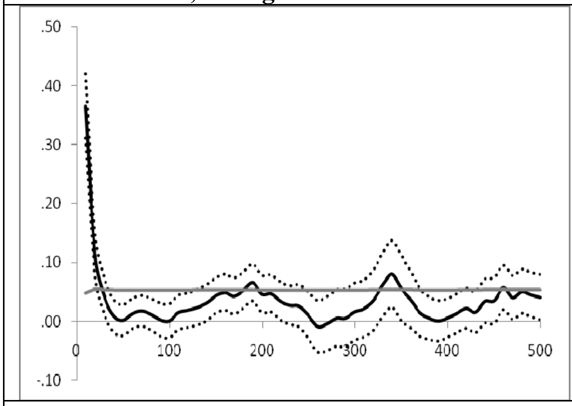
Figure 2. Spatial productivity spillovers. Without agriculture dataset



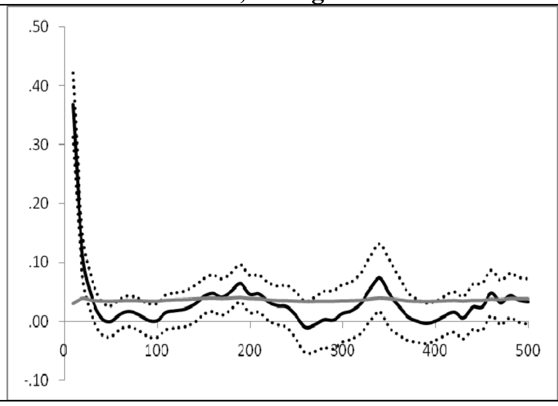
OLS, no regional indicators



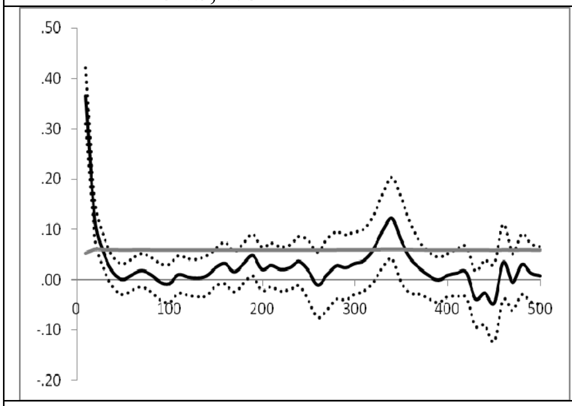
2SLS Elevation, no regional indicators



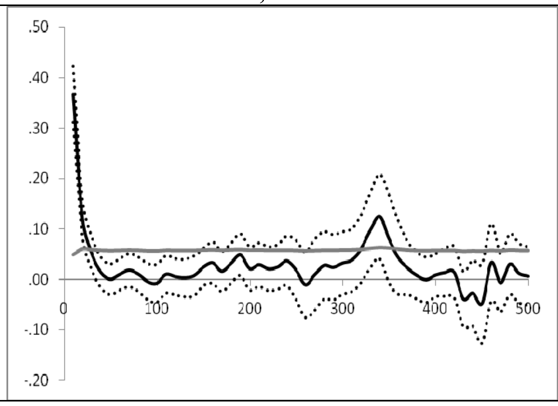
OLS, NUTs-2 indicators



2SLS Elevation, NUTs-2 indicators



OLS, NUTs-3 indicators



2SLS Elevation, NUTs-3 indicators

— Agglomeration

— Spatial productivity spillovers (SPS)

…. Lower and upper bounds for SPS at the 95 per cent significance level