An Inquiry into

SHIFT-AND-SHARE ANALYSIS

with Application to the

Ninth Federal Reserve District

by Garson Sher

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INTRODUCTION

Traditionally there have been two methods of examining economic growth, the "export base" and the "sector" analyses. The former, emphasizing stimuli external to the geographic units considered, focuses on the importation of capital, the broadening of the export base, and other such factors. The latter emphasizes phenomena internal to the geographic unit and directs our attention to changes in patterns of demand and shifts of production from primary (natural resource) to secondary (capital goods) to tertiary (service) sectors. Both these traditional lines of thinking implicitly assume that the geographic unit under consideration is an isolated and somewhat primitive economy (or, if the unit under examination is a country, international dependencies are ignored). Shift-and-Share Analysis represents a reaction to these drawbacks, and it reflects the attempt to focus on the inter-regional dependencies of economies in advanced stages of development.

Economic growth is the result of complex interaction of various forces. However, as a first approximation, regional growth in terms of employment, value added in production, or any other economic variable of interest, may be attributed to three factors:

(1) participation in the growth of the national economy;

(2) regional economic structure; and

(3) comparative advantage.

Shift-and-Share Analysis provides a simple, easy, and quick method of exclusively and exhaustively dividing the magnitude of observed growth into three components, each representing one of the above factors. With very little effort, the method can be adjusted to vary the number of components and the causal factors which they supposedly represent. In recent years, students of regional economics have found this method useful for examination of growth trends, and in 1965 the Department of Commerce published Shift-and-Share figures on employment growth in thirty-two industries for each county in the United States [2, 1965]. Using the counties as building blocks, data can be aggregated for any region -- e.g., a group of states, a river basin, a crop area. The availability of Commerce data and decreasing costs of data processing have made Shift-and-Share Analysis an increasingly attractive form of veritas ex machina.

Part I of this paper is a detailed and illustrated examination of the method. Part II consists of a brief summary of the literature of the method as used in regional economics. Part III discusses preliminary results of the method as applied to employment and other data from the past twenty years in the Ninth Federal Reserve District (Minnesota, the Dakotas, Montana, northwestern Wisconsin, and the Upper Penninsula of Michigan). Part IV considers some of the problems and implicit assumptions involved in interpreting the results and in using the method for forecasting. Part V summarizes the paper and suggests possibilities for future research in applying and modifying the method. "Octant Analysis," a method of presenting Shift-and-Share results diagramatically, is explained and illustrated in an appendix.

I. DESCRIPTION OF THE METHOD

Under Shift-and-Share Analysis, the growth of an industry within a region is divided into two parts: its national share (growth that would have resulted had the regional industry grown at the same rate as the national economy) and shift (that growth in excess of, or less than, the national share). For example, total civilian employment across the United States increased 14% during the first eighty years of the 1960's. Had wage and salary employment in Minnesota exactly kept pace with the national economy, it too would have grown by 14%, but, in fact, it grew by 30%. From the Shift-and-Share viewpoint, wage and salary employment in Minnesota during the period 1960-68 not only grew by the amount of its national share (14%) but in addition experienced a shift of employment from other regions and industries equivalent to 16% of the level prevailing in 1960. (Because the shift was toward Minnesota's wage and salary employment, it is called positive; had it been away from Minnesota's wage and salary employment, it would be negative). Two phenomena are reflected in the difference between the growth rate of wage and salary employment in Minnesota and that for the nation as a whole. First, wage and salary employment growth across the nation increased by 26% - almost double the national share of growth in total civilian employment. Second, wage and salary employment in Minnesota grew at a rate (30%) slightly greater than wage and salary employment across the nation. Consequently, we subdivide total shift into two parts to reflect these phenomena: industrial mix (defined as the growth rate of the industry or sector--in this example, "wage and salary employment" --across the nation in excess of the growth rate of total civilian employment across the nation); and regional component (defined as the growth rate of the industry within the region in excess of its growth rate across the nation).

Although the concepts are fairly standard, the terms national share, industrial mix, and regional component are not. They are, however, both clear and those used in the Commerce Department's county data [2, 1965]. For alternative terminology, see Dunn [8, 1960], Perloff, *et al.* [20, 1960], Thirwall [21, 1967; 22, 1962], Cunningham [7, 1969], Fuchs [12, 1959; 13, 1962; 14, 1962; 15, 1961] and Garrett [17, 1968].

The division of the growth rate into national share, industrial mix, and regional share (or "regional component") is exclusive and exhaustive, as illustrated in Diagram I :

Diagram I demonstrates that the components are defined so that total growth of an industry ("wage and salary") within a region (Minnesota) is identically the sum of that regional industry's national share, industrial mix, and regional component.

We may show this identity algebraically. Let "g" represent the rate of growth. Our components have two dimensions--geographic classification (*e.g.*, "Minnesota") and industrial classification (*e.g.*, "wage and salary"). Let the region be designated by a superscript and the industry by a subscript. Then

g^{us} = national growth rate of all employment

g_i^{us} = national growth rate of employment in industry "i"

g_i^r = growth rate of industry "i" in region "r"

Consequently, for industry "i" in region "r"

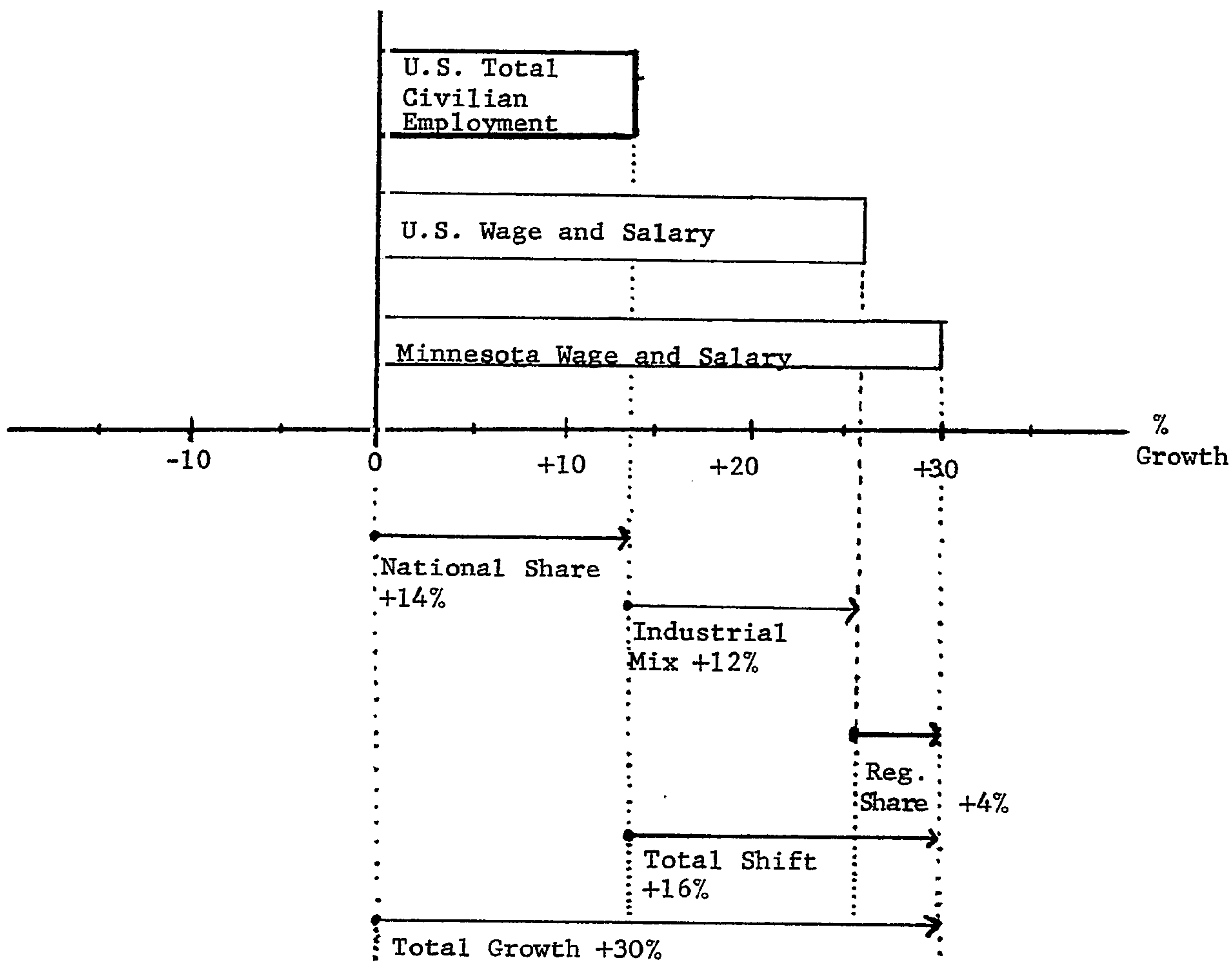
national share = g^{us}

industrial mix = $g_i^{us} - g^{us}$

regional component = $g_i^r - g_i^{us}$

total shift = $g_i^r - g^{us}$

Diagram I



Shift and Share Components

Minnesota Wage and Salary Employment

1960-68

and

$$g_i^r = g^{us} + [g_i^r - g^{us}] = g^{us} + [g_i^{us} - g^{us}] + [g_i^r - g_i^{us}]$$

<u>total growth</u> = <u>national share</u> + [<u>total shift</u>] =

<u>national share</u> + [<u>industrial mix</u>] + [<u>regional component</u>]

In the case above, where:

"i" = "wage and salary"

"r" = Minnesota

we have:

$$g_{w\&s}^{Minn} = g^{us} + [g_{w\&s}^{us} - g^{us}] + [g_{w\&s}^{Minn} - g_{w\&s}^{us}]$$

$$30\% = 14\% + [26\% - 14\%] + [30\% - 26\%]$$

$$= 14\% + [12\%] + [4\%]$$

Another case is that of Minnesota's agricultural employment, which declined between 1960 and 1968, although less rapidly than agriculture in the rest of the nation. Consequently, it showed a positive <u>regional component</u> despite negative <u>total growth</u>.

The growth rate percentages in the examples above used employment at the beginning of the period as the base of calculation. This is the simplest and most intuitively appealing method of calculation -- as well as that underlying the Department of Commerce figures [2]. However, one could just as well use end-of-period levels as the base, or an average of initial and final values [12, 16]. The results are more complex, but the basic concepts are the same.

So far we have discussed Shift-and-Share components as <u>percentage rates</u> of growth. We could just as well define them in terms of numbers of jobs. This point of view would make <u>total growth</u> the increase in employment in, to use the last example, Minnesota agriculture over the period studied. <u>National share</u> would represent the number of additional jobs in the industry in Minnesota had it grown at the rate of national total civilian employment.

The total shift component would be the total growth less the national share. Industrial mix would be the increase in employment had Minnesota agriculture grown at the same rate as all U.S. Agriculture, less the increase in Minnesota agriculture had it grown at the national share rate. Regional share would be the actual increase in employment, less the increase which would have resulted had the state's agriculture grown at the same pace as agriculture across the nation. In fact, this amounts to the same thing as multiplying each of the percentage rate components by the initial value of employment, and this is reflected in the fact that Diagram III (Minnesota agricultural employment, in terms of jobs) is identical to Diagram II (Minnesota agricultural employment in percentages), except for relabelling the axis.

Algebraically, this transformation may be demonstrated as follows.

Let

E_i^r = employment in industry "i" in region "r" at the beginning of the period

E_i^{r*} = the same, but at the end of the period

Thus

$$\underline{\text{Total growth}} = E_i^{r*} - E_i^r$$
$$= E_i^r \cdot (g_i^r)$$

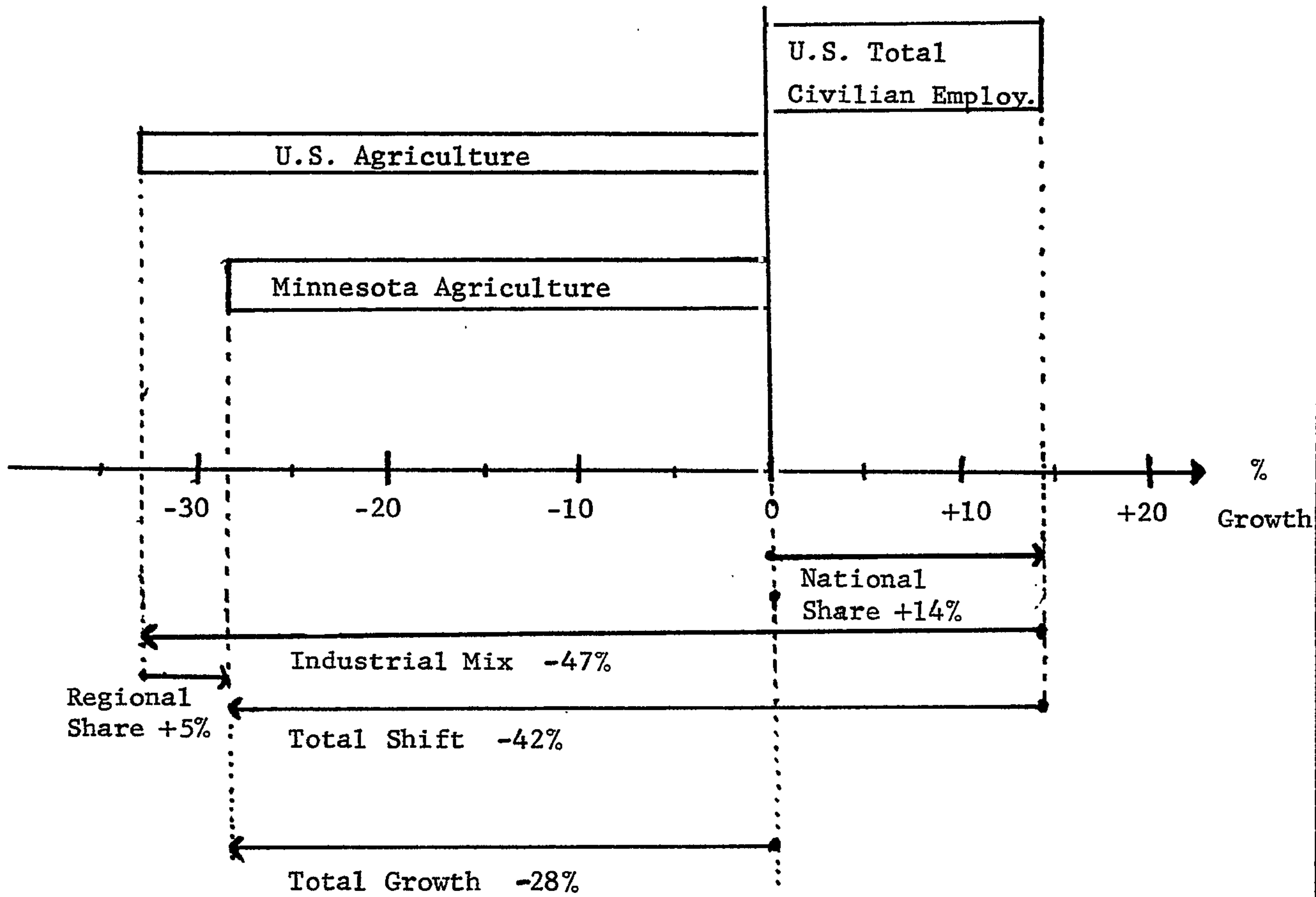
$$\underline{\text{national share}} = E_i^r\ (g^{us})$$

$$\underline{\text{total shift}} = E_i^r g_i^r - E_i^r g^{us}$$
$$= E_i^r \cdot (g_i^r - g^{us})$$

$$\underline{\text{industrial mix}} = (E_i^r g_i^{us} - E_i^r g^{us})$$
$$= E_i^r\ (g_i^{us} - g^{us})$$

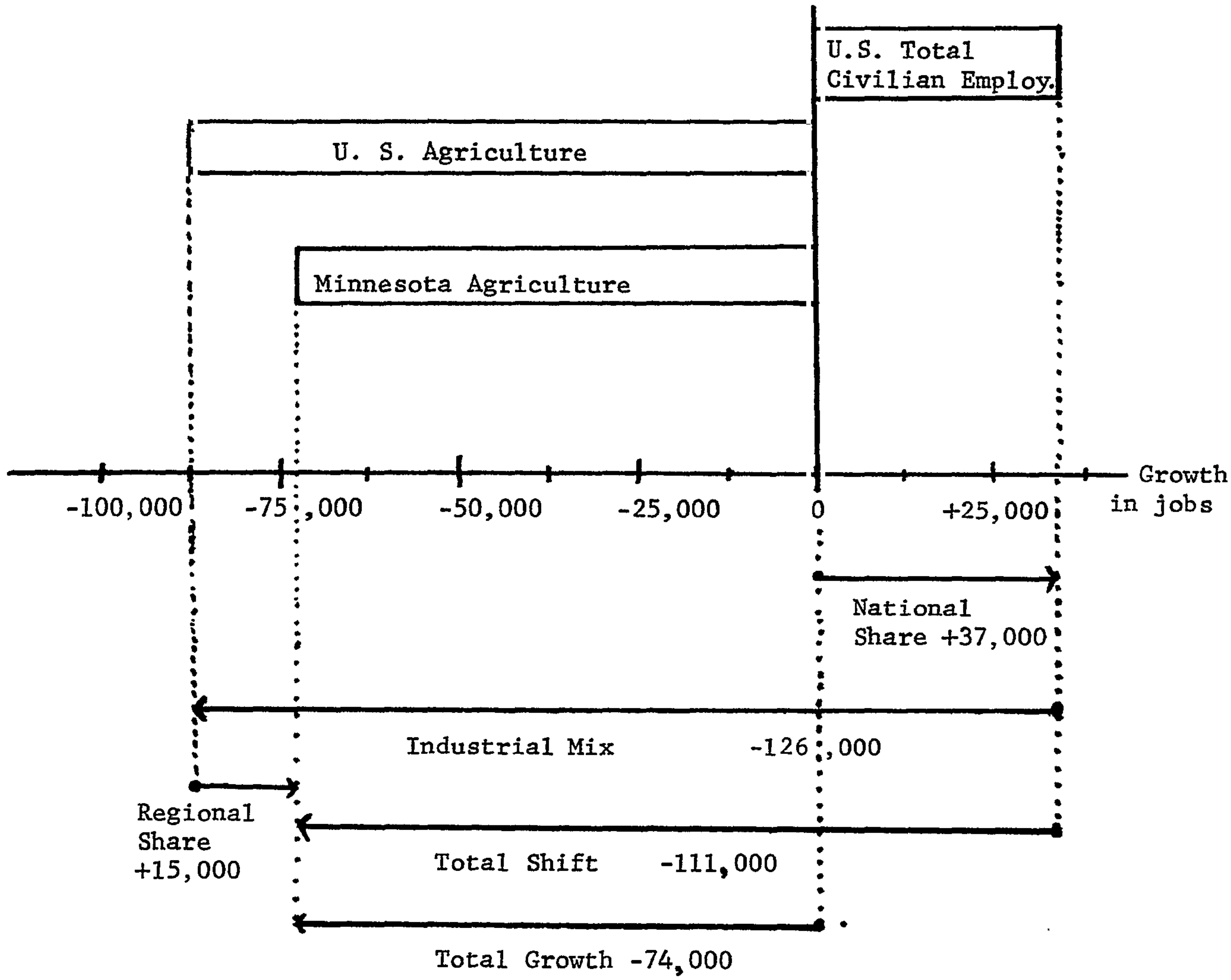
$$\underline{\text{regional component}} = (E_i^{r*} - E_i^r) - (E_i^r g_i^{us})$$
$$= (E_i^r\ g_i^r) - (E_i^r\ g_i^{us})$$
$$= E_i^r\ (g_i^r - g_i^{us})$$

Diagram II



Shift and Share Components
Minnesota Agricultural Employment
1960-68

Diagram III



Shift and Share Components
Minnesota Agricultural Employment
1960-68

and we see that our components, newly defined in terms of jobs, are equivalent to those defined in terms of percentages, each multiplied by the factor "E_i^r", the initial value of employment.

Shift-and-Share Analysis, thus described, will yield a set of components (total growth, national share, total shift, industrial mix, regional component) for each industry in the region under examination. The set of components for Minnesota agricultural employment (1960-68) is shown by Diagram II to be (-28%, +14%, -42%, -47%, +5%). Alternatively, we can refer to Diagram III which yields the set of components in terms of numbers of jobs: (-74,000; +37,000; -111,000; -126,000; +15,000).

In order to compare the performance of one region against another, we reduce the many sets of components to one in each region by summing across industries. (If components are defined in terms of percentages rather than jobs, we take a weighted average of industrial growth rates using the industrial employment concentration ratios, *i.e.*, $E_i^r \div \sum_i E_i^r$, as weights). If the comparison is to be meaningful, the set of industries across which we sum must be the same for the regions being compared. (The set of industries is defined as that collection of all industries considered -- which, in the case of national data, yields the totals on which national share computations are are based). For example, we would not wish to use the set of industries, "agriculture", for one region and compare its aggregated components with those derived from "total civilian employment" in the other. (Note that if the first region has no nonagricultural industry, the two sets are equivalent and thus in this special case such comparison would be meaningful). In addition, the industries over which we sum should be mutually exclusive in order to avoid "double-counting," and they will be conjointly exhaustive of the set of industries by definition. Furthermore, we must have the same set of industries in each region. For example, we should not include in our summations components for "electrical machinery" and "nonelectrical machinery" in Region A while using "machinery" in Region B. Although the aggregated components for total growth, national share, and total shift will not be affected as long as in each region the industries are mutually exclusive, the aggregated components for industrial mix and regional component will be affected unless the relative concentration of the two kinds of machinery in Region B is identical to that across the nation — because of the "g_i^{us}" factor appearing in both components.

If we follow the restrictions outlined in the previous paragraph, we may express our aggregated components for each region "r" algebraically as follows:

	Defined in Terms of Jobs	Defined in Percentages
total growth	$= \sum_i E_i^r g_i^r$	$= \sum_i g_i^r \frac{E_i^r}{E^r}$
	$= \sum_i (E_i^{r*} - E_i^r)$	$= \frac{1}{E^r} \cdot \sum_i E_i^r g_i^r$
	$= E^{r*} - E^r$	$= \frac{1}{E^r} \cdot \sum_i (E_i^{r*} - E_i^r)$
	$= E^r g^r$	$= \frac{1}{E^r} (E^{r*} - E^r)$
		$= \frac{1}{E^r} \cdot g^r \cdot E^r$
		$= g^r$
national share	$= \sum_i E_i^r g^{us}$	$= \sum_i g^{us} \frac{E_i^r}{E^r}$
	$= g^{us} \cdot \sum_i E_i^r$	$= \frac{g^{us}}{E^r} \cdot \sum_i E_i^r$
	$= E^r g^{us}$	$= \frac{g^{us}}{E^r} \cdot E^r$
		$= g^{us}$

$$\underline{\text{total shift}} = \sum_i \{E_i^r (g_i^r - g^{us})\} \qquad = \sum_i \{ \frac{E_i^r}{E^r} (g_i^r - g^{us}) \}$$

$$= \sum_i E_i^r g_i^r - \sum_i E_i^r g^{us} \qquad = \frac{1}{E^r} (\sum_i E_i^r g_i^r - \sum_i E_i^r g^{us})$$

$$= E^r g^r - E^r g^{us} \qquad = \frac{1}{E^r} (E^r g^r - E^r g^{us})$$

$$= E^r (g^r - g^{us}) \qquad = (g^r - g^{us})$$

$$\underline{\text{industrial mix}} = \sum_i E_i^r (g_i^{us} - g^{us}) \qquad = \sum_i \frac{E_i^r}{E^r} (g_i^{us} - g^{us})$$

$$= \sum_i E_i^r g_i^{us} - \sum_i E_i^r g^{us} \qquad = \frac{1}{E^r} (\sum_i E_i^r g_i^{us} - \sum_i E_i^r g^{us})$$

$$= \sum_i E_i^r g_i^{us} - E^r g^{us} \qquad = \frac{1}{E^r} \cdot \sum_i E_i^r (g_i^{us} - g^{us})$$

$$\underline{\text{regional share}} = \sum_i E_i^r (g_i^r - g_i^{us}) \qquad = \sum_i \frac{E_i^r}{E^r} (g_i^r - g_i^{us})$$

$$= \sum_i E_i^r g_i^r - \sum_i E_i^r g_i^{us} \qquad = \frac{1}{E^r} (\sum_i E_i^r g_i^r - \sum_i E_i^r g_i^{us})$$

$$= E^r g^r - \sum_i E_i^r g_i^{us} \qquad = g^r - \frac{1}{E^r} \cdot \sum_i E_i^r g_i^{us}$$

Summation of the components will verify the basic Shift-and-Share identity:

<u>total growth</u> = <u>national share</u> + <u>total shift</u>

= <u>national share</u> + <u>industrial mix</u>

\+ <u>regional component</u>

The algebra above demonstrates that the <u>set of industries</u> used for national data may vary from that used for the regions being compared without biasing the aggregated <u>regional components</u>. As the national set exceeds that of the regions, magnitude will be shifted from national share toward industrial mix or vice-versa, the direction dependent upon whether the "extra" industries are fast- or slow-growing, i.e., how "g^{us}" varies. Of course, the set of industries used for national data must include the set used for the regions, or it will not be possible to compute the components.

If we compute Shift-and-Share components of growth for the United States, we will get sets of components which look much different from the sets we compute for the various regions. When the region and the nation are identical, growth of an industry in the region is the same as growth of the industry in the nation, and their difference, the regional component, is therefore zero. Similarly, total shift and industrial mix are equal, and they also yield zero when the sum of all industries is computed. Total growth will, by definition, equal national share for the nation.

Algebraically, this is the case where "r" = "us," and thus

$$\text{Total Growth} = \sum_i E_i^r g_i^r = \sum_i E_i^{us} g_i^{us}$$

$$= \sum_i [E_i^{us*} - E_i^{us}]$$

$$= \sum_i E_i^{us*} - \sum_i E_i^{us}$$

$$= E^{us*} - E^{us}$$

$$\text{National Share} = \sum_i E_i^r g^{us} = \sum E_i^{us} g^{us}$$

$$= g^{us} \cdot \sum_i E_i^{us}$$

$$= g^{us} E^{us}$$

$$= E^{us*} - E^{us}$$

$$\text{Total Shift} = \sum_i E_i^r (g_i^r - g^{us}) = \sum_i E_i^r (g_i^{us} - g^{us}) = \text{Industrial Mix}$$

$$\underline{\text{Industrial}}\ \underline{\text{Mix}} = \sum_i [E_i^r\,(g_i^{us} - g^{us})]$$

$$= \sum_i [E_i^{us}\,(g_i^{us} - g^{us})]$$

$$= \sum_i [E_i^{us} g_i^{us}] - \sum_i [E_i^{us} g^{us}]$$

$$= \sum_i [E_i^{us*} - E_i^{us}] - g^{us} \cdot \sum_i E_i^{us}$$

$$= [\sum_i E_i^{us*} - \sum_i E_i^{us}] - [g^{us} \cdot E^{us}]$$

$$= [E^{us*} - E^{us}] - [E^{us*} - E^{us}]$$

$$= 0$$

$$\underline{\text{Regional}}\ \underline{\text{Share}} = \sum_i E_i^r\,(g_i^r - g_i^{us}) = \sum_i E_i^{us}\,(g_i^{us} - g_i^{us}) = 0$$

Sofar we have discussed application of the Shift-and-Share method to employment data from the period 1960-68. Fuchs [12, 1959; 13, 1962] and Garret [17, 1968] have applied the method to value-added data, and Fuchs has found a high correlation between components generated from value-added data and those computed from employment data. We could just as well compute Shift-and-Share components of growth of capital investment, inventory levels, wage rates, or any other economic indicators of interest. Obviously, we may choose any time period we feel appropriate. However, if we are looking for trends in Shift-and-Share components over time, we must make adjustments when the time periods compared are not of equal length. For example, a 5% increase over a five-year period should be equated with approximately a 7% increase over a seven-year period [4, 1969, p. 3n].

The Shift-and-Share method is just as applicable to cross-sectional data as to time series. Suppose, for example, that we are interested in 1970 incomes of physicians in Gotham City in comparison with physicians in general and Americans in general. Our <u>set of industries</u> would be "total civilian employment," our <u>industry</u> would be "physicians in private practice," and our region would be Gotham City. Components are given in Table I.

TABLE I. SHIFT-AND-SHARE COMPONENTS

INCOME OF PHYSICIANS IN PRIVATE PRACTICE

GOTHAM CITY, 1970

Civilians employed (United States)	$ 8,000
Physicians in private practice (United States)	32,000
Physicians in private practice (Gotham City)	38,000

Total Income	$38,000	100%**
National Share	8,000	21%
Total Shift (38,000-8,000)	30,000	79%
Industrial Mix (32,000-8,000)	24,000	63%
Regional Component (38,000-32,000)	6,000	16%

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* Since we are dealing with cross-sectional data,"total growth is replaced by the level of the indicator, total income. The Shift-and-Share identity thus adjusted, still holds:

Total Income = National Share + Total Shift

= National Share + Industrial Mix + Regional Component

** Percentages are calculated using total income as the base, thus allocating total income among the three components corresponding to the allocation of total growth when using time series.

Table II demonstrates that the application of Shift-and-Share Analysis is not limited to economics:

TABLE II. SHIFT-AND-SHARE COMPONENTS

I.Q. SCORES OF STUDENTS AT SIWASH COLLEGE, 1970

			Ave. I.Q. (est.)
Set of industries:	U.S. population		100
Industry:	College students		110
Region:	Siwash College		
	College students at Siwash		115
Total Score	112	100%	
National Share	100	89%	
Total Shift	12	11%	
Industrial Mix	10	9%	
Regional Component	2	2%	

There remains yet another aspect of the extreme flexibility of the Shift-and-Share method.

We defined (and named) national share so that each industry in each region examined is compared to the performance of the American economy. However, we may set the standard at any level we wish. (Why the national rate of growth is usually used will be referred to below). We might set the standard at an "ideal" rate of growth, at some "target" rate of growth, or at that rate observed in a base area other than the United States (cf. [9, 10]). If "base area" is substituted for "nation" on the pages preceding, the statements made still hold. However, if the base area chosen *is* the nation, *and* the regions examined are exclusive of each other and together exhaust the nation, then any particular Shift-and-Share component for any industry in the nation will equal the sum of that component for that industry in each region, *i.e.*, the regions will total to yield the nation.

Total Growth: $$\sum_r [E_i^{r*} - E_i^r] = \sum_r E_i^{r*} - \sum_r E_i^r$$

$$= E_i^{us*} - E_i^{us}$$

National Share: $$\sum_r [E_i^r g^{us}] = g^{us} \cdot \sum_r E_i^r$$

$$= E_i^{us} g^{us}$$

Total Shift: $$\sum_r [E_i^r (g_i^r - g^{us})] = \sum_r [E_i^r g_i^r] - \sum_r [E_i^r g^{us}]$$

$$= \sum_r [E_i^{r*} - E_i^r] - \sum_r [E_i^r] \cdot g^{us}$$

$$= [\sum_r E_i^{r*} - \sum_r E_i^r] - E_i^{us} g^{us}$$

$$= [E_i^{us*} - E_i^{us}] - E_i^{us} g^{us}$$

$$= E_i^{us} g_i^{us} - E_i^{us} g^{us}$$

$$= E_i^{us} (g_i^{us} - g^{us})$$

Industrial Mix: $$\sum_r [E_i^r (g_i^{us} - g^{us})] = [\sum_r E_i^r](g_i^{us} - g^{us})$$

$$= E_i^{us} (g_i^{us} - g^{us})$$

Regional Share: $$\sum_r [E_i^r (g_i^r - g_i^{us})] = \sum_r [E_i^r g_i^r] - \sum_r [E_i^r g_i^{us}]$$

$$= \sum_r [E_i^{r*} - E_i^r] - [\sum_r E_i^r] \cdot g_i^{us}$$

$$= [\sum_r E_i^{r*} - \sum_r E_i^r] - E_i^{us} g_i^{us}$$

$$= [E_i^{us*} - E_i^{us}] - E_i^{us} g_i^{us}$$

$$= [E_i^{us} g_i^{us}] - [E_i^{us} g_i^{us}]$$

$$= 0$$

Similarly we may validly add sets of components for sub-regions to obtain the set of components for the region which they compose. Industrial mix for Minnesota agriculture is identical to the sum of the agriculture industrial mix components from each of the state's eighty-seven counties. However, it should be noted that although the components are invariant to geographic aggregation, they are highly sensitive to the level of industrial aggregation. Generally, the more industry is disaggregated in the data-gathering process, the more we would expect magnitude to shift from regional component to industrial mix. (Total growth and national share obviously are unaffected by disaggregation, and so, by the nature of the identity, neither is total shift. However, such is not the case with the two shift components. Since, though, total shift is invariant, we know that whatever magnitude is "lost" to industrial mix due to change in industrial aggregation will be "gained" by regional component). The two extreme cases are illustrative. Suppose the data are completely disaggregated, i.e., each plant is considered a separate industry. Then $(g_i^r = g_i^{us})$, so:

$$\text{Total shift} = (g_i^r - g^{us})$$

$$\text{Industrial mix} = (g_i^{us} - g^{us}) = (g_i^r - g^{us}) = \text{Total shift}$$

$$\text{Regional component} = (g_i^r - g_i^{us}) = (g_i^r - g_i^r) = 0$$

On the other hand, if the data are completely aggregated, that is tantamount to saying that we recognize only one industry, called "output." Then $(g_i^{us} = g^{us})$, so:

$$\text{Industrial mix} = (g_i^{us} - g^{us}) = (g^{us} - g^{us}) = 0$$

$$\text{Regional component} = (g_i^r - g_i^{us}) = (g_i^r - g^{us}) = \text{Total shift}$$

However, as Houston [18, 1967] has shown, the shifting of magnitude from industrial mix to regional component is not necessarily a monotone function of the level of industrial aggregation. Suppose, for example, that we aggregate two industries, the first an industry in which the region is relatively highly specialized and which has a low national growth rate. Let the second account for only a small percentage of the region's activity but have a high national growth rate. Aggregation will lead us to compute industrial mix by adding the two industries and multiplying by a weighted average of their national growth rates. The larger industry being multiplied by the higher (weighted average) rate may well result in a greater change than the smaller industry being multiplied by the lower (weighted average) rate. Thus, aggregation would increase industrial mix and reduce regional component. To illustrate this possibility numerically, let:

$$E_1^r = 50 \qquad E_1^n = 100 \qquad E_1^{n*} = 102 \qquad g_1^n = 2\%$$

$$E_2^r = 10 \qquad E_2^n = 100 \qquad E_2^{n*} = 110 \qquad g_2^n = 10\%$$

$$E_{1+2}^n = 200 \qquad E_{1+2}^{n*} = 212 \qquad g_{1+2}^n = 6\%$$

Then, industrial mix according to the two different calculations would be as follows:

Data Disaggregated: $E_1^r\,(g_1^n - g^n) + E_2^r\,(g_2^n - g^n)$

$$= E_1^r g_1^n + E_2^r g_2^n - (E_1^r + E_2^r)\,g^n$$

$$= (50)\,(.02) + (10)\,(.10) - (E_1^r + E_2^r)\,g^n$$

$$= 2.0 - (E_1^r + E_2^r)\,g^n$$

Data Aggregated: $E_{1+2}^r\,(g_{1+2}^n - g^n)$

$$= (E_1^r + E_2^r)\,g_{1+2}^n - (E_1^r + E_2^r)\,g^n$$

$$= (50 + 10)\,(.06) - (E_1^r + E_2^r)\,g^n$$

$$= 3.6 - (E_1^r + E_2^r)\,g^n$$

Thus, in this case, aggregation increases industrial mix and, consequently, reduces regional component.

- 0 -

From the foregoing detail of the mechanics of Shift-and-Share Analysis, we may abstract the method's two main characteristics:

(1) It is basically a mechanical rearrangement of data by means of an identity; and

(2) it is a method of great flexibility, which enables its application to a wide variety of data.

II. SURVEY OF THE LITERATURE

Creamer [6, 1943] introduces a "shift ratio" (total shift) to measure the redistribution of industrial employment among regions. Perloff [19, 1957] notes various methods of defining regions and argues that definitions of regional boundaries are crucial. He argues that meaningful results require a dynamic method of definition based upon change in the direction of homogeneity and group consciousness. Perloff, Dunn, Lampard, and Muth [8, 1960; 20, 1960] decompose total shift into "differential shift" (regional component) and "proportionality shift" (industrial mix). They discuss the "index number problem" (the arbitrary nature of choosing a method for computing percentage components) and the problem of the "shifting base" (over any significant period of time, changes from the initial conditions interact with those forces originally causing change).

Fuchs [15, 1959] considers the problem of regional definition by comparing the two types of regions which are most desirable on the basis of data availability - states and Standard Metropolitan Statistical Areas (SMSAs). He divides nineteen interstate SMSAs into sections according to state boundaries. Variation within the SMSAs is determined by calculating the 1947-54 growth rate in value-added for each section, then substracting from it the mean of growth rates of the sections in that SMSA. From these figures the standard deviation is calculated:

$$s_1 = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left\{\left(g_i^a - \frac{g_i^a + g_i^b}{2}\right)^2 + \left(g_i^b - \frac{g_i^a + g_i^b}{2}\right)^2\right\}}$$

$$= \sqrt{\frac{2}{n}\sum_{i=1}^{n}\left(g_i^a - \frac{g_i^a + g_i^b}{2}\right)^2}$$

where SMSAs are 1, ... ,n and states are a, b. He also calculates the standard deviation (S_2) for variability of SMSA growth rates for SMSAs entirely within one state. Fisher's Z test for the ratio of variances (i.e., the F test for significance of differences in variances) is applied, and S_1 exceeds S_2 with confidence greater than 95%. Therefore, Fuchs argues, the economic activity of part of an interstate SMSA is more accurately described by that of the rest of the state rather than the rest of the SMSA. He notes that such a difference might be due to the fact that differentials within the SMSAs could reflect, not differences between states, but, differences between central cities (almost always located entirely within one state) and their surrounding "rings". He then calculates separate growth rates for central cities and "rings". Exclusion of central cities from the comparison does not alter the results.

Fuchs's examination of shifts in manufacturing employment and value added in the United States from 1929 to 1954 [12, 1959; 16, 1961; 13, 1962; 14, 1962] is massive and comprehensive. The vast amount of data used, and the many ways they were examined, represent an extraordinary effort. Main points of interest to us are as follows:

Notation and formulation:

The basic idea underlying Shift-and-Share Analysis is the comparison of growth within a region against some standard, and then, for purposes of comparison, normalizing that result to obtain percentage growth. This raises an index number problem: percentage of *what*? Most people using the Shift-and-Share method use initial values as the base for computing percentage change. Fuchs, however, and Garrett [17, 1968] following him, use an average of averages. For example, *regional component* (in percentage terms) would usually answer the question, "How much faster (or slower) did Region X grow than would have been the result if each of its industries grew at the national growth rate for that industry?" Fuchs's comparative gain or loss, adjusted for industrial structure is formulated differently and answers a similar, although somewhat different, question. Fuchs's notation is unfortunate -- a point which has been noted in the literature -- so the method of notation employed in this paper thus far, which hopefully is more conducive to the illustration of certain symmetries, will be continued. To reiterate and supplement, let

E_i^r = value of variable (value added, employment, etc.) at beginning of period examined, for industry (i) in region (r)

E_i^n = same, but for the base area (nation)

E_i^{*n} = same, but for the end of the period

E^{*n} = same, but the total of all industries

g_i^r = rate of growth of industry (i) in region (r), e.g., $g_i^r = \frac{E_i^{*r} - E_i^r}{E_i^r}$

h_i^r = rate of discount of industry (i) in region (r) necessary to deflate end values to get beginning values, i.e.,

$$E_i^{*r}\ (1-h_i^r) = E_i^r$$

$$E_i^r\ (1+g_i^r)\quad (1-h_i^r) = E_i^r$$

thus $$(1-h_i^r) = \frac{1}{1+g_i^r}$$

and $$h_i^r = 1 - \frac{1}{1+g_i^r}$$

g^r = growth rate for all industries in region (r)

h^n = discount rate for the national economy

Fuchs defines his counterpart to the <u>regional component</u> as

$$\frac{1}{2}\cdot\left[\frac{E^{*r} - \sum_i E_i^r \cdot E_i^{*n}/E_i^n}{\text{(larger of the two terms above)}} + \frac{\sum_i E_i^{*r} \cdot E_i^n/E_i^{*n} - E^r}{\text{(Larger of the two terms above)}}\right]$$

The numerators of the two terms may be written as

$$\sum_i E_i^r\ (g_i^r - g_i^n) \text{ and } \sum_i E_i^{*r}\ (h_i^r - h_i^n)$$

$$\text{or } \sum_i E_i^r \left(\frac{g_i^r - g_i^n}{1+g_i^n}\right)$$

The first term numerator is the excess of growth of the variable in region (r) over that which would have obtained had each industry in region (r) grown at the national rate. This amount would be thousands of jobs, millions of dollars of value added, etc. The second term numerator is the same type of measurement, but from the terminal point of view, <u>i.e.</u>, g's are computed on an initial value base, h's on a terminal value base, so the second term numerator represents the difference between the actual initial value of the variable in region (r) with that obtained by discounting each of its industries according to their respective national growth rates. The <u>regional component</u> as defined by most people working with shift-and-share Analysis---and in calculations we have made for the Ninth District---is much simpler, consisting of a simple percentage based on beginning-of-period values of the indicator under consideration. This is equivalent to the numerator of Fuchs's first term divided by total regional initial value of the indicator:

$$\frac{1}{E^r} \cdot \sum_i E_i^r \; (g_i^r - g_i^n)$$

We may compare Fuchs's formula with that just above. If, "on the (weighted) average," we observe a higher growth forward, we would expect, "on the (weighted) average," a higher discount (h) backward.

Letting

r represent the "typical" g_i^r

n represent the "typical" g_i^n

we would expect to observe the pattern appearing in Table III. Thus, we would expect, "on the average," that

(1) the signs of the two terms Fuchs is averaging would be the same (i.e., the left-left and right-right patterns).

(2) unless both the region (r) and the base region or nation have tended to show negative industrial growth rates over the period, Fuchs's formula will tend to be less in absolute value than the "standard" formula.

However, exceptions to tendencies "on the average" may well make the signs of the two terms different as illustrated in Table IV.

TABLE III. VALUES GENERATED BY FUCHS'S FORMULA RELATIVE TO THOSE OF THE "STANDARD" FORMULA

		1st Term				2nd Term				
	Case	Larger Part (*i.e.*, denom.)	Denom.	Num.	Term.	Larger Part (*i.e.*, denom.)	Denom.	Num.	Term.	Abs. Val. of Formula
$g_i^r > 0$	$g_i^r > g_i^n > 0$	left	>	=	<	left	>	=	<	<
	$g_i^r > 0 > g_i^n$	left	>	=	<	left	>	=	<	<
	$g_i^n > g_i^r > 0$	right	>	=	<	right	=	<	<	<
$g_i^r < 0$	$g_i^n > 0 > g_i^r$	right	>	=	<	right	=	<	<	<
	$0 > g_i^r > g_i^n$	left	<	=	>	left	>	=	<	?
	$0 > g_i^n > g_i^r$	right	<	=	>	right	=	>	>	>

TABLE IV. CASE IN WHICH THE TERMS OF FUCHS'S FORMULA ARE OF OPPOSITE SIGN

Industry (i)	E_i^r	g_i^r	g_i^n	$E_i^r \; (g_i^r - g_i^n)$	$E_i^r \left(\frac{g_i^r - g_i^n}{1 + g_i^r} \right)$
1	10	.20	.05	+1.5	+1.43
2	11	.05	.20	-1.8	-1.37
			$\sum_i$	-0.3 First Term Num.	+.06 Second Term Num.

(Denominators in both cases are positive)

Consequently, although tests of Ninth District data using states as regions confirm above "expectations," Fuchs's formula bears no consistent relationship to the "standard" formula. Since the "standard" formula is relatively simple and subject to easy interpretation (the difference between actual growth in the region and that which would have occurred had each industry in the region grown at its national rate), we may ask why Fuchs chose the more complicated measure. He indicates [13, 1962, pp. 40-42] that the variable nature of the denominator of each term is to keep the range between ± 100% for ease in interpretation and so that "it results in a distribution which is symmetrical around zero if comparative growth is randomly distributed." The former argument is questionable, and the latter is not at all clear. The underlying idea is that of percentage, and the possibility of having "± ∞ %" growth with new industries seems a small price to pay for retaining a common base and frame of reference. When each of the two terms is rejected because of an aversion to reliance on early weights (first term) or late weights (second term), and an arithmetic average is taken instead, the original idea of percentage -- and the simple interpretation -- is lost. Consequently, despite the sheer mass and impressive quality of Fuchs's work, our calculations for the Ninth District are based on the simpler "standard" formula. (If we were indifferent between Scotch and Bourbon, we would choose a drink either of one or the other — rather than mix the two half-and-half). The same reasoning applies to Fuchs's complicated <u>comparative industrial structure</u>, his counterpart to <u>industrial mix</u>. (He discusses five other formulae, including the "standard," which he rejected [13, 1962, p. 40n].

<u>Highlights of Fuchs's results</u>:

(1) He rejects shifting consumer demand as the major cause of geographical redistribution of industry, because his statistic corresponding to <u>regional component</u> accounts for much more change than that corresponding to <u>industrial mix</u>. In some cases, jobs follow people (<u>e.g.</u>, the South); in others, people come to jobs (<u>e.g.</u>, California). Comparison of 29 "market-oriented" industries with 192 others yields median shift in percentage of 19.6 for the former but 24.4 for the latter. Half of the total locational shift over the period has been due to four cases in which demand effect has been minimal: aircraft and chemicals (due to climate), and textiles and apparel (due to preference for Southern labor). This finding is in direct contradiction to earlier work by Easterlin [9, 1958]. (Easterlin argues that convergence in income as a trend is overbalanced by dynamic factors, such as development of new products and techniques and, to a large extent, changes in the composition of GNP. The implication is that <u>industrial mix</u> is just as important an item to be examined as <u>regional component</u>, and that the

latter should not be considered as merely the adjustment of the former to an equilibrium state.)

(2) Results are fairly insensitive to variation of the endpoints of the period of time over which growth is measured.

(3) Greater variation in the results is caused by changing the indicator from "employment" to "value-added," which increases total shift, despite high correlation between results based on the two indicators. This may be due to new industries tending to have higher VA/E ratios, and/or greater randomness in the value-added data. Geographically highly concentrated industries tend to shift more by employment than by value-added. Multiple regression analysis between the statistic corresponding to regional component and various factors confirms significance of unionization, climate, and population density, but it denies such to wage levels and the "catching-up" hypothesis.

(4) Fuchs uses his own system of industrial classification and finds high correlation between results based on different levels of industrial disaggregation.

(5) Given the concept of a production function, "employment" is better conceived of as "total labor employed" rather than as "production workers."

(6) Results for 1929-1954 and 1947-1954 are highly correlated, indicating no significant change in the underlying forces causing redistribution.

Ashby [2, 1965] presents Shift-and-Share employment components and an "octant code" for each of thirty-two industries for every county in the United States. (The "octant code" is a device whereby each industry in a region is assigned a one-digit code based on the signs and relative magnitudes of industrial mix and regional component. It is described in the appendix.) As noted in Part I, the counties can be selected to form any region desired and the data aggregated to get components for that region. Because Ashby's work is based upon Census data, which are point-to-point in time, relationships of industries to each other, as well as national share, are subject to distortion by seasonal factors. He introduces [1, 1964] indices of industrial centralization, regional specialization, and homogeneity of industrial-regional structure:

"Centralization of industry *i*" $= C_i = \sum_r \varphi_r$

where $\varphi_r = \dfrac{E_i^r}{E_i^n} - \dfrac{E^r}{E^n}$ when positive, zero otherwise

"Specialization of region r" $= S_r = \sum_i \gamma_i$

where $\gamma_i = \dfrac{E_i^r}{E^r} - \dfrac{E_i^n}{E^n}$ when positive, zero otherwise

"Homogeneity" $= H = 1 - \dfrac{1}{E^n} \cdot \sum_r S_r \; E^r = 1 - \dfrac{1}{E^n} \cdot \sum_i \; C_i \; E_i^n$

Each of the indices varies between zero and unity, becoming larger as the characteristic measured is more prevalent. (S_r can be shown to be identical to Thirwall's [22, 1969] "coefficient of specialization," discussed below). Ashby divides the United States into eight regions and notes that 1940-1960 saw an increase in H, the homogeneity index, and a rise in regional component relative to _industrial mix_. The latter phenomenon is attributed to migration into the cities. Like Fuchs, Ashby disagrees with Easterlin, and he considers _regional component_ to reflect the "dynamic elements of change" and, as the factor of adjustment of _industrial mix_ over time, more important than _industrial mix_. Along this line, Ashby suggests that long-term planning to maximize employment growth should involve inducing negative regional components for industries which are relatively slow-growing nationally.

Houston [18, 1967] responds to Ashby with a critique, the main points of which are as follows:

(1) "...the measure is an identity with no behavioral implications."

(2) "...the economic behavior underlying the two kinds of shifts [_industrial mix_ and _regional component_] is not readily distinguishable.... Shift and Share is not so much an analytic tool as it is a type of measurement.... Shift-and-Share Analysis implicitly assumes that the market area of all goods is national, or uniform if some other base is used.... To be conceptually correct Shift-and-Share Analysis would have to use the market area of an industry as the base against which growth is measured in that industry." That is to say, if the difference between regional and another growth rates is to represent a "comparative advantage," the regional industry should be compared only with other producers with which it competes. (Houston's line of thinking could be carried one step further, to argue

that the components have no meaning unless the classification of "industries" identifies a set of products such that no product has a complement or rival in the set).

(3) The relative magnitudes of the two shift components are highly sensitive to the level of disaggregation of the industrial classification. However, the shifting of magnitude from *industrial mix* to *regional component* is an increasing function of industrial aggregation *only in general*; it is not necessarily a monotone function. [*cf*. pp. 18-20 above].

Ashby [3, 1968] answers that Houston is attacking a straw man for it is not claimed that the *regional component* represents comparative advantage or that Shift-and-Share Analysis is a behavioral growth model. It is just a useful way of grouping information at hand. The components are sensitive to changes in the level of aggregation -- as are most economic measures -- for they reflect the sensitivity of the analysis to different sets of information -- which is as it should be.

Estle [10, 1967] computes Shift-and-Share components for states in New England using New England as the base area. In that New England's economic growth generally was lagging that of the United States, use of New England instead of the nation as the base area has the effect of shifting magnitude from *national share* to *industrial mix*, and from *industrial mix* to *regional component*. The Federal Reserve Bank of Cleveland [11, 1967-1968] examined employment growth performances of Cleveland, Pittsburgh, and Cincinnati during 1950-1966 by using thirteen large American cities as the base area.

Thirwall [21, 1967] applies Shift-and-Share analysis to British employment data and calculates percentage components, "composition effect (*c*)," *i.e.*, *industrial mix*, and "growth effect (*g*)," *i.e.*, *regional component*, for eleven regions in the U. K. Cunningham [7, 1969] notes that *industrial* mix and regional component for each region are essentially weighted averages of growth rates using the regional industrial structure $\frac{E_1^r}{E^r}, \frac{E_2^r}{E^r}, \ldots, \frac{E_m^r}{E^r}$ for weights. He suggests that the national industrial structure $\frac{E_1^{uk}}{E^r}, \frac{E_2^{uk}}{E^r}, \ldots, \frac{E_m^{uk}}{E^r}$ would be a more appropriate set of weights.

Preceding by this method, he derives measures "ψ" (corresponding to Thirwall's "c", industiral mix) and "γ" (corresponding to Thirwall's "g", regional component). He denotes by "ρ" the difference between his measures and Thirwall's

$$(g - \psi) = \rho = (\gamma - c)$$

He also shows that $\rho > 0$ indicates that the region is increasing its concentration in relatively fast-growing industries. Thirwall [22, 1969] answers that "ψ" and "γ" are no more independent of weights than "g" and "c" -- but are just dependent on a different set of weights. Furthermore, whether $\rho > 0$ is equivalent to whether the "coefficient of specialization" is increasing over the period considered. The coefficient of specialization can be shown to be equivalent to Ashby's index of specialization. It is defined as follows:

$$\frac{1}{2}\sum_{i=1}^{m}\left|\frac{E_i^r}{E^r} - \frac{E_i^n}{E^n}\right| \quad \text{(beginning of period)}$$

$$\frac{1}{2}\sum_{i=1}^{m}\left|\frac{E_i^{*r}}{E^{*r}} - \frac{E_i^{*n}}{E^{n*}}\right| \quad \text{(end of period)}$$

If the region is a microcosm of the nation, $\frac{E_i^r}{E^r} = \frac{E_i^n}{E^n}$ for each (i), so the coefficient is zero. At the other extreme, if the two sets of industries, those in the region (i=1,2, ... ,k) and those in the rest of the nation (i=k+1, k+2, ... ,m) are mutually exclusive, and the region is small, the coefficient will approach 1:

$$\frac{1}{2}\sum_{i=1}^{m}\left|\frac{E_i^r}{E^r} - \frac{E_i^n}{E^n}\right|$$

$$= \frac{1}{2}\sum_{i=1}^{k}\left|\frac{E_i^r}{E^r} - \frac{E_i^n}{E^n}\right| + \frac{1}{2}\sum_{i=k+1}^{m}\left|\frac{E_i^r}{E^r} - \frac{E_i^n}{E^n}\right|$$

$$= \frac{1}{2}\sum_{i=1}^{k}\left|\frac{E_i^r}{E^r} - \frac{E_i^r}{E^n}\right| + \frac{1}{2}\sum_{i=k+1}^{m}\left|\frac{0}{E^r} - \frac{E_i^n}{E^n}\right|$$

$$= \frac{1}{2}\left(\frac{1}{E^r} - \frac{1}{E^n}\right)\cdot\sum_{i=1}^{k} E_i^r + \frac{1}{2}\cdot\frac{1}{E^n}\cdot\sum_{i=k+1}^{m} E_i^n$$

$$= \frac{1}{2}\left(1 - \frac{E^r}{E^n}\right) + \frac{1}{2}\cdot\frac{1}{E^n}\left(E^n - E^r\right)$$

$$= \frac{1}{2} - \frac{1}{2}\cdot\frac{E^r}{E^n} + \frac{1}{2} - \frac{1}{2}\cdot\frac{E^r}{E^n}$$

$$= 1 - \frac{E^r}{E^n}$$

Since the region is part of the nation, the <u>set of industries</u> for the region ($i=1,2, \ldots ,k$) is a subset of the <u>set of industries</u> for the nation ($i=1,2, \ldots ,k, k+1, \ldots ,m$), so the coefficient cannot equal 1. (Of course, the smaller the region relative to the nation, the closer the coefficient can approach to 1-- as shown in the derivation above). However, if the region and the base area are mutually exclusive, and the two <u>sets of industries</u> are mutually exclusive, the coefficient can equal 1. Using the superscript (b) to refer to the base area, we would have:

$$\frac{1}{2}\sum_{i=1}^{k}\left|\frac{E_i^r}{E^r} - \frac{E_i^b}{E^b}\right| + \frac{1}{2}\sum_{i=k+1}^{n}\left|\frac{E_i^r}{E^r} - \frac{E_i^b}{E^b}\right|$$

$$= \frac{1}{2} \sum_{i=1}^{k} \left| \frac{E_i^r}{E^r} - \frac{0}{E^b} \right| + \frac{1}{2} \cdot \sum_{i-k+1}^{n} \left| \frac{0}{E^r} - \frac{E_i^b}{E^b} \right|$$

$$= \frac{1}{2} + \frac{1}{2} = 1$$

As Thirwall notes, it is far easier to calculate the coefficient of specialization twice than to determine ρ once. This being the case, the question is, whether "ψ" and "γ" have any significance in and of themselves. Thirwall's "g" (conventionally defined regional component) is that growth in excess of what is regarded as "normal" given the industrial structure existing at the beginning of the period in the region. Cunningham's "ψ", however, answers the question, "Given the peculiar 'abilities' in a region to do 'better' than other regions in certain industries, how much better than 'average' would this region do *if* it were a microcosm of the nation?" But this kind of question, though perhaps interesting, is not too fruitful. If New York City's agriculture sector quadruples, do we really care how much growth that would have been if New York City had an industrial structure identical to that of the United States? Only as the regional industrial structure approaches identity to the national structure would the question cease to be fanciful--but as it approached identity, it would also cease to be relevant.

Garrett [17, 1968] uses Fuchs' method of defining components to calculate comparative growth adjusted for industrial structure (cgafis) (roughly equivalent to conventionally defined regional component plus national share, i.e., regional component plus a constant). He finds that cgafis for the South (Confederacy plus West Virginia) ran higher during 1947-1958 than in 1929-1947. Looking for causes, he divides Southern industries into five mutually exclusive groups:

(1) resource-oriented - 10% or more of input value is from natural resources.

(2) market-oriented - his criteria are unclear, but he gives several references (p. 356n).

(3) labor-oriented - industries highly labor-intensive (higher-than-average ratio of wages to value added) and with lower-than-average wages.

(4) multi-unit firm - 60% or more of employment in multi-unit firms.

(5) unclassified

He then calculates cgafis for each group:

	Employment	Value Added
(1) resource-oriented	11%	15%
(2) market-oriented	15	12
(3) labor-oriented	25	21
(4) multi-unit firm	21	24
(5) unclassified	24	19

The first two classes are taken to reflect national demand factors, and the third supposedly reflects comparative advantage or supply. The high degree of growth in the fourth, multi-unit firm industries, could reflect the working of the "catching-up hypothesis;" yet actual growth is highly correlated with growth at the national level (Spearman's coefficient .81). Furthermore, the net advantage of the South was concentrated in labor-oriented industries --had they grown at the national rate, so would have the whole South. Therefore, he concludes:

(1) "...although regional growth patterns appear to be dominated by national demand conditions, the growth of a region does not depend upon the national pattern of growth facing its industries."

(2) "...a major part of the regional growth in manufacturing of an underdeveloped region within an advanced economy will occur in the form of multi-unit firms."

It would seem that Garrett's findings are due to a factor or factors not uncommon in a less-developed region, i.e., absentee ownership and/or use of "foreign" capital. One would expect that, in all industries (other than those with very localized markets and those peculiar to the region), there would be a strong tendency for units of manufacturing to be branches of "foreign" units. In areas where the region has a strong competitive advantage, however, and one which has persisted over time, the industry would have concentrated in the region, and, although perhaps "foreign" run, would not be a branch. Then we would expect the growth patterns of industries distinguished only by being multiple-unit firm in composition to show up as would others with no comparative advantage, i.e., growing along with national demand--which is what Garrett found. An interesting question would be, what were growth patterns of multi-unit firm industries in other "more developed" regions?

Brown [4, 1969] compares a Shift-and-Share model against two other models used to predict regional employment growth. The regions are SMSAs. The data are drawn from 1947, 1954, 1958, and 1963, and they are grouped by 2-,3-, and 4-digit SIC's. The three models are:

"S&S" — growth of an industry in the region will equal its projected national growth rate plus last period's regional component.

"Ingrow"— growth of an industry in the region will equal its national growth rate during last period.

"Super Ingrow"— growth of an industry in the region will equal its projected national rate of growth.

Since "S&S" is just "Super Ingrow" with a regional adjustment, their relative accuracy is of significance.

To compare the three models, Brown calls upon, and explains, Theil's inequality coefficient (U) and its decomposition. Letting P stand for prediction and A for actual values of the indicator,

$$U = \sqrt{\frac{\sum_i (P_i - A_i)^2}{\sum_i A_i^2}} = \sqrt{\frac{\text{Mean of Squared Errors}}{\text{Mean of Squared Actual Values}}}$$

The magnitude of U enables us to compare the overall performance of the models. To find the weakness of any given model we may break up the numerator of U as follows:

$$\frac{\frac{1}{n}\sum_i (P_i - A_i)^2}{MSE} = 1 = \frac{(\bar{P}-\bar{A})^2}{MSE} + \frac{(S_p - S_a)^2}{MSE} + \frac{2(1-r)S_a S_p}{MSE}$$

= "mean error" + "variance error" + "covariance error"

Brown finds "Super Ingrow" superior to "Ingrow" (with perfect information), and both superior to "S&S." Unfortunately, "S&S" error is concentrated in "covariance error"--which can't be ameliorated by adjusting the model and indicates the unstable nature of the competitive component. (Brown runs tests on various periods of various lengths, and at 2-, 3-, and 4-digit SIC levels of aggregation). A contingency table indicates the randomness of the competitive component with the possible exception of 2-digit level, short period, cases. This is also shown by classifying industries as "fast, medium, slow" and noting insignificant results from tests of differences of means in suceeding periods. Brown then hypothesises that regional component describes a number of different dynamic growth factors and tries to correlate regional component with various factors, *e.g.*, distance to final market, temperature, etc. Results lead him to conclude that there is no real connection between the regional component and economic forces, *i.e.*, that it may be regarded as random. The obvious point of departure from Brown's work is to compare projections of various types with one that uses historical regional components only for those industries with national-type markets.

Conley [5, 1969] argues that investigation of economic growth should focus on total percentage over time, rather than average annual growth due to individual factors, in order to take into account interaction between various factors, diminishing returns, and compounding. Following this line of thinking, there is no problem of "shifting base", contrary to Dunn [8, 1960]. It would seem that the practical solution is somewhere between the extremes -- that we should look at cumulative changes instead of averages of annual rates, but that the period should not be of too great length.

III. APPLICATION TO THE NINTH DISTRICT

U.S. Department of Commerce data by county [2, 1965] have been aggregated to yield a set of components for the Ninth District, each of its constituent states, and the Twin Cities Metropolitan Area. The advantage of using the Commerce data is that results were obtainable from just a few man-days spent working with a desk calculator. However, Commerce data also involve significant drawbacks:

(1) As discussed in Part I above, Commerce components are based on Census data, which are gathered in late March or early April. This makes the results, both regarding total employment and the relationships of particular industries to each other, highly susceptible to seasonal distortion -- and especially so in the Ninth District, which is relatively heavily specialized in agriculture forestry, lumber products, and mining.

(2) Commerce results are available only for 1940-1950 and 1950-1960.

(3) The industries used in Commerce figures do not correspond exactly to those in which we are interested.

Consequently, the much longer, more complex, and more tedious task of constructing Shift-and-Share components from state employment figures was undertaken. Seasonal distortion was avoided by taking for beginning-of-period and end-of-period levels of employment the arithmetic averages of monthly employment figures for the end-point years. This enabled us to calculate components (both in terms of jobs and percentages) and octant codes for 1950-1960 and 1960-1968. However, with this method it was not possible to derive components for northwestern Wisconsin due to lack of data. Also, agricultural and nonagricultural employment data had to be taken from different sources. The incompatibility of these sources is shown by the fact that our components for "self-employed and domestics," taken as a residual from "total civilian employment," "agriculture," and "wage and salary" vary unreasonably over time and between regions. Regions examined were the United States, Minnesota, North Dakota, South Dakota, Upper Michigan, the Five-State Region (i.e., the Ninth District less northwestern Wisconsin), and the Twin Cities. Three sets of industries were used:

(1) "Wage and salary employment" - eight industries. [See Table V.]

(2) "Total civilian employment" - eight industries identical to those of "wage and salary employment," plus "agriculture" and "self-employed and domestics." [See Table VI.]

(3) "Manufacturing" - industries defined by two-digit SIC codes. [See Table VII.] (Because meaningful comparison requires identical sets of industries, as discussed in Part I above, and because industries with low specialization ratios are not reported in detail due to confidentiality provisions, meaningful comparison was possible only between the United States and Minnesota).

Results obtained corresponded to our expectations:

(1) Positive regional components and negative industrial components in agriculture. [cf. Table VI.]

TABLE V

MINNESOTA WAGE AND SALARY EMPLOYMENT

SECTOR	1960 EMPLOYMENT	1968 EMPLOYMENT	TOTAL GROWTH	NATIONAL SHARE	TOTAL SHIFT	INDUSTRIAL COMPONENT	REGIONAL COMPONENT	---(P E R C E N T)----					
								TOTL GRTH	NATL SHRE	TOTL SHFT	INDS COMP	RGNL COMP	OCT
TOT WAGE & SAL	959.9	1243.1	283.2	243.7	39.5	0.7	38.7	30	25	4	0	4	1
MANUFACTURING	229.7	312.8	83.1	58.3	24.8	-17.5	42.3	36	25	11	-8	18	3
MINING	18.1	15.2	-2.9	4.6	-7.5	-6.7	-0.8	-16	25	-41	-37	-4	8
CONSTRUCTION	55.4	63.7	8.3	14.1	-5.8	-6.8	1.1	15	25	-10	-12	2	6
TRANSP, ETC	84.0	84.8	0.8	21.3	-20.5	-14.4	-6.1	1	25	-24	-17	-7	8
TRADE	237.5	295.9	58.4	60.3	-1.9	-4.1	2.2	25	25	0	-2	1	6
FINANCE	47.9	59.0	11.1	12.2	-1.1	-0.2	-0.9	23	25	-2	0	-2	7
SERVICES	137.8	195.8	58.0	35.0	23.0	23.8	-0.8	42	25	17	17	0	4
GOVERNMENT	149.5	215.9	66.4	38.0	28.4	26.6	1.8	44	25	19	16	1	2

NOTES

EMPLOYMENT FIGURES ARE IN THOUSANDS. PERCENTAGES USE 1960 EMPLOYMENT AS A BASE.

COMPONENTS AND PERCENTAGES MAY NOT TOTAL EXACTLY DUE TO ROUNDING.

OCTANT CODE

1-2 --- ON BORDERLINE BETWEEN 1 AND 2

1, 2, 3, 4 -- TOTAL SHIFT IS POSITIVE

5, 6, 7, 8 -- TOTAL SHIFT IS NEGATIVE

EVEN NUMBERS -- INDUSTRIAL COMPONENT DOMINATES TOTAL SHIFT

ODD NUMBERS -- REGIONAL COMPONENT DOMINATES TOTAL SHIFT

```
              IND +

 *            *
    *    4    *   2
       *      *         *
   5      *   *      *     1
             * * *
 ********* 0 ********* REG
            ***            +
   7     *    *    *     3
      *       *       *
    *         *          *
         8    *   6         *
              *               *
                                *
ALONG THIS LINE, TOTAL SHIFT EQUALS ZERO..../ *
```

TABLE VI

MINNESOTA TOTAL CIVILIAN EMPLOYMENT

SECTOR	1960 EMPLOYMENT	1968 EMPLOYMENT	TOTAL GROWTH	NATIONAL SHARE	TOTAL SHIFT	INDUSTRIAL COMPONENT	REGIONAL COMPONENT	TOTL GWTH (PERCENT)	NATL SHRE (PERCENT)	TOTL SHFT (PERCENT)	INDS COMP (PERCENT)	RGNL COMP (PERCENT)	OCT
TOT CIV EMPLT	1396.3	1583.2	186.9	193.5	-6.6	-106.7	100.2	13	14	0	-8	7	6
AGRICULTURE	267.0	193.0	-74.0	37.0	-111.0	-125.9	14.9	-28	14	-42	-47	6	6
SELF EMPL & D	169.5	147.1	-22.4	23.5	-45.9	-91.5	45.6	-13	14	-27	-54	27	6
WAGE & SALARY	959.8	1243.1	283.3	133.0	150.3	110.7	39.6	30	14	16	12	4	2
MANUFACTURING	229.7	312.8	83.1	31.8	51.3	9.0	42.3	36	14	22	4	18	1
MINING	18.1	15.2	-2.9	2.5	-5.4	-4.7	-0.8	-16	14	-30	-26	-4	8
CONSTRUCTION	55.4	63.7	8.3	7.7	0.6	-0.4	1.1	15	14	1	0	2	3
TRANSP, ETC	84.0	84.8	0.8	11.6	-10.8	-4.7	-6.1	1	14	-13	-6	-7	7
TRADE	237.5	295.9	58.4	32.9	25.5	23.3	2.2	25	14	11	10	1	2
FINANCE	47.9	59.0	11.1	6.6	4.5	5.4	-0.9	23	14	9	11	-2	4
SERVICES	137.8	195.8	58.0	19.1	38.9	39.7	-0.8	42	14	28	29	0	4
GOVERNMENT	149.5	215.9	66.4	20.7	45.7	43.9	1.8	44	14	31	29	1	2
SUM OF WAGE AND SALARY SHIFT COMPONENTS....						111.5	36.7						

NOTES

EMPLOYMENT FIGURES ARE IN THOUSANDS. PERCENTAGES USE 1960 EMPLOYMENT AS A BASE.

COMPONENTS AND PERCENTAGES MAY NOT TOTAL EXACTLY DUE TO ROUNDING.

OCTANT CODE

1-2 --- ON BORDERLINE BETWEEN 1 AND 2

1, 2, 3, 4 -- TOTAL SHIFT IS POSITIVE

5, 6, 7, 8 -- TOTAL SHIFT IS NEGATIVE

EVEN NUMBERS -- INDUSTRIAL COMPONENT DOMINATES TOTAL SHIFT

ODD NUMBERS -- REGIONAL COMPONENT DOMINATES TOTAL SHIFT

```
                 IND +
  *          *
     *    4  *  2
        *    *      *
     5     * *    *    1
             * * *
  ********* 0 ********* REG
              ***         +
     7     *  *  *     3
        *     *      *
     *        *         *
           8  *  6         *
              *              *
                               *
ALONG THIS LINE, TOTAL SHIFT EQUALS ZERO..../ *
```

TABLE VII

MINNESOTA MANUFACTURING EMPLOYMENT

SIC	SECTOR	1960 EMPLOYMENT	1968 EMPLOYMENT	TOTAL GROWTH	NATIONAL SHARE	TOTAL SHIFT	INDUSTRIAL COMPONENT	REGIONAL COMPONENT	(PERCENT) TOTL GWTH	NATL SHRE	TOTL SHFT	INDS COMP	RGNL COMP	OCT
TOT MANUFACTURE		229.7	312.8	83.1	40.6	42.5	-2.0	44.5	36	18	18	-1	19	3
DURABLES		112.4	178.2	65.8	19.9	45.9	5.8	40.1	59	18	41	5	36	1
NON-DURABLES		117.3	134.6	17.3	20.8	-3.5	-7.8	4.4	15	18	-3	-7	4	6
DURABLES---														
24	LUMBER	7.7	7.0	-0.7	1.4	-2.1	-1.7	-0.3	-9	18	-27	-22	-4	8
25	FURNITURE	2.4	3.4	1.0	0.4	0.6	0.1	0.4	42	18	24	6	18	1
33	PRI METAL	5.9	6.9	1.0	1.0	-0.0	-0.6	0.6	17	18	0	-11	10	6
34	FAB METAL	14.6	19.7	5.1	2.6	2.5	0.7	1.8	35	18	17	5	12	1
35	NON-ELECT	30.3	61.5	31.2	5.4	25.8	4.5	21.3	103	18	85	15	70	1
36	ELEC MACH	16.0	29.1	13.1	2.8	10.3	2.8	7.5	82	18	64	17	47	1
37	TRANSP EQ	4.4	8.0	3.6	0.8	2.8	0.4	2.4	82	18	64	10	54	1
*	OTH MANUF	31.0	42.6	11.6	5.5	6.1	1.0	5.1	37	18	20	3	17	1
	SUM OF DURABLES SHIFT COMPONENTS....						7.2	38.8						
NON-DURABLES---														
20,21	FOOD, ETC	55.9	56.1	0.2	9.9	-9.7	-10.5	0.8	0	18	-17	-19	1	6
22,23	TEXT/APRL	9.8	10.6	0.8	1.7	-0.9	-0.6	-0.3	8	18	-10	-7	-3	8
26	PAPER	22.2	29.4	7.2	3.9	3.3	-0.6	3.8	32	18	15	-2	17	3
27	PRINTING	19.9	23.6	3.7	3.5	0.2	-0.2	0.4	19	18	1	0	2	3
28,29	CHEM/PETR	5.5	8.0	2.5	1.0	1.5	-0.1	1.6	45	18	28	0	29	3
30,31	RUB/LEATH	4.0	6.9	2.9	0.7	2.2	0.2	2.0	72	18	55	5	50	1
	SUM OF NON-DURABLES SHIFT COMPONENTS....						-11.7	8.3						

* 'OTH MANUF' CONSISTS OF SIC'S 19 (ORDNANCE), 32 (STONE, CLAY, GLASS), 38 (INST), & 39 (MISC).

NOTES

EMPLOYMENT FIGURES ARE IN THOUSANDS. PERCENTAGES USE 1960 EMPLOYMENT AS A BASE.

COMPONENTS AND PERCENTAGES MAY NOT TOTAL EXACTLY DUE TO ROUNDING.

OCTANT CODE

1-2 --- ON BORDERLINE BETWEEN 1 AND 2

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5, 6, 7, 8 -- TOTAL SHIFT IS NEGATIVE

EVEN NUMBERS -- INDUSTRIAL COMPONENT DOMINATES TOTAL SHIFT

ODD NUMBERS -- REGIONAL COMPONENT DOMINATES TOTAL SHIFT

```
               IND +
         *        *
           *   4  *  2
             *    *    *
        5      *  *  *     1
                * * *
         ********* 0 ********* REG
                 ***              +
        7      *  *  *     3
             *    *    *
           *      *      *
              8   *  6     *
                  *          *
                               *
ALONG THIS LINE, TOTAL SHIFT EQUALS ZERO..../ *
```

(2) Generally positive regional components in manufacturing and somewhat negative regional components in other "wage and salary" industries. [cf. Table V, Table VI.]

(3) Strongly negative shift components in mining. [cf. Table V, Table VI.]

The computer programs used are flexible and can be modified easily to produce results for other indicators, time periods, sets of industries, and regional delineations. For example, some preliminary computations have been performed using "personal income", and an attempt was made to compare results using "employment" with figures using "value-added." Because of the data-gathering problem mentioned above, meaningful comparison was possible only with Minnesota. Identical sets of industries (twenty-one two-digit SIC industries) were used for each indicator, and components were calculated for the period 1958-1963. Regional components in dollar terms showed rank correlation of .66 with standard error of .15; when percentages were used, somewhat better results (.74, .12) were obtained. In both cases T values were high enough to reject the independence hypothesis at the 99% level of significance. This result is consistent with, although somewhat weaker than, Fuchs's findings.

Location coefficients have been calculated as a check against regional share figures, and the results are consistent. Ninth District data were used to compute regional components based on different methods used to define the components (conventional, Fuchs, and Cunningham), and results did not differ significantly.

Comparison of components for 1950-1960 derived from Commerce data with those derived from state employment data shows significant differences, not only in magnitudes, but also in signs, due to the difference in the <u>sets of industries</u> used as well as to different methods of gathering data.

IV. CRITIQUE

One may find in the literature various arguments for and against the "validity" of Shift-and-Share Analysis (e.g., [3, 1968; 18, 1967]). These arguments reflect one of those unfortunate controversies wherein the issues of contention begin to become clear only after the battle is joined. The Shift-and-Share approach is not a theory of economic growth. It is merely a method of rearranging available data, without behavioral implications, into a form which hopefully will be conducive to insight. Since the basic Shift-and-Share equation is an identity, and therefore true by definition, the concept of its "validity" is meaningless. However, it is crucial to ferret out the implicit theoretical considerations which underlie the arguments of those who use Shift-and-Share Analysis to support their hypotheses.

Examples presented in Part I of this paper illustrate this point. The statistics presented in Table I would support the hypothesis that doctors in Gotham City benefit from more favorable demand and supply conditions and/or offer a higher quality of service than their colleagues elsewhere. However, such a conclusion implicitly assumes that the composition of physicians' services offered in Gotham does not vary significantly from that of other cities. If, on the other hand, the Gotham medical community were characterized by an unusually high proportion of psychiatrists and other specialists -- whose services differ from that of most doctors sufficient to regard them as differences in kind -- the statistics could not be said to support the hypothesis.

The case presented in Table II would support the hypothesis that, if Junior is to be sent off to college, his father will get 20% more on each dollar invested if Junior enrolls at Siwash. However, there are some implicit assumptions as dubious as they are obvious which must be accepted before the hypothesis can claim support from the Shift-and-Share components.

Statistics do not constitute theory. In order to evaluate any particular use of the Shift-and-Share method, we must look behind the components generated from the data and direct our attention to the theory employed.

When the Shift-and-Share method is applied to examine economic growth, it is even of limited descriptive value. Shift-and-Share Analysis is simple -- and that is its saving grace -- but, since it is concerned only with two points in time, it is essentially an exercise in comparative statics. Economic growth, however, is both an extremely complex, and an essentially dynamic, process -- so we need some theory even to use the data to describe the situation.

Shift-and-Share Analysis has been applied to the study of economic growth because it has been thought that regional growth is due to three factors: (1) participation in national economic expansion; (2) favorable or unfavorable economic structure (<u>e.g.</u>, the argument that the decline of New England was due to concentration in textiles and other industries which were declining all across the country); and (3) comparative advantage. These three factors are reflected in the names of the components: <u>national share</u>, <u>industrial mix</u>, and <u>regional share</u>. (The <u>method</u> is the same as in our IQ score example, but in this case, the <u>theory</u> commends itself to a greater extent). For example, a large part of California's recent employment growth has been in the airframe industry. Shift-and-Share components <u>industrial mix</u> and <u>regional share</u> are both large and positive, indicating that this growth was due not only to the rapid expansion of airframe production across the nation, but also to a comparative advantage in weather enjoyed in California [13, 1962]. To take another example, growth of the textile industry in the South as an indicator of that region's comparative advantage (favorable wage structure) vastly underestimates the quality, for textile production and employment in the South have expanded in the face of a general decline in textiles across the country. This is reflected in a negative industrial mix figure, and a positive (and larger than actual growth) regional share. However, one must emphasize that this model of growth is devoid of behavioral ualities. (The California example, Fuchs argues [13, 1962] is a case of people following job openings, whereas in the Southern case the opposite is true).

The use of Shift-and-Share Analysis for the "three-factors-of-growth" model runs into serious problems.

First, the model is clearly a poor approximation for many industries. The concepts behind national share and industrial mix assume that the goods and services are in a national market. However, many industries are regionally or locally oriented. Local construction, for example, is more directly connected to over-all local economic demand than to any national demand for construction, and local firms compete with each other, not with firms in other regions. For some economic activity, national comparison is relevant (e.g., automobiles), while for other industries (e.g., barbershops) it clearly is not.

Second, since each industry is, in effect, being compared to all others, the resulting division of growth among components is highly sensitive to what set of industries is used in the computations. For example, if the set of industries examined is "Total Civilian Employment," Minnesota manufacturing's industrial mix will be higher than if the set of industries were "Wage and Salary Employment." This is due to the fact that the difference

TABLE VIII. GROWTH OF MINNESOTA

MANUFACTURING EMPLOYMENT

1960 - 1968

Set of Industries	Thousands of Jobs (Percent of 1960 Level)				
	Total Growth	Natl. Share	Total Shift	Ind. Mix	Reg. Share
"Total Civilian Employment"	83.1 (36%)	31.8 (14%)	51.3 (22%)	9.0 (4%)	42.3 (18%)
"Wage and Salary Employment"	83.1 (36%)	58.3 (25%)	24.8 (11%)	-17.5 (-8%)	42.3 (18%)

between the two sets is made up largely by the agriculture industry, which has been sharply declining. The addition of agriculture to wage and salary employment pulls down the average of growth -- and hence the national share component. Consequently, industrial mix (national growth rate of manufacturing applied to 1960 Minnesota manufacturing employment, minus national share) increases. In this example, industrial mix is raised from a negative (unfavorable industrial structure in the region) to a positive figure (favorable structure).

Third, there is the problem of proper definition of a region. Unlike the case of industrial disaggregation, the allocation of total growth among the Shift-and-Share components is insensitive to the level of geographic disaggregation. As noted in Part I of this paper, the sum of any component over all the counties of the United States will be identical to the sum of that component over all the states. However, that does not make the question of what is an appropriate way of delineating regions any more clearcut. Possible criteria are homogeneity of population, similar production patterns, nodality, and administrative divisions (very common, due to data availability). Fuchs's preference for states over SMSAs [15, 1959] and Perloff's argument for flexibility in drawing regional lines [19, 1957] have been discussed in Part II above. If Fuchs is correct, this might help explain why he found <u>total growth</u> to be highly correlated with <u>regional component</u> when using states as regions, whereas Brown [4, 1969], who used SMSAs, found <u>regional component</u> to be a random variable. Fuchs obtained his results despite the fact that he disaggregated his data by industry to a far greater extent than did Brown -- which should have resulted in a greater allocation of growth to <u>industrial mix</u> and away from <u>regional component</u>.

<u>Fourth</u>, unevenness of technological advance is a potentially strong influence which remains behind the scenes, never adequately revealed. This is true not only among industries, but also among regions. For example, transportation improvements in one region could outrun the rate of improvement in the nation as a whole -- the effects of which would be reflected both in <u>industrial mix</u> and <u>regional share</u> components.

<u>Fifth</u>, the <u>shift</u> components, <u>i.e.</u>, <u>total shift</u>, <u>industrial mix</u>, and <u>regional share</u>, are defined in terms of deviation from a norm, and it is all too easy to change the focus of attention from the norm to the normative, especially if one is not careful of the terminology employed. Just as <u>growth</u>, in and of itself, is not necessarily desirable, it is not necessarily "good" to show a growth rate above average, nor is it disgraceful to show growth at a rate less than the national average for a particular industry or all industry. As one scans the literature, the impression is quite clear that some people consider the simultaneous "achievement" of both positive <u>industrial mix</u> and positive <u>regional share</u> as the equivalent of election to the Honor Roll of the Regions.

For every "gain" in one component in a region, there must, by definition, be a "loss" in that component in another region. The relationship between the components and welfare is not at all clear. For example, if we are moving toward a steady-state growth path, we would expect a relative shift of industry as we move toward equilibrium -- and, on considerations of efficiency, we would find it desirable. The same may be said of <u>regional component</u>. If population is growing less rapidly in Region A than in the nation, we might well prefer a slower growth rate of a given economic indicator, industry-by-industry, within Region A than across the nation. In Shift-and-Share figures for the Ninth Federal Reserve District, we note that agriculture shows a negative <u>industrial mix</u> and a positive <u>regional share</u>, with the negative component dominating, <u>i.e.</u>, negative <u>total shift</u>. We might congratulate ourselves that the talents of our farming brethren in the District are so excellent that, given the national decline in agricultural employment, there is a net relative shift of employment into the District. However, we could just as well reason that the positive <u>regional component</u> was due to less mobility in the District as opposed to the rest of the country, <u>i.e.</u>, less ability to bail out of an increasingly unhappy venture. Or the components' signs could -- and probably <u>do</u> -- reflect many other phenomena interacting. In any event, we must be wary of automatically regarding pluses as superior to minuses and large numbers as better than small ones.

<u>Sixth</u>, various indicators have been mentioned without specification of how they are to be measured. For example, should "employment" be the number of "employees" as counted by Department of Commerce surveys? Full-time-laborer equivalents? The "right" choice is not clear -- and, depending upon our choice, we may find the components not all equally sensitive to changes in the rate of unemployment.

<u>Seventh</u>, use of Shift-and-Share figures for forecasting involves all of the preceding problems. Since Shift-and-Share is a form of comparative statics -- a comparison of "before" and "after" snapshots -- forecasting will of necessity be an exercise in extrapolation. The paragraphs immediately above argue that the snapshots are, at best, blurred. Even if we ignore this problem, we are left with the question of <u>what</u> is to be extrapolated. We might choose a vary <u>naïve</u> model by assuming that each of the components (in percentage terms) of the next period studied will be equal to those observed in the last period. Yet almost implicit in this assumption applied to each component are several other assumptions:

<u>national share</u> - that the economy continues on a steady, exponential growth path

<u>industrial mix</u> - that the patterns of technological adjustment, which involve substitution of some inputs for others in the productive process, continue unchanged.

- that observed trends in changing distribution of production among various goods and services reflect trends of change in patterns of demand --which trends will continue
- <u>or</u>, <u>alternatively</u>, that observed changes in the distribution of production represent an adjustment path to a distribution equilibrium consistent with an already changed pattern of demand, <u>and</u> that, in absolute (as opposed to percentage) terms, the speed of adjustment accelerates until equilibrium is reached

regional share - that those factors involved in "comparative advantage" are relatively constant over time

In the case of regional share, the assumption might seem reasonable, for the location, natural resources, density of population, climate, wage levels, educational characteristics of the population, and other such factors which supposedly lead to "comparative advantage" change slowly, if at all, and generally we would be interested in forecasting not too many years into the future. However, we cannot have it both ways. If the future to be examined is just around the corner, the assumption about national share is untenable, for even if the economy were growing according to a steady, exponential path, disturbances (e.g., the business cycle) would be significant over short periods and thus distort the component. The assumptions about the industrial mix component are even more extreme, for they imply not just constant change, but change which accelerates at a constant rate to an equilibrium -- and it is hard to accept the notion of an equilibrium reached with a bang instead of a whimper.

A more reasonable approach to forecasting would seem to be projection of national share and industrial mix components from other data (e.g., national anticipations surveys and consumer plans polls) combined with extrapolation of regional share from previous observations. Brown's examination of this approach [4, 1969] indicates that even the above assumption about regional share is unwarranted, and that regional share, far from reflecting a complex of factors the effects of which are stable and predictable, tends to be a random variable.

Although there is perhaps too little evidence to reach a solid conclusion at this point, it does appear that, whatever value Shift-and-Share may have, it is as a descriptive device, not as a method of forecasting.

V. CONCLUSIONS

The main virtues of Shift-and-Share analysis are its simplicity and its flexibility, both of which are highly valued by the researcher. However, we must keep in mind the fact that these very virtues impose limitations on its use.

As a simple method of rearranging data according to an identity, it is capable of suggesting what kinds of models may be appropriate for explanation of the phenomena observed. However, one should be cautious about expecting such a simple method to take one very far toward understanding of such a complex phenomenon as economic growth.

Its flexibility also requires caution, since results derived are so highly sensitive to the many variations of the method as discussed in Part IV. The researcher must be careful to select the indicator, set of industries, time period, and regional delineation in a manner appropriate to his investigation -- and he must bear in mind that the resulting components are highly dependent upon his choices.

These qualifications to the value of Shift-and-Share analysis may be summarized by reiterating that it is not a theory but merely a method for rearrangement of data. The theory must come from the researcher, not the computer. The value of Shift-and-Share is that it may suggest a model to be tested -- a model including behavioral assumptions and normative judgments which are totally absent from Shift-and-Share by definition.

The value of Shift-and-Share Analysis for presentation of data as well as a first step in model-building indicate further research would be beneficial. Five projects suggest themselves as logical extentions of work so far completed.

First, the simplicity of the "three-factors-of-growth" model might be slightly compromised, but its use as a model greatly enhanced by including a component to reflect over-all regional growth in recognition that many industries compete in regional, not national, markets. For example, the basic identity for some, or all, regional industries might be modified to

$$g_i^r = (g^r) + (g_i^{us} - g^r) + (g_i^r - g_i^{us})$$

or

$$g_i^r = (g^{us}) + (g^r - g^{us}) + (g_i^{us} - g^r) + (g_i^r - g_i^{us})$$

Second, two or more indicators might be used. Zelinsky [23, 1958] used population concentration ratios in combination with employment figures. We might wish to combine one or more economic indicators with such factors as population, transportation, spatial distribution, etc.

Third, components could be calculated over five, three, and two-year periods, which would give enough cases to enable meaningful examination of consistency in sign of the components (*i.e.*, whether they do indeed reflect long-term underlying economic forces in action) and possible trends. (Using state data instead of SMSAs, our results might differ radically from Brown's).

Fourth, we might continue application of the method to data about other indicators, as capital goods expenditure, real wage rates, etc.

Fifth, we might continue work just begun in testing correlation of results using various indicators.

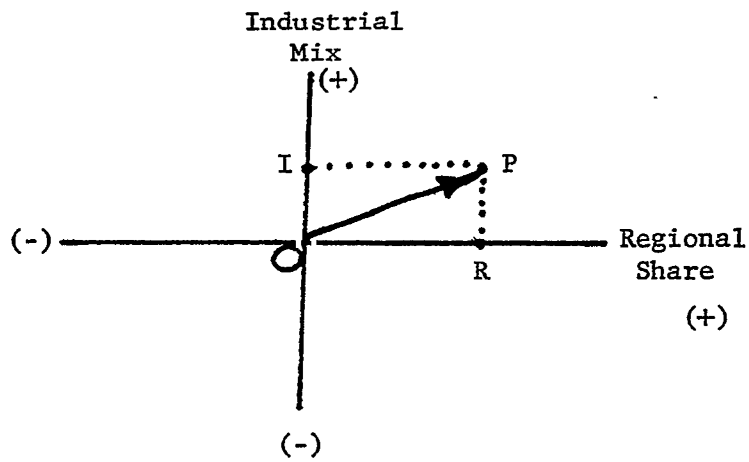
Sixth, a multiequation regional model might be pursued using the basic Shift-and-Share identity as a foundation in the same sense that the national income accounts identity forms the basis for the standard Keynesian model.

Appendix: Octant Analysis

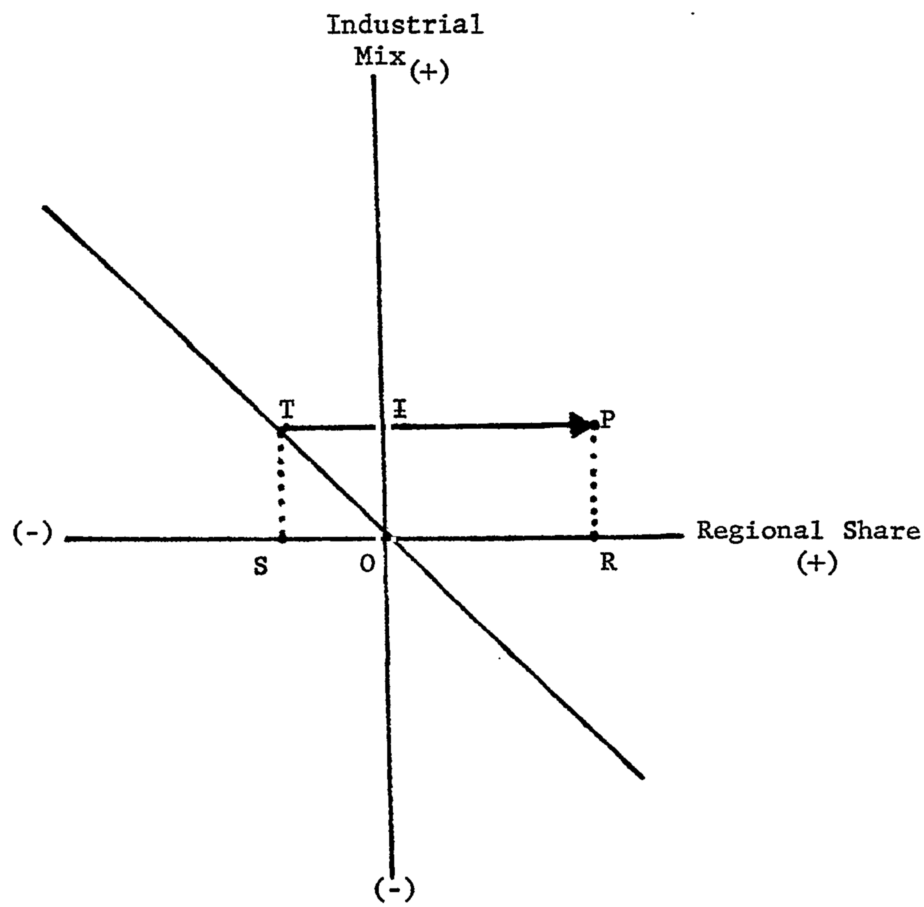
Ashby [2, 1965] has developed a method of illustrating the magnitude of an industry's (or an entire region's) total shift and its allocation between industrial mix and regional component. This technique is useful for making comparisons graphically and for making a simple and relevant division of the possible combinations of the two shift components into a small number of cases. We construct a graph and measure industrial mix on the vertical axis and regional share on the horizontal axis. The units of measurement along the axes may be anything convenient (*e.g.*, thousands of jobs, millions of dollars of value added, percent of initial employment, *et cetera*).(1) Where the axes cross (the origin, "0") is our *zero reference point*. This point represents zero industrial mix and zero regional component. Thus, any combination of regional component and industrial mix will be represented by one and only one point on the graph. If industrial mix is positive, the point will be above the horizontal axis. If regional component is positive, the point will be to the right of the vertical axis. If, for example, industrial mix equals OI, and regional component equals OR, their combination is described by the vector OP.

----

(1) The units, as will be apparent from what follows, must be equal to each other and the same for both axes.



Through the zero reference point we draw a line bisecting the northwest and southeast quadrants. Along this line, the distance from any point to one axis equals the distance to the other. Therefore, any point on this line describes a combination where the industrial mix and regional component are equal in magnitude, but opposite in sign, therefore offsetting each other and making total shift (the total of the two) zero. This line is therefore called the zero reference line. Total shift for any combination is then represented by the vector, parallel to the horizontal axis, from the zero reference line to the point representing the combination. For example, if the two shift components are OR and OI, total shift is represented by the vector TP. The rightward direction of the total shift vector indicates that total shift is positive. The length of the vector (TP, measured in the same units as those used to measure the components along the axes) represents the magnitude of the total shift.(2)



To take another example, let regional component again equal OR, but industrial mix equal to minus OI', where OI' is greater than OR. Then total shift will be described by vector P'T, whose leftward direction denotes negativity.

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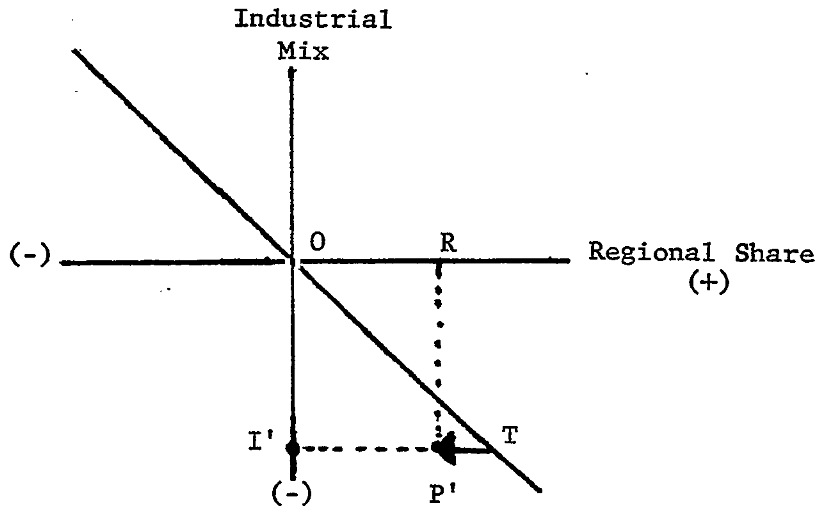
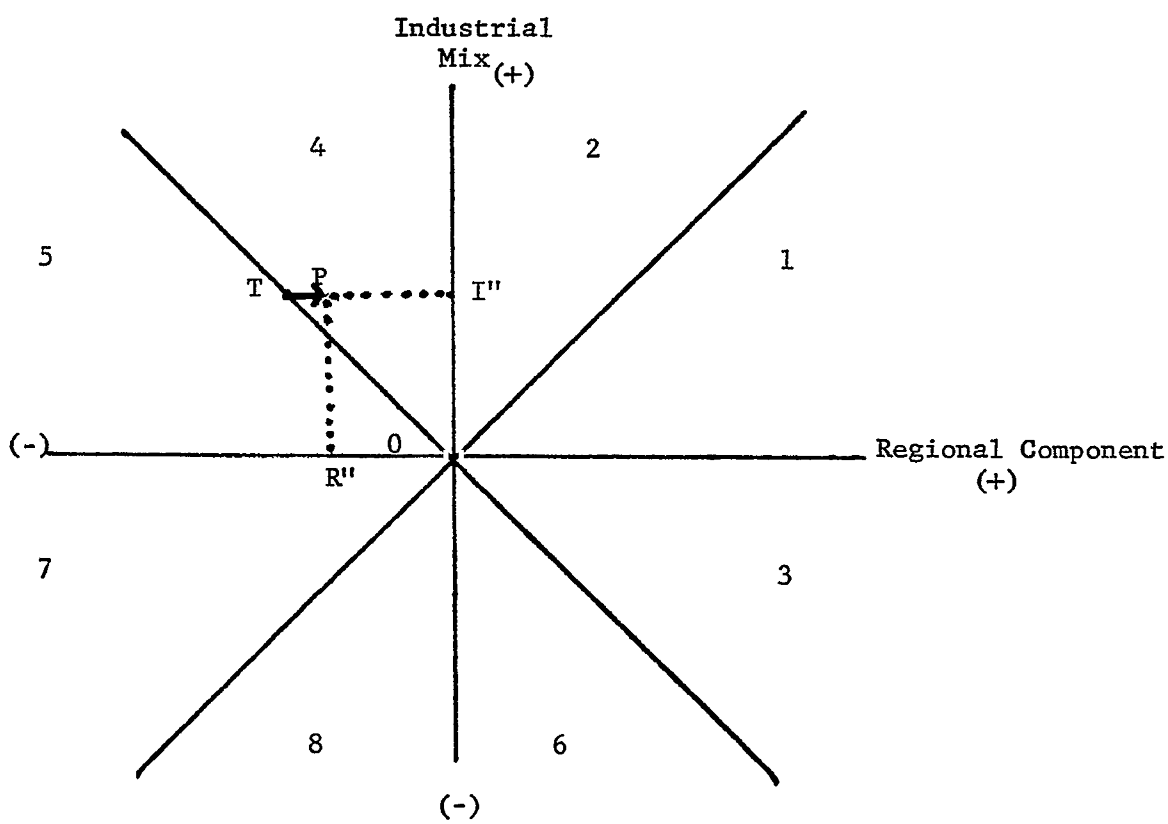
[2]Since IP and RP were drawn at right angles to the two axes, which are at right angles to each other, OIPR is a rectangle, and therefore OR=IP. Since the zero reference line bisects the northwest quadrant, angle TOI=45°. Since TIO is a right angle, and every triangle has 180°, angle OTI=180°-90°-45°=45°= angle TOI. Triangle TIO is an isosceles triangle, and OI=TI. Therefore

Total Shift	=	Industrial Mix	+	Regional Share
	=	OI	+	OR
	=	TI	+	IP
	=	TP		



We pass another line through the <u>zero reference point</u>, this time bisecting the other two quadrants. This divides the graph into eight octants, numbered as shown in the diagram:



In odd-numbered octants, regional component dominates. In even-numbered octants, industrial mix dominates. For example, in octant 4, all points, *e.g.*, P, represent a positive industrial mix and a negative regional component. Since industrial mix dominates (*i.e.*, is the larger in unsigned magnitude), total shift is positive. As noted earlier, total shift is positive in octants 1-4, negative in 5-8. When octant codes are assigned, each industry is coded with a number representing an octant or the zero reference point, or two numbers, representing a borderline case. A summary table of the meaning of the seventeen possible codes follows.

Octant Codes (3)

Area Code	Total Shift	Industrial Mix	Regional Component	Dominant Component
0	0	0	0	(neither)
1	+	+	+	R.C.
2	+	+	+	I.M.
3	+	-	+	R.C.
4	+	+	-	I.M.
5	-	+	-	R.C.
6	-	-	+	I.M.
7	-	-	-	R.C.
8	-	-	-	I.M.
1-2	+	+	+	(neither)
3-6	0	-	+	(neither)
4-5	0	+	-	(neither)
7-8	-	-	-	(neither)
2-4	+	+	0	I.M.
6-8	-	-	0	I.M.
1-3	+	0	+	R.C.
5-7	-	0	-	R.C.

It should be noted that octant codes for industries for the nation will always be either "0", "2-4", or "6-8" (*i.e.*, zero regional component and the total line for the nation will always be coded "0".(4)

The following page illustrates the use of vector graphing to compare regions.

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(3) We have used notation different from that of the Commerce Department's publications [2, 1965] for the borderline and zero reference point cases:

Mpls. Fed.	Commerce
0	I
1-3	A
1-2	B
2-4	C
4-5	D
5-7	E
7-8	F
6-8	G
3-6	H

(4) Discussed on pages - and - of the text.

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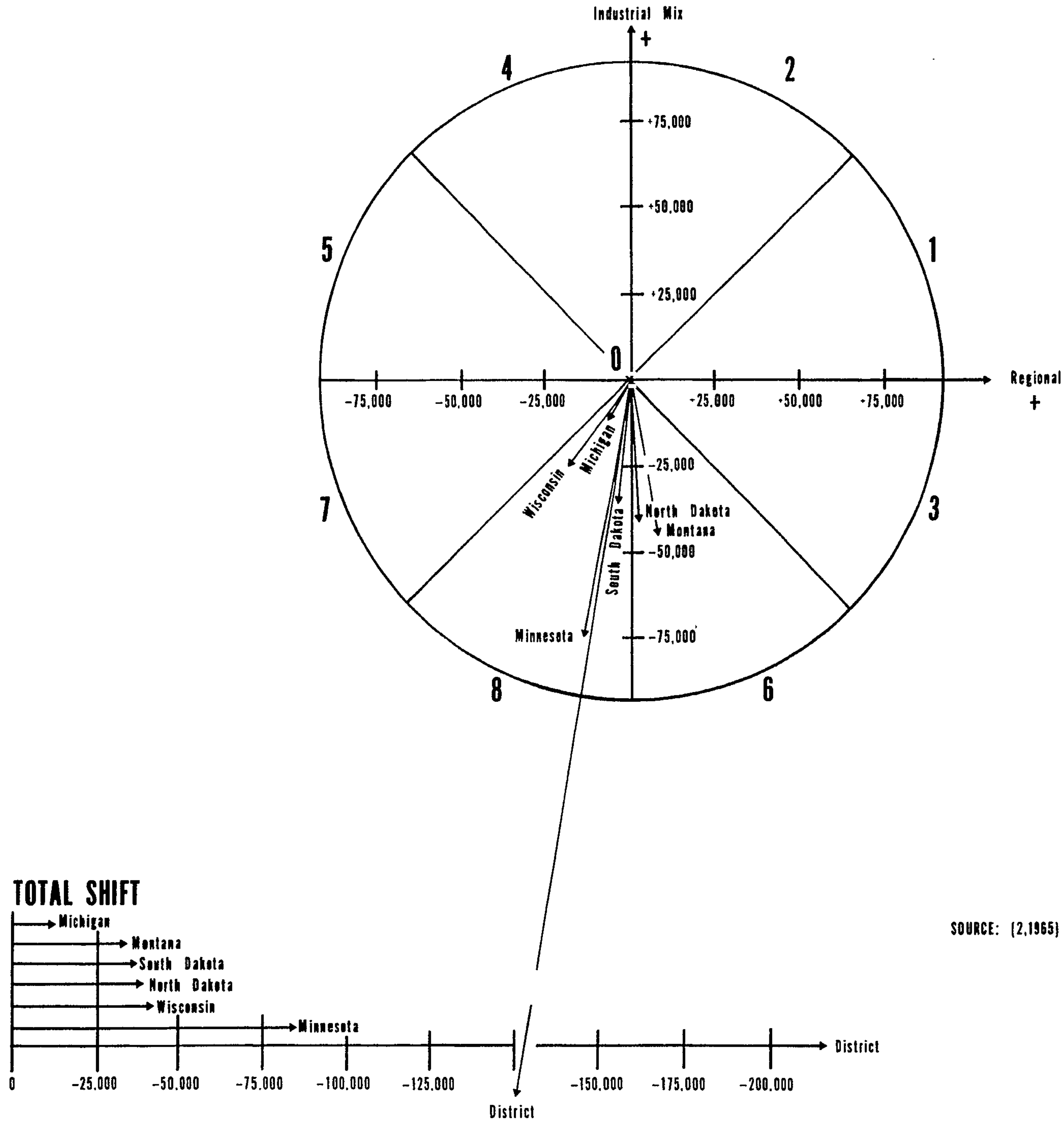

SOURCE: (2,1965)

Bibliography

[1] Ashby, Lowell D., "The Geographical Redistribution of Employment," Survey of Current Business 44:10 (Oct., 1964), pp. 13-20

[2] ___________, Growth Patterns in Employment by County (1940-1950 and 1950-1960), U.S. Department of Commerce/Office of Business Economics, 1965.

[3] ___________, "Reply," So. Econ. Jour. 34:3 (Jan '68)

[4] Brown, H. James, "Shift and Share Projections of Regional Economic Growth: An Empirical Test," Jour. Reg. Sci. 9:1 (Summer, 1969), pp. 1-17.

[5] Conley, Ronald W., "Some Remarks on Methods of Measuring the Importance of Sources of Economic Growth," So. Econ. Jour. 35:3 (Jan., 1969), pp. 224-230.

[6] Creamer, Daniel, "Shifts of Manufacturing Industries," in Industrial Location and National Resources, U.S. National Resources, Planning Board, Washington, D.C., 1943.

[7] Cunningham, N.J., "A Note on the 'Proper Distribution of Industry,' Oxford Economic Papers 21:1 (March, 1969), pp. 122-127.

[8] Dunn, E. S., Jr., "A Statistical and Analytic Technique for Regional Analysis," Papers of the Regional Science Association 6 (1960), pp. 97-112.

[9] Easterlin, R.A., "Long Term Regional Income Changes: Some Suggested Factors," Papers of the Regional Science Association 4 (1958).

[10] Estle, Edwin F., "Manufacturing Employment Changes in New England —— 1947-1967," Federal Reserve Bank of Boston, Business Review (October, 1967), pp. 8-11.

[11] Federal Reserve Bank of Cleveland, "Employment Performances of Cleveland, Pittsburgh, and Cincinnati (1950-1966)"
Part I: Comparison with U.S. (November, 1967-p. 3).
Part II: Comparison with Thirteen Cities (January, 1968—p. 14).
Part III: Updating and Conclusions (March, 1968—p. 15).

[12] Fuchs, Victor R., "Changes in the Location of U.S. Manufacturing Since 1929," Jour. Reg. Sci. 1:2 (Spring, 1959), pp. 1-18.

[13] ___________, Changes in the Location of Manufacturing in the U.S. Since 1929 (New Haven, Yale Press, 1962).

[14] ___________, "Determinants of the Redistribution of Manufacturing in the U.S. Since 1929," Rvw. Econ. &-Stat. 44:2 (May, 1962,) pp. 167-177.

[15] __________, "States or SMA's When Studying Location of Manufacturing?," So. Econ. Jour. 25:3 (January, 1959), pp. 349-355.

[16] __________, "Statistical Explanation of the Relative Shift of Manufacturing Among Regions of the United States," Regional Science Association Papers, VIII, Hague Congress, 1961, pp. 105-126.

[17] Garrett, Martin A., Jr., "Growth in Manufacturing in the South, 1947-58: A Study in Regional Development, So. Econ. Jour. 34:3 (January, 1968), pp. 352-364.

[18] Houston, David B., "The Shift and Share Analysis of Regional Growth: A Critique," So. Econ. Jour. 33:4 (April, 1967), pp. 577-581.

[19] Perloff, Harvey S., "Problems of Assessing Regional Economic Progress," NBER, Studies in Income and Wealth, Vol. 21, Regional Income (Princeton: Princeton University Press, 1957).

[20] __________, Edgar S. Dunn, Jr., E.E. Lampard, and Richard E. Muth, Regions, Resources, and Economic Growth, (Baltimore: Johns Hopkins Press, 1960).

[21] Thirwall, A.P., "A Measure of the 'Proper Distribution of Industry,' Oxford Economic Papers 19:1 (March, 1967), pp. 46-58.

[22] __________, "Weighting Systems and Regional Analysis: A Reply to Mr. Cunningham," Oxford Economic Papers 21:1 (March, 1969), pp. 128-133.

[23] Zelinsky, Wilbur, "A Method for measuring Change in the Distribution of Manufacturing Activity: The United States, 1939-1947," Economic Geography 34:2 (April, 1958).