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# Shift-share analysis for regional health care policy

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**Abstract.** This article implements a shift-share model to investigate, describe, and analyze disease death rates in Missouri. Shift share is used because of its ability to codify data sets. Also, this technique is relatively easy to use and to interpret and understand the results. Shift share overcomes the statistical requirements of equal variance and element independence, yet contains a fair degree of analysis of the major causes of changes in death rates. Using vital statistics data on death rates by type of disease, shift-share components of change are estimated that are national (trends), structural (disease weights), and regional (local conditions) in scope. Such results may be useful in understanding national and regional sources of death rate changes, in allocating health care funds, and in targeting specific diseases for special funding.

## 1. Introduction

This paper investigates the medical health of a region using the popular shift-share economic model. A modified shift-share model is used to analyze health as reflected in the death rates of various diseases. Our purpose is to determine, allocate, and analyze disease death rates using the shift-share effects or components of change. Several Missouri death rates from 1978 to 1988 are investigated. The important shift-share competitive effect suggests that Missouri's health performance is illustrated best by its decreasing death rate in malignant neoplasm and worst by increasing/high death rates in diseases of the heart. The overall U.S. trend, rather than specific local or endogenous factors, accounts for most of the reduction in death rates.

## 2. The model

Shift share, a popular technique of regional economics/science analysis, typically is used to describe various economic changes in a region over a given time period. While shift share has been used as a forecasting tool, it is not a growth model. There are no behavioral or endogenous equations. Also, the model is not designed to explain how a region acquires particular industry mixes (disease mixes, in this paper) or what attracts particular mixes to a region. The shift-share model is basically an accounting model that attempts to separate the causes of change into a shift and a

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share. Actual change in a variable over some given period is different from its expected change which is determined using benchmark figures. This difference or residual is examined and explained further by a shift and a share. The former is a regional structural component affecting change, and the latter is a regional influence/circumstance component affecting change (Dunn 1960, 1980; Ashby 1964, 1966).

Traditional variables used for analysis have been employment or income, but the model also has been used to investigate changes in other variables such as insurance premiums (Halperin and Mabry 1984) and crime (Blair and Mabry 1980). Health data may be used to investigate and analyze changes in death rates or changes in disease costs, disease outcomes, census, lengths of stay, outpatient variables, etc.

In this paper we modify and adapt the conventional shift-share model. The result is a more meaningful interpretation of our health variable, death rates by disease. The focus of shift-share is structural and dynamic differences between a region and a benchmark, the U.S. in this research. Much can be gleaned from the causes (not medical) of changes in death rates that are separated into national, structural, and regional changes. To understand the growth or decline in a region's death rate, the refined shift-share model is implemented to investigate Missouri. Shift-share analysis is used to determine Missouri's fast and/or slow growth disease mix (distribution), its increasing or decreasing share of each disease, as well as its surplus or deficit in specific diseases.

Initially a region's expected death rate share is calculated based on the overall national death rate and the national structure (disease distribution). To the extent the estimated change in a death rate differs from the actual death rate change, a shift and/or a share movement has occurred. The next step is to compare each disease's national death rate with the overall national death rate. These two elements of change aid in evaluating the region's mix or proportion of diseases.

Finally, each disease's national death rate is compared to its regional counterpart. These results provide information about the region's share of a particular disease and how it has changed due to regional factors. The shift-share model is used for tracing and assigning causes of regional changes because the region is structurally different from the benchmark. Model results also may help regions prioritize various health factors.

The conventional shift-share model is replaced with a modified version that allows a more meaningful interpretation of shift-share results. The conventional/traditional model does not allow for, nor was it designed for, line by line (i.e., industrial or disease level) analysis of the variables. Dunn (1980, pp. 188-189) suggests that conventional individual cell calculations are meaningless. Esteban-Marquillas (1972) and Bishop and Simpson (1972) also suggest the need for a reformation if shift-share interpretations are to extend to the cell level. That is, traditional shift-share is not useful for analyzing particular disease death rate changes. It is meaningful only for analyzing the region as a whole or the aggregate death rate for a region using the summary line results (Dunn 1980; Esteban-Marquillas 1972; Bishop and Simpson 1972).

Using refinements from Dunn that are illustrated in his comprehensive study of U.S. urban settlements (1980) based on Esteban-Marquillas (1972), a shift-share model we call DEM is formulated to produce meaningful line (cell) results as well as the conventional overall summary line results. The three components of change are:

- A national growth effect;
- A disease-mix effect, traditionally the industry-mix shift effect; and
- A competitive (differential shift, regional share) effect (Stilwell 1969; Barff and Knight 1988; Hoppes 1991, 1994).

This model has the capability to interpret specific disease results in a manner similar to how summary line results are interpreted.

Regression analysis and analysis of variance in a shift-share framework may create problems. If one is interested in differences among specific regional death rates, one may violate the ANOVA assumption of equal variance. There is no reason to assume that regional variation is either small or random; therefore, statistical testing may not be appropriate. Shift-share analysis is used to describe, without the rigor of statistical testing, change in a particular variable or set of variables by allocating the causes of change. This difference is more appearance than real to some (Fothergill and Gudgin 1979).

The actual change in a variable is subtracted from its national growth proportional (expected) change, and the residual is allocated to changes that occur because the region and the benchmark are not congruent. They are likely to differ either in terms of structure, dynamics, or growth rates.

The shift-share effects or components of change and their relationships are illustrated as,

$$AC = NGE + DME + CE$$

where:

- AC = Actual change;
- NGE = National growth effect;
- DME = Disease mix effect; and
- CE = Competitive effect.

The conventional industrial mix component is changed to disease mix. The DEM shift-share formulae are,

$$(1) \text{ National Growth Effect: } NGE = r (b_i/b) \times ((b_{it}/b_i) - 1)$$

$$(2) \text{ Disease Mix Effect: } DME = (r_i - (r \times b_i/b)) \times ((b_{it}/b_i) - 1)$$

$$(3) \text{ Competitive Effect: } CE = r_i ((r_{it}/r_i) - (b_{it}/b_i))$$

where:

- r = Total death rate per 100,000 in the region in the base year;

- b = Total death rate per 100,000 in the U.S. in the base year;
- i = Individual disease; and
- t = Terminal year.

The national growth effect, NGE, is the change in regional death rates due to the change in U.S. death rates. In order to estimate this effect it is assumed in traditional shift-share analysis that regional and U.S. death rates are structurally and dynamically congruent. The DEM model adjusts (normalizes) the regional structure in order to make it a micronation before calculating components. The national distribution of diseases is mirrored in the region. Also, it no longer is assumed that each death rate will change at the U.S. overall rate, but at its U.S. rate. The difference between Missouri's expected death rate share, NGE, and its actual death rate is allocated between a shift and a share. The shift, DME, is the shift-share adjustment because of differences in the regional disease structure. The share, CE, is the shift-share adjustment because of endogenous regional factors/circumstances affecting death rates.

DME is the change in regional death rates obtained after we subtract from the actual death rate the following result. Each disease death rate is made proportional to its U.S. proportion and is assumed to grow at its U.S. rate. DME indicates (through positive and negative results) a relatively fast or slow growing regional disease death rate (structure). A region may experience an increase or decrease in death rates as it shares disproportionately in various diseases. For each disease the DME weights the region's share, the surplus or deficit, and the national growth rate.

CE is the change in death rates due to the difference between regional and U.S. death rates for each disease. These results traditionally indicate regional comparative advantages or disadvantages. Given our variables, the region would like to be in a comparative disadvantage mode with negative results because the variables are deemed to be bad. Shift-share cell results are summed by column in order to determine the summary line figures. These aggregates are used to analyze Missouri's overall performance. When the three effects are summed horizontally, their total equals the actual change in the region's death rate over the decade.

### 3. Model results

#### 3.1 Overall results for Missouri

Under most circumstances, positive numbers are considered to be good because they imply growth or increases. Given our variables, however, negative numbers are looked upon positively because they imply a decrease in a bad variable, the death rate.

Negative results mean that death rates have declined or are lower than national levels. Shift-share favorable results are (1) a negative NGE, indicating a decline in death rates in the U.S., (2) a negative DME, indicating that the disease mix in Missouri is favorable (not as unfavorable as) the U.S., and (3) a negative CE, indicating that Missouri has a comparative disadvantage in this disease or a lower death rate than the U.S.

Using the summary line statistics, Missouri's overall death rate (as measured by its disease structure) decreased 51.7 deaths per 100,000 from 1978 to 1988. Shift-

Table 1. Causes of death: shift-share effects\*

Causes of death**	Missouri		U.S.		U.S. growth rate	Adjusted death rate	National growth effect	Disease mix effect	Competitive effect	Surplus deficit
	1978	1988	1978	1988						
Diseases of heart	380.2	359.3	334.3	311.3	-0.069	377.7	-26.0	-0.17	5.3	2.5
Malignant neoplasms	200.5	212.7	181.9	197.3	0.085	205.5	17.4	-0.43	-4.8	-5.0
Cerebrovascular diseases	97.3	71.1	80.5	61.2	-0.269	91.0	-21.8	-1.52	-2.9	6.3
Accid/adverse effects	53.6	43.6	48.4	39.5	-0.184	54.7	-10.1	0.20	-0.1	-1.1
Pneumonia	33.3	37.7	26.7	31.6	0.184	30.2	5.5	0.57	-1.7	3.1
Diabetes mellitus	16.8	16.0	15.5	16.4	0.058	17.5	1.0	-0.04	-1.8	-0.7
Suicide	12.2	13.3	12.5	12.4	-0.008	14.1	-0.1	0.02	1.2	-1.9
Chronic liver disease/cirrhosis	10.7	7.3	13.8	10.7	-0.225	15.6	-3.5	1.10	-1.0	-4.9
Atherosclerosis	16.7	8.6	13.3	9.0	-0.323	15.0	-4.9	-0.54	-2.7	1.7
Total	821	770	727	689	-0.052	821.3				
Summary line							-42.4	-0.8	-8.5	0.0

Source: *Statistical Abstract, 1980-90, Vital Statistics*

\* Based on Dunn (1980) and Esteban-Marquillas (1972). See Hoppes (1991)

\*\* Deaths per 100,000

**Table 2.** Shift-share effect percentages\*

Causes of death	% National growth effect	% Disease mix effect	% Competitive effect	Missouri change in death rate
Diseases of heart	124	1	-25	-20.9
Malignant neoplasms	143	-3	-39	12.2
Cerebrovascular diseases	83	6	11	-26.2
Accidents/adverse effects	101	-2	1	-10.0
Pneumonia	126	13	-39	4.4
Diabetes mellitus	-127	5	222	-0.8
Suicide	-10	1	109	1.1
Chronic liver disease/cirrhosis	103	-32	29	-3.4
Atherosclerosis	60	7	33	-8.1
Summary line	82	2	16	-51.7

\*Relative weights of the shift-share effects

share allocates the causes for this decrease in death rates among the NG, DM, and CE effects. Table 1 illustrates these estimates in the summary line row, while Table 2 illustrates the relative sizes of each shift-share component.

The national growth effect is responsible for 82.0 percent of the decline in Missouri's death rates. Of the 51.7/100,000 fewer deaths, 42.4 are due to a nationally declining death rate. Because of Missouri's disease structure (that is, the mix of diseases in the state), the DME indicates that deaths per 100,000 declined another 0.8 per 100,000 or 1.5 percent. The negative DME implies that Missouri has a favorable mix of diseases resulting in a lower overall death rate than the U.S. This small number buttresses the hypothesis that Missouri and the U.S. are similar with respect to disease structure.

Part of the decrease in Missouri death rates is due to the competitive effect. This effect is the only one that compares Missouri to the U.S. in terms of death rates. It takes into account the fact that Missouri death rates by type of disease differ dynamically from their U.S. counterparts. The negative result indicates that the overall death rate is lower in Missouri than the U.S. The summary line row in Table 1 shows that the competitive effect accounts for another 8.5 per 100,000, or 16.4 percent, decrease in overall Missouri death rates.

Possible endogenous regional implications from the CE are that Missourians are healthier, on average, due to medical care, genes, or living healthier, etc. because they have lower death rates relative to the U.S. average. While the shift-share CE indicates a comparative disadvantage (lower disease death rates) for Missourians, it does not indicate what the composition of the comparative disadvantage is. SSA results, however, may provide insights into which death rates should be investigated further to determine regional advantages and disadvantages.

### 3.2 Missouri results by type of disease

Further insights may be gleaned from the shift-share cell entries, the estimates of the causes of change in specific disease death rates. The cells in Table 1 contain these

estimates. Again, negative NGE, DME, and CE results are favorable and indicate that:

- There has been a decline in the overall death rate in the U.S. in six of the nine diseases. This is the NGE;
- Five of the nine diseases are not as prominent in Missouri as in the U.S. This is the DME; and
- Seven of the nine diseases have a lower death rate in Missouri than in the U.S., the CE.

The national growth effect estimates the expected disease death rates over the decade. It measures the change in the disease death rate by assuming that a particular disease death rate is proportional to the national share and that regional and national growth rates are the same. Based on U.S. behavior, malignant neoplasms should have shown the largest increase, 17.4 deaths per 100,000, followed by pneumonia (5.5 deaths per 100,000) and diabetes mellitus (1.0 deaths per 100,000). Shift share adjusts this U.S. cause of increased death rates for regional (Missouri) structure and dynamics.

The region is not a congruent micronation and its diseases may not behave in lock-step with the nation. Our modified shift-share model makes additional calculations based on the region having a different disease distribution as well as different disease growth rates. The regional structure, measured by the DME, reduces the death rates of malignant neoplasms 0.4 per 100,000. The regional disease dynamic, measured by CE, accounts for another decrease of 4.8 per 100,000. Thus, Missouri's actual death rate for this disease increased 12.2 per 100,000 not 17.1.

Regional disease structure suggests that malignant neoplasms are not as fatal in Missouri as in the U.S. Regional dynamics suggests that this disease is not growing as fast as (or, in some cases, is declining faster than) in the U.S. As determined by shift share, Missouri is doing better than predicted when such predictions are based on U.S. dynamics. Further analysis is needed to explain the local phenomena that may account for this behavior. Additional intra-Missouri shift-share analyses would help to isolate particular areas or diseases that have reduced or heightened death rates.

Table 2 illustrates the contributions made by each shift-share component to the total change in particular death rates. It is insightful to investigate by disease the weights or relative importance of each shift-share component. A caveat is that some death rates have declined by large percentages due to their initial small base, e.g., diabetes and suicides.

The largest decline in a death rate during the decade, 20.9 per 100,000, occurred in diseases of the heart. Table 2 shows that national factors account for 124 percent of this decrease. In addition, Missouri's disease mix lowered the death rate another 1 percent. But Table 1 reveals that Missouri has a comparative advantage in heart diseases. This fact caused a 25 percent increase in the death rate. Technically, this appears in Table 2 as a decrease in a decreasing death rate. Local disadvantages, which are good, are recorded for malignant neoplasms and pneumonia where regional factors



**Table 3.** Disease mix outcome effects combinations

Outcome	Surplus/deficit	U.S. Growth rate
Good	(-) deficit—diabetes, malignant neoplasms	(+) growing disease—diabetes, malignant neoplasms
(-)	(+) surplus—heart disease, cerebrovascular, atherosclerosis	(-) declining disease—heart disease, cerebrovascular, atherosclerosis
Bad	(-) deficit—acid/adverse, suicide, chronic liver/cirrhosis	(-) declining disease—accidents/adverse, suicide, chronic liver/cirrhosis
(+)	(+) surplus—pneumonia	(+) growing disease—pneumonia

contributed to a 39 percent decrease in otherwise increasing U.S. death rates for each of these diseases.

Besides standard shift-share results, other useful statistics are generated by DEM in the calculation of the DME but are codified and obfuscated in Table 1. These items are illustrated in Table 3 (Dunn 1980, p. 190). In the model the disease mix effect is more than the traditional positive or negative statistic. Because of the manner in which the disease mix effect is calculated, one can and should consider both the disease death rate surplus or deficit and the U.S. disease growth rate. A surplus occurs when the local death rate/structure is larger than its normalized estimate.

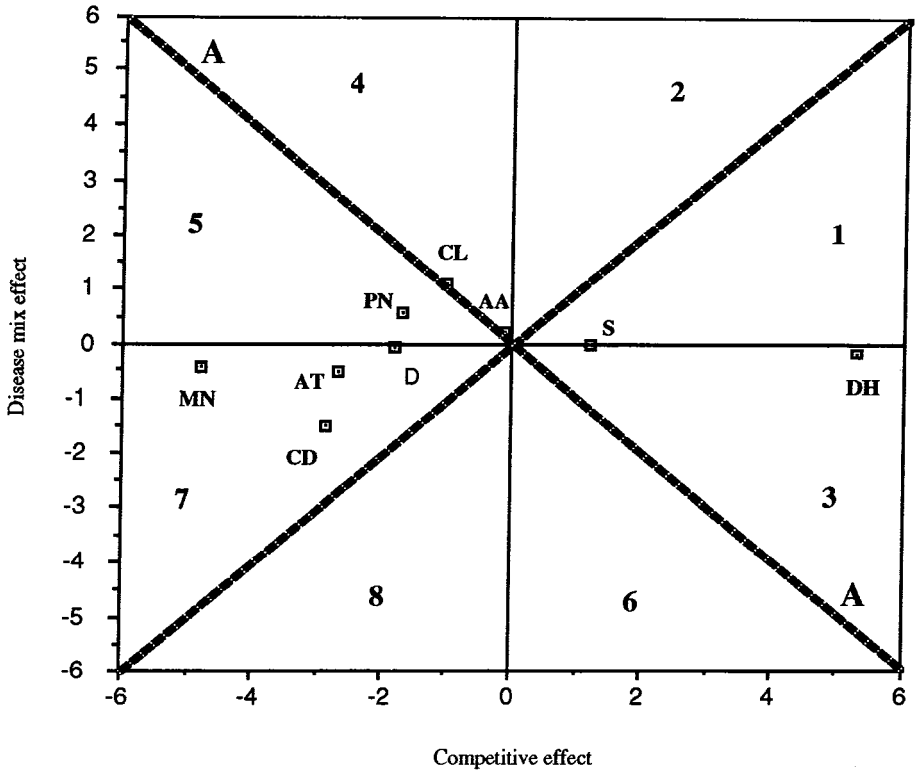
The diseases with good or improving DMEs are illustrated in Table 3 and in Table 1. Good (negative) outcomes occur if the region has a surplus (+) in a nationally declining (-) disease death rate or has a deficit (-) in a nationally growing (+) disease death rate. Bad (positive) outcomes occur with deficits in declining disease death rates or with surpluses in growing disease death rates.

Five of nine diseases have good outcomes. Shift-share results indicate an improvement in their death rates at the regional vis-à-vis national level. One good scenario from Table 3 is the region's disease death rate deficit and increasing disease death rate in diabetes and malignant neoplasms. Missouri is also relatively healthier in three other diseases in which it has a surplus, but the disease death rate has declined nationally. The worst bad health case scenario, a regional surplus and a growing death rate, occurs in only one disease category: pneumonia. Other bad scenarios occur for accidents/adverse effects, suicide, and chronic liver disease/cirrhosis

Figure 1 shows the shift-share results for the region using an octant representation (Ashby 1966). Figure 1 helps us visualize and target particular diseases that are the most problematic or are outliers. The graph compares the two most important shift-share effects, DME and CE, which when combined show the net relative shift.

Octants conventionally are numbered 1 through 8, representing best to worst scenarios when considering desirable variables such as employment or income. There are cases in health care where decreases are good—lower death rates, costs, shorter stays, etc. In standard shift-share analysis, 1-4 octants, above line AA, indicate a good prognosis for the region, because in each case the positive effect dominates—

Figure 1. Disease mix effect versus competitive effect 1978-1988



there is a positive net relative shift. When the CE dominates the DME we have the best case. Generally CE is deemed the most important effect because it suggests endogenous development, while NGE and DME suggest growth. The CE has long-run endogenous implications such as better local health habits, physicians, hospital care, etc., (or, conventionally, productivity and R & D versus output increases, exogenous factors) (Dunn 1980, pp. 173-175).

Policy implications regarding the allocation of funds to particular diseases can be gleaned from Figure 1's shift-share results. Because death rates are negative goods, the best scenarios are when a negative shift-share effect dominates. The preferable result is a competitive effect that is more negative than a negative disease mix effect; this occurs in octant 7. Octants, from best to worst, are 7, 8, 5, 6 (all below line AA). The worst four are octants 4, 3, 2, 1 (the worst).

For Missouri no diseases are located in octants 8, 6, and 2. There are four diseases located in the best octant, 7—malignant neoplasms, cerebrovascular diseases, diabetes, atherosclerosis. Pneumonia is located in octant 5 (not as preferable as octant 7), but there is still a dominant negative effect. Suicide death rates are increasing nationally, and Missouri rates are increasing faster than the national average; hence, its location in the worst octant, 1. The overall relative performance of Missouri is excellent, as indicated by its location in octant 7 (-8.5, -0.8).

Further research using intra-Missouri as well as interstate data could provide insightful comparisons. Detailed state health data, however, are difficult to align from state to state and with U.S. data.

#### 4. Summary and conclusions

In this paper a prominent analytical tool used by regional economists, shift-share analysis, has been described and applied to a region's change in disease death rates. Some adjustments to shift share are suggested for its use at the disease (cell) vis-à-vis the regional (summary line) level. This technique does not explain the occurrence or distribution of the various diseases. It does, however, trace, categorize, and describe the reasons for changes in death rates couched in terms of national growth, the distribution of diseases, and regional characteristics. Such analysis may aid in the decision-making process in allocating funds among diseases based on shift-share effects and prognoses.

This paper's shift-share analysis indicates that Missouri experienced the largest decreases in death rates in diseases of the heart and cerebrovascular diseases. The decreases are mostly due to the national growth effect and the U.S. trend. But while the region showed a decreased share in death rates in cerebrovascular diseases, it showed an increased share in diseases of the heart not shared by most other regions. Missouri mirrors closely the U.S. trends. Yet the U.S. death rate trend is slightly downward in suicides, while Missouri experienced a small rate increase. Based on the competitive effect, Missouri fairs best in reducing death rates in malignant neoplasms and worst in diseases of the heart. The overall good prognosis for Missourians is illustrated by its position in the best possible octant, number seven.

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