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Spatial shift-share analysis: new developments and some findings for the Spanish case

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Abstract

According to Dunn (1960) the main feature of shift-share analysis is the computation of geographical shifts in economic activity. Nevertheless, the traditional shift-share analysis assumes a specific region to be independent with respect to the others and therefore this approach does not explicitly include spatial interaction.
Some authors such as Hewings (1976) and Nazara and Hewings (2004) recognized the convenience of considering spatial dependence between spatial units by means of the definition of a spatial weights matrix.
In this paper an analysis of these models is carried out, leading to a more realistic approach to the evolution of employment. An empirical application is also presented summarizing the main findings for the Spanish case.

Keywords: Shift-share analysis, spatial dependence, employment, EPA.

JEL Codes: R11, R15

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1. Introduction

Shift-share analysis is a statistical tool allowing the study of regional development by means of the identification of two types of factors. The first group of factors operates in a more or less uniform way throughout the territory under review, although the magnitude of its impact on the different regions varies with its productive structure. The second type of factors has a more specific character and operates at the regional level.

Although according to Dunn (1960) the main objective of the shift-share technique is the quantification of geographical changes, the existence of spatial dependence and/or heterogeneity has barely been considered.

The classical shift-share approach analyses the evolution of an economic magnitude between two periods identifying three components: a national effect, a sectoral effect and a competitive effect. However, this methodology focuses on the dependence of the considered regions with respect to national evolution but it does not take into account the interrelation between geographical units.

The need to include the spatial interaction has been recognized by Hewings (1976) in his revision of shift-share models. In the classical formulation this spatial influence is gathered in a certain way, since the local predictions should converge to the national aggregate. Nevertheless, at the same time the estimation of the magnitude of the sector i in the region j is supposed to be independent of the growth of the same sector in another region k, an assumption which would only make sense in the case of a self-sufficient economy.

The increasing availability of data together with the development of spatial econometric techniques allow the incorporation of spatial effects in shift-share analysis.

The estimation of spatial dependence is needed for both the identification of the effects and the computation of forecasts. The aim is to obtain a competitive effect without spatial influence, allowing the distinction between a common pattern in the neighbouring regions and an individual pattern of the specific considered region.

This paper starts with a brief exposition of the classical shift-share identity, also describing the introduction of spatial dependence structures through spatial weights matrices.

In the third section some models of spatial dependence are presented including the approach of Nazara and Hewings (2004) and some new proposals. An application of these models to Spanish employment is presented in section four and the paper ends with some concluding remarks summarized in section five.

2. Shift-share analysis and spatial dependence

The introduction of spatial dependence in a shift-share model can be carried out by two alternative methods. The first one, which is the aim of this paper, is based on the modification of the classical identities of deterministic shift-share analysis by adding some new extensions.

The second is based on a regression model (stochastic shift-share analysis) and the inclusion of spatial substantive and/or residual dependence.

According to Isard (1960), any spatial unit is affected by the positive and negative effects transmitted from its neighbouring regions. This idea is also expressed by Nazara and Hewings (2004), who assign great importance to spatial structure and its impact on growth. As a consequence, the effects identified in the shift-share analysis are not independent, since similarly structured regions can be considered in a sense to be "neighbouring regions" of a specified one, thus exercising influence on the evolution of its economic magnitudes.

2.1. Classical shift-share analysis

If we denote by X_{ij} the initial value of the considered economic magnitude corresponding to the i sector in the spatial unit j, X'_{ij} being the final value of the same magnitude, then the change experienced by this variable can be expressed as follows:

$$X'_{ij} - X_{ij} = \Delta X_{ij} = X_{ij}r + X_{ij}\left(r_i - r\right) + X_{ij}\left(r_{ij} - r_i\right) \qquad (1.1)$$

$$r = \frac{\sum_{i=1}^{S}\sum_{j=1}^{R}(X'_{ij} - X_{ij})}{\sum_{i=1}^{S}\sum_{j=1}^{R}X_{ij}} \qquad r_i = \frac{\sum_{j=1}^{R}\left(X'_{ij} - X_{ij}\right)}{\sum_{j=1}^{R}X_{ij}} \qquad r_{ij} = \frac{X'_{ij} - X_{ij}}{X_{ij}}$$

The three terms of this identity correspond to the shift-share effects:

National Effect	$EN_{ij} = X_{ij}r$
Sectoral or structural Effect	$ES_{ij} = X_{ij}\left(r_i - r\right)$
Regional or competitive Effect	$ER_{ij} = X_{ij}\left(r_{ij} - r_i\right)$

As it can be appreciated, besides the national growth we should consider the positive or negative contributions derived from each spatial environment, known as the net effect. Thus the sectoral effect collects the positive or negative influence on the growth of the specialization of the productive activity in sectors with growth rates over or under the average, respectively. In turn, the competitive effect collects the special dynamism of a sector in a region in comparison with the dynamism of the same sector at the national level.

Once the regional and sectoral effects are calculated for each industry, their sum provides a null result, a property which Loveridge and Selting (1998) call "zero national deviation".

The shift-share analysis has some limitations derived, in the first place, from an arbitrary election of the weights, which are not updated with the changes of the productive structure. Secondly, we need to notice that the results are sensitive to the degree of sectoral aggregation and furthermore, the growth attributable to secondary multipliers is assigned to the competitive effect when it should be collected by the sectoral effect, resulting in the dependence of both effects.

Besides the previously described problems, Dinc et. al. (1998) emphasize the complexity related to the increasing of the spatial dependences between the sectors and the regions, which should be reflected in the model by means of the incorporation of some term of spatial interaction.

A solution to the interdependence between the sectoral and regional components, derived from the fact that both effects depend on the industrial structure, is given by Esteban-Marquillas (1972) who introduced the idea of "homothetic change". This concept is defined as the value which would take the magnitude of sector i in region j , if the sectoral structure of that region is assumed to be coincident with the national one. In this way, the homothetic change of sector i in region j is given by the expression:

$$X_{ij}^{*} = \sum_{i=1}^{S} X_{ij} \frac{\sum_{j=1}^{R} X_{ij}}{\sum_{i=1}^{S}\sum_{j=1}^{R} X_{ij}} = \frac{\sum_{j=1}^{S} X_{ij}}{\sum_{i=1}^{S}\sum_{j=1}^{R} X_{ij}} \sum_{j=1}^{R} X_{ij} \qquad (1.2)$$

leading to the following shift-share identity:

$$\Delta X_{ij} = X_{ij} r + X_{ij}\left(r_i - r\right) + X_{ij}^{*}\left(r_{ij} - r_i\right) + \left(X_{ij} - X_{ij}^{*}\right)\left(r_{ij} - r_i\right) \qquad (1.3)$$

The third element of the right hand side of the equation is known as the "net competitive effect", which measures the advantage or disadvantage of each sector in the region with respect to the total. The part of growth not included in this effect when $X_{ij} \neq X_{ij}^{*}$ is called the "locational effect", corresponding to the last term of identity (1.3) and measuring the specialization degree.

An alternative approach is provided by Arcelus (1984), whose model includes a specific regional effect (which is similar to the national effect in the classic identity) and a sectoral regional effect, reflecting the amount of growth derived from the regional industry-mix:

$$ER_{ij} = X_{ij}\left(r_j - r\right) \qquad (1.4)$$

$$ESR_{ij} = X_{ij}\left[\left(r_{ij} - r_j\right) - \left(r_i - r\right)\right] \qquad (1.5)$$

It must be noted that these models include a comparison between region and nation but nevertheless they still assume each specific region to be independent from the others and therefore no spatial patterns are included.

2.2. The structure of spatial dependence: Spatial Weights

We need to develop a more complete version of shift share identity since each region should not be considered as an independent reality. It must also be kept in mind that the economic structure of each spatial unit will depend on some regions that are "neighbouring regions" in some sense. A suitable approach is the definition of a spatial weights matrix, thus solving the problems of multi-directionality of spatial dependence. In this way, Tobler´s law of geography (1979) is assumed, establishing that any spatial unit is related to any other, this relation being more intense when the considered units are closer.

The concept of spatial autocorrelation attributed to Cliff and Ord (1973) has been the object of different definitions and, in a generic sense, it implies the absence of independence between the observations, showing the existence of a functional relation between what happens at a spatial point and in the population as a whole.

The existence of spatial autocorrelation can be expressed as follows:

$$\mathrm{Cov}\left(X_j, X_k\right) = E\left(X_j X_k\right) - E\left(X_j\right) E\left(X_k\right) \neq 0 \tag{1.6}$$

X_j X_k being observations of the considered variables in units j and k, which could be measured in latitude and length, surface or any spatial units. In the empirical application included in this paper these spatial units are the European territorial units NUTS-III at the Spanish level.

In general terms, given N regional observations it would be necessary to establish N^2 terms of covariance between the observations. Nevertheless, the symmetry allows the reduction of this size to $\frac{N(N-1)}{2}$.

The spatial weights are collected in a squared, non-stochastic matrix whose elements w_{jk} show the intensity of interdependence between the spatial units j and k.

$$W = \begin{bmatrix} 0 & w_{12} & \cdot & w_{1R} \\ w_{21} & 0 & \cdot & w_{2R} \\ \cdot & \cdot & \cdot & \cdot \\ w_{R1} & w_{R2} & \cdot & 0 \end{bmatrix} \tag{1.7}$$

According to Anselin (1988), these effects should be finite and non-negative and they could be collected according to diverse options. A well-known alternative is the

Boolean matrix, based on the criterion of physical contiguity and initially proposed by Moran (1948) and Geary (1954). These authors assume $w_{jk}=1$ if j and k are neighbouring units and $w_{jk}=0$ in another case, the elements of the main diagonal of this matrix being null.

In order to allow an easy interpretation, the weights are standardised so that they satisfy the following conditions:

$$0 \le w_{jk} \le 1$$

$$\sum_k w_{jk} = 1 \text{ for each row j}$$

$$\tilde{X} = WX$$

According to the last condition, the value of a variable in a certain location can be obtained as an average of the values in its neighbouring units.

Together with the advantages of simplicity and easy use, the considered matrix shows some limitations, such as the non-inclusion of asymmetric relations, which is a requirement included in the five principles established by Paelink and Klaasen (1979).

The consideration of different criteria for the development of the spatial weights matrix can deeply affect the empirical results. Thus, the contiguity can be defined according to a specific distance: $w_{jk} = 1 \;\; d_{jk} \le \delta \;\; d_{jk}$ being d_{jk} the distance between two spatial units and δ the maximum distance allowed so that both be considered neighbouring units.

In a similar way the weights proposed by Cliff-Ord depend on the length of the common border adjusted by the inverse distance between both locations:

$$w_{jk} = \frac{b_{jk}^{\beta}}{d_{jk}^{\alpha}} \tag{1.8}$$

b_{jk} being the proportion that the common border of j and k represents with respect to the total j perimeter. From a more general perspective, weights should consider the potential interaction between the units j and k and could be computed as: $w_{jk} = \frac{1}{d_{jk}^{\alpha}}$ and $w_{jk} = e^{-\beta d_{jk}}$.

In some cases the definition of weights is carried out according to the concept of "economic distance" as defined by Case et al. (1993) with $w_{jk} = \frac{1}{|X_j - X_k|}$ X_j and X_k being the per capita income or some related magnitude. Some other authors as López-Bazo et al. (1999) propose the use of weights based on commercial relations.

The consideration of a binary matrix with weights based only on distance measures guarantees exogeneity but it can also affect the empirical results as indicated by López-Bazo, Vayá and Artís (2004). In this sense, it would be interesting to compare these results with those related to some alternative weights defined as a function of the economic variables of interest.

Some alternative definitions have been developed by Fingleton (2001), with $w_{ij} = GDP^2{}_{t=0} d_{ij}^{-2}$ and Boarnet (1998), whose weights increase with the similarity between the investigated regions.

$$w_{jk} = \frac{\frac{1}{|X_j - X_k|}}{\frac{1}{\sum_j |X_j - X_k|}} \tag{1.9}$$

The matrix proposed by Molho (1995) focuses on the employment levels E_j:

$$w_{jk} = \frac{E_j e^{(-\eta D_{jk})}}{\sum_{l \neq j} E_l e^{(-\eta D_{jl})}} \tag{1.10}$$

with $w_{jj} = 0$. This definition assumes that the *spillover* effect of a specific area is a direct function on its size, measured as the number of employees, and an inverse function of the distance between the considered areas, η being a smoothing parameter.

Given the diversity of options for the specification of weights, Stetzer (1982) establishes three basic ideas in the context of a space-temporary model: the existence of different results depending on the considered weights, the risk of a wrong specification of spatial weights and, finally, the need of a set of rules allowing the definition of suitable weights.

3. Models of spatial dependence

In this section we present some proposals for the inclusion of the spatial structure in a shift-share model, and analyse their suitability.

The extension of the shift-share model proposed by Nazara and Hewings (2004) introduces the spatially modified growth rates according to the previously assigned spatial weights:

$$r_{ij} = r + \left(r_{ij}^{v} - r\right) + \left(r_{ij} - r_{ij}^{v}\right) \qquad (1.11)$$

where r_{ij}^{v} is the rate of growth of the i sector in the neighbouring regions of a given spatial unit j which can be obtained as follows:

$$r_{ij}^{v} = \frac{\left(\sum_{k \in v} w_{jk} X_{ik}^{t+1} - \sum_{k \in v} w_{jk} X_{ik}^{t}\right)}{\sum_{k \in v} w_{jk} X_{ik}^{t}} \qquad (1.12)$$

and the rate of growth of the total employment is also defined for each unit j as a function of its neighbouring structure:

$$r_{j}^{v} = \frac{\left(\sum_{k \in v} w_{jk} X_{k}^{t+1} - \sum_{k \in v} w_{jk} X_{k}^{t}\right)}{\sum_{k \in v} w_{jk} X_{k}^{t}} \qquad (1.13)$$

It must be noted that the w_{jk} elements correspond to the previously defined matrix of standardized weights by rows. In any case, regional interactions are supposed to be constant between the considered periods of time as is usually assumed in spatial econometrics.

Three components are considered in expression(1.11), the first one corresponding to the national effect, which is equivalent to the first effect of the classical (non spatial) shift-share analysis.

In the second place, the sectoral effect or *industry mix* neighbouring regions-nation effect shows a positive value when the evolution of the considered sector in the neighbouring regions of j is higher than the average.

Finally, the third term is the competitive region-neighbouring regions effect and compares the rate of growth in region j of a given sector i with the evolution of the spatially modified sector. Thus, a negative value of this effect shows a regional evolution that is worse than the one registered in the neighbouring regions, meaning that region j fails to take advantage of the positive influence of its neighbouring regions.

A weakness can be found in the previously defined model, since a single spatial weight matrix is considered for the computation of the different spatially modified rates of sectoral and global growth. This assumption would not be so problematic if we used, instead of endogenous matrices, the binary matrix, which would vary sensitively depending on the sectoral or global adopted perspective.

On the other hand, the use of the same structure of weights in the initial and final periods could be considered excessively simplistic, suggesting the need of developing some dynamic version.

It is worth noting that in expressions (1.12) and (1.13) an average value is obtained of the considered variable as a function of the values of its neighbouring regions. The introduction of spatial dependence could be carried out more intuitively by considering the variables in relative terms such as the growth rates and thus decomposing the spatially modified rate of growth $\left(Wr_{ij}\right)$ according to the following expression:

$$Wr_{ij} = r + \left(r_i - r\right) + \left(Wr_{ij} - r_i\right) \tag{1.14}$$

As it can be seen only the sectoral-regional rate of growth is modified and therefore the global and sectoral rates of growth are computed as an aggregation of the evolution registered in sub-regional levels. This fact can be easily understood since the global and sectoral rates of growth are the results of economic evolution including spatial dependence.

Nevertheless another identity could be considered by defining rates of growth over the spatially modified variables:

$$Wr_{ij} = r^v + \left(r_i^v - r^v\right) + \left(Wr_{ij} - r_i^v\right) \tag{1.15}$$

An alternative approach to what extent a spatial unit is being affected by the neighbouring territories would consist in introducing homothetic effects analogous to those defined by Esteban-Marquillas (1972) but referring to regional environment. In this way, we would be able to define the value the magnitude of the sector i in the

region j would have taken if the sectoral structure of j were similar to its neighbouring regions. More specifically, the homothetic change with respect to the neighbouring regions would be given by the expression:

$$X_{ij}^{v} = \sum_{i=1}^{S} X_{ik} \frac{\sum_{k \in v} X_{ik}}{\sum_{i=1}^{S} \sum_{k \in v} X_{ik}} \tag{1.16}$$

A more complete option is based on the use of spatial weights matrix. In this case the economic magnitude is defined in function of the neighbouring values, and therefore the concept of homothetic employment would be substituted by *spatially influenced employment*, which would be computed according to a certain structure of spatial weights (W) and the employment effectively computed for each combination region-sector. The identity would then be the following

$$\Delta X_{ij} = X_{ij} r + X_{ij}\left(r_i - r\right) + X_{ij}^{v*}\left(r_{ij} - r_i\right) + \left(X_{ij} - X_{ij}^{v*}\right)\left(r_{ij} - r_i\right) \tag{1.17}$$

where the value of the magnitude in function of the neighbouring regions is obtained as:

$$X_{ij}^{v*} = \sum_{k \in V} w_{jk} X_{ik} \tag{1.18}$$

V being the set of neighbouring regions of j.

One of the drawbacks of this *spatially influenced employment* is related to the fact that, as a consequence of the considered expression, it can be observed that: $\sum_{i,j} X_{ij}^{v*} \neq \sum_{i,j} X_{ij}$.

This could introduce two kinds of doubts with respect to the utility of this definition: on the one hand, the magnitudes of the effects for each sector-region are going to be in some cases sensitively different to those obtained in the equivalent model of Esteban-Marquillas (1972), leading to a more difficult interpretation and comparison of the obtained results. On the other hand, as a result of the structure of the spatial weights, the expected level of employment would be different to the effective one.

In order to try to solve both problems, an alternative interpretation of modified employment is proposed based on a new spatially modified structure of sectoral weights based on the spatially influenced employment (1.18): $\frac{\sum_{j=1}^{R} X_{ij}^{v*}}{\sum_{i=1}^{S}\sum_{j=1}^{R} X_{ij}^{v*}} = \frac{X_i^{v*}}{X^{v*}}$, leading to the values:

$$X_{ij}^{v**} = X_j \frac{X_i^{v*}}{X^{v*}} \tag{1.19}$$

It must be noticed that this new concept satisfies the identity $\sum_{i,j} X_{ij}^{v**} = \sum_{i,j} X_{ij}$, although substantial differences are found in the distribution of the variable for each combination sector-spatial unit. The substitution of the expression (1.19) in (1.17) leads to the identity:

$$X_{ij} r + X_{ij}(r_i - r) + X_{ij}^{v**}(r_{ij} - r_i) + (X_{ij} - X_{ij}^{v**})(r_{ij} - r_i) \tag{1.20}$$

4. The property of additivity region-region

The study of spatial interrelations suggests the need of a prior exploratory analysis allowing the detection of spatial autocorrelation. The objective is to analyse whether the spatial structure of the investigated phenomenon is significant and can be easily interpreted and also if it is possible to obtain any information referring to the process generating this distribution in the space.

The detection of spatial autocorrelation can be carried out by means of diverse tests such as those of Geary (1954) and Moran (1948). This last alternative will be used in the empirical applications of this work and is based on the expression:

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n}\sum_{jl=}^{n} w_{ij} z_i z_j}{\sum_{i=1}^{n} z_i^2}; i \neq j \tag{1.21}$$

with $z_i = X_i - \overline{X}$ and $S_0 = \sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}$.

With regard to the distribution used in the statistical tests, Cliff and Ord (1981) show that if the sample size is sufficiently large, then the Moran test can be carried out from an asymptotically normal distribution. For Upton and Fingleton (1985) this normality depends on the number of considered links and the way in which they are connected, that is, on the structure of the spatial weights matrix.

Once the presence of spatial autocorrelation is detected we should examine the fulfilment of the additivity property in the extended models.

Haynes and Machunda (1987) analyse the problems related to the traditional extensions of shift-share analysis with regard to this property of "additivity region-region" also denoted "transformations invariance". From an empirical point of view, the independence of any decomposition of a magnitude with respect to the level of detail of the considered data (including both sectoral and spatial perspectives) is desirable. The following conditions are required for this decomposition:

- For a given sector, the sum of the shift-share components for all the spatial levels included in a specific region j is equal to the corresponding component computed at the j regional level.
- For a given region j, the shift-share component of a sector i is equal to the sum of the respective components of all the sub-sectors including in sector i.

In the traditional version each of the components satisfies the first condition while the second condition is verified only for the national effect.

Stokes (1974) shows that the competitive effect modified according to the Marquillas criteria does not satisfy the property of additivity region-region and the following expression holds:

$$E^{*}_{ijt-1}\left(r_{ij}-r_{i}\right) \overset{?}{=} E^{*}_{ij_1t-1}\left(r_{ij_1}-r_{i}\right)+E^{*}_{ij_2t-1}\left(r_{ij_2}-r_{i}\right) \tag{1.22}$$

It must be noted that the previous expression is not strictly correct since it does not keep in mind that the growth rate of a region can be expressed as a function of the growth rates of the spatial units included in it. In fact, it can be shown that if a region is divided into its corresponding components, then its growth rate can be obtained as a weighted average of the sub-regional growth rates, that is to say, given by $r_j = \sum_{k=1}^{n} \frac{X_{j_k}}{X_j} r_{jk}$, where k denotes the spatial units included in region j.

Haynes and Machunda (1987) consider that the analysis of Stokes (1974) of the property of additivity region to region is wrong since it does not include the former reasoning about the rates of regional growth. In the empirical application included in the next paragraph we analyse the fulfilment of this property for each sector, so that the sum of the competitive effect for the considered regions is $\sum_j X_{ij}\left(r_{ij} - r_{ij}^{v}\right) = 0$ in (1.11) or

$\sum_{j=1}\left(X_{ij}^{v*}\left(r_{ij} - r_i\right) + \left(X_{ij} - X_{ij}^{v*}\right)\left(r_{ij} - r_i\right)\right) = 0$ in (1.17) .

5. Some findings for the Spanish case

The previously described developments can be applied to the Spanish case, analysing the sectoral evolution of regional employment.

More specifically, in this section we focus on the four main economic activities (agriculture, industry, construction and services) assuming the European territorial units NUTS-III at the Spanish level leading to a total of 47 provinces[1].

The information has been provided by the Spanish Economically Active Population Survey (EPA) whose methodology has been modified in 2005 due to several reasons:

- The need to adapt to the new demographic and labour reality of Spain, due mainly to the increase in the number of foreign residents
- The incorporation of new European regulations in accordance with the norms of the European Union Statistical Office (EUROSTAT)
- The introduction of improvements in the information gathering method (changes in questionnaires and interviews carried out by the CATI method).

The shift-share analysis has been carried out during the period 1999-2004 leading to some interesting findings related to sectoral and spatial patterns.

[1] According to the methodology of our study, Ceuta and Melilla, the Balearic and Canary Islands are excluded since the definition of neighbouring region does not exactly fit these cases.

The detection of spatial autocorrelation has been carried out through the usual tests, leading to the conclusion that a positive spatial autocorrelation exists between the Spanish provinces[2].

Our study focuses on the competitive effect in order to empirically verify the fulfilment of the additivity condition. Table 1 summarizes the results for this effect according to different considered procedures.

Table 1: Aggregation of the competitive effect by regions in different models

Models	**Agriculture**	**Industry**	**Construction**	**Services**
Model (1.11) [Nazara and Hewings (2004)]	-16.389	-165.8	34.9	70.15
Model (1.14)	29.262	251.694	-80.413	-211.446
Model (1.15)	21.670	240.823	-46.809	-182.338

As previously stated, the spatial shift-share analysis of Nazara and Hewings does not satisfy the property of additivity, since $\sum_{j=1}^{R} X_{ij}\left(r_{ij} - r_{ij}^{v}\right) \neq 0$.

On the other hand, it should be noted that the results of models (1.14) and (1.15) are not strictly comparable with those previously obtained, since the decomposition criteria are not the same. In this case the expected variation of the employment during the period 1999-2004 is decomposed into three different effects according to the spatially modified sectoral-regional rates of growth: $\tilde{R} = WR$ R being the matrix of growth rates and W the matrix of binary spatial weights. The spatial aggregation leads to a non-null result, as is shown in table 1.

Regarding the model (1.17) derived from the expected employment $X_{ij}^{v*} = \sum_{k \in V} w_{jk} X_{ik}$, the spatial net competitive effect and the spatial locational effect result in zero.

In order to avoid the previously described problems related to changes in employment we have also computed the results obtained when spatially modified sectoral weights are considered: $\dfrac{\sum_j X_{ij}^{v*}}{\sum_i \sum_j X_{ij}^{v*}} = \dfrac{X_i^{v*}}{X^*}$ for both the spatial net competitive effect (SNCE*) and the spatial locational effect (SLE), thus satisfying the additivity condition.

[2] More specifically, the analysis of the employment rates referred to the initial year leads to a Moran´s I z-value=5.987 with null p-value. Similar results (z=4.822, p=0) are obtained when analysing the employment rate of growth in the considered period, also leading to the rejection of the non-autocorrelation hypothesis.

The results of the spatial net competitive effect for European territorial units NUTS-III at the Spanish level are summarized in table 2.

Table 2: Spatial net competitive effect (SNCE*) by sectors and NUTS III Spanish provinces, according to Model 1.20

	NUTS III	Agriculture	Industry	Construction	Services	TOTAL
1	Álava	-3.442	2.816	-5.978	-6.217	-12.821
2	Albacete	2.242	-1.137	-1.468	-4.229	-4.592
3	Alicante	12.361	-2.932	28.278	14.743	52.449
4	Almería	1.490	17.148	12.819	14.173	45.629
5	Asturias	-4.186	-4.694	-8.477	-3.531	-20.888
6	Ávila	0.438	2.946	0.198	-7.672	-4.090
7	Badajoz	3.109	0.007	-5.129	-6.818	-8.832
8	Barcelona	-27.497	-39.795	-1.667	-49.333	-118.292
9	Burgos	-0.437	1.331	-5.804	-1.630	-6.540
10	Cáceres	1.087	4.519	-3.720	-9.331	-7.444
11	Cádiz	-0.169	-1.639	2.363	1.316	1.870
12	Cantabria	-0.944	2.891	-4.154	11.421	9.213
13	Castellón de la Plana	3.908	4.130	5.229	-15.592	-2.325
14	Ciudad Real	1.001	1.609	-1.863	-5.571	-4.824
15	Córdoba	1.044	0.856	0.028	11.746	13.673
16	Coruña (A)	-8.410	7.036	-10.008	-3.887	-15.269
17	Cuenca	1.561	-1.014	0.308	-2.631	-1.776
18	Girona	-2.193	3.397	2.469	14.021	17.694
19	Granada	4.135	3.335	-2.896	13.656	18.230
20	Guadalajara	0.540	1.539	0.019	9.035	11.133
21	Guipúzcoa	-9.348	-2.829	-12.275	-4.139	-28.591
22	Huelva	1.241	-10.282	2.195	2.597	-4.249
23	Huesca	0.194	2.827	-0.833	-4.626	-2.438
24	Jaén	-1.559	-5.266	-5.300	-1.503	-13.629
25	León	-2.481	0.924	-3.067	-25.058	-29.682
26	Lleida	-0.011	3.920	-4.440	-2.298	-2.828
27	Lugo	-1.611	9.701	-5.184	-3.732	-0.826
28	Madrid	39.135	-5.642	35.504	72.853	141.850
29	Málaga	11.766	-0.444	19.460	-10.354	20.427
30	Murcia	8.972	20.136	12.491	0.858	42.456
31	Navarra	-1.383	1.735	-5.520	-7.878	-13.045
32	Orense	0.423	-2.692	-3.921	-17.392	-23.581
33	Palencia	-0.704	2.899	-0.184	-4.834	-2.823
34	Pontevedra	-7.854	7.224	-4.732	-4.292	-9.654
35	Rioja (La)	-0.605	0.848	1.583	5.183	7.010
36	Salamanca	1.939	-0.570	1.009	-7.490	-5.112
37	Segovia	0.573	3.897	-1.491	-6.153	-3.174
38	Sevilla	4.675	-5.318	6.442	29.941	35.740
39	Soria	-0.563	0.395	-0.168	-4.695	-5.031
40	Tarragona	-2.013	14.323	-0.483	-8.225	3.602
41	Teruel	0.807	0.088	0.361	-6.077	-4.821
42	Toledo	-0.734	1.067	-0.224	3.501	3.610
43	Valencia	-10.507	6.763	-2.893	44.493	37.855
44	Valladolid	-5.284	-2.494	-3.247	-13.210	-24.234
45	Vizcaya	5.465	-4.545	-18.209	-19.005	-36.293
46	Zamora	-1.022	12.288	-2.334	1.081	10.013
47	Zaragoza	1.028	-2.708	-0.598	-7.304	-9.581
	Total	16.175	48.595	4.488	-24.090	45.167

The comparison of these results with the values of the Esteban-Marquillas model (1.3), show coincidences in the signs of the computed effects, since the same rates of growth are applied. Nevertheless, as is shown in table 3, some outstanding changes are found in the magnitude of the effects due to the use of the new spatially modified structure of sectoral weights.

Table 3: Ratios SNCE/SLE**

	Agriculture	Industry	Construction	Services
SNCE**/SLE	1.058	0.998	1.004	0.993

More differences are detected in the spatial locational effect. For instance, the spatial locational effect is positive when the evolution of sector i in region j is better than the evolution of this sector $\left(r_{ij} - r_i\right) > 0$ and the employment is above the expected value based on its neighbouring links $\left(X_{ij} - X_{ij}^{v**}\right) > 0$. An important redistribution of the locational effect is produced by the application of the new spatially modified structure. Table 4 summarizes the values of the spatial locational effect based on the new spatially modified structure of sectoral weights according to model (1.20).

Table 4: Spatial locational effect (SLE*) by sectors and NUTS III Spanish provinces, according to Model 1.20

	NUTS III	Agriculture	Industry	Construction	Services	TOTAL
1	**Álava**	1.710	1.743	1.416	0.676	5.545
2	**Albacete**	0.684	-0.029	0.044	0.178	0.878
3	**Alicante**	-4.493	-0.397	-0.070	0.001	-4.959
4	**Almería**	2.391	-12.037	2.187	0.114	-7.346
5	**Asturias**	-1.109	0.034	-0.079	0.116	-1.038
6	**Ávila**	0.426	-1.221	0.077	0.373	-0.346
7	**Badajoz**	3.164	-0.003	-1.531	0.277	1.907
8	**Barcelona**	22.763	-18.079	0.380	0.565	5.629
9	**Burgos**	-0.024	0.424	-0.536	0.216	0.081
10	**Cáceres**	0.585	-2.525	-2.304	-0.148	-4.392
11	**Cádiz**	-0.020	0.507	0.524	0.069	1.080
12	**Cantabria**	-0.061	0.219	-1.029	-0.886	-1.758
13	**Castellón de la Plana**	-0.301	1.990	-0.426	2.212	3.474
14	**Ciudad Real**	0.410	-0.348	-1.012	0.403	-0.546
15	**Córdoba**	0.941	-0.135	0.001	-0.816	-0.008
16	**Coruña (A)**	-6.871	-0.958	-1.030	0.291	-8.567
17	**Cuenca**	3.237	0.356	0.087	0.506	4.186
18	**Girona**	0.718	0.476	0.194	-0.285	1.103
19	**Granada**	3.284	-1.709	-0.695	0.459	1.339
20	**Guadalajara**	0.026	0.029	0.004	-0.473	-0.413
21	**Guipúzcoa**	6.243	-1.686	2.303	0.363	7.223
22	**Huelva**	1.578	1.719	0.366	-0.346	3.318
23	**Huesca**	0.186	-0.618	-0.008	0.223	-0.217
24	**Jaén**	-2.621	1.179	-0.117	0.211	-1.348
25	**León**	-1.005	-0.167	-0.043	-0.205	-1.421
26	**Lleida**	-0.011	-1.347	-2.009	0.214	-3.153
27	**Lugo**	-6.451	-5.410	0.742	1.089	-10.031
28	**Madrid**	-34.692	1.155	-5.538	15.328	-23.748
29	**Málaga**	-5.255	0.236	5.456	-1.977	-1.540
30	**Murcia**	7.328	-3.493	0.265	-0.041	4.059
31	**Navarra**	0.034	0.777	0.461	1.076	2.348
32	**Orense**	0.269	0.329	-0.599	1.138	1.138
33	**Palencia**	-0.462	-0.203	0.024	0.175	-0.465
34	**Pontevedra**	-7.784	0.234	-0.338	0.642	-7.246
35	**Rioja (La)**	-0.188	0.483	-0.130	-1.148	-0.983
36	**Salamanca**	0.431	0.277	0.061	-0.962	-0.193
37	**Segovia**	0.423	-1.139	-0.248	0.136	-0.827
38	**Sevilla**	0.549	1.691	-0.381	3.141	5.000
39	**Soria**	-0.799	0.029	0.034	0.800	0.063
40	**Tarragona**	-0.328	-1.643	-0.183	0.388	-1.765
41	**Teruel**	0.717	0.016	0.041	1.184	1.958
42	**Toledo**	-0.149	0.281	-0.090	-0.652	-0.611
43	**Valencia**	4.052	0.890	-0.008	0.141	5.075
44	**Valladolid**	1.524	-0.375	0.122	0.112	1.384
45	**Vizcaya**	-4.573	-0.921	0.047	-0.703	-6.150
46	**Zamora**	-2.335	-8.387	-1.127	-0.151	-12.001
47	**Zaragoza**	-0.312	-0.841	0.204	0.065	-0.884
	Total	-16.175	-48.595	-4.488	24.090	-45.167

The fulfilment of the additivity is observed in the last rows of tables 2 and 4, while table 5 summarizes the ratio between the spatial locational effect (SLE**) and the locational effect (LE) of Esteban-Marquillas (1972).

Table 5: Ratio SLE/LE**

	NUTS III	Agriculture	Industry	Construction	Services	TOTAL
1	Álava	1.125	1.003	1.019	0.939	1.033
2	Albacete	0.847	1.093	1.170	0.857	0.855
3	Alicante	1.179	1.016	-1.296	-0.006	1.166
4	Almería	0.967	0.997	0.975	8.070	1.000
5	Asturias	0.828	0.769	0.681	0.824	0.817
6	Ávila	0.946	0.995	0.989	0.874	1.265
7	Badajoz	0.949	0.995	0.986	0.852	0.906
8	Barcelona	1.071	1.005	1.020	0.620	1.240
9	Burgos	0.494	1.007	0.955	0.950	2.018
10	Cáceres	0.907	0.996	0.993	1.794	1.023
11	Cádiz	0.682	0.993	0.981	1.154	1.004
12	Cantabria	0.541	1.029	0.983	0.917	0.918
13	Castellón de la Plana	3.512	1.004	1.057	0.953	0.911
14	Ciudad Real	0.881	0.990	0.992	0.912	1.179
15	Córdoba	0.942	0.987	0.923	0.908	0.241
16	Coruña (A)	0.937	0.984	0.959	0.914	0.945
17	Cuenca	0.974	0.994	0.985	0.965	0.975
18	Girona	1.202	1.016	0.947	0.743	1.243
19	Granada	0.935	0.996	0.982	1.264	0.923
20	Guadalajara	0.469	1.127	0.981	0.882	0.918
21	Guipúzcoa	1.090	1.004	1.024	0.926	1.080
22	Huelva	0.958	0.987	0.974	0.950	0.976
23	Huesca	0.946	0.990	0.681	0.873	1.183
24	Jaén	0.968	0.990	0.835	0.952	0.939
25	León	0.880	0.988	0.764	6.982	1.017
26	Lleida	0.950	0.994	0.990	0.930	0.996
27	Lugo	0.986	0.996	1.031	0.976	0.990
28	Madrid	1.066	0.990	1.029	1.035	1.083
29	Málaga	1.141	0.996	0.985	1.038	2.102
30	Murcia	0.937	0.988	0.829	0.872	0.890
31	Navarra	-0.795	1.005	1.055	0.951	1.021
32	Orense	0.920	0.983	0.972	0.903	0.895
33	Palencia	0.922	0.970	1.034	0.837	0.975
34	Pontevedra	0.947	1.071	0.942	0.955	0.943
35	Rioja (La)	0.850	1.004	1.056	0.969	0.938
36	Salamanca	0.801	0.996	0.933	1.058	6.935
37	Segovia	0.931	0.993	0.974	0.759	1.078
38	Sevilla	0.681	0.993	1.080	1.072	0.983
39	Soria	0.963	1.030	1.022	0.960	0.994
40	Tarragona	0.747	0.982	0.989	0.870	0.954
41	Teruel	0.942	1.012	0.963	0.965	0.957
42	Toledo	0.787	1.008	0.989	0.964	0.899
43	Valencia	1.167	1.017	0.392	-0.823	1.221
44	Valladolid	1.236	1.015	1.131	0.547	1.176
45	Vizcaya	1.070	1.011	-1.448	1.234	1.063
46	Zamora	0.976	0.997	0.991	0.952	0.992
47	Zaragoza	1.222	1.007	1.013	0.558	1.144
	Total	1.076	1.015	0.961	0.998	1.040

6. Concluding Remarks

This paper summarizes some alternative ways to include spatial interrelations in a shift-share model. Since these alternatives are usually based on the definition of spatial weights, each proposal leading to different results, some rules have been specified in order to avoid wrong specifications.

The inclusion of spatial relations in the well-known shift-share identity allows the use of spatial econometrics techniques thus providing a wide variety of possibilities in regional analysis.

Furthermore, the introduction of a spatially modified competitive effect can be useful for understanding the effects on employment of some regional policies, that also affect their neighbouring regions.

The empirical application of these models to regional Spanish employment shows that the higher competitive effects are found in the agricultural and construction sectors, while industry and services lead to lower results.

More outstanding changes have been found in the locational effect, whose signs could be affected by the proposed specification for spatial relations.

Finally, we must emphasize that these procedures present certain limitations, mainly related to their deterministic character and also to the arbitrariness inherent in considered spatial relations. Therefore further research needs to be carried out, including both stochastic formulation and an exhaustive study of the spatial weights matrices.

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