THE SHIFT-SHARE METHODOLOGY: DEFICIENCIES AND PROPOSED REMEDIES

*Paul Kochanowski, Wayne Bartholomew, and Paul Joray**

Introduction

This paper analyzes two versions of the shift-share technique: the conventional approach, sometimes referred to as the national growth rate method, and the Esteban-Marquillas revision of the conventional approach. In addition to the finding that the conventional approach incorrectly computes the competitive effect because regional structure and growth commingle, it is demonstrated that the share and industry-mix effects also differ widely between the two techniques, sometimes in sign as well as in magnitude. It also is shown that regardless of technique, intertemporal comparisons of competitive effects cannot avoid the interaction of structural and growth effects because the structure of the reference economy changes over time. The paper provides two revisions of the Esteban-Marquillas formulation that remedy the intertemporal problem. A case study is undertaken to document the significance of the issues raised.

As a descriptive technique, shift-share analysis of a regional economy purports to:

* Determine the extent to which structural and competitive effects cause a region to behave differently from a larger reference economy.

* Uncover the role structural and competitive effects play in explaining the relative performance of two or more regions when both are compared to the same reference economy.

* Analyze how structural and competitive effects contribute to the trend over time in a regional economy's performance relative to that of a larger reference economy.

*Indiana University at South Bend.

A shift-share model satisfies these goals only if the structural and competitive effects into which it decomposes a region's employment changes represent differences in a regional economy's composition of employment and its industry growth rates. A structural effect must measure only structure, a competitive effect only competitiveness. This is an obvious point. Nonetheless, this paper shows that the widely used (see Andrikopoulos, Blair and Mabry, Edwards, Green and Allaway, Halperin and Mabry, Kahley, Ledebur, Merrifield, and Tervo and Okko [1, 4, 6, 9, 10, 13, 15, 17, 20]) conventional shift-share model, which decomposes employment changes into a share effect, an industry-mix effect, and a competitive effect, commingles structural and growth effects to the point that all three effects can be shown to be a function of structure. This leads to the conclusion that for this model, structure determines everything. Moreover, although the Esteban-Marquillas [7] reformulation corrects for cross-sectional commingling of structural and growth effects, it nevertheless fails to avoid such interactions in time series applications. It is demonstrated that a region with a competitive advantage that has not changed over time may appear to have lost that advantage because of the commingling of structural and growth effects. Finally, several revisions of the Esteban-Marquillas formulation are suggested that eliminate the possibility of such perverse outcomes.[1]

Across Region Comparisons

Let S_{ij} and S_{iR} symbolize the proportion of the total employment represented by the ith industry in region j and reference economy R, respectively, G_{ij} and G_{iR} the growth rates of the ith industry in j and R, respectively, G_{TR} the growth rate of total employment in the reference economy, and E_{oj} the base period employment in region j. The following equations represent the conventional (CV) and the Esteban-Marquillas (EM) models:

---

[1] This paper concentrates on the independence of the three shift-share effects. Nonetheless, a number of other writers emphasize a variety of other issues. For example, issues such as the additivity across regions of the competitive effect [2, 11], base period versus ending period structural weights [3, 8, 12], and practical problems in interpreting the allocative effect [14] all have received considerable attention. An excellent summary of these and other issues surrounding the shift-share methodology is found in [5].

	Effect		CV	EM
(1)	Share	(SE_{ij})	$E_{oj}S_{ij}G_{TR}$	$E_{oj}S_{iR}G_{iR}$
(2)	Industry-Mix	(IM_{ij})	$E_{oj}S_{ij}(G_{iR}\text{-}G_{TR})$	$E_{oj}(S_{ij}\text{-}S_{iR})G_{iR}$
(3)	Competitive	(CE_{ij})	$E_{oj}S_{ij}(G_{ij}\text{-}G_{iR})$	$E_{oj}S_{iR}(G_{ij}\text{-}G_{iR})$
(4)	Allocative	(AE_{ij})		$E_{oj}(S_{ij}\text{-}S_{iR})\ (G_{ij}\text{-}G_{iR})$

In both cases, the sum of the effects equals the actual changes in employment. $E_{oj}S_{ij}G_{ij}$ equals the change in employment for industry i, and the total change in employment equals $\Sigma E_{oj}S_{ij}G_{ij}$ over all of the n industries where i = 1, 2, . . . , n. Simple algebraic manipulation generates the difference between the jth and kth region for each effect as:

CV Model

(5) $\Delta SE_{ijk} = E(S_{ij}\text{-}S_{ik})G_{TR}$

(6) $\Delta IM_{ijk} = E(S_{ij}\text{-}S_{ik})\ (G_{iR}\text{-}G_{TR})$

(7) $\Delta CE_{ijk} = E[S_{ij}(G_{ij}\text{-}G_{iR})\text{-}S_{ik}(G_{ik}\text{-}G_{iR})]$

EM Model

(8) $\Delta SE_{ijk} = 0$

(9) $\Delta IM_{ijk} = E(S_{ij}\text{-}S_{ik})G_{iR}$

(10) $\Delta CE_{ijk} = E(G_{ij}\text{-}G_{ik})S_{iR}$

(11) $\Delta AE_{ijk} = E[(S_{ij}\text{-}S_{iR})\ (G_{ij}\text{-}G_{iR})\text{-}(S_{ik}\text{-}S_{iR})\ (G_{ik}\text{-}G_{iR})]$

where ΔSE_{ijk} measures the difference in the share effect for the ith industry between the jth and kth region, ΔIM_{ijk}, ΔCE_{ijk}, ΔAE_{ijk} the same differences for the other effects, and E represents a normalization factor. Normalization is necessary because regions may differ in size, thereby introducing a scale effect. For example, E may equal 10,000 which would yield each of the differences in effects between the two regions per 10,000 employees.

An apparent difference surfaces in the way these two techniques handle the competitive effect. Other writers have noted that the CV model leads to differences in regional competitive effects even when none exists (see Arcelus, Herzog and Olsen, and Stevens and Moore [2, 12, 19]). Equation (7) shows why this occurs. Assume that $(G_{ij}-G_{iR}) = (G_{ik}-G_{iR}) = G_i$ and $G_i > 0$. Equation (7) becomes

(12) $\Delta CE_{ijk} = EG_i(S_{ij}-S_{ik})$

If industry i is more (less) important in the jth region than in the kth region, the jth region will appear to be at a competitive advantage (disadvantage) when none exists by definition. Thus, regions with different structures will have competitive effect differences that partially mirror these structures.

The EM correction of this defect consists of isolating into the allocative effect (AE) all of the terms where structure and growth covary. This can be seen from multiplying out the EM allocative effect for the jth region.

(13) $AE_{ij} = S_{ij}(G_{ij}-G_{iR})-S_{iR}(G_{ij}-G_{iR})$

Equation (13) represents the difference in the competitive effect given by the CV and EM formulations. Therefore, instead of commingling structural and growth effects, as the CV model does, the EM technique isolates each effect in a separate term.

But there is a much less apparent and perhaps equally important difference in these techniques with respect to the share and industry-mix effects. Not only the magnitude, but the sign of the share effect and industry-mix effect for a particular industry in some cases depend on the technique employed. The algebraic differences between the CV and EM techniques for equations (1) and (2) above yield the degree to which the techniques differ.

(14) $SE_{cv\text{-}em} = E_{oj}\,[S_{ij}G_{TR}-S_{iR}G_{iR}]$

(15) $IM_{cv\text{-}em} = E_{oj}\,[S_{iR}G_{iR}-S_{ij}G_{TR}]$

Using the fact that $\Sigma S_{ij}G_{TR} = G_{TR}\Sigma S_{ij} = G_{TR}$ and $\Sigma S_{iR}G_{iR} = G_{TR}$, one can see that equations (14) and (15) will equal zero over all n industries. In the aggregate (that is, over all industries), the share and industry-mix effects are identical regardless of technique. Nevertheless, one can see also that any difference in the mix effect for the ith industry will lead to differences in the opposite direction in the share effect. Thus, for a particular industry, the distribution of the employment changes between the industry-mix and share effects will depend entirely on which technique one utilizes.

To emphasize these offsets, a hypothetical example is constructed using data given below in Table 1. The shift-share results based on these data are found in Table 2.

In Table 2, regardless of the structure of the jth region, the share effect and industry-mix effect for each of the two industries sum to the same number for the CV and EM techniques. For example, when S_1 = 0.10, the share effect computed by the conventional model for industries 1 and 2 is 10.40 and 93.60, respectively which sums to 104. Although the share effect computed by the Esteban-Marquillas model results in different numbers for industries 1 and 2 of 72 and 32, it also leads to the aggregate result of 104. Similarly, the total industry-mix effect at any structure is identical for the two techniques. For instance, when S_1 = 0.3, the CV technique calculates the industry-mix effects for industries 1 and 2 to be 4.80 and -16.80, respectively, which sums to -12. The EM technique computes the same industry-mix effects as -36 and 24 which also sums to -12. This validates the statement above. In the aggregate, these techniques give identical results.

But it is at the microlevel of the industry where the techniques diverge. Notice the reversals in signs for the two techniques on the industry-mix effect. The CV technique shows positive industry-mix effects for industry 1 but negative industry effects for industry 2 over the various possible structures. One would have to conclude that while industry 1 is helping propel region j ahead of the reference economy, industry 2 is acting as a drag. On the other hand, if the EM technique were used, industry 2 would receive the praise and industry 1 the blame.

The conventional technique seems to have an inherent flaw, as it allows the structure of the regional economy to permeate all three effects.[2] For example, there is a direct relationship between S_{1j}, the

[2]Gordon et al. [8] hint at this interdependency by showing that the share effect (*reference effect* in their terminology) has algebraic counterparts in the industry-mix effect. Nonetheless, they seem to

proportion of employment in region j accounted for by industry 1, and the share, industry-mix, and competitive effects. Moreover, an inverse relationship exists between S_{1j} and these same effects for industry 2. Obviously, for each industry, each effect will be highly correlated to each of the other two because they all relate to structure. In short, structure determines everything.

The Esteban-Marquillas technique, in contrast, calculates three independent effects and one effect in which structure and growth interact. From data in Table 2, one can verify that only the industry-mix effect depends on the structure of region j. The share and competitive effects are completely independent of that structure. Clearly, each effect is independent of the other two. Consequently, the industry-mix and competitive effects capture unique aspects of the regional economy relative to the reference economy; the former, regional structure, relative to that of the reference economy; the latter, regional growth, relative to that of the reference economy.

Across Time Comparisons

The Esteban-Marquillas model calculates three independent effects that allow employment changes to be disaggregated into three independent unique factors. This, in turn, permits regional comparisons that highlight interregional structural and competitive dissimilarities. Nonetheless, the commingling of structure and competitiveness appears unavoidable when comparisons of such effects are made for the same region between two time periods. To see this, define S_{ijt} as the proportion of total employment accounted for by industry i in the jth region at the beginning of time period t and G_{ijt} as the growth rate of industry i in the jth region in time period t. S_{iRt} and G_{iRt} represent the comparable structural and growth measures for the reference economy. Comparing SE, IM, and CE for two time periods, t = 0 and t = 1, yields:

---

miss the implication of this (namely that the two effects are interdependent) and try to correct for it using median values for growth rates of industries in the reference economy. While such median growth rates shift the employment change from share effect to industry-mix effect, they do nothing to break the interdependency of the two effects.

Conventional Model Across Time

(16) $\Delta SE_{ij01} = E[S_{ij1}G_{TR1} - S_{ij0}G_{TR0}]$

(17) $\Delta IM_{ij01} = E[S_{ij1}(G_{iR1} - G_{TR1}) - S_{ij0}(G_{iR0} - G_{TR0})]$

(18) $\Delta CE_{ij01} = E[S_{ij1}(G_{ij1} - G_{iR1}) - S_{ij0}(G_{ij0} - G_{iR0})]$

Esteban-Marquillas Model Across Time

(19) $\Delta SE_{ij01} = E[S_{iR1}G_{iR1} - S_{iR0}G_{iR0}]$

(20) $\Delta IM_{ij01} = E[(S_{ij1} - S_{iR1})G_{iR1} - (S_{ij0} - S_{iR0})G_{iR0}]$

(21) $\Delta CE_{ij01} = E[(G_{ij1} - G_{iR1})S_{iR1} - (G_{ij0} - G_{iR0})S_{iR0}]$

(22) $\Delta AE_{ij01} = E[(S_{ij1} - S_{iR1})(G_{ij1} - G_{iR1}) - (S_{ij0} - S_{iR0})(G_{ij0} - G_{iR0})]$

Inspection of the above results reveals the impossibility of separating structural from growth components in any of the effects. In the CV model, ΔIM_{ij01} not only depends on S_{ij1} and S_{ij0} (as it should), but also on $(G_{iR1} - G_{TR1})$ and $(G_{iR0} - G_{TR0})$. Thus, it will be impossible to know whether a change in the composition of the regional economy or a change in the relative growth rate of the ith industry in the reference economy caused the change in ith region's industry mix. Moreover, in the CV formulation, changes over time in the competitiveness of the regional economy, ΔCE_{ij01}, will result from changes in $(G_{ij1} - G_{iR1})$ and $(G_{ij0} - G_{iR0})$, which measure trends in competitiveness, but also from structural shifts as given by S_{ij1} and S_{ij0}.[3]

[3]Mead and Ramsay [16] also formulate a dynamic version of the conventional shift-share model that they use to measure the differential impacts of recessions on the Massachusetts economy. Riefler [18] applies this model to Nebraska's economy to analyze the 1973-1975 recession versus the 1981-1982 recession. Neither paper deals with the interdependency of specific effects, however. Yet because equations (16), (17), and (18) above yield the change in employment between the two time intervals, whether those time intervals be recessions, expansions, or identical places in the business cycle, commingling of effects must occur. Using the terminology of this paper, Mead and Ramsay's equation (6) [16, p. 39] is given for the ith industry as:

The EM model suffers from similar problems. Trends in the industry-mix effect will depend both on how the structure of the region changes over time as well as the ith industry's relative performance in each time period in the reference economy. Trends in the competitive effect will reflect a combination of changes in competitiveness, as given by $(G_{ij1}-G_{iR1})$ and $(G_{ij0}-G_{iR0})$, and changes in the structure of the reference economy. Even with no change in structure or competitiveness of a region over time, the CV and EM formulations still generate nonzero ΔIM_{ij01} and ΔCE_{ij01}:

No Change in Structure $S_{ij1} = S_{ij0}$

(23) CV Model: $\Delta IM_{ij01} = ES_{ij0}[(G_{iR1}-G_{iR0})-(G_{TR1}-G_{TR0})] \neq 0$

(24) EM Model: $\Delta IM_{ij01} = E[(S_{ij0}-S_{iR0})\ (G_{iR1}-G_{iR0})] \neq 0$

No Change in Competitiveness $(G_{ij1}-G_{iR1})=(G_{ij0}-G_{iR0})$

(25) CV Model: $\Delta CE_{ij01} = E[(S_{ij1}-S_{ij0})\ (G_{ij0}-G_{iR0})] \neq 0$

(26) EM Model: $\Delta CE_{ij01} = E[(S_{iR1}-S_{iR0})\ (G_{ij0}-G_{iR0})] \neq 0$

Consequently, if one compares the competitiveness of a region over two time intervals, that comparison reveals a combination of three changes:

* A change in the competitiveness of the region;
* A change in structure of the reference economy; and

$$dChE_i = dE_i\{(G_{TRO}) + (G_{iR0}-G_{TR0}) + (G_{ij0}-G_{iR0})\} + E_i\,\{(G_{TR1}-G_{TR0}) + [(G_{iR1} = G_{TR1}) - (G_{iR0}-G_{TR0})] + \{(G_{ij1}-G_{iR1}) - (G_{ij0}-G_{iR0})]\}$$

Because $E_i = ES_{ij}$, where E is total regional employment, $dE_i = dE(S_{ij}) + E(dS_{ij})$. Consequently, each element in the expression $dE_i\{\ \}$ will be weighted by dS_{ij} and each element in $E_i\{\ \}$ will be weighted by S_{ij}. Thus, a commingling of structural and growth components occurs in both the Mead-Ramsay pure employment effect (i.e., $dE_i\{\ \}$) and the Mead-Ramsay pure recession effect (i.e., $E_i\{\ \}$).

* The interaction of structural changes in the reference economy with competitive changes in the region.

It is even possible to imagine perverse situations where competitiveness, as measured by $(G_{ij0}-G_{iR0})$, is positive in the beginning, remains the same between the two time periods, and yet turns negative when measured by ΔCE_{ij01} because $(S_{iR1}-S_{iR0}) < 0$. Thus, one might be led to conclude falsely that the competitiveness of the ith industry had deteriorated.

Suggested Modifications of the EM Model

The problem the EM model encounters when measuring intertemporal shifts in a region's industry mix or competitiveness stems from the fact that the reference economy also experiences change over time. For example, the industry-mix effect provides false signals because G_{iR1} does not equal G_{iR0}. The competitive effect also misinforms, as S_{iR1} differs from S_{iR0}. Such problems do not surface with interregional comparisons inasmuch as structural and growth characteristics of the reference economy remain constant across regions.

As a starting point to correct this problem, the term $(S_{ij1}-S_{iR0})G_{iR0}$ is added to and subtracted from the industry-mix effect and the term $(G_{ij1}-G_{iR1})S_{iR0}$ to and from the competitive effect. The change over time in the industry mix becomes:

$$(27)\quad \Delta IM_{ij01} = E[(S_{ij1}-S_{iR1})G_{iR0}-(S_{ij0}-S_{iR0})G_{iR0}] + E(S_{ij1}-S_{iR1})(G_{iR1}-G_{iR0})$$

while the change over time in the competitive effect becomes

$$(28)\quad \Delta CE_{ij01} = E[(G_{ij1}-G_{iR1})S_{iR0}-(G_{ij0}-G_{iR0})S_{iR0}] + E(S_{iR1}-S_{iR0})(G_{ij1}-G_{iR1})$$

The final term in each expression measures the interaction of a regional characteristic with a changing characteristic in the reference economy. For example, $(S_{ij1}-S_{iR1})(G_{ij1}-G_{iR0})$ is the interaction between the growth rate change of the ith industry in the reference economy and the change in structure of the region. Similarly, $(S_{iR1}-S_{iR0})(G_{ij1}-G_{iR1})$ is the interaction of structural change in the reference economy with competitiveness of the region. Combining these reference economy interaction terms for the ith industry into RE_{ij}, the modified EM model is given as:

Dynamic EM Model-Modification 1

(29) $\Delta SE_{ij01} = E[S_{iR1}G_{iR1} - S_{iR0}G_{iR0}]$

(30) $\Delta IM_{ij01} = E[(S_{ij1} - S_{iR1})G_{iR0} - (S_{ij0} - S_{iR0})G_{iR0}]$

(31) $\Delta CE_{ij01} = E[(G_{ij1} - G_{iR1})S_{iR0} - (G_{ij0} - G_{iR0})S_{iR0}]$

(32) $\Delta AE_{ij01} = E[(S_{ij1} - S_{iR1})(G_{ij1} - G_{iR1}) - (S_{ij0} - S_{iR0})(G_{ij0} - G_{iR0})]$

(33) $RE_{ij01} = E[(S_{ij1} - S_{iR1})(G_{iR1} - G_{iR0}) + (S_{iR1} - S_{iR0})(G_{ij1} - G_{iR1})]$

One can verify that if the region's structure relative to that of the reference economy has not changed or if the region's growth rate of the ith industry relative to that industry in the reference economy has not changed, then ΔIM_{ij01} and $\Delta CE_{ij01} = 0$. In brief, no commingling of effects occurs in either the industry-mix or competitive effects. All of the interactions between structure and growth are in the terms ΔAE_{ij01} and RE_{ij01}.

Perhaps the major objection to this modification is the arbitrariness in respect to the time period used for the reference economy's structure and growth rates. Obviously, G_{iR1} and S_{iR1} could be used in place of G_{iR0} and S_{iR0}. If this were done, RE_{ij01} would become

(34) $RE_{ij01} = E[(S_{ij0} - S_{iR0})(G_{iR1} - G_{iR0}) + (S_{iR1} - S_{iR0})(G_{ij0} - G_{iR0})]$

The problem is that there is no rationale to prefer one time period's structure and growth rate over any other.

As a way around this dilemma, the two period average of the reference economy's S_{iR} and G_{iR} is calculated. Define S_{iRA} as $(S_{iR0} + S_{iR1})/2$ and G_{iRA} as $(G_{iR0} + G_{iR1})/2$. The dynamic EM model can be written as:

Dynamic EM Model-Modification 2

(35) $\Delta SE_{ij01} = E[S_{iRA}G_{iRA} - S_{iRA}G_{iRA}] = 0$

(36) $\Delta IM_{ij01} = E[(S_{ij1}-S_{iR1})G_{iRA}-(S_{ij0}-S_{iR0})G_{iRA}]$

(37) $\Delta CE_{ij01} = E[(G_{ij1}-G_{iR1})S_{iRA}-(G_{ij0}-G_{iR0})S_{iRA}]$

(38) $\Delta AE_{ij01} = E[(S_{ij1}-S_{iRA})(G_{ij1}-G_{iR0})-(S_{ij0}-S_{iRA})(G_{ij0}-G_{iR0})]$

This modification of the EM model also has the desired property that ΔIM_{ij01} depends entirely on structural changes in the jth region over time and ΔCE_{ij01} entirely on competitiveness of the jth region over time. In addition, it uses structural and growth information on the reference economy in both time periods. The major drawback of modification 2 is that by using an average of S_{iR0} and S_{iR1} and G_{iR0} and G_{iR1}, it suppresses the information contained in the term RE_{ij01}. That information provides an explicit measure of the interaction between changes in the regional and reference economies. Such information may be of some value in understanding the performance over time of a regional economy relative to that of the larger reference economy.

Case Study

The above analysis implies that the conventional (CV) and Esteban-Marquillas (EM) techniques will not generate the same results across regions or for the same region over time. Nonetheless, the real issue involves the significance of these differences. If they are relatively minor, it matters little which technique one uses or whether one uses more complex variants of the shift-share model that more adequately isolate effects. As a way of addressing these empirical issues, a specific case is examined. The case study utilizes data for the fifty states for the intervals 1972-1977 and 1977-1984.[4] The analysis concentrates on employment changes in two industries--manufacturing and services. Both industries exhibit wide structural dissimilarities across states and over time. By selecting these industries, the results purposely are skewed toward showing the largest differences across regions and time periods. Hence, the results

[4]These data come from *County Business Patterns* [21] for the years 1972, 1977, and 1984.

provide the very strongest case on the importance of the issues raised earlier.

The case study focuses on the testing of the following hypotheses:

H1: Substantial differences in effects (perhaps even sign differences) will result between the CV and EM techniques.

H2: A significant interaction of structural and growth effects exists, leading to distortions in making across region comparisons using the CV technique.

H3: A significant reference economy effect exists, leading to distortions in making across time comparisons for the same region when using the EM technique.

H4: The share, industry-mix, and competitive effects will not be independent in the CV technique, but will be for the EM technique.

The tests utilize relatively simple and straightforward methods. In testing H1, each of the effects was calculated by state using the nation as the reference economy. The test also summarizes sign and size differences between techniques. In testing H2 and H3, the allocative effect of equation (4) and the reference economy effect of equation (33) were computed. Both of these effects measure the extent to which either across region structural differences or intertemporal changes in the reference economy contaminate the competitive effect. The traditional zero covariance statistical test of independence was used to test H4. Zero covariance implies a zero simple correlation coefficient, so that such correlation coefficients provide clues as to the importance of interdependency between effects.

Tables 3 through 6 contain findings used to test H1 to H4. Data in Tables 3 and 4 tend to reiterate conclusions drawn earlier from the hypothetical example in Table 2. The CV and EM techniques yield very different results at the microlevel of the industry. (Recall that in the aggregate these techniques generate the same overall results.) For example, the mean values of the industry-mix effects differ by a factor of as much as 16. Perhaps more importantly, a substantial number of cases (40 percent to 60 percent) exist whereby the sign of the industry-mix effect for manufacturing and services differs from one technique to another (i.e., the CV technique may indicate a positive effect on employment change, while the EM technique is negative, and vice versa). As shown in equations (14) and (15), these techniques distribute employment changes between share and industry-mix effects in such a way that each time they disagree on the sign of one effect, they disagree automatically on the other. In brief, there is reasonably strong support for H1; thus, the industry-mix contribution to employment change will depend for its sign and magnitude on which technique one employs.

Tables 3 and 4 also provide information to ascertain the importance of structural and growth interaction in the CV model. The allocative effect, introduced by Esteban-Marquillas to isolate the commingling of structure and growth, represents the difference between the competitive effect calculated by the CV method and competitive effect calculated by the EM formulation. On average, this correction appears small, generally less than one percent. Nonetheless, a two standard deviation spread around the mean indicates for manufacturing a 12.8 percent range in the 1972-1977 interval and a 6.2 percent rate in the 1977-1984 interval. The range between the highest and lowest values for manufacturing is 19.8 percent.

One may argue that the results tend to refute H2. As noted above, they do, on average. Nevertheless, the characteristics of Nevada, which has one of the largest allocative effects in both manufacturing and services, illustrates just how the commingling of structure and growth distorts the competitive effect. With the exception of the District of Columbia, Nevada's employment structure has the lowest percentage of manufacturing jobs (6 percent versus 30.2 percent for the U.S.) and the highest percentage of service employment (47 percent versus 21.6 percent). In addition, Nevada's manufacturing sector experienced rapid growth during the 1972-1977 interval of 76 percent, while its service sector grew during that period at a rate of 46 percent. Because of the lopsided nature of Nevada's economic structure, the CV technique grossly understates how well Nevada did in manufacturing and grossly overstates its performance in services. For example, the actual calculations for these techniques for Nevada for the 1972-1977 interval per 100,000 base period total employees are:

CV Technique

$CE_m = .06\ (.76-.05)\ (100000) = 4{,}260$

$CE_s = .47\ (.47-.266)\ (100000) = 9{,}588$

EM Technique

$CE_m = .302(.76-.05)\ (100000) = 21{,}442$

$CE_s = .216\ (.47-.266)\ (100000) = 4{,}406$

Allowing Nevada's structure to weight its competitive effects yields an inaccurate impression of what actually transpired in the 1972-1977 interval. This is particularly so when comparisons are made to other states. Kansas, for instance, had a growth rate for manufacturing of 31 percent, in contrast to Nevada's 76 percent. Yet the conventional technique calculates the competitive effects per 100,000 base period employees for Kansas as 6,849 and for Nevada as 4,260. Thus, although one might be tempted to dismiss the importance of the Esteban-Marquillas contribution because on average its consequences appear small, specific cases such as that mentioned above argue otherwise.

The last columns of Tables 3 and 4 contain information on the reference economy effect. Those computations are based on equation (34) above. Recall that this effect isolates the interaction of intertemporal changes in the structure and growth of the region with changes in the structure and growth of the reference economy (in this case, the U.S. economy). On average, the effect accounts for fewer than 100 employees per 100,000 total base period employees, providing only the weakest support for H3. Moreover, even the extreme cases represent at the most a 5 percent correction. For the most part, the effect is small because the reference economy did not experience major changes in manufacturing or services during the 1972-1984 interval. Manufacturing started the interval at 30.2 percent of all employment and ended the interval at 24.8 percent, a decline of about one-half of one percent per year over the 12 years. Services as a proportion of total employment changed by even less. Furthermore, annual growth rates of manufacturing and services did not differ significantly between time intervals. Consequently, changes taking place in the reference economy were not large enough to make the reference effect of much importance.

The final set of tables, Tables 5 and 6, provides information on the independence of the share, industry-mix, and competitive effects. Table 5 contains results for manufacturing and Table 6 results for services. The lack of independence in the CV technique surfaces in the first row of Table 5, where the share and industry-mix effect correlate perfectly. Moreover, significant correlations exist between the competitive effect and both share and industry-mix effects. This reiterates earlier discussion that the conventional technique does not generate three separate independent effects that can be summed to obtain an overall employment change. Instead, the commingling of structure and growth links them, leaving their interpretation open to question.

The EM technique should eliminate this problem. By design, it isolates the interaction of structure and competitiveness in the allocative effect. Surprisingly, data in Tables 5 and 6 indicate that the EM model only partially succeeds in providing independent effects. Those data prove that the share and industry-mix effects, as calculated by the Esteban-Marquillas technique, are completely independent effects; so too are the share and competitive effects. Yet in Table 5, there is a significant correlation coefficient during the 1972-1977 interval between the industry-mix and competitive effects.

That correlation seems impossible, given the nature of the EM technique. The industry-mix component of the EM model contains no information on a region's growth because it weights the region's structural deviation from that of the reference economy by growth rates for that reference economy. Moreover, the EM competitive effect includes no information on the region's structure because it weights the region's industry growth rate deviations from that of the reference economy by the structure of the reference economy. Hence, the correlation found cannot be related to the EM technique.

What the correlation between the industry-mix and competitive effects suggests, however, is a violation of the basic underlying assumption upon which any shift-share technique must rest. For the shift-share technique to calculate independent industry-mix and competitive effects, the growth rates of a region's industries cannot depend on that region's employment structure. In many instances, this assumption probably holds. But in the 1972-1977 interval, the growth rate of manufacturing in a region correlated significantly with the structure of that region's employment. Regions with high percentages of manufacturing jobs grew more slowly than those with low percentages. About 27 percent of the across state variation in the growth rate of manufacturing in the 1972-1977 interval resulted from differences in the importance of manufacturing across regions.[5] Under such circumstances, structural and competitive effects commingle regardless of what technique one employs. Thus, although confirmation of H4 is found, an inherent weakness in applying the shift-share methodology is discovered.

Concluding Comments

This paper focuses on evaluating two shift-share techniques with respect to their ability to provide across region descriptions of the factors that account for employment changes and their ability to account for intertemporal employment changes for a particular region. Although the study started with the idea of determining whether the conventional and Esteban-Marquillas techniques decomposed employment changes for an industry into three separate and independent effects, in the process of answering this question, it was revealed that although the aggregate results over a region's industries for the share and industry-mix effects are identical, the detail provided by each technique varies considerably. The case study of manufacturing and service industries documents this. Not only does the magnitude of the share and industry-mix effects vary widely from technique to technique, but in about 50 percent of the cases the signs of these effects also differ. Users of the shift-share technique should be aware that their judgment on how the mix of industries is affecting employment changes in a region hinges on the technique they employ.

If one's goal is to generate a share, industry-mix, and competitive effect that are designed to be independent of each other, one would select the Esteban-Marquillas technique over the conventional

[5]Similar results were found for the 92 counties of Indiana. Using the state as the reference economy, a correlation of -0.47 exists between the industry mix and competitive effects for manufacturing during the 1977-1984 time interval. In the case of services, the correlation of industry mix and competitive effects if -0.262. Thus, in the 1977-1984 time interval, the structure of county employment accounts for 22 percent of the across county variation in the growth of manufacturing employment and 7 percent of the across county variation in the growth of service employment.

technique. A hypothetical example and a case study document the lack of independence of the effects determined by the conventional technique. It is demonstrated that the share and industry-mix effects perfectly correlate in the conventional technique and that the commingling of structure and competitiveness in the competitive effect tends to make all three effects interdependent. Analysis of the case study further reveals that although across all regions the commingling of structure and competitiveness in the competitive effect is not that great, the magnitude of the distortion in specific cases is sizable.

Even though the Esteban-Marquillas technique seemingly isolates three independent effects, it is recognized in making intertemporal comparisons for a single region that changes in the reference economy's structure and industry growth rates may interact with changes taking place in the region--industry-mix and competitive effects may no longer relate only to structure or growth. This effect, which is termed the *reference economy effect* in this paper, is much smaller than anticipated and, at least for the 1972-1984 period, relatively unimportant.

Finally, in analyzing the independence of the share, industry-mix, and competitive effects for the Esteban-Marquillas formulation by using data from a case study, it is found that the industry-mix and competitive effects, although constructed to be independent, are empirically strongly correlated. This investigation discloses that the strong interdependence in industry-mix and competitive effects stems from a violation of an implicit assumption of the shift-share technique, namely, that a region's industry growth rates do not depend on that region's structure. Obviously, this single finding does not invalidate the use of the shift-share technique. Nonetheless, it should send up a red flag to users. Clearly, situations exist where the shift-share technique, even the Esteban-Marquillas version, may not be able to separate industry-mix and competitive effects. Where data allow, it is recommended that users correlate structural measures and growth rates across regions and from these results determine the applicability of the shift-share methodology.

References

1. Andrikopoulos, Andreas A., "A Synthesis of the Production Function and the Shift-Share Model: A New Regional Modelling Approach," *Regional & Urban Economics*, 4 (November 1980), pp. 539-560.

2. Arcelus, Francisco J., "An Extension of Shift-Share Analysis," *Growth & Change*, 15, no. 1 (January 1984), pp. 3-8.

3. Barff, R.A. and P.L. Knight, III, "Dynamic Shift-Share Analysis," *Growth & Change*, 18, no. 2 (Spring 1988), pp. 1-12.

4. Blair, D.W. and R.H. Mabry, "Regional Crime Growth: An Application of the Shift-Share Technique," *Growth & Change*, 11, no. 1 (January 1980), pp. 48-51.

5. Dawson, J., *Shift-Share Analysis: A Bibliographic Review of Technique and Application* (Monticello, IL: Vance Bibliographies, 1982.)

6. Edwards, J. Arwel, "Industrial Structure and Regional Change: A Shift-Share Analysis of the British Columbia Economy 1961-1970," *Regional Studies*, 3 (1976), pp. 307-317.

7. Esteban-Marquillas, J.M., "A Reinterpretation of Shift-Share Analysis," *Regional & Urban Economics*, 2 (1972), pp. 9-16.

8. Gordon, J.R., W.B. Hackett, and D. Mulkey, "Using the Shift-Share Technique in Economies with Widely Varying Sectoral Growth Rates: Observations and a Suggested Model Modification," *The Review of Regional Studies*, 10, no. 1 (Spring 1980), pp. 57-67.

9. Green, Robert T. and Arthur W. Allaway, "Identification of Export Opportunities: A Shift-Share Approach," *Journal of Marketing*, 49, no. 1 (Winter 1985), pp. 83-88.

10. Halperin, Sanford and Rodney H. Mabry, "Property and Casualty Insurance Lines Comparison: A Shift-Share Analysis," *Journal of Risk & Insurance*, 51, no. 3 (September 1984), pp. 524-535.

11. Haynes, K. and Z. Machunda, "Considerations in Extending Shift-Share Analysis: Note," *Growth & Change*, 18, no. 2 (Spring 1987), pp. 1-10.

12. Herzog, Henry W. and Richard Olsen, "Shift-Share Analysis Revisited: The Allocation Effect and the Stability of Regional Structure," *Journal of Regional Science*, 17, no. 3 (December 1977), pp. 441-454.

13. Kahley, William J., "What's Behind Patterns of State Job Growth?" *Economic Review Federal Reserve Bank of Atlanta* (May 1986), pp. 4-18.

14. Keil, S., "On the Value of Homotheticity in the Shift-Share Framework," paper presented at the 1989 meetings of the Mid-Continent Regional Science Association, June 1989.

15. Ledebur, Larry and Ronald L. Moomaw, "A Shift-Share Analysis of Regional Labor Productivity in Manufacturing," *Growth & Change*, 14, no. 1 (January 1983), pp. 2-9.

16. Mead A.C. and G.A. Ramsay, "Analyzing Differential Responses of a Region to Business Cycles," *Growth and Change*, 13, no. 1 (1982), pp. 38-42.

17. Merrifield, John, "The Role of Shift-Share in Regional Analysis," *Regional Science Perspectives*, 13, no. 1 (1983), pp. 48-54.

18. Riefler, Roger F., "Comparative Cyclic Behavior of an Agricultural Economy: Nebraska in the 70s and 80s," *Review of Regional Studies*, 16, no. 1 (1986), pp. 24-30.

19. Stevens, Benjamin and Craig L. Moore, "A Critical Review of the Literature on Shift-Share as a Forecasting Technique," *Journal of Regional Science*, 4 (November 1980), pp. 419-437.

20. Tervo, Hannu and Paavo Okko, "A Note on Shift-Share Analysis as a Method of Estimating the Employment Effects of Regional Economic Policy," *Journal of Regional Science*, 23, no. 1 (February 1983), pp. 115-121.

21. U.S. Bureau of Census, *County Business Patterns* (all states), 1972, 1977, 1984, (Washington, D.C.: U.S. Government Printing Office.)

Table 1
Data Used in Hypothetical Example

Characteristic	**Region j**	**Reference**
E	1,000	----
S_1	0 to 1.0	0.60
S_2	1.0 to 0	0.40
G_1	0.15	0.12
G_2	0.10	0.08
G_{TR}	----	0.104

Table 2
Comparison of CV and EM Methods for Hypothetical Data

Structure S_{1j}	Share Effect Industry 1 CV	Share Effect Industry 1 EM	Share Effect Industry 2 CV	Share Effect Industry 2 EM	IM Effect Industry 1 CV	IM Effect Industry 1 EM	IM Effect Industry 2 CV	IM Effect Industry 2 EM
0	0	72.00	104.00	32.00	0	-72.00	-24.00	48.00
0.10	10.40	72.00	93.60	32.00	1.60	-60.00	-21.60	40.00
0.20	20.80	72.00	83.20	32.00	3.20	-48.00	-19.20	32.00
0.30	31.20	72.00	72.80	32.00	4.80	-36.00	-16.80	24.00
0.40	41.60	72.00	62.40	32.00	6.40	-24.00	-14.40	16.00
0.50	52.00	72.00	52.00	32.00	8.00	-12.00	-12.00	8.00
0.60	62.40	72.00	41.00	32.00	9.60	0	-9.60	0
0.70	72.80	72.00	31.20	32.00	11.20	12.00	-7.20	-8.00
0.80	83.20	72.00	20.80	32.00	12.80	24.00	-4.80	-16.00
0.90	93.60	72.00	10.40	32.00	14.40	36.00	-2.40	-24.00
1.00	104.00	72.00	0	32.00	16.00	48.00	0	-32.00

Structure	Competitive Effect Industry 1 CV	Competitive Effect Industry 1 EM	Competitive Effect Industry 2 CV	Competitive Effect Industry 2 EM	Allocative Effect Industry 1	Allocative Effect Industry 2
0	0.00	18.00	20.00	8.00	-18.00	12.00
0.10	3.00	18.00	18.00	8.00	-15.00	10.00
0.20	6.00	18.00	16.00	8.00	-12.00	8.00
0.30	9.00	18.00	14.00	8.00	-9.00	6.00
0.40	12.00	18.00	12.00	8.00	-6.00	4.00
0.50	15.00	18.00	10.00	8.00	-3.00	2.00
0.60	18.00	18.00	8.00	8.00	0	0
0.70	21.00	18.00	6.00	8.00	3.00	-2.00
0.80	24.00	18.00	4.00	8.00	6.00	-4.00
0.90	27.00	18.00	2.00	8.00	9.00	-6.00
1.00	30.00	18.00	0.00	8.00	12.00	-8.00

Table 3
Comparison of Industry Mix, Allocative and Reference Economy Effects Across States: Manufacturing

	Industry Mix 1972-1977 CV	Industry Mix 1972-1977 EM	Industry Mix 1977-1984 CV	Industry Mix 1977-1984 EM	Allocative Effect 1972-1977	Allocative Effect 1977-1984	Reference Economy Effect
Mean	-1,883	-159	-4,946	31	-1,140	-250	-87
Standard Deviation	748	542	1,993	147	3,206	1,549	944
Highest Value	-432	715	-1,070	317	3,038	3,228	2,203
Lowest Value	-3,089	-1,210	-8,583	-238	-16,806	-7,250	-2,089
Sign Disagreement	21		26		----	----	----

Values shown are per 100,000 base period total employees in a state

Table 4
Comparison of Industry Mix, Allocative and Reference Economy Effects Across States: Services

	Industry Mix 1972-1977 CV	Industry Mix 1972-1977 EM	Industry Mix 1977-1984 CV	Industry Mix 1977-1984 EM	Allocative Effect 1972-1977	Allocative Effect 1977-1984	Reference Economy Effect
Mean	3,274	189	6,339	137	7	78	31
Standard Deviation	916	1,666	1,805	2,916	1,016	786	1,339
Highest Value	7,258	7,438	14,144	13,952	5,307	4,693	5,326
Lowest Value	2,107	-1,933	676	-3,655	-4,502	-2,215	1,730
Sign Disagreement	30		28		----	----	----

Values shown are per 100,000 base period total employees in a state

Table 5
Zero Order Correlation Coefficients Betrween Share Effect (SE), Industry Mix Effect (IM), Competitive Effect (CE) and Allocative Effect (AE): Manufacturing

Conventional Technique

	SE77	IM77	CE77	SE84	IM84	CE84
SE77	1.0000	-1.0000**	-.3453*	.9899**	-.9899**	-.1622
IM77	-1.0000**	1.0000	.3453*	-.9899**	.9899*	.1622
CE77	-.3453*	.3453*	1.0000	-.2810	.2810	.4153*
SE84	.9899**	-.9899**	-.2810	1.0000	-1.0000**	-.0592
IM84	-.9899**	.9899**	.2810	-1.0000**	1.0000	.0592
CE84	-.1622	.1622	.4153*	-.0592	.0592	1.0000

Esteban-Marquillas Technique

	SE77	IM77	CE77	AE77	SE84	IM84	CE84	AE84
SE77	1.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
IM77	.0000	1.0000	-.5190**	.5238**	.0000	-.9899**	-.2299	.2221
CE77	.0000	-.5190**	1.0000	-.8880**	.0000	.4799**	.4163*	-.4232**
AE77	.0000	.5238**	-.8880**	1.0000	.0000	-.5149**	-.2830	.4614**
SE84	.0000	.0000	.0000	.0000	1.0000	.0000	.0000	.0000
IM84	.0000	-.9899**	.4799**	-.5149**	.0000	1.0000	.1310	-.1920
CE84	.0000	-.2299	.4163*	-.2830	.0000	.1310	1.0000	-.5640**
AE84	.0000	.2221	-.4232**	.4614**	.0000	-.1920	-.5640**	1.0000

* Significance L.E. 0.01
** Significance L.E. 0.001

Table 6
Zero Order Correlation Coefficients Betrween Share Effect (SE), Industry Mix Effect (IM), Competitive Effect (CE) and Allocative Effect (AE): Services

Conventional Technique

	SE77	IM77	CE77	SE84	IM84	CE84
SE77	1.0000	1.0000**	.0051	.9791**	.9791**	.1595
IM77	1.0000**	1.0000	.0051	.9791**	.9791**	.1595
CE77	.0051	.0051	1.0000	-.0636	-.0636	.4322**
SE84	.9791**	.9791**	-.0636	1.0000	1.0000**	.1329
IM84	.9791**	.9791**	-.0636	1.0000**	1.0000	.1329
CE84	.1595	.1595	.4322**	.1329	.1329	1.0000

Esteban-Marquillas Technique

	SE77	IM77	CE77	AE77	SE84	IM84	CE84	AE84
SE77	1.0000	.0000	.0000	.0000	.4410**	.0000	.0000	.0000
IM77	.0000	1.0000	-.0285	.0802	.0000	.9791**	.1257	.1918
CE77	.0000	-.0285	1.0000	.3835*	.0000	-.0826	.3181	.2605
AE77	.0000	.0802	.3835*	1.0000	.0000	.0095	.2345	.8822**
SE84	.4410**	.0000	.0000	.0000	1.0000	.0000	.0000	.0000
IM84	.0000	.9791**	-.0826	.0095	.0000	1.0000	.1067	.1521
CE84	.0000	.1257	.3181	.2345	.0000	.1067	1.0000	.2715
AE84	.0000	.1918	.2605	.8822**	.0000	.1521	.2715	1.0000

* Significance L.E. 0.01
** Significance L.E. 0.001