TOWARDS REGIONAL GROWTH DECOMPOSITION WITH NEIGHBOR'S EFFECT: A NEW PERSPECTIVE ON SHIFT-SHARE ANALYSIS

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Towards Regional Growth Decomposition with Neighbor's Effect: A New Perspective on Shift-Share Analysis[1]

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Abstract

The goal of this paper is twofold. The first goal is to incorporate spatial structure within shift-share analysis, to take into account interregional interaction in the decomposition analysis. Secondly, this paper develops a taxonomy of regional growth rate decompositions. A taxonomy of the spatial structure is presented; it comprises twenty alternative decomposition structures, including the original standard shift-share analysis as well as six alternative structures outlined in the taxonomy for non-spatial structures.

1. Introduction

"Damned be him who cries, 'hold! enough!'" (Shakespeare)

The appearance of yet another paper offering to extend shift-share analysis will be greeted by many with disdain, since the prevailing sentiment might suggest "enough already!" The present paper does in fact offer an extension but in a way that has not been considered in the literature and reflects some currently prevailing ideas about the way in which spatial effects should be considered in regional analysis. For some unexplained reason, issues of spillover, spatial contamination, spatial competition and complementarity have not been broached in the shift-share literature. This paper offers a modest opening to this new line of inquiry.

Shift-share analysis (Dunn, 1960) has been a very popular tool in regional analysis. Its wide usability stems from its simplicity in capturing the underlining changes in the variables under consideration. Stevens and Moore (1980) advance two factors to account for its popularity. First,

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the procedure is technically simple. Shift-share analysis requires only relatively modest amounts of data that are generally accessible , making the resulting analysis fast and reasonably accurate. Secondly, while the technique has been criticized, it has not yet been subjected to critical empirical tests, which might raise serious doubts about the accuracy of the any forecasts based on the resulting decompositions. The criticism notwithstanding, the underlying ideas of shift-share analysis have appeared in many econometric models of regional economies.

The purpose of this paper is twofold. First, this paper proposes an extension of shift-share analysis to include the spatial structure of regions. One way to carry out such a task will be explored in section three, following a brief review of the methodology in section two. The discussion considers how spatial structure might be depicted with the use of a spatial weight matrix. Subsequently, it will be shown how this weight matrix can be used to arrive at a model of a spatial shift-share decomposition. Also to be introduced in this section is the notion of simple and combined effects, leading to a step-by-step decomposition. Secondly, this paper proposes a taxonomy of regional growth decompositions; this will be the topic addressed in section four. As a point of departure, the taxonomy of the non-spatial model will be considered. It will be shown later than one of the decomposition structures in this taxonomy is nothing but the standard shift-share analysis. Subsequently, the taxonomy of spatial models is examined. The incorporation of the spatial context boosts the number possible decompositions to twenty alternative structures. Here it will be shown that both the standard shift-share model, as well as six alternative structures in the non-spatial decomposition, can be identified within the taxonomy of the spatial decompositions. The paper concludes with some reflective commentary.

2. Shift-Share Analysis

In the standard framework, shift-share analysis decomposes a region's sectoral growth into three effects: national, industry-mix, and regional-shift effects. In this paper, employment will be used as the variable of interest to illustrate this shift-share decomposition. Let g denote the regional employment growth, i.e., $g = (e^{t+1} - e^{t}) / e^{t}$ where e is regional employment and superscript t denotes time. Further, let G denote the national counterpart, i.e., $G = (E^{t+1} - E^{t}) / E^{t}$ where E is national employment. The appearance of subscript *i* will denote a reference to a specific sector *i*, and the absence of subscript to a variable for the whole sector. Therefore, g is the growth rate of regional employment of all sectors, while g_i signifies the growth rate of regional employment in sector *i*. A similar distinction applies to G and G_i. A point of departure for the shift-share analysis is the following equation:

$$\Delta e_i = (growth)e_i \tag{1}$$

The shift-share analysis decomposes the *growth* into several parts.

$$\Delta e_i = \left[G + (G_i - G) + (g_i - G_i)\right] e_i \tag{2}$$

The national effect is shown by Ge_i, i.e., the number of additional employment had the regional employment in sector *i* followed the national all-sector growth rate. The industry-mix effect is shown by $(G_i - G)e_i$, i.e., the number of additional employment that is due to national growth in sector *i*. This effect will be positive if the national sector *i* grows faster than the average growth of total employment in the country. Finally, the regional shift effect is shown by $(g_i - G_i)e_i$. This is the number of additional regional employment that results from the region specializing in sector *i*.

There have been many reviews and extensions of shift-share use, especially in regional analysis. Rosenfeld (1959) raises a problem that the regional shift (competitive) effect is not only affected by the special dynamism of the sector, but is also affected by the specialization of the regional employment in the activity. In response to that problem, Esteban-Marquillas (1972) propose the use of a homothetic employment in sector *i* and region *r*, leading to the identification of the allocation effect. Further modifications proposed by Arcelus (1984), as well as by Haynes and Machunda (1987), accentuate the importance of the homothetic employment and allocation effect. Several other theoretical advancements of the shift-share analysis include Klaasen and Paelinck (1972), Sakashita (1973), Theil and Gosh (1980), Haynes and Dinc (1997), Dinc and Haynes (1999).

Attempts to put the analysis in a probabilistic framework were made by, among others, Buck and Atkins (1976), Berzeg (1978, 1982), and Patterson (1991).

Shift-share analysis is meant to analyze the performance of a specific region over a period of time. What is missing so far from this analysis is the recognition of spatial structure, within which a particular region is located, as an important element in the growth accounting. It goes without saying that regions are interconnected one with another. This is exactly a logical consequence of the fact that regions are spatial sub-units within a country. It is important, once again to recall what Isard (1960) argued, that "… although [we] may be concerned with a particular region, [we] investigate further… [because] … To any given region are transmitted the ups and downs of regions which are its neighbors" (words in square brackets added). The general idea here is that the decomposed effects are not spatially independent; the performance of surrounding regions, or regions with similar structures, or regions that are dominant trading partners will all have an influence on the growth performance of a particular region. The current decomposition posits a strictly hierarchical view of influence – the nation influences that region but one region does not influence another region (i.e., there is no horizontal interaction).

3 Shift-share with spatial structure

3.1 Incorporating spatial structure

Consider again equation (2), that serves as the basic formulation of the shift-share analysis. This formulation directly evaluates the accomplishment of a particular region in comparison to the national performance. Two important elements that are used for the comparison are G and G_i. In retrospect, however, despite the existence of a direct regional-national comparison, shift-share analysis still considers a region as an independent identity with respect to other regions in the country. In other words, there is no recognition of interregional interaction, whereas in fact, a particular region does not exist in isolation from other regions and a single region's economic performance may depend in large part on the performance of a subset of other regions more than on the nation as a whole. This notion needs to be included in the shift-share analysis. However, before the proposed model is presented, it is in order to discuss first how the regional interaction can be depicted.

Regional interaction here is captured in an $(R \times R)$ weight matrix, where *R* is the number of regions in the system. This matrix, *W,* with a typical element of w_{rs} denotes the degree of interaction between two regions *r* and *s*. Naturally, the r^{th} row shows the structure of this region's interaction with other regions in the system. A zero entry means that the two regions have no interaction, and a non-zero entry means that two regions *r* and *s* interact.[2] It is standard practice to set the main diagonal elements, i.e., w_{rs} where $r = s$, equal to zero.

The important question to address is how to quantify this interaction, i.e., what are the appropriate variables to represent the degree of interaction in a regional system. There are two broad classes to consider: physical geography and economic. In terms of physical geography, it is important to refer to the first law of geography (Tobler, 1979) stating that all locations on a map are interrelated, with closer places being more so than distant ones. Thus, interregional interaction is perceived as having an inverse relationship with geographic distance. In actual applications, for instance, the distance can be measured between the major cities or centroids in two regions. Another geographical variable that is also of common use to represent the interaction is the length of shared common boundaries. The longer is the shared common boundary between two regions, the higher is the perceived or potential interactions between them. A different class of variables denoting the interaction makes use of economic variables, leading to measures of economic distance. Here interaction is measured by way of economic outcomes or potentials. For instance, when interaction is measured by trade activities, two regions *r* and *s* may be economically closer than *r* and *t* although *t* may be geographically located somewhere in between the first two.

One way to present the weight matrix *W* is in its row-standardized version. The matrix is transformed in such a way that each row sums to unity. Let us name this row-standardized weight matrix by $\tilde{W}$. In this case, an entry of $\tilde{w}_{rs} = 0.2$, for example, means that 20 percent of region *r*'s interaction is with region *s*. The row-standardized weight matrix is useful to obtain the spatial lag variable, which posits a central role in the spatial shift-share analysis below.

[2] No indication is provided of the strength of the interaction in this specification

3.2 Spatial structure in a shift-share decomposition

Consider calculating the all-sector employment growth rate for neighbors of a particular region *r*, denoted by $\vec{g}$. It is given by

$$\vec{g} = \frac{\left(\sum_{s=1}^{R} \tilde{w}_{rs} e^{t+1} - \sum_{s=1}^{R} \tilde{w}_{rs} e^{t} \right)}{\sum_{s=1}^{R} \tilde{w}_{rs} e^{t}} \tag{3}$$

where $\tilde{w}_{rs}$ is the element of row-standardized weight matrix $\tilde{W}$ denoting the intensity of *r*'s interaction with region *s*, where G_i; e^t and e^{t+1} are the all-sector employment for time *t* and *t*+1, respectively. For a specific sector *i*, the growth rate for the *r*'s neighbor is given by

$$\vec{g}_i = \frac{\left(\sum_{s=1}^{R} \tilde{w}_{rs} e_i^{t+1} - \sum_{s=1}^{R} \tilde{w}_{rs} e_i^{t} \right)}{\sum_{s=1}^{R} \tilde{w}_{rs} e_i^{t}} \tag{4}$$

where all variables are as previously defined and e_i^t and e_i^{t+1} are the all-sector employment for time *t* and *t*+1, respectively.

One way to incorporate the spatial effect in the shift-share analysis is by replacing the term G_i in equation (2) with $\vec{g}_i$, providing:

$$(growth)_i = \left[G + (\vec{g}_i - G) + (g_i - \vec{g}_{\boldsymbol{i}}) \right] \tag{5}$$

The main difference between this decomposition (5) with the standard one (2) is in the use of the spatial lag variable $\vec{g}_i$, instead of the usual G_i. The latter denotes the growth rate of sector *i*'s at the national level, while the former denotes the growth rate of sector *i*'s in the neighborhood regions. The three effects are as follows: the first component of the right hand side is the usual national effect, the second part of the right hand side denotes the difference between the sectoral growth rates for the neighbors and the all-sector national growth. This effect can be called the *nation-region industry-mix effect*. Note that the industry-mix here is different from that defined in the standard shift-share analysis. In the standard form, the industry mix effect is denoted as the difference between the region's sector *i* with the national growth. A positive number here will signify a fact that the sector *i* in the neighbor regions grows more rapidly than the national total. This effect should capture the positive impact of neighbors' specialization in a particular sector to the study region.[3] The third part is sector *i*'s growth difference between the particular region in study with its corresponding neighbors. This effect can be called the *neighbor-region sectoral regional-shift effect*. A positive value here signifies a case where sector *i* in the region in study exceeds that in its corresponding neighbors. In a sense, this effect captures the negative impact of neighbors' specialization in sector *i*.[4]

Next, consider two classes of effects: simple effect and combined effect. The simple effect is an effect that measures differences of only one aspect of the growth component. In the non-spatial shift-share, there are two components that can form the simple effect. The first of these is the sectoral differences; an example for this is the above national industry-mix effect, which is given by $(G_i - G)$. The effect measures one difference: between sector *i* and all sectors, both at the same national level. The second component is the spatial-unit differences, i.e., between nation and region. The other effect in the standard shift-share analysis, namely the regional shift effect $(g_i - G_i)$ is an example of this. This effect measures the difference between the regional and national growth rates, both for the same sector *i*. These two examples also show us that the standard shift-share analysis consists of merely simple effects. The combined effect, on the other hand, measures differences of more than one aspect at the same time. An example of this is the national-neighbor industry-mix effect, $(\tilde{g}_i - G)$, given in the spatial shift-share decomposition (5). It measures at the same time the

[3] The notion how neighbours positively affect the study region is beyond the scope of the shift-share analysis. However, as a side note, the notion can be materialized through agglomeration process.

[4] Again, how neighbour can bring negative effect to the study region is beyond the shift-share analysis. However, one may imagine a situation where the two regions are in competition one with another.

sectoral difference (between sector *i* and all sectors) as well as the spatial-unit difference (between the neighbors of region *i* and the nation). Hence, the spatial units in the spatial shift-share analysis comprise the nation, the region and the neighbor.

It is argued here that a combined effect can be expressed in terms of sequence of simple effects. This process is referred to as the step-by-step decomposition. Applying this decomposition to the national-neighbor industry-mix effect, $(\vec{g}_i - G)$, results in:

$$(\vec{g}_i - G) = (\vec{g}_i - \vec{g}) + (\vec{g} - g) + (g - g_i) + (g_i - G_i) + (G_i - G) \tag{6}$$

where all variables are as previously defined. The step-by-step decomposition produces five effects as follows:

1. *Neighbor industry-mix effect*, i.e., $(\vec{g}_i - \vec{g})$. This effect denotes sector *i*'s growth in comparison to all sectors in the neighboring regions. A positive (negative) effect signifies the fact that sector *i* grows faster (slower) than the all sectors in the neighboring regions.
2. *Neighbor-nation regional-shift effect*, i.e., $(\vec{g} - g)$. This effect denotes the difference in growth of all sectors between the region in study and its neighbors. A positive (negative) effect means that all sectors in the neighboring regions grow faster (slower) than the region in study.
3. *Regional industry-mix effect*, i.e., $(g - g_i)$. This effect denotes sector *i*'s growth in comparison with all sectors in the particular region in study. A positive (negative) effect signifies the fact that sector *i* grows slower (faster) than the all sectors in that region.
4. *Regional-shift effect*, i.e., $(g_i - G_i)$. This effect is identical to the one that appears in the standard shift-share analysis, as shown in equation (2). For better clarification, this effect will be referred to as *regional-national sectoral regional-shift effect*. The term region-nation is used to denote the source of the shift, i.e., between sector *i*'s regional and national growth rates.
5. *Industry-mix effect*, i.e., $(G_i - G)$. Again, this effect is identical to the one appearing in the standard shift-share analysis, as shown in equation (2). Henceforth, this effect will be called the *national industry-mix effect*.

As a final observation on the above decomposition, two adjacent effects can be put together without changing the overall outcome. The first and the second effect can be combined to yield $(\vec{g}_i - \vec{g}) + (\vec{g} - g) = (\vec{g}_i - g)$. The result combines the neighbor industry-mix and neighbor-region regional-shift effect. Likewise, the third and the fourth effects can be put together, providing $(g - g_i) + (g_i - G_i) = (g - G_i)$. It combines the regional industry-mix and region-nation sectoral regional-shift effects.

On the other hand, the neighbor-region sectoral regional-shift effect in equation (6), given by $\left(g_i - \vec{g}_i\right)$, is itself a simple effect. Thus, there is no immediate need to express it in terms of a series of other simple effects.[5]

4 A taxonomy of regional growth decomposition

This section outlines the taxonomy of shift-share analysis. The non-spatial model will be discussed first and it will be shown here that the standard shift-share analysis is just one possible outcome of several regional growth decomposition structures. Subsequently, decomposition involving spatial considerations will be reviewed. Again, it will be shown that the spatial shift-share as discussed above is just one of several possible decompositions of regional growth.

3.1 Taxonomy of non-spatial model

Consider again the standard shift-share analysis as shown in equation (2):

$$growth = G + (G_i - G) + (g_i - G_i) \tag{7}$$

[5] Still if desired, one can express a simple effect in terms of series of other simple effects. The analogue is going around the block to visit the apartment across your hall. Still, if one does so for the neighbor-region sectoral regional-shift effect, he/she will find the following decomposition structure $\left(g_i - \vec{g}_i\right) = \left(g_i - G_i\right) + \left(G_i - G\right) + \left(G - g\right) + \left(g - \vec{g}\right) + \left(\vec{g} - \vec{g}_i\right)$. Note that all of the relevant effects here resembles those in the equation (6), except the new effect $\left(G - g\right)$. We can call this the *national-regional all-sector regional-shift effect*. Positive effect here reflects a situation where the national growth rate is greater than the regional counterpart, for the whole sector

There are three different effects: national, national industry-mix, and regional-national sectoral regional-shift effects. The decomposition involves four relevant variables: G, G_i, g and g_i; but in a decomposition, only three variables are involved; in equation (2), these three are G, G_i, and g_i. Two sets of G and G_i cancel each other out, leaving g_i which is nothing but the *growth* that is meant to be decomposed in the first place. Note further that, because two sets of G and G_i cancel each other out, then a position of either one will determine the positions of other relevant variables. In equation (2) above, with the intention to single out the national effect, the variable G is positioned in the first effect. It should not be hard to see that given G occupying the first effect, the position of G_i in the whole decomposition is determined: G_i will have to occupy the outer positions of the second and third effects combined.

Further note that, still by singling out the G effect as shown above, there is another possible variable to occupy the outer positions of the second and third effects combined. This variable is g; therefore, the decomposition will now become:

$$growth = G + (g - G) + (g_i - g) \tag{8}$$

Now, aside from the first, national effect, there are two different effects that do appear in (6). The second effect, denoted by $(g - G)$ can be called the negative of the *national-regional all-sector regional-shift effect*. The third effect, denoted by $(g_i - g)$ is the *negative of own-region industry-mix effect*.

The above two alternative decompositions, shown by equations (7) and (8), are obtained by isolating the national effect to occupy the first effect. An alternative set of decompositions can also be obtained by singling out variables other than G. One can isolate the effect of G_i, and g. For each of them, there will be two possible decomposition structures. Thus, there are altogether six alternative decomposition structures. They are presented in Table 1.[6]

[6] Although we have established that the national industry mix and the national-regional sectoral regional-shift effect in the standard shift-share formulation are simple effects, one can still carry out the step-by-step decomposition to them. If one does so for the regional-national sectoral regional-shift effects, one will get $(g_i - G_i) = (g_i - g) + (g - G) + (G - G_i)$. These effects are the regional industry-mix, the negative of national-regional all-sector regional-shift, and the national

<<insert table 1 here>>

4.2 Taxonomy of spatial model

With the spatial model, there are six relevant variables: G, G_i, g, g_i, $\vec{g}$, and $\vec{g}_i$. There are three pairs of interactions between sector *i* and all sectors on three different spatial units: region, neighbor, and nation. The last two variables signify the growth rate in the neighboring regions: for all sectors, and for sectors *i*, respectively.

Following the above logic, then there are five variables that are possible to single-out, i.e., occupying the first effect in the decomposition; they are G, G_i, g, $\vec{g}$, and $\vec{g}_i$. Once the first effect is determined, then there are three variables left to occupy the outer positions of the second and the third effects combined. For the sake of comparison with earlier results, this decomposition technique will be illustrated for the non-spatial perspective. To begin, the national effect will be isolated, i.e., G will be put in the first position. Then, there are four possible variables to occupy the outer positions of the second and third effects combined - g, G_i, $\vec{g}$, and $\vec{g}_i$. Therefore, there are 20 possible decomposition structures that can be made by acknowledging the importance of spatial structure. All of these decomposition structures, together with names of the relevant effects, can be found in table 2. Note that the first two structures in each of the models D, E and F, match the six decomposition structures of the non-spatial model. It is also shown in the table that model D.1 is identical to model A.1, that is the standard shift-share analysis. The decomposition structure presented earlier in section 3.2 is model D.3.

<<insert table 2 here>>

The decision to choose the appropriate spatial model can be carried out by observing several aspects. As has been shown earlier, a particular interest in the role of interregional interaction will reduce the feasible decomposition to 14 structures. Another aspect to consider is the kind of effect to be

industry-mix effects. These three effects are exactly what are formulated by Arcelus (1984) under different names. The first and the third effects, i.e., $(g_i - g) + (G - G_i)$, is named the regional industry-mix effects and denoted by RI_{ij}, while the one in the middle, i.e., $(g - G)$ is called the regional growth effect and denoted by R_{ij} in Arcelus (1984:6). Naturally, each of industry-mix and regional-shift effects shown in Table 1 can be further decomposed using the step-by-step method.

isolated; the singled-out effect is an effect by which the regional sectoral growth is perceived to increase. The standard shift-share always assumes an isolation of the national all-sector growth. If the isolation of other effects is preferred, the alternative is shown in models E to H.

The other aspect to consider is the combination of effects in the decomposition structures. For example, the inclusion of the industry-mix as well as the regional-shift effects would require the used of one of seven models: D.3, D.4, F.3, F.4, H.1, H.2 and H.3. The other structures contain either only industry-mix or regional-shift effects. Of course, a structure containing only regional-shift effects may still be of use to reveal the changes in regional economic structure. For an example, consider model E.3. All effects here pertain specifically to characteristics of sector *i*. One can see that the regional shift in this model takes place hierarchically, i.e., between the region and the neighbor $(g_i - \vec{g}_i)$, between the neighbor and the nation $(\vec{g}_i - G_i)$, and finally the national effect G_i.

The next viable aspect to consider is what kind of regional shift to examine: sectoral as oppose to overall (all-sector), or region-neighbor as opposed to region-nation. Referring to the seven structures that provide a combination of industry-mix and regional shift together, examination of sectoral regional-shift will yield three options - D.3, F.3, and H.2. The other four examine the region-shift effects in the context of the all sectors. If there is a preference to examine the regional-shift effects involving the relationship between the region and the nation, the choice will be limited to model H.2 only. Other than H.2, the decomposition contains the regional-shift effects involving the region and the neighbor.

Another aspect to consider, naturally, is the composition of the industry-mix component. In similar fashion to the options for the regional-shift, various types of industry-mix are possible and may be a basis to determine the appropriate decomposition structure to use.

5 Concluding Remarks

This paper has accomplished two tasks. First, it has provided a way to incorporate spatial structure within the shift-share analysis so that it will be possible to take into account interregional interaction in the decomposition analysis. The inclusion of interregional interaction makes it possible to analyze the regional performance, not only in terms the national growth rates as the benchmark, but also in terms of those of the 'neighboring' regions. Of course, the notion of neighbor goes beyond that of physical contiguity, and can include those in economic sense. Using the step-by-step decomposition technique, it is still possible to analyze the standard shift-share effects in the spatial shift-share analysis.

This paper then further moved to the elaboration of the taxonomy of regional growth rate decomposition. To outline the taxonomy, the non-spatial model was presented and then elaborated with a spatial version that includes the spatial structure of regions in a country. In the taxonomy without spatial structure, consisting of six possible alternatives, the standard shift-share analysis is just one of several other alternative decomposition structures. In turn, in the taxonomy of the spatial structure, comprising twenty alternative decomposition structures, the original standard shift-share analysis is again reinvented. It is also shown that the six alternative structures under the non-spatial taxonomy are subset of the larger feasible decomposition structure under the taxonomy with spatial variables.

The advantages of these approaches lie in the possibility of incorporating spatial structure in decomposing the growth performance of a region by considering the idea of an explicit hierarchy of effects – national, surrounding regions and the region itself. Clearly, a great deal more empirical testing will be required to explore alternative presentations of the spatial structure; for example, the structure of interregional trade flows could be used to inform the structure of the spatial weight matrix. In this case, the spatial analysis will not be limited to nearest neighbor effects. The rapid growth in the set of tools available from spatial econometrics offers the opportunity to make significant advances in the presentation of shift share decompositions on the one hand and the incorporation of more flexible shift-share formulations in econometric models of regional systems.

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Table 1
Taxonomy of regional growth decomposition in non-spatial model

A. Isolating the national effect *G*

Model A.1 $growth = G + (G_i - G) + (g_i - G_i)$

Existing effects: national, national industry-mix, and the negative of national-regional sectoral regional shift effects

Model A.2 $growth = G + (g - G) + (g_i - g)$

Existing effects: national, negative of national-regional all-sector regional shift, and the own-region industry mix effects

B. Isolating the national sectoral effect G_i

Model B.1 $growth = G_i + (G - G_i) + (g_i - G)$

Existing effects: national sectoral, negative of national industry-mix, and the negative of national-regional industry mix effects

Model B.2 $growth = G_i + (g - G_i) + (g_i - g)$

Existing effects: national sectoral, negative of national-sectoral industry-mix, and the own-region industry mix effects

C. Isolating the regional effect *g*

Model C.1 $growth = g + (G - g) + (g_i - G)$

Existing effects: sectoral, national-regional all-sector regional shift, and the negative of national-regional industry-mix effects

Model C.2 $growth = g + (G_i - g) + (g_i - G_i)$

Existing effects: sectoral, national-regional industry-mix, and national-regional sectoral regional shift effects

Table 2

Taxonomy of regional growth decomposition in spatial model

Model	Growth decomposition model	Included effects
D	**Isolating the national effect *G***	
D.1	$growth = G + (G_i - G) + (g_i - G_i)$	(identical to model A.1)
D.2	$growth = G + (g - G) + (g_i - g)$	(identical to model A.2)
D.3	$growth = G + (\vec{g}_i - G) + (g_i - \vec{g}_i)$	National, negative of national-neighbor sectoral industry-mix, and negative of neighbor-region sectoral regional-shift effects
D.4	$growth = G + (\vec{g} - G) + (g_i - \vec{g})$	National, negative of national-neighbor regional shift, and negative of neighbor-region industry mix effects
E	**Isolating the national sectoral**	**effect G_i**
E.1	$growth = G_i + (G - G_i) + (g_i - G)$	Identical to model B.1
E.2	$growth = G_i + (g - G_i) + (g_i - g)$	Identical to model B.2
E.3	$growth = G_i + (\vec{g}_i - G_i) + (g_i - \vec{g}_i)$	National sector, negative of national-neighbor sectoral regional-shift, negative of neighbor-regional sectoral regional-shift effects
E.4	$growth = G_i + (\vec{g} - G_i) + (g_i - \vec{g})$	National sectoral, negative of national-neighbor industry mix, negative of neighbor-region industry mix
F	**Isolating the regional effect *g***	
F.1	$growth = g + (G - g) + (g_i - G)$	Identical to model C.1
F.2	$growth = g + (G_i - g) + (g_i - G_i)$	Identical to model C.2
F.3	$growth = g + (\vec{g}_i - g) + (g_i - \vec{g}_i)$	Regional, neighbor-region industry-mix, negative of neighbor-region sectoral regional-shift effects
F.4	$growth = g + (\vec{g} - g) + (g_i - \vec{g})$	Regional, neighbor-region all-sector regional-shift, negative of neighbor-region industry-mix effects

Table 2 (cont.)
Taxonomy of regional growth decomposition in spatial model

Model	Growth decomposition model	Included effects
G	**Isolating the sectoral neighbor effect** $\vec{g}_i$	
G.1	$growth = \vec{g}_i + (G - \vec{g}_i) + (g_i - G)$	Sectoral neighbor, nation-neighbor industry-mix, negative of nation-region industry mix
G.2	$growth = \vec{g}_i + (G_i - \vec{g}_i) + (g_i - G_i)$	Sectoral neighbor, nation-neighbor sectoral regional-shift, negative of nation-region sectoral regional-shift effects
G.3	$growth = \vec{g}_i + (g - \vec{g}_i) + (g_i - g)$	Sectoral neighbor, negative of neighbor-region industry mix, own-region industry-mix effects
G.4	$growth = \vec{g}_i + (\vec{g} - \vec{g}_i) + (g_i - \vec{g})$	Sectoral neighbor, neighbor industry-mix, negative of neighbor-region industry mix effects
H	**Isolating the neighbor effect** $\vec{g}$	
H.1	$growth = \vec{g} + (G - \vec{g}) + (g_i - G)$	Neighbor, nation-neighbor all-sector regional-shift, negative of nation-region industry-mix effects
H.2	$growth = \vec{g} + (G_i - \vec{g}) + (g_i - G_i)$	Neighbor, nation-neighbor industry mix, negative of nation-region sectoral regional-shift effects
H.3	$growth = \vec{g} + (g - \vec{g}) + (g_i - g)$	Neighbor, negative of neighbor-region all-sector regional-shift, own-region industry-mix effects
H.4	$growth = \vec{g}_i + (\vec{g} - \vec{g}_i) + (g_i - \vec{g})$	Neighbor, neighbor industry-mix, negative of neighbor-region industry-mix effects