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A Summary of the Literature on Shift-share Analysis

Abstract

Shift-share analysis is a method of decomposing regional income or employment growth patterns into expected (share) and differential (shift) components. Since its inception in the 1940s, over seventy academic contributions have criticized, defended, and extended the original concept. These contributions are summarized, and research needs for the future are identified.

I. INTRODUCTION TO SHIFT-SHARE ANALYSIS

Regional development occurs within a national framework and is partially a function of economic factors that take place at the macro level. Yet, it has been well-documented that regional economies do not behave as smaller, monolithic sub-divisions of a larger, national whole (Danson, Lever and Malcolm, 1980; Doeringer et al., 1987). A country's overall economic growth trends are not often replicated at the regional level. These marked spatial inequalities between a nation's economy and its disaggregated regional components are difficult to analyze and describe. Equally complex is the task of examining lateral variations in growth; two regions having similar economic structures may not necessarily be alike in growth performance. Incongruent industrial growth is also common; the same industries located in different regions can diverge significantly in their economic performance. Regional economics has attempted to develop techniques to analyze differences among regional growth patterns. Shift-share analysis[1] is one method to describe growth of sub-national economies. The description of the economy provided by shift-share can be used in research that explores the reasons for change. It is strictly a descriptive technique. By itself, it cannot be used to elicit the determinants economic trends.

The technique was first applied in the U.S. to calculate employment change from 1939-1954 (Dunn, 1960). Its origins date from the 1940's when an economist for the U.S. Bureau of Labor and Statistics developed the concept of "location shifts" used to measure growth trend differences between the nation and its states (Creamer, 1942, p.85). Contributions by Fuchs (1962) and Ashby (1964) formalized the "classic" shift-share equation and helped popularize the technique. Shift-share is utilized by regional economists, community planners, and policy analysts to provide quick sketches of the economic landscape of both rural and urban areas. A reason for shift-share's frequent application is its ease of use: an analysis requires only a modest amount of commonly compiled data.

While shift-share has been enthusiastically employed, significant reservations about the technique surfaced in the late 1960s and dominated the literature of the early 1970s. Tempered academic support for the technique re-emerged in the mid-1980s. Much recent attention has re-examined of some of shift-share's more serious limitations (Barff and Knight, 1988; Casler, 1989; Kochanowski et al., 1989; Holden et al., 1987; Holden et al., 1989; Kurre and Weller, 1989; Patterson, 1991).

Critics cite the lack of theoretical substance in the technique and point to practical obstacles such as sensitivity to disaggregation as reasons for limiting its use. Richardson (1978) described shift-share analysis as "a harmless pastime for small boys with pocket calculators" and considered it to be one of the most overvalued tools employed by regional economists (p.202). Advocates of shift-share countered that "when a technique is simple and apparently useful, it will be both widely used and heavily criticized" (Fothergill and Gudgin, 1979, p.309). The general consensus is that reasoned application of the technique can yield modest though often qualified insights about regional growth (Merrifield, 1983).

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[1]Shift-share analysis has also been called components of change analysis, particularly in British academic literature.

Despite the number of authors writing about shift-share, few comparative studies are found in the literature.[2] Research has seldom focused on systematically dissecting the merits of the various shift-share models. No empirical studies comprehensively test the criticisms, claims and theoretical assertions of competing models.

II. THE CLASSIC MODEL

Although shift-share analysis begins with the classic model[3], all models have the same general conceptual explanation of growth. Shift-share analysis decomposes regional growth into separate and unique factors influencing the prosperity of spatially distinct areas. Most shift-share models are mathematical identities expressing economic upswings (or downturns) as a function of three broad factors: the national growth effect, the industrial mix effect, and the competitive effect. Between any two time periods, the observed change in growth is assumed to be the sum of these three effects or components[4]. Since economic growth is difficult to measure directly, changes in the level of regional employment or personal income have become accepted surrogates for economic growth.

A. The Classic Shift-Share Equation

The classic shift-share model is defined as:

$$E_{ij}^{t} - E_{ij}^{t-1} = \Delta E_{ij} = NE_{ij} + IM_{ij} + CE_{ij} \quad (1)$$

E^{t}_{ij}=Employment (income) in the ith sector in the jth region at time t

NE_{ij}=National Growth Effect

IM_{ij}=Industrial Mix Effect

CE_{ij}=Competitive Effect

The three effects are computed as follows:

$$NE_{ij} = E_{ij}(e_{oo}) \quad (2)$$

$$IM_{ij} = E_{ij}(e_{io} - e_{oo}) \quad (3)$$

$$CE_{ij} = E_{ij}(e_{ij} - e_{io}) \quad (4)$$

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[2]Most studies comparing shift-share models treat only two models. Since more than 10 specifications are in the literature, these enquiries are limited in scope.

[3]The classic model was the first model to be formulated and applied. It was two decades before alternative models were introduced.

[4]Components will be used throughout this paper to refer concisely to the three growth effects: the national growth effect, industry effect mix and competitive effect.

Where small "e" denotes employment (income) growth rates, parentheses indicate multiplication, and:

e_{ij}= the percentage of change in employment (income) in industry i, region j relative to a base year

e_{io}= the percentage change in nationwide employment (income) for industry i

e_{oj}= the percentage change in total employment (income) for region j

e_{oo}= the percentage change in nationwide employment (income)

Since e_{oo}, e_{io}, and e_{ij} are simple growth rates over time, an expanded version of the shift-share model presented in equation 1 is:

$$\Delta E_{ij} = NE_{ij} + IM_{ij} + CE_{ij} = E_{ij}^{t-1}\left(\frac{E_{oo}^{t}-E_{oo}^{t-1}}{E_{oo}^{t-1}}\right) + E_{ij}^{t-1}\left(\frac{E_{io}^{t}-E_{io}^{t-1}}{E_{io}^{t-1}} - \frac{E_{oo}^{t}-E_{oo}^{t-1}}{E_{oo}^{t-1}}\right) + E_{ij}^{t-1}\left(\frac{E_{ij}^{t}-E_{ij}^{t-1}}{E_{ij}^{t-1}} - \frac{E_{io}^{t}-E_{io}^{t-1}}{E_{io}^{t-1}}\right) \quad (5)$$

where:
i= the number of sectors or industries in a region or nation (i=1,2,...s)

j= the number of regions in an geographical area (j=1,2,...r)

Capital "E" denotes employment or income levels:

E_{ij}= employment (income) in the ith sector in the jth region

E_{oj}= employment (income) in all industries in the jth region $=\Sigma_i E_{ij}$

E_{io}= national employment (income) in the ith industry $=\Sigma_j E_{ij}$

E_{oo}= total national employment (income) $\Sigma_i \Sigma_j E_{ij}$

Depending on the analyst's objectives, for a given region, each of the three components can be estimated for an individual industry or summed over all industries and calculated for the entire region.

B. Interpretations of the Shift-Share Components

A good working understanding of the meaning of each component is essential. A more in-depth explanation of the role of each component follows.

1. National Growth Effect

The national growth effect is the "amount that total regional employment would have grown if it grew at precisely the same rate as total employment in the nation as a whole" (Stilwell, 1969, p.163). Implicitly, the model asserts that the industries in a region will grow at approximately the rate of national industries unless the region has a comparative advantage or disadvantage[5] (Bishop and Simpson, 1972).

2. Industry Mix[6]

Most regions do not have identical industrial profiles. Some regions are home to a preponderance of slow-growing sectors, while others may specialize in sectors with growth rates that are higher than the national average. The industry mix effect in the shift-share equation tries to capture these regional variations in industrial composition. The industry mix is the amount of growth attributable to differences in the **sectoral makeup** of the region versus that of the nation.

The summation of the industry mix over each of the industries in the region, IM_{oj}, provides a total industry mix effect for all sectors in the region. A positive total industry mix implies the region is specialized in industries that, nationally, are experiencing greater growth than the overall national average.[7] A negative total industry mix means that a region has higher than average proportions of people employed in industries that are sluggish relative to the average growth of all national industries.

A definition from which shift-share derives part of its name is that of the regional share. The sum of the national growth effect and the industry mix ($NE_{oj}+IM_{oj}$) are together called the region's proportion or share of growth. Both the national growth effect and the industry mix effect are exogenous factors that are determined by national growth rates, not local or regional economic conditions. Together, they comprise the region's expected growth--the growth that would occur in the region if each of the industries grew at the same rate as the nation as a whole.

3. Competitive Effect[8]

If industry i in region j grows at anything other than the sum of the national growth effect and the industry mix (i.e. the region's share), the the residual is ascribed to the competitive effect. The competitive effect is a "shift" from what would be expected if the region's industry grew at exactly

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[5]Since each component in the shift-share equation can be positive, negative or zero, a positive national growth rate does not necessarily imply that the total change in employment calculated from the shift-share equation will also be positive.

[6]The industry mix has also been referred to as the compositional mix, structural component, proportionality shift, and the proportionality effect.

[7]Again, because the other components in the equation may be positive, negative or zero, a region that has a strong industrial base of industries growing faster than the national average growth for all industries could conceivably have a growth rate below that of the nation, if the other national growth effect or the competitive effect is large and negative.

[8]The competitive effect has also been called a regional shift, differential shift, regional proportion, regional effect and the competitive component.

the proportion of national growth and industry mix. Implicit in shift-share analysis is the assumption that regional economies should grow at national growth rates unless there are comparative advantages or disadvantages operating at the regional level (Bishop and Simpson, 1972). A positive competitive effect means that a region's industry is growing faster than the national average industry growth rate and a negative competitive effect implies that a region's industrial growth is lagging behind national industries manufacturing the same products (Stevens and Moore, 1980).

The growth attributed to the competitive effect is the value that is left after the national growth effect and industry mix are subtracted. This residual is inferred to result from factors that are unique to the region. The competitive effect arises "from interregional differences affecting a given area's attractiveness to the activity," (James and Hughes, 1973, p.223). These differences develop because of endogenous factors inherent to the region (Dawson, 1982). The competitive effect can be thought of as a measurement of a region's competitive edge or comparative advantage in the production of the goods in the ith industry.

While the shift-share competitive effect describes whether regional conditions favor or discourage growth, it does not provide answers as to why a strongly positive shift exists in one region but not in another. Reasons for differential growth arise from an amalgam of factors, which may include different levels of resource endowments, multiplier effects, agglomeration economies, or policy measures such as low business taxes or high investsments in human capital formation. By itself, shift-share cannot ferret out which factors are at work in various regions. (Berzeg, 1978).

III. CRITICISMS

Much of the early work in shift-share analysis focused on the weaknesses of the technique and sought to isolate the model's shortcomings and determine the extent to which they jeopardized the integrity of the model. Other contributions focused on improving upon the classic shift-share equation. The following section describes the significant criticisms of the model and details the major contributions in the literature.

A. Lack of Theoretical Base

Shift-share has been criticized as a technique that provides "measurement without explanation" (Bartels et al., 1982, p.17). Houston (1967) charged that shift-share disaggregated growth arbitrarily without providing any rationale for the division, nor any economic theory useful to analysts in the interpretation of its results. Houston asserted that without a theoretical framework, shift-share was no more useful than bare employment and growth rate statistics. Richardson (1978) expressed a deeper skepticism in the ability of shift-share to provide useful economic insights to regional growth and warned that "Its use as a...guide to policy is dangerous" (p.206).

While shift-share is not a robust behavioral growth model, adherents argue that it is a useful tool whose purpose is to identify and describe rather than explain growth forces (Ashby, 1968). Stilwell (1969) noted that the "whys" of differences in growth amongst industries are questions best answered by using other economic models such as location analysis or case studies. Shift-share could play a role in this process by providing an initial measurement of these differences.

Recognizing the advantages of building a theoretical foundation around the technique, efforts have also been made to link shift-share models with the roots of causation of the three shift-share components. Chalmers and Beckhelm (1976) used location theory to explain the competitive effect as a comparative advantage resulting from regions possessing differing profit potentials. Consumer markets, intermediate markets, supply wages and supplier availability were used as proxies for firm costs and revenues. These five factors were included as independent variables in a standard regression model to determine if they could be correlated with the competitive effect. Results indicated that for some industries the competitive effect seemed to be well-explained by consumer markets, intermediate market potential, and, to a lesser extent, supply (1976, p.21). But these relationships did not hold for all industries, and their step-delete method of constructing the regressions has since fallen from favor among econometricians.

Theil and Gosh (1980) suggested the use of the RAS method in place of shift-share. RAS is an iterative technique used to estimate cell values from column and row totals. Theil and Gosh suggested using base year values of local sector employment or income as a starting point for the RAS procedure, together with terminal year total income or employment for the column and row totals. The RAS estimates of local sector income or employment could then be compared with actual income or employment in the terminal year. Because the RAS model possessed a theoretical home in location theory, the authors noted that this alternative offered a technique that was more rigorous and equally easy to calculate. The second advantage to RAS lay in its industrial and regional symmetry, a common obstacle in the traditional shift-share approach.[9] But Haynes and Machunda (1987) argue that RAS also has a drawback. RAS does not provide the comprehensive decomposition that shift-share offers.

Sakashita (1973) used a multi-regional growth model developed with Kamoike as a theoretical base for shift-share. Using a Cobb-Douglas production function with labor and capital inputs, he derives a growth equation, incorporating growth and structural components somewhat analogous to the shift-share components. Making several restrictive assumptions, a general equilibrium is derived in which sectoral growth rates are endogenous to the model. Sakashita's work also includes empirical testing of the model supporting the hypothesis that there are theoretical explanations that well-describe the relationship between the growth components (Dawson, 1982). Casler (1989) constructed a regional input growth model and linked shift-share components to factor demand for labor.

There has been considerable debate as to whether the competitive effect actually has the economic interpretations ascribed to it. In Buck's (1970) empirical study of northwest England and Merseyside, the factors impacting the value of the competitive effect were found to be spurious and random. Of the forty-one firms surveyed in two industrial counties in the U.K., twenty had no significant impact on the value of the competitive effect. Of the remaining businesses, Buck found five had competitive effects attributable to erroneous industrial classification. Eight firms' competitive effects were due to "lack of product homogeneity."[10] Three firms owed their changes in the competitive effect to unique shocks such as corporate takeovers resulting in layoffs that adversely altered the region's competitive effect. The final five businesses

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[9]See the section, "Regional Additivity and the Esteban-Marquillas Reformulation"

[10]Buck noted that since many firms produce products with varying levels of income elasticity of demand, growth in the competitive effect may be the result of growth in one small segment of the industry. To illustrate this, he provided an example of a photo industry which introduces a new and successful film product. While consumer demand for the rest of the industry products sags, the competitive effect may rise due to an increase in demand in one isolated segment of the market.

displayed positive competitive effects attributed to direct government assistance. Buck emphasized that there was no apparent spatial explanation for the competitive effect but that the type of market analyzed did appear to have a role in the value and sign of the component.[11]

MacKay (1968) also questioned the analytical strength of shift-share's competitive effect and posited that the technique fails to adequately characterize the influences that industrial interdependence and linkages have on regional growth. MacKay illustrated the omission of multiplier effects using a simple example. He posited that two regions, both with established service industries could include, among other businesses, successful hairdressing salons. MacKay argued that if the number of hairdressers grew faster in one region versus another, this change would be considered a competitive advantage for the region which experiences rapidly expanding beauty shops. Yet, a more likely cause of regional differences in the prosperity of hairdressing could likely be more directly explained not by comparative advantages in one region which make it more efficient in providing hair cuts, but instead because of a thriving manufacturing base in one region which causes an increase in income and promotes growth in all service sectors. MacKay termed the competitive effect a meaningless "rag-bag" because as a residual term it collects all change in growth that could not be explicitly absorbed by the national growth and industry mix effects. Due to its lack of accounting for industrial linkages, the shift-share equation would consistently under-represent the importance of industrial structure.

Randall (1974) noted that the slow rate of growth in U.K. manufacturing during 1959-68 was largely the result of its linkages to shipbuilding, an industry experiencing significant decline during this decade. Randall argued that the linkages between manufacturing and shipbuilding were concealed in a standard shift-share analysis, and he attempted to estimate the growth rate of manufacturing in the absence of a decreasing demand for shipbuilding. Calculations suggested that the competitive effect was overly negative and that taking account of direct and indirect linkages to shipbuilding merited an upward adjustment of the competitive effect by 15 to 20 percent.

In their study of the economic impacts brought on by the advent of oil drilling in Aberdeen, Scotland in the 1970s, Harris et al. (1987) used shift-share analysis to calculate employment change and found that the competitive effect accounted for the greatest degree of employment increase. However, this positive competitive effect was largely due to the fortuitous resource endowment uncovered by oil exploration rather than any relative locational advantages in, for example, manufacturing or services. Stilwell (1970) warned against concluding that large, negative competitive effects provide evidence that a region has a weak comparative advantage and is somehow inefficient in its enterprises. This can be especially true when employment is used to gauge the performance of an industry: a firm that acquires labor-saving equipment may reduce the number of people it employs, but increase its comparative advantage and income in the process.

B. Disaggregation and the Shift-Share Components

A long-standing problem in the use of shift-share analysis is that the values of the components vary depending on the degree of disaggregation selected. As the classification of industries is split into finer categories,

[11] Buck himself emphasized inherent weaknesses in his methodology. Much of the data was collected through business interviews making it likely that disclosures may not have been complete or accurate. Because the survey region was also limited, the statistical significance of his findings as well as the extent to which his conclusions can be generalized are questionable.

the industry mix accounts for a larger and larger portion of growth and the competitive effect tends to decrease in importance. In the limit, the value of the competitive effect will reach zero.

Consider an example in which disaggregation is carried out until an individual grocery store represents the entire industry. This hypothetical disaggregation could begin with a coarse classification that separates services from manufacturing. Services could then be split into retail, and retail can be furthered narrowed to food stores. Food stores can be divided into full stock and convenience stores. This process of dividing the industry into finer distinctions could continue until, at the most pronounced level of disaggregation, a single grocery store--for example an organic food co-operative with a particular mix of items on its shelves--comprises the entire industry. At this level of classification $e_{ij}=e_{io}$, forcing the value of the competitive effect, $E_{ij}(e_{ij}-e_{io})$, to zero (Houston, 1967).

This problem is not necessarily limited to unusually fine industrial classifications. Levels of disaggregation embodied in data more commonly available are also subject to variability in the estimates of the components. If shift-share is calculated for the same set of data at both the two-digit and four-digit SIC level, the resulting values for the industry mix and competitive effect will likely differ.

It is not possible to anticipate how much the values will differ. Although the industry mix and competitive effect will tend to grow larger and smaller respectively as disaggregation becomes extreme, this occurs only in the limit. For any single aggregation or disaggregation, the degree and direction of change in the components is unpredictable (Houston, 1967).

Recognizing that finer levels of industrial classification lead to difficulties in shift-share may not help an analyst avoid disaggregation pitfalls. Data disaggregated to a desired classification level may not be readily available. Even if coarser data exists, critics are highly skeptical of this approach and emphasize that because no preferred theoretical level of disaggregation exists *a priori*, shift-share could easily be manipulated by analysts who "...cook results by adjusting the fineness of industry detail" (Richardson, 1978, p.205).

Several efforts have been made to determine whether the degree of sensitivity of shift-share models to disaggregation is great enough to produce unreliable results. Fuchs (1959) calculated Spearman coefficients of rank correlation to compare component values at the four, three and two-digit levels of classifications. Results indicated that the three and four-digit values differed only slightly from one another and that the choice of whether to use total employment or value added had a far greater impact on the variability of the results than did the selection of a level of disaggregation.

Contrary to Fuchs, Buck (1970) found substantial variation in the value of shift-share components when the level of disaggregation was adjusted. Standard disaggregation levels also "gravely underestimated" the role of the industrial structure for the regions examined (1970, p.447). Harris et al. (1987) found mixed results. Shift-share results conducted at two levels of disaggregation indicated that when three broad categories of industries with positive competitive effects were disaggregated, six of the thirteen sub-classifications became negative. However, the negative values were small relative to the positive differentials. In his study of west central Scotland, Randall (1974) found that the value of the competitive effect shrank as the level of disaggregation increased.

Fothergill and Gudgin (1979) used standard regional divisions in the U.K. to disaggregate both manufacturing and total employment data from 1952-

1975. They determined that the values of the competitive effect varied only slightly for different levels of industrial classification. Their analysis concluded that the discrepancies between the values of the components at various disaggregation levels were substantial "...only in cases of large industries with significant growth differences between branches and with branches spatially concentrated in different areas" (p.311).

Fothergill and Gudgin also suggested that the fact the competitive effect could be forced to zero in extreme disaggregation was theoretically interesting but unimportant for analysts since severely narrow classifications had little practical use in actual shift-share applications. They stressed that the emphasis should instead be placed on developing meaningful contexts to explore the effects of disaggregation; comparing "like with like" and choosing a level of classification no finer than necessary could by-pass some of the disaggregation quagmires.

Others also asserted that disaggregation was a concern but not a cancer in shift-share. Ashby (1968) argued that variation was to be expected in shift-share and that skepticism should instead be directed at any model which produced identical values regardless of the disaggregation level, because this would imply the model is model insensitive to new information. Stilwell (1969 and 1970) and Casler (1989) pointed out that other regional economic techniques suffer from disaggregation problems and that the shift-share model could not be dismissed on these grounds alone.

C. Base Versus Terminal Year Weights

In the shift-share model, the weight is the level of employment or income (E_{ij}). The values that shift-share computes for the national growth effect, industry mix and competitive effect are dependent on how the equation is weighted. The analyst must chose whether to weight with values from the base year, the terminal year, or some combination thereof. Regardless of the weight chosen, two sources of bias emerge. The first is that the calculations do not take into account changes in the weight over the studied time period. Second, the components do not reflect any adjustments in the industry mix that occur because of a host of regional changes including demographic shifts, business cycles, birth of new markets, or strengthened infrastructure. The difficulties resulting, often called the choice-of-weights problem, can best be illustrated by an example.

Consider a hypothetical shift-share analysis calculated for the city of Detroit for two periods, the era marking the advent of the automobile, and any year several decades later. Selecting either the base year or the terminal year would bias the shift-share results. The base year does not reflect the coming revolution in the auto industry, and the shift-share components will under-estimate the industrial effect of auto manufacturing. Conversely, the terminal year conveys a high level of employment relative to other Detroit industries that did not always exist. Thus, the terminal weight cannot express that car manufacturing was not always as vital to the Detroit area as it is in the year used for the analysis. Results will overstate the degree of specialization in Detroit's auto industry.

The problem of weighting in shift-share analysis has been likened to the difficulties that occur in using economic indexes (Dunn, 1960). Like indexes, the shift-share choice-of-weights problem occurs because the weights calculated for the industrial structure in the base or terminal year are assumed to hold for all years in the time period of interest. This assumption must be made in performing the analysis, but becomes less and less valid as the shift-share equation is used to examine increasingly longer time spans. Changes in the regional industrial structure over time are not captured in the analysis (Herzog and Olsen, 1977). A region having a concentration of industries with declining growth at the base year could, for example, modify its composition and this would not be accounted for in a model that uses initial year weights (Dawson, 1982). Or, as the above example illustrates, the use of terminal year weights can over-exaggerate growth in an industry which is on the upswing.

Much of the literature has been devoted to measuring the significance of the bias and suggesting alternative formulations that dampen its impact. Using Spearman's coefficients of rank correlation to analyze U.S. manufacturing data from 1929-1954, Fuchs (1959) measured the correlation of results obtained when base versus terminal year weights were used. The competitive effect was found to be insensitive to the choice of weights.[12] But the industry mix values did change depending on whether beginning or end years were used and thus results computed with base weights were not as well correlated with results computed with terminal weights.[13] Because of the variability in the industry mix, Fuchs proposed that the base and terminal year employment levels be averaged to remedy this problem. Others suggested calculating mid-year rates to minimize weighting bias (Klaassen and Paelinck, 1972).

The literature does not seem to recognize that averaging, however, may or may not mitigate the bias depending on which way it leans. In some cases, averaging the two weights will result in a value which is less accurate than if the straight base or terminal year had been used.

Stilwell (1969) advocated the use of terminal weights in what he termed the "reversed composition shift." This revision was suggested to strengthen the model by identifying regions "not yet suffering from declining employment shares, but perhaps likely to do so" and could also pinpoint areas with past negative shifts that had a potential to grow in the future due to specialization in fast-paced industries (1969, p.170).

Ashby (1970) dismissed Stilwell's contribution arguing that it was a synthesis of both initial and terminal years and noted that although "the base against which rates are computed can be *any* convex combination of the initial and terminal values" (p.298), Stilwell's choice was too extreme and wandered far from the use of a "fifty-fifty arithmetic convex base" that had been recommended and used in other applications.

Fothergill and Gudgin (1979) downplayed the severity of the weighting problem noting that it was a significant obstacle only in less common circumstances in which the industrial structure changed dramatically and rapidly over the period being studied. In general, they noted that "for many purposes the choice of base year will make little practical difference" (p.313). Using U.K. regional employment data from 1952-1975, they found that despite some significant changes in the industrial makeup, the choice of a base year had a negligible impact on the shift-share results in ten of the eleven British regions surveyed.

Others noted that the choice-of-weights problem became much less pronounced as the time period under study shortened. (Dunn, 1960). This is because as the time period is narrowed, it becomes less likely that industrial structure can change appreciably. Recognizing this, Thirlwall split his data set for the years 1948-1963 into three sub-sections (1967). Lack of annual data and the technological state of computers likely prevented this technique from becoming commonplace. Yet, explicit acknowledgement that the weight problem could taper off as component calculations approached yearly estimation

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[12] (r=.964)

[13] (r=.752)

was absent in the literature even after practical obstacles dissipated. This oversight prevailed until Barff and Knight (1988) developed what they termed "dynamic shift-share analysis."

Barff and Knight (1988) declared that "The problems presented by changing industrial mix and by compound growth are eliminated by calculating the three shift-share effects for every year of the study period" (p.3). In their case study of industrial manufacturing in New England from 1939-1984, dynamic shift-share emerged as a stronger method than the traditional approach, which was dubbed "comparative static" analysis.

A final problem, also addressed by Fuchs, is that of selection of the exact year to serve as the base or terminal weight. Fuchs questioned how sensitive shift-share results would be if the chosen weight emanated from a year of particularly unusual economic circumstances, such as a localized recession. He examined the impact that a spurious choice of base and terminal years had on shift-share results and found that for long time spans[14], the choice of the base year did not have a significant impact on the results. For shorter time spans, the choice of years became more important, but never fell below r=.900 (Fuchs, 1959).

Although the problem of weighting became widely cited as a drawback to shift-share analysis, research has not generally focused on determining the degree, direction and pattern of variance in the components (Dawson, 1982). With few exceptions, (Kochanowski et al., 1989) Barff and Knight's contribution has been largely untested.

D. Interdependence of the Industrial Mix and Competitive Effects

Rosenfeld (1959) noted that the value of the competitive effect (CE_{ij}) is not only a function of growth in industry i for region j but is also influenced by the concentration of regional employment in the given industry. This assertion was investigated by Esteban-Marquillas (1972) who concurred that the level of a region's employment in an industry, E_{ij}, partially determines CE_{ij}. To illustrate this connection between components, Esteban-Marquillas provided a simple example. Consider two regions, A and B. Assume:

i. $E_{oA}=E_{oB}$
(Both regions employ the same number of people.)

ii. $e_{iA}=e_{iB}$
(Both regions share the same growth rate for the ith industry.)

iii. $E_{iA}\neq E_{iB}$
(Employment in the ith industry of region A is not the same as employment in the ith industry of region B.)

The competitive effects for industry i in regions A and B are:

$$CE_{iA}= E_{iA}(e_{iA}-e_{io}) \tag{6}$$

$$CE_{iB}= E_{iB}(e_{iB}-e_{io}) \tag{7}$$

As long as condition iii. holds, the values computed for CE_{iA} will not equal CE_{iB}--different numbers of employees working in the ith sector in each of the regions results in altering the competitive effect. This is counter-intuitive. The definition of the competitive effect implies that regions with identical growth rates in an industry will possess the same comparative

[14]A long time span was defined as >24 years. A short time-span was defined as <8 years. It is not clear how the author classified values falling between these ranges.

advantage/disadvantage. The influence of E_{ij} on the competitive effect suggests that the industrial structure of a region determines both its industry mix and its competitive effect.

This co-mingling of effects casts doubt on the purity of the competitive effect. Because the competitive effect is interwoven with the industry mix, determining how much of regional growth reflects a true comparative advantage and how much is actually due to industry structure becomes difficult.

IV. ALTERNATIVE MODELS

In response to the limitations attributed to the classic shift-share models, many attempts have been made to improve upon the shift-share equation. Several authors have proposed more than one reformulation.[15] A total of ten models contributed by six authors are reviewed in this section.[16] Each purports to solve a particular difficulty attributed to the classical model or strives to lend new insights and interpretation unavailable to analysts using the traditional expression.

A. Esteban-Marquillas (I)

The first major reformulation of the shift-share model attempted to address the problem of interdependence between the competive and industry mix effects, which critics considered to be the biggest obstacle facing the classic model (Stevens and Moore, 1980). To purge interdependence from shift-share, Esteban-Marquillas (1972) revised the competitive effect of the classic equation by introducing two new concepts, homothetic employment and the allocation effect. The new model is:

$$\Delta E_{ij} = NE_{ij} + IM_{ij} + CE^{*}_{ij} + AE_{ij} \tag{8}$$

where:

$$\begin{aligned} NE_{ij} &= E_{ij}(e_{oo}) \\ IM_{ij} &= E_{ij}(e_{io}-e_{oo}) \\ CE^{*}_{ij} &= E^{*}_{ij}(e_{ij}-e_{io}) \\ AE_{ij} &= (E_{ij}-E^{*}_{ij})(e_{ij}-e_{io}) \end{aligned} \tag{9}$$

Homothetic employment (E^{*}_{ij}) is incorporated in CE^{*}_{ij} in (9) to rid the competitive effect of "regional structural influence" and thus end its interdependence with the industry mix[17] (Herzog and Olsen, 1977, p.444). It is defined as:

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[15]This is true of Esteban-Marquillas (1972), Arcelus (1984), and Sihag and McDonough (1989).

[16]To avoid confusion, when two models are developed by the same author, they are labelled (I) and (II). Thus, Esteban-Marquillas (I) will define a different reformulation than Esteban-Marquillas (II).

[17]For equations (6) and (7), this would result in the same value being inserted in for E_{iA} and E_{iB} so that $CE_{iA}=CE_{iB}$.

$$E^*_{ij} = \frac{(E_{oj})(E_{io})}{(E_{oo})} \qquad (10)$$

and can be interpreted as the employment sector i of region j would have if the region and the nation were identical in structure[18] (Esteban-Marquillas, 1972, p.251).

Substituting E^*_{ij} for E_{ij}, the competitive effect becomes:

$$CE^*_{ij} = E^*_{ij}(e_{ij} - e_{io}) \qquad (11)$$

The homothetic competitive effect, CE^*_{ij}, provides a measure of a region's comparative advantage or disadvantage in industry i relative to the nation. To complete the identity, a new component, the allocation effect, (AE_{ij}), is introduced (9). Thus the classical shift-share competitive effect is decomposed into two parts, the homothetically-adjusted competitive effect and the allocation effect.

The allocation effect is composed of two parts, the expected employment and the differential. The expected employment, $(E_{ij}-E^*_{ij})$, is a measure of regional specialization in industry i. The expected employment indicates whether there are more or less people employed in the industry than would be expected given the average national employment levels for the same industry.

The second element of the allocation effect, the differential, $(e_{ij}-e_{io})$, is a measure of regional comparative advantage in industry i. It indicates whether the region's industry is growing faster than the same industries in other parts of the nation. Together, the two pieces provide a measure of whether the region is specializing in industries in which it has a comparative advantage. The larger the total allocation effect, "the better its employment is distributed among the different sectors, according to their respective advantages" (Esteban-Marquillas, 1972, p.252).

It may be illuminating to emphasize the difference between the industry mix specialization and the specialization measured by the allocation effect. The industry mix provides a measure of how much a region is specializing in industries which are growing faster than other industries in the nation (e.g. the growth in the CD player industry versus average national growth).

The homothetic component, CE^*_{ij}, provides information about a different type of specialization: "CE^*_{ij} measures the competitive advantage, or lack thereof, of region j as compared to the nation's with respect to sector i, while AE_{ij} takes into account region j's specialization in the products of sector i (Arcelus, 1984, p.4). The allocation effect indicates the degree to which a region is specializing in industries that are growing faster than those same industries at the national level (i.e. the growth of CD player industry in region j versus the growth of the CD player business in the nation).

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[18] For example, if the number of people employed nationally in industry i is 1 million, the total national workforce is 100 million and region j employs 50,000 people in industry i, homothetic employment E^*_{ij} would be:

$$E^*_{ij}=50,000\left(\frac{1\ million}{100\ million}\right)=500$$

A positive allocation effect may mean that a region is specializing in industries that are growing at a rate that is faster than the nation. But this is not the only possibility. Both the expected employment and the differential can be negative, positive or zero. The possible signs for the expected and differential and their interpretations are summarized in Table 1.

Table 1
Signs and Interpretations of
Expected and Differential Growth Components
(Esteban-Marquillas I Model)

		Expected Growth: $(E_{ij}-E^*_{ij})$		
Differential Growth: $(e_{ij}-e_{io})$		+	-	0
	+	(+)(+)=+	(-)(+)=-	(0)(+)=0
	-	(+)(-)=-	(-)(-)=+	(0)(-)=0
	0	(+)(0)=0	(0)(-)=0	(0)(0)=0

(Adapted from Herzog and Olsen, 1977, p.445)

For example, if the region is specializing in an industry that is growing faster than national average growth rates, the values for the allocation effect would be (+)(+), implying a comparative advantage exists and that the region is capitalizing on it. However, a positive allocation could also result if the expected employment and the differential are both negative, i.e. (-)(-), meaning that the region is not specializing in an industry which is growing slower at the regional level than at the national level, implying that a comparative disadvantage is at work but that the region has rightly de-emphasized this industry in its sectoral mix. The other possible combinations have analogous interpretations.

Esteban-Marquillas' contribution has been pivotal in the shift-share field. Most major revisions of the classic model after 1972 have included some concept of homotheticity.

1. Additivity, Asymmetry, and the Esteban-Marquillas Model

It has been suggested that the allocation effect creates a richer shift-share equation as compared to the classic model, providing more information about specialization and comparative advantage. (Herzog and Olsen, 1977). But the first Esteban-Marquillas model has been challenged on several fronts.

Stokes (1974) argued that the Esteban-Marquillas model created asymmetry problems. Symmetry is an important condition in the shift-share model. In the context of disaggregation, symmetry implies that the sum of the shift-share components for all subregions yields the total value of the components in the region at large. For industrial disaggregation symmetry means that the sum of the shift-share components for all sub-classifications of industries sums to the total industry component values:

$$i. \quad NE_{oo}=\sum_{i=1}^{n}\sum_{j=1}^{m} NE_{ij}$$

$$ii. \quad IM_{oo}=\sum_{i=1}^{n}\sum_{j=1}^{m} IM_{ij}=0$$

$$iii. \quad CE_{oo}=\sum_{i=1}^{n}\sum_{j=1}^{m} CE_{ij}=0$$

Where $_{oo}$ represents aggregation over the nation. If these conditions are not met, the shift-share model is said to be asymmetric.

Under the classic shift-share model, these conditions hold for regional disaggregation but not industrial disaggregation. Stokes illustrated by proof that the Esteban-Marquillas model suffered from both regional and industrial asymmetry brought about by disaggregation. This problem was also reiterated by Beaudry and Martin (1979) and Theil and Gosh (1980).

The lack of regional additivity came to be acknowledged by others (Herzog and Olsen, 1977; Dawson, 1982). A close examination of the Stokes and Beaudry and Martin proofs was not attempted until nearly a decade later when Haynes and Machunda (1987) declared that the methods used by both sets of authors were incorrect[19] and demonstrated that the Esteban-Marquillas model and a subsequent important extension (Arcelus, 1984) were free from asymmetry under regional disaggregation. Haynes and Machunda have not been refuted. Subsequent reviewers of Haynes and Machunda remark that their contribution "cleared the way and set the standard for future extensions and empirical applications of shift-share analysis" (Sihag and McDonough, 1989). No empirical work has confirmed or denied the existence of a regional summability problem as it relates specifically to the Esteban-Marquillas model, although Sihag and McDonough demonstrated additivity with a reformulation of their own which was loosely based on Esteban-Marquillas' structure.

2. Empirical Work with the Esteban-Marquillas Model

Empirical research had been aimed at determining the extent to which the Esteban-Marquillas represents an overall improvement in the shift-share field. Results have been mixed. Herzog and Olsen (1977) explored the new equation's strengths and weaknesses in an extensive analysis that looked at employment change in the U.S. from 1960-1970. The authors computed component values for both the classic model and the Esteban-Marquillas reformulation using 173 Bureau of Economic Analysis areas. Only six out of the total U.S. regions had positive allocation effects. This result seemed inconsistent with rational economic behavior; the researchers questioned why so many regions seemed to be

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[19]Specifically, Stokes argued that in order to preserve region-to-region summability it must be true that:

$$E_{ij}^{*(t-1)}(e_{ij}-e_{io}) = E_{ij1}^{*(t-1)}(e_{ij1}-e_{io}) + E_{ij2}^{*(t-1)}(e_{ij2}-e_{io})$$

Where 1, 2 are subregions of the larger whole, j.

Haynes and Machunda maintained that Stokes had not incorporated the explicit relationship between e_{ij} and its sub-regional growth rates, e_{ij1} and e_{ij2}. Haynes and Machunda asserted that e_{ij} "is equal to a weighted average of the rates of growth of the individual subregions belonging to the larger region" (1987, p. 72).

specializing in industries in which they lacked a comparative advantage (1977, p.448).

Further inspection led the authors to conclude that the choice of weights was culpable for the low numbers of positive allocation effects. The weights--the difference between actual and homothetic employment, $(E_{ij}-E^*_{ij})$--were defined at the base year. Thus, the study made the implicit assumption that the industrial structure that existed in 1960 also prevailed in the terminal year, 1970.

In the classical model, weighting affected the magnitude of the components. In the Esteban-Marquillas model the weights changed the sign and magnitude of the allocation effect and thus resulted in interpretations that did not accurately describe the economic conditions in the region.[20]

When the terminal year was used instead of the base to compute the component values, the allocation effect changed signs in directions consistent with rational economic behavior. Herzog and Olsen concluded that the Esteban-Marquillas (I) reformulation provided more insights into regional specialization but suffered from the problem of sign switching in the allocation effect when intertemporal comparisons were made. These changes were greater than in the classic model.

The study did not employ dynamic shift-share or attempt to calculate a weight reflecting average industrial structure over the decade studied. A Scottish study (Lythe, Begg and Sorley, 1976) used annual data to examine the Esteban-Marquillas reformulation found that asymmetry was reduced and that the choice-of-weights problem, the chief issue raised by Herzog and Olsen, became non-existent. Work which duplicates Herzog and Olsen's depth of data analysis but employs dynamic shift-share in connection with the new model has not been performed.

Beaudry and Martin (1979) argued that Herzog and Olsen's findings were not at all inconsistent with the convergence growth hypothesis. The convergence hypothesis states that if $E_{ij}<E^*_{ij}$, then $e_{ij}>e_{io}$. That is, a competitive advantage cannot be maintained indefinitely in the face of changing demography, markets and factor prices. They argued that allocation effects displaying positive expected signs and negative differential signs **or** negative expected signs and positive differential signs support the convergence hypothesis.

Danson, Lever and Malcolm (1980) used five years of data, 1952, 1963, 1973, and 1976 to analyze growth behavior for inner cities in the U.K during 1952-1976. Using the Esteban-Marquillas reformulation, they found that the allocation effect had only a small effect on overall employment change for the cities examined but that the total competitive effect had differential impacts on inner and outer city areas. In an analysis of employment data from Illinois, Beck and Herr (1990) also found that the allocation effect "makes little difference except perhaps for the manufacturing and wholesale trade sectors", where the allocation effect change the traditional competitive effect by more than twenty percent (p. 40).

B. Esteban-Marquillas (II)

In the same (1972) article, Esteban-Marquillas also utilized homothetic employment to develop a second formulation:

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[20]Herzog and Olsen noted that the classical shift-share model could also result in a sign change if the employment structure were altered, but emphasized that this occurred only in the instance that components are summed over all industrial sectors and evaluated for an entire region".

Esteban-Marquillas (II)

$$\Delta E_{ij} = E_{ij}-E_{ij}^{t-1} = NE_{ij}+IM_{ij}+CE_{ij}+AE_{ij} \tag{12}$$

where:

$$\begin{aligned} NE_{ij}&=E_{ij}^{*}(e_{io}) \\ IM_{ij}&=(E_{ij}-E_{ij}^{*})(e_{io}) \\ CE_{ij}&=E_{ij}^{*}(e_{ij}-e_{io}) \\ AE_{ij}&=(E_{ij}-E_{ij}^{*})(e_{ij}-e_{io}) \end{aligned} \tag{13}$$

While the competitive effect and allocation effect are identical in Esteban-Marquillas (I) and (II), both the national growth effect and the industry mix are modified in the second model. Homothetic employment is extended to the national growth effect, which is multiplied by the industry growth rate. This component can be interpreted as the amount of employment (income) a region would have if its industry structure was exactly that of the nation. The industrial mix also incorporates homotheticity. The industry mix is now the amount of growth a region experiences because it is more concentrated in industry i than the rest of the nation.[21] Whether an area's industry mix increases or decreases depends on how the industrial structure of the region changes over time as well as how well the industry i performs in the national economy.

With few exceptions, Estaban-Marquillas' second reformulation has not been adopted by subsequent authors. One of the exceptions was Kochanowski et al. (1989) who observed that the second reformulation successfully separated the industry mix and the competitive effect, but that this division could not be maintained in time series applications. This prompted Kochanowski et al. to develop another model, based on Esteban-Marquillas, which was free of interdependence over time.

C. Kochanowski, Bartholomew, and Joray

The Kochanowski et al. (1989) model is a departure from the standard shift-share. Rather than examine simple change in growth between two time periods, the Kochanowski model instead examines the change in shift-share components across time periods. The difference can best be illustrated. The preceding shift-share models consider:

$$\Delta E_{ij}=E_{ij}^{t}-E_{ij}^{t-1} \tag{14}$$

Kochanowski's model calculates the difference in total change from period to period:

$$\Delta E_{ij}^{t}-\Delta E_{ij}^{t-1}=(E_{ij}^{t}-E_{ij}^{t-1})-(E_{ij}^{t-1}-E_{ij}^{t-2}) \tag{15}$$

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[21]This implies that if $(E_{ij}-E_{ij}^{*})>0$ and e_{io}, the industry mix adds to regional growth.

Specifically the model asserts:

$$\Delta E_{ij}^{t}-\Delta E_{ij}^{t-1} = NE_{ij}+IM_{ij}+CE_{ij}+AE_{ij}+RE_{ij} \tag{16}$$

where:

$$\begin{aligned}
NE_{ij} &= E_{oj}\left[\left(\frac{E_{io}^{t}}{E_{oo}^{t}}\right) e_{io}^{t}\right] - \left[\left(\frac{E_{io}^{t-1}}{E_{oo}^{t-1}}\right) e_{io}^{t-1}\right] \\
IM_{ij} &= E_{oj}\left[\left[\left(\frac{E_{ij}^{t}}{E_{oj}^{t}}\right) - \left(\frac{E_{io}^{t}}{E_{oo}^{t}}\right)\right] e_{io}^{t-1} - \left[\left(\frac{E_{ij}^{t-1}}{E_{oj}^{t-1}}\right) - \left(\frac{E_{io}^{t-1}}{E_{oo}^{t-1}}\right)\right] e_{io}^{t-1}\right] \\
CE_{ij} &= E_{oj}\left[\left[\left(e_{ij}^{t}-e_{io}^{t}\right)\left(\frac{E_{io}^{t-1}}{E_{oo}^{t-1}}\right)\right] - \left[\left(e_{ij}^{t-1}-e_{io}^{t-1}\right)\left(\frac{E_{io}^{t-1}}{E_{oj}^{t-1}}\right)\right]\right] \\
AE_{ij} &= E_{oj}\left[\left[\left(\frac{E_{ij}^{t}}{E_{oj}^{t}}\right)-\left(\frac{E_{io}^{t}}{E_{oo}^{t}}\right)\right]\left(e_{ij}^{t}-e_{io}^{t}\right) - \left[\left(\frac{E_{ij}^{t-1}}{E_{oj}^{t-1}}\right) - \left(\frac{E_{io}^{t-1}}{E_{oo}^{t-1}}\right)\right]\left(e_{ij}^{t-1}-e_{io}^{t-1}\right)\right] \\
RE_{ij} &= E_{oj}\left[\left[\left(\frac{E_{ij}^{t}}{E_{oj}^{t}}\right)-\left(\frac{E_{io}^{t}}{E_{oo}^{t}}\right)\right]\left(e_{io}^{t}-e_{io}^{t-1}\right) + \left[\left(\frac{E_{io}^{t}}{E_{oj}^{t}}\right)-\left(\frac{E_{io}^{t-1}}{E_{oo}^{t-1}}\right)\right]\left(e_{ij}^{t}-e_{io}^{t}\right)\right]
\end{aligned} \tag{17}$$

The new specification was developed after empirical work by the authors found that the use of either classic shift-share or Esteban-Marquillas (II) to compare intertemporal growth "cannot avoid the interaction of structural and growth effects because the structure of the reference economy changes over time" (p.65). The last term in the model, RE_{ij}, is the reference economy effect.[22] This term was expected to alleviate the interactions over time and "measures the interaction of a regional characteristic with a changing characteristic in the reference economy"[23] (p.73).

The authors believed that introducing this effect would separate temporal changes within a region's structure from those at the national level. This piece of the model was expected to limit dependence of components in the Esteban Marquillas model. In applying their model, Kochanowski et al. found that the value of the reference economy effect was small, implying that distortions resulting from across time comparisons were not as significant as expected in Esteban-Marquillas (II). Subsequent work has not utilized this specification.

D. Structural Base

The structural base model, a predecessor to Esteban-Marquillas, has been predominantly used in the U.K. The structural base model's national growth effect and industrial mix components are identical to those of Esteban-Marquillas (II). The competitive effect, however, is not calculated using a homothetic weight and is identical to the classical shift-share competitive effect:

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[22] Although the notation is the same, RE_{ij} should not be interpreted as Arcelus' regional growth effect.

[23] The reference economy refers to the national economy.

$$\Delta E_{ij} = E_{ij}^{t}-E_{ij}^{t-1}= NE_{ij}+IM_{ij}+CE_{ij} \tag{18}$$

$$\begin{aligned} NE_{ij}&=E_{ij}^{*}(e_{io}) \\ IM_{ij}&=(E_{ij}-E_{ij}^{*})\, e_{io} \\ CE_{ij}&=E_{ij}(e_{ij}-e_{io}) \end{aligned} \tag{19}$$

Prior to the development of the Bishop and Simpson (1972) and Esteban-Maquillas (1972) formulations, this method tended to be favored in British shift-share studies while the American literature focused exclusively on the use of the classic model (Bishop and Simpson, 1972). While no authors have directly compared and contrasted the structural base and classic approaches, an advantage of the structural base approach would appear to be that it strips the national growth effect of any dependence on regional structure in diaggregated applications. (When the components are aggregated to the regional level, the structural base and classic models are identical.)

E. Bishop and Simpson

Bishop and Simpson (1972) developed their model in response to the shortcomings they believed were inherent in the structural base and classic models. Bishop and Simpson charge that without the use of relative weights, the "the structural effect of individual industries is strongly influenced by the trade cycle and by other non-regional variations in employment growth." (p.61.) Bishop and Simpson use an example of an industry with stable employment during a time of national decline to illustrate the problems they see in the structural base model. Intuitively, regions with employment in the stable industry should show a positive industrial mix for that industry, but the fact that e_{io} is zero means the industrial mix component must be zero, even though the industry is doing better than the national average. The introduction of e_{oo} to the industry mix standardizes industrial growth by growth in total national employment. It should be noted that when aggregated to the regional level, Bishop and Simpson's model produces results identical to the classic model, because $E^{*}_{ij}(e_{io}-e_{oo})$ sums to zero when aggregated over all industries of a region.

$$\Delta E_{ij} = E_{ij}^{t}-E_{ij}^{t-1} = NE_{ij}+IM_{ij}+CE_{ij} \tag{20}$$

$$\begin{aligned} NE_{ij}&=E_{ij}(e_{oo})+E_{ij}^{*}(e_{io}-e_{oo}) \\ IM_{ij}&=(E_{ij}-E_{ij}^{*})\,(e_{io}-e_{oo}) \\ CE_{ij}&=E_{ij}(e_{ij}-e_{io}) \end{aligned} \tag{21}$$

Applications of the Bishop and Simpson model have been limited. Collis and Mallier (1985) used the Bishop and Simpson specification to examine slowdowns in manufacturing employment in Conventry, England, from 1971 to 1978. Their results indicated that overall changes in the region's economy stemmed from both an adverse industry mix and a negative competitive effect. When comparing local manufacturing employment to national manufacturing employment, the shift-share model indicated that national decline in the industry also had a role in the demise of the region's economic health. Since the results from the Bishop and Simpson model were not evaluated against other models' results, it is difficult to assess the advantages of this reformulation.

F. Arcelus (I)

One of the more recent developments in the shift-share model was made by Arcelus (1984) who used the Esteban-Marquillas (I) framework to derive two potentially powerful extensions. Arcelus made several contributions to shift-share models. His first model extended the concept of homotheticity to all components in the shift-share equation. His second model considered the impacts on the regional employment brought about by strictly regional economic factors. We discuss these models in turn.

The first model developed out of Arcelus' contention that Esteban-Marquillas (I) did not "go far enough in exploiting the properties of E_{ij}^*" (p.4). Instead of confining the use of the homothetic employment weight to the competitive effect, Arcelus extended it to all components in the model:

$$\Delta E_{ij} = E_{ij}^{t} - E_{ij}^{t-1} = EN_{ij} + DN_{ij} + EM_{ij} + DM_{ij} + CE_{ij} + AE_{ij} \qquad (22)$$

where:

$$\begin{aligned} EN_{ij} &= E_{ij}^*(e_{oo}) \\ DN_{ij} &= (E_{ij} - E_{ij}^*)(e_{oo}) \\ EM_{ij} &= E_{ij}^*(e_{io} - e_{oo}) \\ DM_{ij} &= (E_{ij} - E_{ij}^*)(e_{io} - e_{oo}) \\ CE_{ij} &= E_{ij}^*(e_{ij} - e_{io}) \\ AE_{ij} &= (E_{ij} - E_{ij}^*)(e_{ij} - e_{io}) \end{aligned} \qquad (23)$$

This formulation divides all shift-share components into expected and differential components, just as the competitive component had been divided in Esteban-Marquillas' work. EN_{ij}, EM_{ij}, and CE_{ij} are interpreted as the expected employment. The differentials are the remaining values. For example, EN_{ij} is the expected national growth rate, composed of the employment the region would expect if were structured like the nation (E_{ij}^*), and if it grew like the nation. The differential national growth effect, DN_{ij}, is the difference between actual employment and homothetic employment, multiplied by the national growth rate. This effectively separates the national growth effect into discrete expected and differential effects.

There is some intuitive meaning to these extensions. Consider the differential national growth effect. If e_{oo} is negative, implying a recession, and $(E_{ij}-E_{ij}^*)$ is also negative, implying lower than average employment in that industry, then the local differential national growth effect for that industry would be positive. In other words, the recession affects that industry less than it would elsewhere because local employment in the industry is below the national average. Similarly, expansionary effects will be larger in a local industry that employs a greater proportion local people than the national share of employment in that industry, that is, $(E_{ij}-E_{ij}^*)>0$.

Using this intuition on the industry mix, the homothetic industry mix measures the change in employment for industry i in region j resulting from the differences in the growth rates, e_{io} and e_{oo}. When the difference is positive and when base employment less homothetic employment is positive, the industry mix has a positive effect on overall employment. Additional information can be obtained if IM_{ij} is summed over all industries. The resulting value, IM_{oj}, provides a measure of whether or not the region is specializing in industries that are growing.

G. Arcelus (II)

Although it was widely recognized that all three of the components of the classic shift-share model depend, partially or completely, on the behavior of national growth (Houston, 1967), Arcelus (1984) was the first to speculate that this dependency made the shift-share an incomplete expression of growth facts because it ignored important factors operating at the regional level.

To modify the over-dependence on national markets, Arcelus developed a second model in the same (1984) article, adding a component that measures the strength of local markets. This model incorporates the intuitive notion that "growing regions are expected to affect the employment levels of the industries in their midst in ways different than stagnant or backward regions do." (p.6). The model is:

$$\Delta E_{ij} = E_{ij}^{t}-E_{ij}^{t-1} = EN_{ij}+DN_{ij}+EM_{ij}+DM_{ij}+RE_{ij}+RM_{ij} \tag{24}$$

where:

$$\begin{aligned} &EN_{ij}=E_{ij}^{*}(e_{oo}) \\ &DN_{ij}= (E_{ij}-E_{ij}^{*})(e_{oo}) \\ &EM_{ij}=E_{ij}^{*}(e_{io}-e_{oo}) \\ &DM_{ij}= (E_{ij}-E_{ij}^{*})(e_{io}-e_{oo}) \\ &RE_{ij}=E_{ij}^{*}(e_{oj}-e_{oo})+(E_{ij}-E_{ij}^{*})(e_{oj}-e_{oo}) \\ &RM_{ij}=E_{ij}^{*}[(e_{ij}-e_{oj})-(e_{io}-e_{oo})] + (E_{ij}-E_{ij}^{*})[(e_{ij}-e_{oj})-(e_{io}-e_{oo})] \end{aligned} \tag{25}$$

The difference between Arcelus (I) and Arcelus (II) is that the last two components in Arcelus (II) include two explicit values to take into account the growth a region experiences because the regional economy is growing.[24]

RE_{ij} is the "regional counterpart" of NE_{ij}. It reflects the part of employment change that occurs because growth occurs within a region's boundaries. This implies, for example, that a positively growing national economy, coupled with a rapidly expanding local economy, makes for an overall greater growth in a region. Similarly, RM_{ij} is the counterpart of IM_{ij}. RM_{ij} indicates whether the industry possesses a comparative advantage within the region itself.

Unlike their national equivalents, both RE_{ij} and RM_{ij} are, like the competitive and allocation effect, endogenously determined effects: their values and magnitudes reflect local circumstances and conditions that either increase or decrease growth in the region.

H. Sihag and McDonough (I) and (II)

Extending concepts developed by Arcelus, Sihag and McDonough (1989) internationalized the model to reflect broader economic frontiers. The authors argue that given the expansion of trade, many regional industries no longer are limited to selling to two tiers, the local level or the national

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[24]There are two ways to specify Arcelus (II). If, as above, RE_{ij} and RM_{ij} are not split into an expected and differential, the result, when multiplied through and canceled is a model without homothetic components. A homothetic model can be obtained by splitting the regional components just as in the four preceding components. The approach depends on whether the analyst desires a homothetic specification.

sector. Rather, many industries are suppliers in global markets. Therefore, Sihag and McDonough argued that the competitive effect should not only reflect a comparative advantage in industry i relative to the nation, but that this advantage must also exist at the international level for a local economy to experience endogenous growth. To reflect this shift in economic boundaries, the authors formulated two models that incorporate a world growth effect.

The first model incorporates the concept of homotheticity and emulates Arcelus (I) but adds international growth rates and employment values:

$$\Delta E_{ij} = E_{ij}^{t} - E_{ij}^{t-1} = WE_{ij} + WI_{ij} + CE_{ij} + AE_{ij} \tag{26}$$

$$\begin{aligned} WE_{ij} &= E_{ij}^{**}(e_{ooo}) + (E_{ij} - E_{ij}^{*})\, e_{ooo} + (E_{ij}^{*} - E_{ij}^{**})\, e_{ooo} \\ WI_{ij} &= E_{ij}^{**}(e_{ioo} - e_{ooo}) + (E_{ij} - E_{ij}^{*})(e_{ioo} - e_{ooo}) + (E_{ij}^{*} - E_{ij}^{**})(e_{ioo} - e_{ooo}) \\ CE_{ij} &= E_{ij}^{**}(e_{ij} - e_{io}) + E_{ij}^{**}(e_{io} - e_{ioo}) \\ AE_{ij} &= (E_{ij} - E_{ij}^{*})(e_{ij} - e_{ioo}) + (E_{ij}^{*} - E_{ij}^{**}) + (e_{ij} - e_{ioo}) \end{aligned} \tag{27}$$

Triple subscripts denote growth rates for the largest reference economy, the world economy. Double subscripts indicate growth rates for the second reference economy, the national economy. Specifically:

e_{ioo} = % change in worldwide employment (income) for industry i
e_{ooo} = % change in worldwide employment (income)
e_{io} = % change in nationwide employment (income) for industry i
e_{oo} = % change in nationwide employment (income)

The world homothetic employment (income) is defined as:

$$E_{ij}^{**} = E_{oj}\left(\frac{E_{ioo}}{E_{ooo}}\right) \tag{28}$$

National homothetic employment (income) is defined as:

$$E_{ij}^{*} = E_{oj}\left(\frac{E_{io}}{E_{oo}}\right) \tag{29}$$

The drawbacks to this reformulation are that it requires "world employment" or "world employment in the industry," which is difficult data to obtain. In a region possessing many industries, some of which are involved in international business and others which are devoted exclusively to local supply, the model may not be appropriate and seems best suited for looking at employment change in isolated industries that are strongly based in international markets.

Sihag and McDonough's model, however, may have an extension not originally considered by its authors. The reference economies do not have to be global; and the concept of calculating growth based at an intermediate and macro level (i.e. national or trading block) could be utilized. For example, a shift-share analysis of U.S. counties could use Sihag and McDonough but instead of using international value and national values, it could incorporate national values (the triple subscripts) as the largest reference economy and state rates (the double subscripts) could be utilized as an intermediate reference economy. Thus, local county growth would have both a state and national component, possibly more accurately portraying the dual effects that national and state growth have on the micro-level growth of regions.

This adaptation might be particularly useful for regions that have widely different employment levels. Dawson (1982) noted that if a few regions dominate an industry, they account for almost all of industry growth, thus driving down the difference of $(e_{io}-e_{oo})$ and $(e_{ij}-e_{io})$ and result in small values for the industry mix and the competitive effect which underestimate the true importance of these factors.

The second Sihag and McDonough model emulates Arcelus (II) by utilizing a regional growth effect and a regional industry mix effect, RE_{ij} and RI_{ij}.[25] It also introduces e_{oj}, the growth rate in the region, which serves as the base which is compared to the two reference economies, the world economy and the national economy, or, for the more common applications of regional analysis, the nation and the state. This model is one of the few recent models which does not utilize homothetic weights in its formulation:

$$\Delta E_{ij} = E_{ij}^{t}-E_{ij}^{t-1} = WE_{ij}+WI_{ij}+NE_{ij}+NI_{ij}+RE_{ij}+RI_{ij} \quad (30)$$

where:

$$\begin{aligned} &WE_{ij}=E_{ij}(e_{ooo}) \\ &WI_{ij}=E_{ij}(e_{ioo}-e_{ooo}) \\ &NE_{ij}=E_{ij}(e_{oo}-e_{ooo}) \\ &NI_{ij}=E_{ij}(e_{io}-e_{oo}) \\ &RE_{ij}=E_{ij}(e_{oj}-e_{oo}) \\ &RI_{ij}=E_{ij}(e_{ij}-e_{oj})-E_{ij}(e_{io}-e_{oo})-E_{ij}(e_{ioo}-e_{ooo}) \end{aligned} \quad (31)$$

Empirical work has not been conducted to determine the utility of adding a second reference economy which effectively adds another layer of growth rates to consider in shift-share calculations. As to the choice of which of the two models to use, selecting Sihag and McDonough (I) over Sihag and McDonough (II) depends largely on the usefulness of the assumptions made in the Arcelus models because each emulates the two Arcelus extensions, adding only the concept of world effects.

I. Discussion

The above ten reformulations comprise the bulk of work that has been done to improve the classic shift-share model. The most recent literature tends to employ the classic model, Esteban-Marquillas (I) and, occasionally, Arcelus (I). Identifying models that exhibit the greatest potential for widespread application is difficult as there is little work that supports the *a priori* use any particular model. There have been virtually no comparative studies that examine the advantages and disadvantages of models using the same data set, and no work to date has comprehensively undertaken a comparative analysis of existing reformulations.

Despite the lack of empirical research, a few observations about the models can be made. In general, the "best" model may be a function of what is expected from shift-share. For example, Arcelus (II) explicitly includes the regional growth effect and regional industry mix, which describe the degree that regional factors encourage local employment (income). Analysts interested in the importance of the regional profile in accounting for growth may gravitate towards this model.

It is clear from the intricacy of some of the models that there may be a trade-off between the complexity of calculations and the value of its extra information. Sihag and McDonough (I) requires the computation of two

[25]This model was contained in a footnote and was not directly treated by the authors.

homothetic components and nine sub-values within the model, while the classic model requires the calculation of only three comparatively uncomplicated elements.

There is also a question of the value of models that use homothetic employment levels as weights. It has not been clearly demonstrated that these models have ended dependency between components. This choice can only be determined after comparing the performance of non-homothetic and homothetic models, and because this has not been systematically attempted in the literature, an analyst choosing between models may be forced to compare results from both types of models.

V. APPLICATIONS OF SHIFT-SHARE ANALYSIS

In its various specifications, shift-share analysis has been applied to five broad areas: regional growth theory, forecasts, historical analysis and current description, and policy prescriptions. The attempts to shape shift-share into a behavioral growth model have already been detailed (see section III. A.) Such work has been modest when contrasted with the effort that has been devoted to empirically examine shift-share's ability to describe regional growth, measure policy effects and predict future growth. These three research avenues are explored below.

A. Describing Regional Growth

While some contributions to the shift-share literature have focused exclusively on scrutinizing the model's shortcomings, others have accepted the technique and used it to examine historical and current data. A large portion of the empirical work has focused on simple documentation of the impact of economic cycles on regional areas and has attempted to isolate the reasons for differential responses to growth across regions and industries. These applications of shift-share analysis illuminate the type and variety of information that can be produced.[26]

One of the first uses of shift-share to examine the dynamics of rural county growth was undertaken by Curtis (1972) in an analysis of income and employment changes in four low-income Alabama counties. Results indicated that for these regions, the national growth effect played the strongest role in generating income and employment (approximately 94 percent of the total change) and the competitive effect, reflecting local factors, had only a nominal effect in job creation and income expansion.

Ledebur and Moomaw (1983) extended the classic model to examine labor productivity differences and labor productivity changes in U.S. manufacturing. The authors investigated whether differences seen in growth across regions is the result of different industry mixes or is caused by differences in labor productivity between individual industries. They found that industry mix could explain a substantial amount of productivity differences among regions. Of the nine geographical regions that they divided the U.S. into, the competitive effect was responsible for over half of the divergence from national trends in four divisions. Four other divisions had industry mixes which accounted for over fifty percent of the deviations from U.S. productivity. When shift-share analysis was used to calculate productivity change, indexed for the nine census divisions, the authors found that industry mix did not account for changes in regional productivity.

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[26]Applications have not been limited to economic growth measurement. Shift-share has been employed to analyze rural retail trade patterns (Senf, 1988), population changes (Paris, 1970), fuel consumption variation (Isserman, 1977), and regional crime growth (Blair and Mabry, 1980).

Randall (1973) examined growth patterns of west central Scotland from 1959-1968 and found that overall employment in the region decreased by 10,000 at a time when the national growth effect, based on U.K. growth, would have predicted an increase of 50,000 jobs. Over 91 percent of the adverse change was attributed to the competitive effect, and industrial structure played only a minor role in overall job loss.

In a detailed study of the patterns of growth in the Montachusett region, a constellation of 18 north-central counties in Massachusetts, Doeringer et al. (1987) employed shift-share to determine why employment growth differences were so sharp amongst counties in the region. Results over both a long and short time series indicated that the industry mix was the most important factor in the decline of growth in the Montachusett region. Most of its manufacturing was concentrated in industries that had dramatic declines in employment during downward business cycles. Doeringer et al. concluded that visible factors such as taxes and energy costs explained only a small amount of variation in growth rates.

By measuring regional multipliers and calculating shift-share results, Harris et al. (1987) considered the possibility that offshore drilling in Aberdeen, Scotland, and an accompanying influx of oil industries displaced regional industry and caused decreases in traditional sources of local employment, such as manufacturing. A combination of shift-share analysis and historical examination of employment data helped authors conclude that of every 100 oil jobs created in Aberdeen, at least 8 jobs were lost in the non-oil sector. Job loss was heavily concentrated in a few industries traditionally important in the local economy.

B. Measuring Policy Impacts

The general approach used to examine regional policy with shift-share analysis is to examine how the value of the competitive effect changes between the policy-on and policy-off period. If the measure is introduced at the local level, it is assumed that the impacts will be observed in changes in the level of growth, e_{ij}. This assumption implies that the competitive effect will change after the policy is activated and that this change can be distinguished from other factors such as business cycles or structural changes in industry which operate independent of policy but which may have a similar impact on growth.

Moore and Rhodes (1973) established a with-without framework and used shift-share analysis to determine the effectiveness of British regional policies offering incentives to firms locating in chronically underemployed areas of the country. Without a policy injection, Moore and Rhodes asserted that an industry in a region could be expected to perform similarly to national growth rates for these same industries. The introduction of a policy change then could be measured as the divergence between the "expected" growth, that of national growth rates and the "actual" growth rate, that which in fact prevails in the region after the policy is implemented. Choosing a pre-policy base year of 1963, Moore and Rhodes defined expected growth in manufacturing employment as:

$$\sum_{i}[(E_{ij(1963)})(e_{io(1950,51,52,\ldots71)})] \qquad (32)$$

where: i is the number of industries.

To examine the effects of policy, the authors plotted actual and expected employment for regions that had been targeted for development. Moore and Rhodes concluded from these results that national government efforts to stimulate job creation in the 1960s were moderately successful.

Isserman and Merrifield (1982) embraced some of the logic of Moore and Rhodes but argued that selecting national industrial growth rates as the reference by which a region's industrial growth was measured against was not satisfactory. Instead, they created a control group composed of counties with similar attributes to the study county, which had received $12 million in economic aid over a three-year period. The "control group" indicated what would have happened in the absence of a funding injection. The authors concluded that the assistance generated more than $25 million in benefits, but warned that methodological issues arising in the study indicated that the technique needed refinement, was not without problems, and could not be universally applied to all regions.

In a review of approaches to measuring the impact of regional policy, Bartels et al. (1982) argued against using shift-share to assess policy effects because explicit variables measuring policy instruments are not incorporated into the model. Bartels et al. also questioned the possible interaction that regional policy could have on national and industrial growth rates, essentially challenging the contention that policy effects discretely influence the competitive effect alone.

This concern was also shared by Tervo and Okko (1983) who, in a review of Moore and Rhodes, argued that the effects of regional policy would not be confined to the regional level alone. If the policy change increased new employment nationally, the result would affect the national growth effect and the industry mix as well. Only in the case in which policy created a redistribution of existing employment between regions could the competitive effect be characterized as a reasonable measure of the maximum benefits of regional policy initiatives. Tervo and Okko argued that the degree of change seen in the components of the shift-share equations depends on the size of the region receiving the assistance. The authors introduced a reformulation that distributes the policy impact to all three components in the shift-share model.

Shift-share results have also been used to determine whether a region should receive assistance. Stilwell (1968) cautiously advocated directing policy to areas having highly negative competitive effects. Kirk (1971) used shift-share projections in an effort to isolate regions that had the greatest potential to increase employment with the assistance of federal funding for economic development. Using a regression model to forecast employment, Kirk identified counties in his sample area which promised high rates of employment change and advocated that this information be used to determine spatial allocation of funding. As such, the technique was recommended as a way to target regions needing government assistance.

In his criticism of Kirk, Buck (1976) argued that a negative competitive effect should not be interpreted as an indication that a region is less efficient than other regions because it could be the case that exceptionally low or high competitive effect values may be the result of casual factors that have no spatial or geographical basis.

Mead and Ramsay (1983) modified the shift-share equation to examine the impact of recessions in regions possessing different industrial bases. An ex-post analysis of Massachusetts industry indicated that various policies introduced to encourage industrial diversification appeared to have only slightly minimized the impact of a recession. The study also used shift-share to examine government efforts to jumpstart multiple sectors of a flagging state economy. The effectiveness of these industry-wide policy interventions were also found to have only minor impacts on overall growth.

Grimes and Ray (1988) used shift-share to examine whether regions with right-to-work laws grow faster than those that permit union shop arrangements. Because economic development agencies tend to use right-to-work legislation as a way to attract industry to their regions, the authors sought to determine how effective this policy really was in stimulating regional employment growth. Findings indicated that areas with right-to-work policies held a comparative advantage in employment growth when compared to the non-right-to-work areas.

C. Forecasting Regional Economic Growth

Shift-share was originally conceived as a descriptive tool to examine ex-post changes in regional growth. Yet, much of its notoriety and criticism arises from its widespread use as a regional employment projection model. From its early stages of development, forecasting became a common expectation of the model. Applying shift-share to forecasting involves comparing past growth in a regional industry against the growth of the same industry at the national level. The difference in these growth rates is projected forward and is used to predict the size and direction of change in future industry growth.

Calculating a forecast with the shift-share model involves a slight reorganization of the classic shift-share equation to incorporate future time. Assuming exogenous predictions for both future national and industry employment are available, these values yield future national growth (e_{oo}^{t+1}) and industry mix (e_{io}^{t+1}) values. The future competitive effect, e_{ij}^{t+1}, is an endogenous prediction. The accuracy of the forecast thus depends almost wholly on the ability to reliably predict the sign and magnitude of the competitive effect in future time. To do this, the shift-share analyst assumes a functional form for the competitive effect that best incorporates the assumptions made about the way it is expected to grow.

By the late 1960s, skepticism about shift-share's forecasting accuracy and concern over its frequent use spawned a wealth of academic enquiry bent on uncovering its flaws as a prediction model. Brown (1969) conducted the first empirical studies investigating the strength of shift-share projections. Shift-share forecasts were compared with those computed using two alternative models, Ingrow and Super Ingrow[27]:

$$\textit{INGROW}: \quad E_{ij}^{t+1}-E_{ij}^{t}=E_{ij}^{t}\left[\left(\frac{E_{io}^{t}}{E_{io}^{t-1}}\right)-1\right] \tag{33}$$

$$\textit{SUPER INGROW}: \quad E_{ij}^{t+1}-E_{ij}^{t}=E_{ij}^{t}\left[\left(\frac{E_{io}^{t+1}}{E_{io}^{t}}\right)-1\right] \tag{34}$$

Ingrow projects the growth in industry i for region j as a function of past national growth in industry i, i.e. *historical* growth, (t-1) is used. Super Ingrow projects regional growth in industry i as function of *future* national growth in industry i, i.e. *projected* growth, (t+1), is used (Brown, 1969).

[27]Ingrow and Super Ingrow can be classified as constant share models. Implicitly, they make the assumption that regional industries will expand at the rate of national growth, implying that the share of national employment for each industry will not change (Stevens and Moore 1980, p. 423).

Brown assumed a constant competitive effect. This implies that the income or employment shift seen in the last period is expected to continue in the periods that are being forecast.[28] Mathematically, this is represented:

$$CE_{ij}^{t} = CE_{ij}^{t+1} \tag{35}$$

Brown's findings were three-fold. First, shift-share was not as accurate in its predictions as Ingrow or Super Ingrow. Second, there did not appear to be a relationship between the competitive effect and economic variables assumed to be important for regional growth. Finally, the value of the competitive effect seemed to be unstable. Brown noted that this variability could not be explained and concluded that it was random. He remarked, "if the component is unstable and changes without pattern, policy decisions made on the basis of the historical components probably will not be relevant to succeeding periods." (p.10). Random variation implies unpredictable instability. Changes in the competitive effect without pattern make projections based on the historical value of the component suspect.

Brown's work initiated extensive investigation into the power of shift-share projections[29]. Paraskevopoulos (1971), Floyd and Sirmans (1973), and James and Hughes (1975) examined Brown's criticisms and, in independent studies, produced results indicating more stability in the competitive effect and thus implying a greater potential for shift-share as a forecasting tool.

Working separately, Kuehn (1971) and Miller (1974) both utilized regression analysis to explore the stability of the competitive effect over time. Using ordinary least squares, Kuehn regressed historical values of the competitive effect on future values to determine what percentage of variance could be explained by assuming that the competitive effects were solely determined by past values. Examining all major sectoral divisions in 372 counties over four states for the years 1940-1970, Kuehn found that eighteen of the 29 industries displayed little to no stability, but for a few sectors, the r^2 hovered around .80.

Miller's regression analysis also examined shift-share forecasting and, contrary to Brown, produced results indicating that a constant share model predicted better than Ingrow. Other significant findings focused on the regression estimates for the industry mix and competitive effect. Constructed analogously to Kuehn's, the single variable regression models computed estimates at both the state and county level. The standard error for the estimated competitive effects at the state and county level were 9.3% and 18% respectively, indicating that forecasts could be enormously inaccurate. The industry mix, estimated at the county level, exhibited more stability, resulting in a modest r^2 value of .69 and a standard error of 6.7%.

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[28]For example, if industry X added 400 jobs in the last period, the assumption of a constant shift would imply that in the next period the same level of employment expansion would occur. This assumption is usually argued as reasonable as a comparative advantage in the present is assumed to imply future expansion as well. As Kurre and Weller (1989) accurately point out, this assumption implicitly embraces the cumulative growth hypothesis. Neoclassical growth theory would not support the assumption of a constant shift as it implies that a positive comparative advantage cannot be maintained over time.

[29]A summary of the literature concerning the use of shift-share as a forecasting technique is provided by Stevens and Moore (1980). Their insightful review of shift-share contributors is utilized throughout this section.

Recognition of the problematic use of the shift-share model for prediction also prompted the development of "improved" versions. James and Hughes (1973) introduced a modified shift-share model and tested it against the standard constant shift model. Their model:

$$\frac{E_{ij}^{t}}{E_{io}^{t}} = (NE_{ij}^{t-1} + IM_{ij}^{t-1})^{CE_{ij}^{t}} \tag{36}$$

produced larger errors in all empirical tests. Like its predecessor, the revised formulation also suffered from errors caused by incomplete covariation, indicating that the modification did not strengthen the predictive power of shift-share.

Other efforts have been made to improve the shift-share forecasting model. Hellman (1976) explored the utility of four shift-share models to predict state employment in New Jersey, but looked at total employment instead of changes in employment. This difference has made it difficult to compare Hellman's findings with other work which is largely devoted to examining employment change. This criticism also applies to Zimmerman (1975) who used New Jersey employment data to make shift-share projections and concluded that her modified model and a constant shift-share model performed better than other projection techniques.

Ireland and Moomaw (1981) used the competitive effect as an independent variable in a regression analysis examining factors related to industrial investment in Oklahoma, and found that the variable compared favorably to regional growth in statistical tests. Andrikopoulos et al. (1987) replicated Ireland and Moomaw's work for twenty industries in Ontario and Quebec, and found that the competitive effect did not perform well in forecasting industrial investment.

Recent work has been less discouraging in its assessment of the accuracy of shift-share projections. In an attempt to identify the factors that stimulate investment in local industry, Andrikopolous et al. (1990) used the competitive effect as the dependent variable in a time series analysis of growth in Quebec and found that the method was comparable to an alternative specification which used regional growth rates as a proxy for local economic climate.[30] Due to the small number of statistically significant equations and relatively poorer performance in a simulation exercise, the authors concluded that using the competitive effect to predict the level of investment in a region was nct a marked improvement over a simpler model (p.28) but was also no worse at the task of describing the factors prompting investment.

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[30]The models differed by the selection of the relevant regional variable. The generalized models are:

$I=\alpha+\beta(Q)+\tau(NE_{ij})+\delta(CE_{ij})+u_i$
versus
$I=\alpha+\beta(Q)+\tau(R_{ij})+u_i$

where I=investment
Q= output
NE_{ij}= national growth effect
CE_{ij}= competitive effect
R_{ij}= growth rate for industry i, region j

A modest empirical study projecting export earnings using shift-share illustrated that the technique could be a reliable forecasting tool if reasonable modifications are undertaken which limit the ambition of the forecasts. (Williamson, 1980). Williamson advocated limiting projections to larger urban areas to ensure greater stability of the competitive effect, shortening the range of the forecast to under a decade, using the finest level of industrial disaggregation available, and analyzing projection information in tandem with historical information to help confirm the likelihood of estimates as ways to improve accuracy. Prudent applications of shift-share to forecasting, he wrote, "can be the most accurate of the several simple alternatives that are available" (p.23).

More recently, Kurre and Weller (1989) produced a more optimistic perspective of the use of shift-share in forecasting. Using time series data, authors applied ten forecasting models (three of which utilized shift-share) to determine which models best forecast the regional economic projections for Erie County, Pennsylvania. Shift-share proved to provide the second and third most accurate results of all techniques applied.

Using covariance analysis to test the stability of the competitive effect, Gerking and Barrington (1981) conducted a time-series analysis spanning 25 years and 429 two-digit SIC industries over 38 states. They found that instability of the competitive effect is highly variable across industrial sectors and that in over 35 percent of cases examined, statistical tests for temporal stability were not able to reject the hypothesis of competitive effect stability.

In their review of the forecasting models, Stevens and Moore (1980) concluded that shift-share analysis had not undergone rigorous, standardized empirical tests to determine its forecasting power. Especially prior to the 1980s, research has not generally attempted to contrast shift-share forecasting results with other non-shift-share techniques. Despite recent contributions, the forecasting literature produces little definitive evidence to indicate any stability in the competitive effect over time (1980, p.427). Given that instability is implied by microeconomic theory, it may not be productive to try to manipulate the competitive effect to accomplish stability.[31]

VI. STATISTICAL TESTING AND SHIFT-SHARE MODELS

Because shift-share models are mathematical identities, the calculated components of any model are deterministic and cannot be statistically tested. Without statistical testing, the validity of the models is difficult to assess, and the comparison of alternative models is confined to non-statistical, often subjective criteria. In an effort to overcome the evaluation limitations imposed on shift-share because it cannot be statistically analyzed, several efforts have been made to specify the equation's components as regression or ANOVA models, both of which can be subjected to standard statistical tests.

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[31]It is assumed in perfect competition that excess profits lead to the entrance of firms into markets where there is positive producer surplus. Increased competition results, and excess profits tend to zero in the limit. If the competitive effect is assumed to represent a comparative advantage in which a firm enjoys increased profits because of local circumstances, neoclassical theory would dictate that in the face of unrestricted entry, this competitive effect would diminish over time. Regional growth patterns can be analyzed using this basic assertions as a hypothesis. The convergence hypothesis suggests that if $E_{ij}>E^{*}_{ij}$, then $e_{ij}<e_{io}$ (Beaudry and Martin, 1979, p. 389).

The specification of a true econometric shift-share model began with Weeden (1974) who transformed the shift-share model into an ANOVA model. Weeden developed a model predicting that the differences between regional national growth rates could be attributed to structural differences. Using time series data he also examined the ANOVA results when industrial classification and male/female dummies were added.

Buck and Atkins (1976) built on Weeden's contribution to develop an ANOVA model to analyze the findings of Moore and Rhodes.

$$e_{ij}=\beta_i D_i+\beta_j D_j+u_{ij} \tag{37}$$

where:

e_{ij}= *employment growth in industry i region j less national employment growth*
D_i= *dummy variable for industry i*
D_j= *dummy variable for region j*
u_{ij}= *random error term*

The estimated coefficients of the regression β_i and β_j are values which reflect industrial and regional advantages of the area being examined. The β_i describe how much industrial structure contributes to growth in the region. Positive values for these coefficients imply that the industry has a positive effect on regional growth; similarly, negative values imply that the industry slows region growth. The β_j provide a measures of the extent to which regional factors contribute to producing a growth rate greater than the nation. To rid the model of heteroskedasticity, the authors weighted the components of the regression equation by the importance of the industry in the region.[32]

These estimated coefficients are then used to compute a composition and growth component. The composition component is analogous to industry mix in the shift-share equation and is defined as:

$$\sum_{i=1}^{n}\left(\frac{E_{ij}}{E_{oj}}-\frac{E_{io}}{E_{oo}}\right)\beta_i \tag{38}$$

The bracketed term is the difference between the relative importance of the industry in the region and the relative importance of the industry in national growth. This value is multiplied by β_i. The composition component describes the average regional advantage and industrial advantage associated with each industry.

The growth effect is a difference of the advantage of region j subtracted from the average advantage that all regions possess. This average advantage is summed over all regions and weighted by the importance of each region in its contribution to national growth. The result is a measure of how the region's industries do compared to the average. It is analogous to the competitive effect.

[32]For example, if an industry grows from one employee to 10 in the time period, this change of 1000% will add significant variance to the model but actually accounts for a small amount of overall change in the industry. Weighting corrects for such error.

$$\beta_j - \sum_{j=1}^{n}\left(\frac{E_{oj}}{E_{oo}}\right)\beta_j \tag{39}$$

Bartels et al. (1982) note that the Buck and Atkins model, although useful, implies that only industry-wide changes across a region are identified by the model. Non-systematic differential growth is captured completely in the residual component or the growth effect.

Patterson (1990) built upon the Buck and Atkins model, introducing what he termed a full-analogue regression model for shift-share. Unlike the Buck and Atkins model, Patterson's model includes a national growth effect.[33] Instead of Buck and Atkins' method of using ($e_{ij}-e_{oo}$) as the dependent variable, Patterson inserted E_{ij} and suggested solving the equation as a constrained minimization problem, thus eliminating the need to normalize the estimated parameters. Patterson asserted that the chief accomplishment of a full-analogue model over traditional shift-share was that it attained true independence between the national growth effect, industry mix and the competitive effects.

Berzeg (1978) also developed a model similar to Buck and Atkins', which explicitly accounted for the national growth effect. He also confirmed the Buck and Atkins assumption that without weighted by sector and industry importance, the model was heteroskadastic.

Emmerson et al. (1975) specified another covariance model. Making the assumption that growth is an exponential function of the form[34]:

$$e_{ij}^{t_1} = \log\left(\frac{E_{ij}^{t_1}}{E_{ij}^{t_0}}\right) \tag{40}$$

a covariance model is defined which is analogous to the shift-share model:

$$e_{ij}^{t} = (\alpha + \beta_j + \gamma_i + \delta_i)\ t + e_{ij}^{t} \tag{41}$$

$$\begin{aligned} \alpha &= e_{oo} \\ \beta_j &= (e_{oj} - e_{oo}) \\ \gamma_i &= (e_{io} - e_{oo}) \\ \delta_{ij} &= (e_{ij} - e_{oo}) \end{aligned} \tag{42}$$

[33]In a footnote, Patterson notes that in empirical studies using New Zealand data, his model incorporating a national variable consistently provided stronger test statistics (particularly adjusted R^2) than did the Buck and Atkins model.

[34]Alternative specifications which allow for growth to be linear or quadratic were also presented by the authors.

Assuming that:

$$\sum_j \beta_j = 0 \;,\; \sum_i \gamma_i = 0 \;,\; \sum_i \sum_j \delta_{ij} = 0 \qquad (43)$$
$$\epsilon = {}^{t}_{ij} \sim N(0, \sigma)$$

it is possible, as in the Buck and Atkins model, to estimate the parameters using dummy variables, compute test statistics and perform hypothesis testing. The authors apply their model to time series data of California industrial employment. F-statistics are calculated for the equation's coefficients to provide an index of the effect of region-specific conditions on industrial growth. Emmerson et al. also suggested that the covariance model could be used to make forecasting projections and had potential as an explanatory model in that explanatory variables, such as policy dummies, could be included to isolate the role of policy in promoting or sustaining growth. Gerking (1976) proved that the Emmerson et al. model would produce biased forecasts and suggested a slight modification in the use of the estimated parameters in forecasting to reduce the bias. Berzeg (1984) demonstrated that the Emmerson et al. model effectively weighted the yearly observations in a disproportionate and seemingly illogical fashion. He provided an alternative formulation, which reduced, but did not eliminate, weighting problems in this type of model.

VII. CONCLUSIONS

Shift-share has come a long way in the nearly forty years since its development. The method has inspired statistical offspring such as the models proposed by Theil and Gosh (1980); Weeden (1974); Emmerson, Ramanathan and Ramm (1975) and their successors, and at least ten modifications of the original method have claimed to be improvements upon Creamer's basic formulation. What is needed now is a comprehensive comparsion of these alternative formulations, so that future analysts do not need to wade through a myriad of conflicting claims in their search for an appropriate model. The authors are preparing such an analysis. Once this is completed, the better shift-share models will be applied to measuring the effectiveness of economic development policies.

For those interested in shift-share as a means of projecting regional growth, a clear direction for future research arises from the literature. It has been shown that the competitive effect is only stable for certain sectors or regions, and that stability of the competitive effect cannot be assumed in making projections. This finding should not be particularly surprising, since microeconomic theory predicts that advantages gained through innovation will erode over time. Instability of the competitive effect does not necessarily mean that shift-share cannot be used in projecting regional employment or income. Instability simply means that analysts must take greater care in predicting how the competitive effect will change in the future. Barff and Knight (1988) demonstrate the effectiveness of computing each component annually, and their contribution is a first step in this direction. Time series analysis could be combined with Barff and Knight's method to develop more dependable forecasts of regional change.

Shift-share analysis needs to be applied to new problems. The method could, for example, be applied to equal employment opportunity questions, with ethnicity or gender replacing the regional dimension in the analysis. Effort should also be made to take shift-share out of historically theoretical setting and put it into a framework useful to communities, especially planners and developers. This work is forthcoming.

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