A New Shift-Share Method*

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Abstract

Shift-share analysis is a decomposition technique widely used in regional studies to quantify an industry-mix effect and a competitive effect on the growth of regional employment (or any other relevant variable) relative to the national average. This technique has always been subject to criticism for its lack of theoretical basis. This paper presents a critical assessment of the methods suggested by Dunn (1960) and by Esteban-Marquillas (1972) and proposes a new shift-share method, which separates out the two effects unambiguously. By way of illustration, we provide an application to manufacturing employment in the Belgian provinces between 1995 and 2007.

Keywords: economic structure; regional economics; shift-share; Belgian manufacturing employment

JEL Classification: R10, R11, R12, R58

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1 Introduction

Shift-share analysis is a decomposition technique widely used in regional studies to identify sectoral effects - the one resulting from the sector's weights in the economy and the other from the sectors' growth rates - leading to inequality in employment growth across regions (Murray 2010).[1] Although the method was developed in the early 1940s, it is generally attributed to Dunn (1960) in the literature.[2] The objective of shift-share analysis is to compare the sectoral distributions of employment growth between two geographical areas (usually a region versus the nation as a whole) in order to answer three questions: i) Does the regional economic structure yield more growth than the national one? ii) Is the regional sectoral growth higher on average than the national one? iii) From the results to i) and ii), which one from the structure or the sectoral efficiency contributes more to the observed differential in aggregate employment growth between the region and the nation?

What shift-share analysis can offer is to propose ordinal variables to answer i) and ii) and a decomposition technique to answer iii). As the shift-share technique is an accounting identity, any formula satisfying this identity is mathematically correct. Therefore, whereas many decompositions are mathematically possible, only one should answer questions i), ii) and iii) unambiguously. While various shift-share decompositions have been proposed in the literature, none is fully convincing yet. The first important decomposition method was proposed by Dunn (1960), who defines a growth effect from the economic structure of regional employment - which the literature calls an "industry-mix effect" after Esteban-Marquillas (1972) - and finds a residual, which is meant to measure what Esteban-Marquillas (1972) calls a "competitive effect" or, for others in the literature, a

[1]The method has been applied to many other indicators such as income, population and productivity. This paper, like many previous studies using this technique, focuses on employment as this data is easily available at regional level.

[2]The origins of shift-share decomposition are not too clear as the literature variously attributes its authorship. Ray (1990) cites Jones (1940) as the first publication using shift-share analysis.

"regional effect".[3] Rosenfeld (1959) soon criticized this residual arguing that the competitive effect in Dunn's method was not properly defined, as it included some of the industry-mix effect.[4] As a response to this criticism, Esteban-Marquillas (1972) modified the shift-share technique by adding a third component to construct another competitive effect. This third component, called the "allocation effect", is the residual required by the accounting identity.

Both methods raised a lot of criticism (Houston (1967); Richardson (1978)). Within this, we can single out the lack of theoretical foundations (see e.g. Bartels et al. (1982)) and Cunningham (1969)'s observation that both Dunn and Esteban-Marquillas' decompositions yielded two solutions with different values for the industry-mix and competitive effects. These deficiencies sparked off many shift-share reformulations so as to deepen the analysis of regional effects of growth (Arcelus 1984); to include interregional and international trade flows in the analysis (Sihag & McDonough (1989); Markusen et al. (1991); Dinc & Haynes (2005)); and to take short-term fluctuations into account within the study periods (Barff & Knight III 1988). None of these corrections, however, fundamentally departs from the methods of Dunn (1960) and Esteban-Marquillas (1972) as all of these extensions, in fact, remained based on either.

In the present paper, we argue that the decomposition methods proposed by the shift-share literature do not solve the methodological problems identified by Rosenfeld (1959) and Cunningham (1969). In particular, we consider that the definition of the competitive effect is not only flawed in Dunn (1960) but also in Esteban-Marquillas (1972). As a result, both methods fail to separate out a structural effect and a competitive effect relative to the national average. This may lead to incorrect numerical results in empirical studies and inaccurate policy advice. The contribution of this paper is to provide: 1) a

[3] Although we prefer "sectoral efficiency effect" to designate the effect of the sectors' growth rates, we will use, in this paper, the term "competitive effect" as in the literature.

[4] Dunn's shift-share method was first published in French (Dunn 1959) with Rosenfeld's reply appearing in the same publication.

comprehensive study of the methods of Dunn (1960) and of Esteban-Marquillas (1972); 2) a test to assess the validity of any shift-share technique and 3) a new technique, which solves the definitional and technical shortcomings of the traditional shift-share methods.

The paper is organized as follows. Section 2 discusses the usefulness of shift-share analysis. The methods of Dunn (1960) and of Esteban-Marquillas (1972) are presented and examined in Section 3 and Section 4 respectively. Section 5 develops a test for shift-share methods. Section 6 presents a new shift-share decomposition. Section 7 provides an application of this new technique to employment variations in the manufacturing sector of the Belgian provinces between 1995 and 2007 and compares the results with those of the other two methods. Finally, section 8 presents our conclusions.

2 On the Merits of Shift-Share Analysis

The growth rate of aggregate employment at the regional (or national) level can be disaggregated into a sum of sectoral growth rates weighted by the shares of sectors in regional (or national) employment. The aggregate employment growth performance thus depends on the economic structure (the weights) and the growth rate of each sector. If we observe that the growth rate of regional employment is lower than the national one, it can be interesting to investigate the extent to which the difference is attributable to the effect of the weights, on the one hand, and to the effect of the mean of the sectoral growth rates, on the other. This investigation requires to separate the effect of the economic structure from that of the average growth performance of all sectors.

If there were observable ordinal variables to measure these two effects, regressing the employment growth differential observed annually between the region and the nation on the differentials of these two variables would be good enough to realize this investigation.[5]

[5]As an alternative to shift-share accounting, Weeden (1974), Buck & Atkins (1976), Berzeg (1978)

Such a variable can easily be created in order to measure the effect of the growth performance of sectors: it suffices to take the sum of the sectoral growth rates weighted by a uniform distribution of sectors, which eliminates any effect of the economic structure.[6] Once this variable is avalaible for the region and the nation, the differential between the two territories can be put in as an explanatory variable.

Yet, there is no obvious way of constructing an ordinal variable to measure the economic structure because an economic structure defined as the distribution of sectors is not a variable with an intrinsic ordering. Therefore, taking the difference between the regional and national distributions of sectors would not make any sense and taking the difference between the regional and national shares of sectors weighted by a uniform distribution of sectoral growth rates would necessarily equal zero. The construction of such a variable thus requires a non-uniform distribution of sectoral growth rates, which means that the economic structure cannot be isolated from the sectoral growth rates. The question is then: what non-uniform distribution? As mathematically there is an infinity of non-uniform distributions of sectoral growth rates, it is impossible to state whether, in total, the regional or the national economic structure yields more employment growth.

The contribution of shift-share analysis lies in yielding ordinal variables to measure an effect of the economic structure and an effect of the sectoral growth rates on the observed differential in aggregate employment growth between two territories. Separating these two effects clearly amounts to an accounting exercise and shift-share analysis aims at providing a technique to do so.

and Patterson (1991) have developed econometric analyses of structural effects on regional growth based on binary variables.

[6]Let us emphasize that whenever the distribution of sectors is non-uniform the growth performance of sectors is not purged of any effect of the economic structure.

3 Dunn (1960)'s Shift-Share Method

3.1 The Decomposition Method

Shift-share analysis organizes data along three dimensions: geography, sectors of activity and time. The shift-share method proposed by Dunn (1960) consists in comparing regional employment growth observed in the data with a hypothetical employment growth that the region would have experienced, were its growth rate equal to the national one. The objective of the method is to decompose the difference between these two employment variations into two components: a structural effect (industry-mix effect) and a competitive effect.[7] Formerly, for a region j, we have[8]

$$\sum_{i=1}^{I}(n_{i,t+1}^{j} - n_{i,t}^{j}) - \sum_{i=1}^{I} n_{i,t}^{j} r_{t+1} = \sum_{i=1}^{I} n_{i,t}^{j}(r_{i,t+1} - r_{t+1}) + \sum_{i=1}^{I} n_{i,t}^{j}(g_{i,t+1}^{j} - r_{i,t+1}) \tag{1}$$

where $n_{i,t+1}^{j}$ is employment in sector $i = 1, ..., I$ of region j at time $t+1$, $g_{i,t+1}^{j}$ is the employment growth rate between time t and $t+1$ in sector i of region j, and $r_{i,t+1}$ and r_{t+1} are the national employment growth rates between time t and $t+1$ in, respectively, sector i and the total economy. The left-hand side of Equation (1) is the difference in observed and hypothetical regional employment growth between time t and $t+1$. On the right-hand side, the first component (industry-mix effect), $\sum_{i=1}^{I} n_{i,t}^{j}(r_{i,t+1} - r_{t+1})$, quantifies the effect of the economic structure of region j on the regional employment variation between time t and $t+1$. If employment in all sectors at the national level were to grow at the rate of national employment or if the regional and national economic structures were identical, this component would equal zero and the economic structure of region j

[7] Dunn (1960) refers to the industry-mix and competitive effects respectively as the differential and proportionality effects.

[8] The development of this decomposition is given in Appendix A.

would not matter for employment growth. The second component (competitive effect), $\sum_{i=1}^{I} n_{i,t}^{j}(g_{i,t+1}^{j} - r_{i,t+1})$, quantifies the effect of the relative sectoral growth performance of region j on regional employment variation between time t and $t+1$. In order for this component to equal zero, the employment growth rates in each sector would need to be the same at the regional and national levels.

If we want to express the difference between observed and hypothetical regional employment growth in terms of percentage change, we divide Equation (1) by $\sum_{i=1}^{I} n_{i,t}^{j}$ and obtain

$$g_{t+1}^{j} - r_{t+1} = \frac{\sum_{i=1}^{I} n_{i,t}^{j}(r_{i,t+1} - r_{t+1})}{\sum_{i=1}^{I} n_{i,t}^{j}} + \frac{\sum_{i=1}^{I} n_{i,t}^{j}(g_{i,t+1}^{j} - r_{i,t+1})}{\sum_{i=1}^{I} n_{i,t}^{j}} \tag{2}$$

where $g_{t+1}^{j} = \frac{\sum_{i=1}^{I}(n_{i,t+1}^{j} - n_{i,t}^{j})}{\sum_{i=1}^{I} n_{i,t}^{j}}$ is the employment growth rate of region j between time t and $t+1$. The left-hand side of Equation (2) is the difference between the observed regional and national growth rates, and the two components are now expressed in terms of percentage change. A better way to understand Dunn (1960)'s decomposition is to rewrite the industry-mix effect in Equation (2) as:

$$g_{t+1}^{j} - r_{t+1} = \left(\frac{\sum_{i=1}^{I} n_{i,t}^{j} r_{i,t+1}}{\sum_{i=1}^{I} n_{i,t}^{j}} - \frac{\sum_{i=1}^{I} m_{i,t} r_{i,t+1}}{\sum_{i=1}^{I} m_{i,t}} \right) + \frac{\sum_{i=1}^{I} n_{i,t}^{j}(g_{i,t+1}^{j} - r_{i,t+1})}{\sum_{i=1}^{I} n_{i,t}^{j}} \tag{3}$$

where $m_{i,t}$ is the national employment in sector i at time t. To rewrite the industry-mix effect, we used the fact that $\frac{\sum_{i=1}^{I} n_{i,t}^{j} r_{t+1}}{\sum_{i=1}^{I} n_{i,t}^{j}} = r_{t+1} = \frac{\sum_{i=1}^{I} m_{i,t} r_{i,t+1}}{\sum_{i=1}^{I} m_{i,t}}$. Finally, we can rewrite Equation (3) in terms of shares in total employment in region j and at the national level:

$$g_{t+1}^{j} - r_{t+1} = \sum_{i=1}^{I}(\omega_{i,t}^{j} - \theta_{i,t}) r_{i,t+1} + \sum_{i=1}^{I} \omega_{i,t}^{j}(g_{i,t+1}^{j} - r_{i,t+1}) \tag{4}$$

where $\omega_{i,t}^{j} = \frac{n_{i,t}^{j}}{\sum_{i=1}^{I} n_{i,t}^{j}}$ is the share of sector i in region j in total employment in region j and

$\theta_{i,t} = \frac{m_{i,t}}{\sum_{i=1}^{I} m_{i,t}}$ is the share of sector i at the national level in total national employment.

3.2 A Critical Assessment

In Equation (4), the industry-mix effect, $\sum_{i=1}^{I}(\omega_{i,t}^{j} - \theta_{i,t})r_{i,t+1}$, is obtained by associating the national sectoral growth rates to the regional and the national economic structures while the competitive effect, $\sum_{i=1}^{I}\omega_{i,t}^{j}(g_{i,t+1}^{j} - r_{i,t+1})$, is obtained by associating the regional economic structure to the regional and national sectoral growth rates. In other words, this method makes a choice on the territorial basis of the growth rates to compute the industry-mix effect, and on the basis of the economic structure to compute the competitive effect. Dunn (1960) chose the national growth rates to calculate the industry-mix effect and the regional economic structure to calculate the competitive effect. We argue that this choice is arbitrary. He could equally have chosen the regional growth rates for the industry-mix effect and the national economic structure for the competitive effect. This decomposition leads to the same difference between the regional and national employment growth rate but yields different values for the two effects if the region and the country have different economic structures and growth rates[9]:

$$g_{t+1}^{j} - r_{t+1} = \sum_{i=1}^{I}(\omega_{i,t}^{j} - \theta_{i,t})g_{i,t+1}^{j} + \sum_{i=1}^{I}\theta_{i,t}(g_{i,t+1}^{j} - r_{i,t+1}) \tag{5}$$

In the absence of any explicit criterion, there is no *a priori* reason to prefer one decomposition to the other.[10] Therefore, the shift-share method based on Dunn (1960) cannot deliver a unique value for each of the two effects.

Moreover, Rosenfeld (1959) emphasized that the competitive effect in Equation (4) was inconsistent: if two regions have identical sectoral growth rates but different economic

[9] In Appendix B we show how to move from Equation (4) to Equation (5).
[10] Cunningham (1969) came to the same conclusion.

structures they will have different competitive effects, which means that the economic structure affects the value of the competitive effect. From Equations (4) and (5) it clearly appears that neither decomposition suppresses all influence of the economic structure on the competitive effect.

4 Esteban-Marquillas (1972)'s Shift-Share Method[11]

4.1 The Decomposition Method

When Dunn presented his shift-share method in 1959, Rosenfeld (1959) identified an inconsistency in his definition of the competitive effect. He showed that if two regions have identical growth rates by sector but different economic structures, they will have different competitive effects relative to the national average because the competitive effect depends on the economic structure. As a result, the competitive effect is not purged of any industry-mix effect. Esteban-Marquillas (1972) proposed a solution that has since become the standard shift-share method. His solution computes the competitive effect as the difference between the sectoral regional and national growth rates weighted by the national economic structure. This implies the addition of a third component, called the "allocation" component, to Equation (1). Formerly, we have

$$\begin{aligned}\sum_{i=1}^{I}(n_{i,t+1}^{j}-n_{i,t}^{j})-\sum_{i=1}^{I}n_{i,t}^{j}r_{t+1} &= \sum_{i=1}^{I}n_{i,t}^{j}(r_{i,t+1}-r_{t+1})+\sum_{i=1}^{I}m_{i,t}(g_{i,t+1}^{j}-r_{i,t+1})\\ &+ \sum_{i=1}^{I}(n_{i,t}^{j}-m_{i,t})(g_{i,t+1}^{j}-r_{i,t+1}) \qquad (6)\end{aligned}$$

[11] Although Esteban-Marquillas (1972) gets the credit for the decomposition method into three components, Cunningham (1969) had actually proposed it three years earlier. For reasons unknown to us, the latter's pioneering work is hardly cited.

where $\sum_{i=1}^{I} m_{i,t}(g_{i,t+1}^{j} - r_{i,t+1})$ is the newly-defined competitive effect and $m_{i,t} = \sum_{i=1}^{I} n_{i,t}^{j} \left(\frac{\sum_{j=1}^{J} n_{i,t}^{j}}{\sum_{i=1}^{I} \sum_{j=1}^{J} n_{i,t}^{j}} \right)$ is the "homothetic employment", i.e., the hypothetical employment that region j would have, were its economic structure identical to the national one. The last term in Equation (6) is the allocation effect, i.e., the product of the difference between the observed and hypothetical economic structure of region j and the difference between the regional and national employment growth rate in sector i. In applied papers, the economic interpretation of the allocation effect is evasive and often omitted. In their original works, both Esteban-Marquillas (1972) and Cunningham (1969) interpret a positive allocation effect as the contribution of regional specialization in sectors in which the regional growth rates are relatively the highest, and a negative allocation effect as a lack of regional specialization in the fastest growing sectors. In addition, Cunningham (1969) hints that the allocation effect can be indicative of a convergence (negative allocation effect) or a divergence (positive allocation effect) of the regional and the national economic structures.

In order to better understand the solution proposed by Esteban-Marquillas (1972), let us divide Equation (6) by $\sum_{i=1}^{I} n_{i,t}^{j}$ in order to rewrite it in terms of percentage change

$$\begin{aligned} g_{t+1}^{j} - r_{t+1} &= \frac{\sum_{i=1}^{I} n_{i,t}^{j}(r_{i,t+1} - r_{t+1})}{\sum_{i=1}^{I} n_{i,t}^{j}} + \frac{\sum_{i=1}^{I} m_{i,t}(g_{i,t+1}^{j} - r_{i,t+1})}{\sum_{i=1}^{I} n_{i,t}^{j}} \\ &+ \frac{\sum_{i=1}^{I} (n_{i,t}^{j} - m_{i,t})(g_{i,t+1}^{j} - r_{i,t+1})}{\sum_{i=1}^{I} n_{i,t}^{j}} \end{aligned} \tag{7}$$

and, then, in terms of employment shares:

$$g_{t+1}^{j} - r_{t+1} = \sum_{i=1}^{I} (\omega_{i,t}^{j} - \theta_{i,t}) r_{i,t+1} + \sum_{i=1}^{I} \theta_{i,t}(g_{i,t+1}^{j} - r_{i,t+1}) + \sum_{i=1}^{I} (\omega_{i,t}^{j} - \theta_{i,t})(g_{i,t+1}^{j} - r_{i,t+1}) \tag{8}$$

4.2 A Critical Assessment

We argue that Esteban-Marquillas (1972)'s decomposition method brings no improvement to Dunn (1960)'s for the following three reasons:

1. This method does not solve the main problem posed by the absence of unique values for the industry-mix and competitive effects in Dunn (1960)'s method. By comparing Equation (4) with Equation (8), we can observe that the solution proposed by Esteban-Marquillas (1972) uses the same territorial basis to compute the two effects: the national growth rates to compute the industry-mix effect and the national economic structure to compute the competitive effect. Not only is this choice arbitrary but it also requires a residual term (allocation effect) to satisfy the equality. It would have been possible to use the regional territorial basis to compute both effects, which requires the same allocation effect:[12]

$$g^j_{t+1}-r_{t+1}=\sum_{i=1}^{I}(\omega^j_{i,t}-\theta_{i,t})g^j_{i,t+1}+\sum_{i=1}^{I}\omega^j_{i,t}(g^j_{i,t+1}-r_{i,t+1})-\sum_{i=1}^{I}(\omega^j_{i,t}-\theta_{i,t})(g^j_{i,t+1}-r_{i,t+1}) \tag{9}$$

   Equation (9) changes the territorial basis of the sectoral growth rates in Equation (5) to compute an industry-mix effect with the same territorial basis as in the competitive effect, and adds a residual term to satisfy the equality. The values of the two effects are different between Equations (8) and (9) while the residual terms - the allocation effects - are of opposite signs. The allocation effect allows the modification of the competitive effect in Equation (8) and of the industry-mix effect in Equation (9). No more than Dunn's solution can Esteban-Marquillas' deliver a

[12] As Esteban-Marquillas (1972) looked for a competitive effect that would not vary for two regions with the same sectoral growth rates, Equation (8) is the most appropriate one. From a theoretical point of view, though, it is no longer justified to use Equation (8) rather than Equation (9).

unique value for the industry-mix and competitive effects.[13]

2. This method is unnecessary to solve the inconsistent example identified by Rosenfeld (1959). In fact, this inconsistency can be solved without adding a third component by Equation (5). Let us recall that Equation (5) is:

$$g^j_{t+1} - r_{t+1} = \sum_{i=1}^{I} (\omega^j_{i,t} - \theta_{i,t}) g^j_{i,t+1} + \sum_{i=1}^{I} \theta_{i,t} (g^j_{i,t+1} - r_{i,t+1})$$

   where $\sum_{i=1}^{I} \theta_{i,t}(g^j_{i,t+1} - r_{i,t+1})$ is the same competitive effect as the one constructed by Esteban-Marquillas (1972) in Equation (8). To the best of our knowledge, nobody has yet thought of this solution to Rosenfeld's inconsistent example. Nevertheless, contrary to what is commonly believed, the solution proposed by Esteban-Marquillas (1972) does not solve the inconsistency identified by Rosenfeld as the former does not succeed in removing any influence of the economic structure on the computation of the competitive effect.

3. This method adds a problematic residual term (allocation effect). First, it is unnecessary (see previous point). Second, when its value is different from zero, the value of the competitive effect is necessarily different from that of Dunn's method based on Equation (4), and the value of the industry-mix effect is different from that of Dunn's method based on Equation (5). How to justify this unless one proves that Dunn's method is wrong? Third, the economic interpretation of this allocation effect given by Esteban-Marquillas (1972) and Cunningham (1969) refers to an effect of the economic structure, which should in fact be captured by the industry-mix effect in the first place.

[13]Once again, Cunningham (1969) came to the same conclusion.

We can conlude that Esteban-Marquillas (1972)'s method does not bring any improvement to Dunn (1960)'s. In the next two sections, we propose a simple test to identify a relevant shift-share method and then propose a new technique. We show that whereas both Esteban-Marquillas (1972)'s and Dunn (1960)'s methods fail this test, our technique comes out successfully.

5 A Shift-Share Test

Shift-share analysis aims at answering the following question: does a region's economic structure impact its growth performance positively or negatively? If it does negatively, the effect of the structure may be offset by the average growth performance of all sectors. Therefore, it would be interesting to discover whether the economic structure of a region is a relative strength (or weakness) in terms of growth and whether this strength (or weakness) is reinforced or offset by relatively higher (or lower) sectoral efficiency. A shift-share technique should be able to separate out these two effects unambiguously.

5.1 Two Difficulties

The first difficulty to tackle in shift-share analysis is the absence of order for an economic structure. What we call an economic structure is a distribution of sectors with no intrinsic ordering. A region may specialize in some sectors more than others. We will say that a region or a nation specializes in a given sector if its employment share is larger than the uniform share. There is no *a priori* good or bad specialization. The regional specialization may be different from the national one but, without considering an associated variable, it is impossible to conclude that the regional specialization is better than the national one. Moreover, the specialization may vary between the region and the nation while their distribution of employment across sectors may be identical. For instance, employment shares can be 20% in sector A and 80% in sector B for the region while being the opposite for the nation. Although the distributions of employment shares are identical, the regional and national specializations are different.

When the distribution of sectors is associated with their corresponding sectoral growth rates, it is possible to conclude that a specialization will yield more or less employment growth. Yet, another difficulty arises if we want to disentangle the effect of specialization from the effect of growth rates. This is precisely the objective of shift-share analysis. We will now show that neither of the methods proposed by Dunn (1960) and Esteban-Marquillas (1972) solves this difficulty.

5.2 A Simple Shift-Share Test

Table 1 presents two numerical examples. In Example 1, the region and the nation are identical in all respects: the economic structures and the growth rates are the same for each sector. Obviously, there is no difference between regional and national employment growth, and any shift-share technique should find zero industry-mix and competitive effects. Table 2 shows that the shift-share techniques of Dunn (1960) and Esteban-Marquillas (1972) find the expected results. In Example 2, we keep the same pairs of data (employment shares and growth rates) as in Example 1 but assign them to different sectors between the two geographical units. The distribution of shares and growth rates is exactly the same as previously but the specializations are now different: the region specializes in Sector B while the nation does in Sector A. The difference between the regional and national growth rates between t and $t + 1$ should be zero. Moreover, any shift-share technique should conclude that the industry-mix and the competitive effects are null. Each geographical unit specializes in the highest performing sector and none has a systematic advantage in employment performance in all sectors. We can observe that the shift-share techniques of both Dunn (1960) and of Esteban-Marquillas (1972) fail this test (Table 2). In fact, by choosing the national growth rates to compute the industry-mix effect, both techniques implicitly consider that the national specialization is better than the regional one. In the case, this conclusion turns out to be wrong, as regional and national employment growth rates are identical.

Table 1: Two numerical examples

	Region		**Nation**	
	Share of total employment at t	Employment growth rate between t and $t+1$	Share of total employment at t	Employment growth rate between t and $t+1$
Example 1				
Sector A	80%	5%	80%	5%
Sector B	20%	4%	20%	4%
Example 2				
Sector A	20%	4%	80%	5%
Sector B	80%	5%	20%	4%

Table 2: Dunn (1960)'s and Esteban-Marquillas (1972)'s shift-share methods under test

	Growth rate differential (%)	Industry-mix effect (%)	Competitive effect (%)	Allocation effect (%)
Example 1				
Dunn's decomposition	0.0	0.0	0.0	-
EM's decomposition	0.0	0.0	0.0	0.0
Example 2				
Dunn's decomposition	0.0	-0.6	0.6	-
EM's decomposition	0.0	-0.6	-0.6	1.2

Growth rate differential = difference between the regional and the national aggregate employment growth rates

EM = Esteban-Marquillas' shift-share method

Table 3: Our shift-share method under test

	Growth rate differential (%)	Industry-mix effect (%)	Competitive effect (%)
Example 1			
Our decomposition	0.0	0.0	0.0
Example 2			
Our decomposition	0.0	0.0	0.0

Growth rate differential = difference between the regional and the national aggregate employment growth rates

6 A New Shift-Share Decomposition

A valid shift-share technique should result in a unique decomposition of the growth differential between two geographical units into an industry-mix effect and a competitive effect. In addition, this technique should solve Rosenfeld's inconsistency and pass the test of Example 2. The new technique we now propose provides the solution to separate out unambiguously an effect of the economic structure and a competitive effect.

Our technique starts with the construction of the competitive effect. Rosenfeld (1959) rightly pointed out that the competitive effect should not be influenced by the economic structure if one wanted to separate out an effect from the economic structure and an effect from the sectoral growth rates. Both Dunn (1960)'s and Esteban-Marquillas (1972)'s methods fail in building such a competitive effect. As mentioned in Section 2, the only way to purge the competitive effect from any influence of the economic structure is to associate a uniform distribution of sectors to the sectoral growth rates. Therefore, we define the competitive effect as

$$\sum_{i=1}^{I} \frac{1}{I} \left(g^{j}_{i,t+1} - r_{i,t+1} \right) \tag{10}$$

where I is the number of sectors and $\frac{1}{I}$ is the employment share of each sector. Equation

(10) is the difference between the arithmetic means of the regional and national sectoral growth rates. If Equation (10) is positive, the arithmetic mean of the sectoral growth rates is higher in the region than in the nation. In that case, the sectors, on average, yield more growth in the region than in the nation. Then, we calculate the effect of the economic structure (or the industry-mix effect) as the residual, i.e., as the difference between the differential in the aggregate employment growth rates ($g^j_{t+1} - r_{t+1}$), on the one hand, and Equation (10), on the other hand, which yields:

$$\sum_{i=1}^{I} \left(\omega^j_{i,t} - \frac{1}{I} \right) g^j_{i,t+1} - \sum_{i=1}^{I} \left(\theta_{i,t} - \frac{1}{I} \right) r_{i,t+1} \tag{11}$$

where $\sum_{i=1}^{I} \left(\omega^j_{i,t} - \frac{1}{I} \right)$ and $\sum_{i=1}^{I} \left(\theta_{i,t} - \frac{1}{I} \right)$ are the regional and national specialisations respectively. As mentioned in Section 2, the economic structure is a distribution of sectors and the difference between these two terms is meaningless. As such, we cannot say which specialization is better than the other. Yet the specialisations associated with their corresponding sectoral growth rates, as it comes out in Equation (11), are ordinal variables measuring employment growth due to specialization. Equation (11) allows us to determine which of the two specializations yields more employment growth. If Equation (11) is positive, then the regional economic structure yields more employment growth than the national one. Our new shift-share decomposition equation thus is the sum of Equations (10) and (11):

$$g^j_{t+1} - r_{t+1} = \left[\sum_{i=1}^{I} \left(\omega^j_{i,t} - \frac{1}{I} \right) g^j_{i,t+1} - \sum_{i=1}^{I} \left(\theta_{i,t} - \frac{1}{I} \right) r_{i,t+1} \right] + \sum_{i=1}^{I} \frac{1}{I} \left(g^j_{i,t+1} - r_{i,t+1} \right) \tag{12}$$

Equation (12) accounts for the observed difference between the regional and national aggregate employment growth rates and separates out the industry-mix and the competitive effects unambigously. Finally, Table 3 shows that our method passes the shift-share test as it yields the expected results for the industry-mix and competitive effects in Example 2.

Let us insist that our method is a major departure from the approach commonly used in the shift-share literature. Dunn (1960) and Esteban-Marquillas (1972) compare an actual regional growth rate with two hypothetical regional growth rates that would result if the sectoral growth rates or the economic structure were identical to those of the nation. Therefore, the actual and hypothetical growth effects of the economic structure and the sectoral growth rates are mixed up in their decomposition formula. Our method only uses actual data, computes actual growth effects in both geographical units and compare them. It enables us to decompose the aggregate growth rate of any geographical unit into two terms, which capture the two effects we are interested in: the growth effect of the economic structure and the growth effect of the sectoral growth performances. The regional and national decompositions are the following:

$$g^j_{t+1} = \sum_{i=1}^{I} \left(\omega^j_{i,t} - \frac{1}{I}\right) g^j_{i,t+1} + \sum_{i=1}^{I} \frac{1}{I}\, g^j_{i,t+1} \qquad (13)$$

$$r_{t+1} = \sum_{i=1}^{I} \left(\theta_{i,t} - \frac{1}{I}\right) r_{i,t+1} + \sum_{i=1}^{I} \frac{1}{I}\, r_{i,t+1} \qquad (14)$$

The growth effect of the economic structure is measured by $\left(\sum_{i=1}^{I} \left(\omega^j_{i,t} - \frac{1}{I}\right) g^j_{i,t+1}\right)$ in the region and by $\left(\sum_{i=1}^{I} \left(\theta_{i,t} - \frac{1}{I}\right) r_{i,t+1}\right)$ in the nation. It is positive if the territory specializes, on average, in fast-growing sectors, i.e. in sectors which experience a relative high growth rate. The growth effect of the sectoral growth performances is measured by $\left(\sum_{i=1}^{I} \frac{1}{I}\, g^j_{i,t+1}\right)$ in the region and by $\left(\sum_{i=1}^{I} \frac{1}{I}\, r_{i,t+1}\right)$ in the nation. Equations (13) and (14) are independant from each other and can be used to create ordinal variables for the economic structures in the region and in the nation.[14] With our new shift-share decomposition, we can compare the two growth effects of a geographical unit with those of any other geographical unit without defining a reference territory. For instance, if one wants to assess whether the specialization of the region is favourable or harmful to its growth performance, in comparison with the nation, it is enough to compare the growth effect of the regional economic structure $\left(\sum_{i=1}^{I}\left(\omega_{i,t}^{j}-\frac{1}{I}\right)g_{i,t+1}^{j}\right)$ with the growth effect of the national one $\left(\sum_{i=1}^{I}\left(\theta_{i,t}-\frac{1}{I}\right)r_{i,t+1}\right)$. If one wants to assess the total regional growth performance in terms of industrial specialization and sectoral efficiency relative to the nation, one has to take the difference between Equations (13) and (14), which yields Equation (12).

7 An application to employment in the Belgian manufacturing sector between 1995 and 2007

By way of illustration, we propose to carry out a shift-share analysis of employment variations in the manufacturing sector in the Belgian provinces and the Brussels region between 1995 and 2007, and to compare the results of our technique with those of the traditional shift-share methods. Data on 14 sub-sectors of the manufacturing sector was retrieved from the Belgian Central Bank's database for the 10 Belgian provinces and for Brussels, as listed in the first column of Table 4. At the national level, data shows that manufacturing employment decreased by 13.4% over that period. The second column of the table displays the employment growth rate differential of each province and Brussels relative to the national growth rate. We then computed the industry-mix and the competitive effects using Dunn (1960)'s technique (third and fourth columns), the same two effects

[14]In growth regressions, it would be possible to use this ordinal variable measuring the growth effect of the economic structure as an explanatory variable.

plus the allocation effect using Esteban-Marquillas (1972)'s technique (fifth to seventh columns) and the industry-mix and the competitive effects using our new technique (last two columns). This exercise clearly shows that Dunn (1960)'s and Esteban-Marquillas (1972)'s techniques can lead to very misleading measures of the competitive and the industry-mix effects. For instance, in the province of Liège, where employment fell 3.6% under the national average, the industry-mix effect and the competitive effect amount to respectively 4.0% and -7.6% with Dunn (1960)'s method, as against 4.0% and 0.1% (while the allocation effect reaches -7.7%) with Esteban-Marquillas (1972)'s method, and -0.8% and -2.8% with our own method. In terms of policy prescriptions, the conclusions based on our decomposition technique stood in clear contrast with those of Dunn (1960) and of Esteban-Marquillas (1972): the economic structure of the Province of Liège does not provide it with a relative structural advantage in terms of employment growth. In light of these comparative evidence, we recommend the use of our technique in shift-share studies.

Table 4: A shift-share analysis of the industrial sector in the Belgian provinces and the region of Brussels between 1995 and 2007

Provinces	Growth rate differential[1] (%)	Dunn (1960) Industry-mix effect (%)	Dunn (1960) Competitive effect (%)	Esteban-Marquillas (1972) Industry-mix effect (%)	Esteban-Marquillas (1972) Competitive effect (%)	Esteban-Marquillas (1972) Allocation effect (%)	Our method Industry-mix effect (%)	Our method Competitive effect (%)
Antwerpen	2.0	2.5	-0.5	2.5	-1.7	1.2	5.8	-3.8
Limburg	1.3	0.0	1.3	0.0	5.0	-3.7	-4.3	5.6
Oost-Vlaanderen	-4.4	-4.0	-0.4	-4.0	0.9	-1.3	-4.8	0.4
Vlams-Brabant	-4.6	1.6	-6.2	1.6	-9.5	3.4	4.2	-8.7
West-Vlaanderen	5.9	-4.7	10.6	-4.7	10.7	-0.1	-1.3	7.2
Brabant wallon	35.5	5.0	30.5	5.0	24.7	5.7	14.0	21.5
Hainaut	-1.0	1.0	-2.0	1.0	1.3	-3.3	-8.7	7.7
Liège	-3.6	4.0	-7.6	4.0	0.1	-7.7	-0.8	-2.8
Luxembourg	16.5	5.3	11.2	5.3	7.8	3.5	8.5	8.0
Namur	17.2	4.4	12.8	4.4	10.2	2.7	8.9	8.4
Brussels	-18.9	0.3	-19.2	0.3	-17.2	-2.0	-2.6	-16.3

Growth rate differential: difference between the provincial and the national total employment growth rates

Source: Belgostat; calculations: authors

8 Conclusion

The shift-share method is an accounting technique which aims at determining whether the aggregate growth performance of a region relative to the national average is the result of its economic structure or/and the growth rates of its sectors. Hence, the accounting formula should be able to separate out the two components unambiguously. This paper attempts to show that the traditional shift-share methods proposed by Dunn (1960) and Esteban-Marquillas (1972) fail to do so due to a flawed definition of the competitive effect.

Instead of these, the shift-share decomposition technique we recommend here is based on a competitive effect defined as the sum of the sectoral growth rates weighted by a uniform distribution of sectors. This is the only way to eliminate any effect of the second component, the economic structure, which is computed as the residual. Thus the separation between the two components is unambiguous.

Since all accounting shift-share methods are mathematically correct, we designed a simple test to assess the conceptual accuracy of shift-share methods and rule out inaccurate ones. The test confirms the flaws that we identified in Dunn (1960)'s and Esteban-Marquillas (1972)'s methods and validates the relevance of our own.

Finally, our empirical application on employment in the Belgian manufacturing sector between 1995 and 2007 shows that the three methods can yield very different results for the industry-mix and competitive effects. Even though shift-share analysis does not shed light on the causes of regional growth, it is very useful in identifying and quantifying these possible sources of regional growth performance. Therefore, the conceptual accuracy of the accounting technique is compelling in order to deliver the right assessment in regional studies.

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A The original decomposition of Dunn (1960)

Let us define employment in sector i at time t in region j by $n^j_{i,t}$ and in the nation by $m_{i,t}$. Equation (1) is obtained from the difference between the regional and national employment variations:

$$
\begin{aligned}
\frac{\sum_{i=1}^{I} n^j_{i,t+1}}{\sum_{i=1}^{I} n^j_{i,t}} - \frac{\sum_{i=1}^{I} m_{i,t+1}}{\sum_{i=1}^{I} m_{i,t}} &= (1+g^j_{t+1}) - (1+r_{t+1}) \\
&= \frac{\sum_{i=1}^{I} n^j_{i,t}(1+g^j_{t+1})}{\sum_{i=1}^{I} n^j_{i,t}} - \frac{\sum_{i=1}^{I} n^j_{i,t}(1+r_{t+1})}{\sum_{i=1}^{I} n^j_{i,t}} \\
&= \frac{\sum_{i=1}^{I} n^j_{i,t} g^j_{t+1}}{\sum_{i=1}^{I} n^j_{i,t}} - \frac{\sum_{i=1}^{I} n^j_{i,t} r_{t+1}}{\sum_{i=1}^{I} n^j_{i,t}} \\
&= \frac{\sum_{i=1}^{I} n^j_{i,t} g^j_{i,t+1}}{\sum_{i=1}^{I} n^j_{i,t}} - \frac{\sum_{i=1}^{I} n^j_{i,t} r_{t+1}}{\sum_{i=1}^{I} n^j_{i,t}} + \frac{\sum_{i=1}^{I} n^j_{i,t} r^j_{i,t+1}}{\sum_{i=1}^{I} n^j_{i,t}} - \frac{\sum_{i=1}^{I} n^j_{i,t} r^j_{i,t+1}}{\sum_{i=1}^{I} n^j_{i,t}} \\
&= \frac{\sum_{i=1}^{I} n^j_{i,t}(r_{i,t+1} - r_{t+1})}{\sum_{i=1}^{I} n^j_{i,t}} + \frac{\sum_{i=1}^{I} n^j_{i,t}(g^j_{i,t+1} - r_{i,t+1})}{\sum_{i=1}^{I} n^j_{i,t}}
\end{aligned}
$$

where we used the fact that $\sum_{i=1}^{I} n^j_{i,t} g^j_{t+1} = \sum_{i=1}^{I} n^j_{i,t} g^j_{i,t+1}$.

Therefore, $g^j_{t+1} - r_{t+1} = \frac{\sum_{i=1}^{I} n^j_{i,t}(r_{i,t+1} - r_{t+1})}{\sum_{i=1}^{I} n^j_{i,t}} + \frac{\sum_{i=1}^{I} n^j_{i,t}(g^j_{i,t+1} - r_{i,t+1})}{\sum_{i=1}^{I} n^j_{i,t}}$. By multiplying both sides by $\sum_{i=1}^{I} n^j_{i,t}$, and taking the fact that $\sum_{i=1}^{I} n^j_{i,t} g^j_{t+1} = \sum_{i=1}^{I}(n^j_{i,t+1} - n^j_{i,t})$, we obtain Equation (1).

B Two possible decompositions following Dunn (1960)

Equation (4) is the rewriting of the decomposition proposed by Dunn (1960):

$$g^j_{t+1} - r_{t+1} = \sum_{i=1}^{I}(\omega^j_{i,t} - \theta_{i,t})r_{i,t+1} + \sum_{i=1}^{I}\omega^j_{i,t}(g^j_{i,t+1} - r_{i,t+1}) \tag{15}$$

By adding and subtracting $\sum_{i=1}^{I}(\omega^j_{i,t} - \theta_{i,t})g^j_{i,t+1}$ and $\sum_{i=1}^{I}\theta_{i,t}(g^j_{i,t+1} - r_{i,t+1})$ to Equation (15) we obtain

$$\begin{aligned} g^j_{t+1} - r_{t+1} &= \sum_{i=1}^{I}(\omega^j_{i,t} - \theta_{i,t})r_{i,t+1} + \sum_{i=1}^{I}(\omega^j_{i,t} - \theta_{i,t})g^j_{i,t+1} - \sum_{i=1}^{I}(\omega^j_{i,t} - \theta_{i,t})g^j_{i,t+1} \\ &+ \sum_{i=1}^{I}\theta_{i,t}(g^j_{i,t+1} - r_{i,t+1}) - \sum_{i=1}^{I}\theta_{i,t}(g^j_{i,t+1} - r_{i,t+1}) + \sum_{i=1}^{I}\omega^j_{i,t}(g^j_{i,t+1} - r_{i,t+1}) \end{aligned}$$

After rearranging the terms,

$$\begin{aligned} g^j_{t+1} - r_{t+1} &= \sum_{i=1}^{I}(\omega^j_{i,t} - \theta_{i,t})g^j_{i,t+1} + \sum_{i=1}^{I}(\omega^j_{i,t} - \theta_{i,t})(r_{i,t+1} - g^j_{i,t+1}) \\ &+ \sum_{i=1}^{I}\theta_{i,t}(g^j_{i,t+1} - r_{i,t+1}) + \sum_{i=1}^{I}(\omega^j_{i,t} - \theta_{i,t})(g^j_{i,t+1} - r_{i,t+1}) \end{aligned}$$

and, finally, since two terms cancel out, we obtain another decomposition:

$$g^j_{t+1} - r_{t+1} = \sum_{i=1}^{I}(\omega^j_{i,t} - \theta_{i,t})g^j_{i,t+1} + \sum_{i=1}^{I}\theta_{i,t}(g^j_{i,t+1} - r_{i,t+1}), \tag{16}$$

which is Equation (5), a decomposition that yields different values for the industry-mix and the competitive effects compared to Equation (4), if the region and the country have different economic structures and growth rates.