AN EXTENSION TO THE SHIFT-SHARE TECHNIQUE FOR PREDICTING AND EVALUATING CHANGES IN EMPLOYMENT GROWTH

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Introduction

Shift-share analysis is a popular methodology for comparisons between regional and national growth rates. When comparing a state's economy with the national economy, the latter is selected as the base. Alternatively, when the interest is at the substate level, the state is selected as the base. Three components explain the differentials between a subregion and the base in a traditional shift-share equation. The first component, base growth, measures the effect in employment, earnings, output, or any other indicator variable if the subregion grew at the base rate during a specified period of time. It is the change in the indicator variable attributable to the growth of the base. The second is the structural component, called also the *industry mix*, which measures a region's growth if every industry in the region grew at that industry's base rate less the base growth effect. The third is the differential component, also called the *competitive shift effect*, which reflects the differentials between a region's actual change and the change expected if each industrial sector grew at the base rate. It is a residual that captures the effects not accounted for by the other components.

A great deal of research is devoted to use, criticism, and modification of shift-share. Haynes and Machunda (1987) classify contributions to shift-share methodology into two categories; one entails the use of other methods to overcome some of the shortcomings of shift-share, and the other provides extensions to its conventional decomposition. Barff and Knight (1988) provide an extension, the *dynamic shift-share*, whereby yearly data between two periods are employed instead of the customary beginning and end periods as well

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as annual growth rates. This way, changes in industrial mix are updated continuously. Sihag and McDonough (1989) utilize an extension where the international effect plays a role in the model. McDonough and Sihag (1991) provide another extension by incorporating multiple bases into shift-share. Mead and Ramsay (1982) extend the use of shift-share to evaluate regional differential responses to economic cycles such as the severity of a recession. Riefler (1986) has applied this approach to compare the similarity between the nation and the state of Nebraska in the two major recessions of the 1970s and 1980s. Riefler (1991) again used this model to provide an assessment of the economic policy pursued in the state of Nebraska during the 1980s. Finally, Markusen, Noponen, and Driessen (1991) give a summary of the shortcomings of shift-share and another suggestion for extension. They disaggregate the national growth and industrial mix components into components that take into account growth in employment due to changes in exports, imports, and domestic demand and add a component to reflect gains in labor productivity. Lewis and Romrell (1991) provide an excellent summary of the literature. They also provide an interesting adaptation of dynamic shift-share in their analysis of change in the intermountain region.

The above sample of issues and procedural attempts attempt to improve shift-share and to make it responsive to economic reality. One major shortcoming is that empirical results of the components cannot be subjected to statistical testing. The durability of the shift-share technique, which spans some 50 years, however, attests to the informational importance of the analysis. The purpose of this paper is to suggest methodologies based on regression and analysis of variance, as suggested by Berzog (1978) and Fothergill and Gudgin (1979), that can supplement the information obtained from shift-share. States' annual growth rates of employment in nine industrial sectors are examined. These sectors are agriculture, forestry, and fishery; mining; construction; manufacturing; transportation, communications, and public utilities; wholesale trade; retail trade; finance, insurance, and real estate; and services. Past data were obtained from the Bureau of Economic Analysis (1980), and projected data to the year 2000 were obtained from Johnson, Kort, and Friedenberg (1990).

Table 1 provides means and coefficients of variation for employment annual growth rates. The first two columns provide those values for the 1969-1979 period. The third and fourth columns give 1979-1988 values, and projected values for 1988-2000 are listed in the final two columns. The table reveals that only agriculture and services grew at faster rates in 1979-1988 than in the 1969-1979 period. On the other hand, only mining and manufacturing were projected to grow from 1979-1988 to 1988-2000. Thus, sectoral declines in growth rates of employment characterize the two periods with the average growth rates being smallest in the latter, projected period. The coefficients of variation in Table 1 show that the variation in states' growth rates generally increased from 1969-1979 to 1979-1988 while the average was decreasing. The variation is projected to decline from 1979-1988 to 1988-2000.

Table 1—Annual Growth Rates of U.S. Employment of Industrial Sectors

	1969-1979		1979-1988		1988-2000	
Industry	Mean	CV	Mean	CV	Mean	CV
Agriculture	3.64	0.96	5.04	0.31	2.71	0.17
Mining	2.37	1.13	-1.06	4.40	0.11	5.00
Construction	3.41	0.94	1.35	2.24	0.64	0.89
Manufacturing	1.47	1.65	-0.29	5.28	0.47	1.11
Transportation	1.82	0.92	1.42	0.97	1.04	0.38
Wholesale Trade	4.35	0.56	1.15	1.60	0.94	0.48
Retail Trade	3.30	0.55	2.29	0.56	1.18	0.33
FIRE	4.40	0.48	3.42	0.48	1.12	0.31
Services	3.64	0.36	4.19	0.26	2.02	0.19

Source: BEA (1980) and Johnson, Kort and Friedenberg (1990)

Note: CV is the coefficient of variation (standard deviation divided by the mean). Agriculture includes forestry and fisheries; transportation includes communications and public utilities; and FIRE stands for finance, insurance, and real estate

Shift-Share and Regression: A Comparison by States

The proposed procedure, intended for use in studying patterns of growth rates in employment in nine industrial sectors in a similar fashion as shift-share, belongs to a family that may appropriately be called *component of change models*. Both approaches are designed to decompose economic variables of interest into regional and national effects. The procedure, however, relies on regression methodology which may assist in evaluating results obtained from a dynamic form of shift-share as suggested by Barff and Knight. Both methods can show whether significant changes in the competitive effects have occurred and can assist in predicting future patterns of growth. The methodology is borrowed from Congdon and Shepherd (1988) and was adopted by Nissan (1992) for a comparative study of regional metropolitan and nonmetropolitan convergence of growth rates of income and population.

States' annual growth rates in the projected period 1988 to 2000 were regressed on the corresponding data of an initial period 1979 to 1988, and, in turn, the data for 1979 to 1988 were regressed on data of the previous period 1969 to 1979. A central assumption is that when two random variables X and Y jointly follow a bivariate normal probability law, then the conditional distribution for Y given X is, according to Larson

(1982), normal with mean (expected or equivalently predicted value) estimated by least squares as

$$(1)\ Y'_i = \overline{Y} + b(X_i - \overline{X}).$$

where:

Y'_i = The expected or predicted value;
$\overline{Y}$ = The national annual growth rate mean of an industrial sector in the later period;
X_i = The observed value; and
$\overline{X}$ = The annual growth rate mean in a former period for the same industrial sector.

In a manner similar to shift-share, the difference between later (Y_i) and initial (X_i) state annual employment growth rates are disaggregated into

$$(2)\ Y_i - X_i = (Y'_i - X_i) + (Y_i - Y'_i) = (\overline{Y} - \overline{X}) + (b-1)(X_i - \overline{X}) + (Y_i - Y'_i).$$

The first and second terms on the right side of equation (2) form the structural component of the growth applying to all states which is composed of changes in national average ($\overline{Y} - \overline{X}$) and a portion that reflects the influence of national trend on a state, $(b-1)(X_i - \overline{X})$. When $b = 1$, $b - 1 = 0$, and what remains of the national contribution to a state's growth is ($\overline{Y} - \overline{X}$). When $b \neq 1$, the national contribution in excess of ($\overline{Y} - \overline{X}$) will be in the amount of $(b-1)(X_i - \overline{X})$, which may be positive or negative depending on whether $b > 1$ or $b < 1$ and on whether $X_i > \overline{X}$ or $X_i < \overline{X}$. For instance, if $b > 1$ and $X_i > \overline{X}$, the structural component increases in excess of average change ($\overline{Y} - \overline{X}$) by an amount equal to $(b-1)(X_i - \overline{X})$. Therefore, the structural components (the first two terms) depict the difference between what the rate of growth of employment in a state would have been if each of its industries had grown at the respective industries' national rates and the rate of growth of employment in the country as a whole. The third part of equation (2), ($Y_i - Y'_i$), is the residual between an actual observation in the later period and its prediction from regression, called the *differential change*. When positive (negative), the indication is that state i has grown (declined) relative to other states. It depicts the extent to which the state's respective industry growth rates are greater (lesser) relative to other states. This is comparable information to the important differential shifts in shift-share as pointed out by Rigby (1992).

Regression results on the state level of employment in the nine industrial sectors are presented in Table 2. Two symbols, A and B, are used in that table to identify periods of analysis. The symbol A(B) identifies columns for regression of 1979-1988 (1988 to 2000) growth

Table 2—Regression Results of Industrial Sectors Employment Annual Growth Rates

Industry	Intercept a A	Intercept a B	Slope b A	Slope b B	t-value A	t-value B	r A	r B
Agriculture	4.62	1.68	0.15	0.21	2.56*	6.72*	0.36*	0.69*
Mining	-0.82	0.14	-0.16	0.05	-0.62	3.04*	-0.09	0.40*
Construction	3.07	0.70	-0.51	-0.05	-4.45*	-1.87**	-0.54*	-0.26**
Manufacturing	-0.89	0.54	0.40	0.26	5.85*	8.13*	0.64*	0.76*
Transportation	1.01	0.72	0.23	0.23	2.00*	8.59*	0.28*	0.78*
Wholesale Trade	0.67	0.76	0.11	0.16	1.03	6.11*	0.15	0.66*
Retail Trade	1.36	0.74	0.28	0.19	3.05*	5.54*	0.40*	0.62*
FIRE	3.39	0.64	0.01	0.14	0.07	6.18*	0.01	0.66*
Services	3.05	0.92	0.31	0.26	2.91*	4.79*	0.38*	0.74*

Source: Computations from equation (1)

Note: A refers to results of regressing 1979-1988 states' growth rates on corresponding 1969-1979, while B similarly refers to regressing 1988-2000 on 1979-1988. Agriculture includes forestry and fisheries; transportation includes communications and public utilities; and FIRE stands for finance, insurance, and real estate

* Significance at .05
** Significance at .10

rates (Y) on the corresponding values (X) in 1969-1979 (1979-1988). The correlation coefficient r is positive and statistically significant in almost all cases.

To establish statistical significance of the three components shown in equation (2), the appropriate t-tests require the use of the standard error of the three estimators. The variances (the squares of the standard errors) can be estimated by

$$V[\overline{Y} - \overline{X}] = (1/n)\,[S_X^2 + S_Y^2 - 2rS_xS_y];$$

$$V[(b-1)\,(X - \overline{X})] = (b-1)^2\left(\frac{n+1}{n}\right)S_X^2 \approx (b-1)^2 S_X^2; \text{ and}$$

$$V[Y - Y'] = S_Y^2(1 - r^2),$$

where:

X and Y	=	Initial and terminal periods, respectively;
S^2 and S	=	Sample variance and standard deviation, respectively;
Y_i'	=	The predicted value from regression of equation (1);
r	=	The correlation coefficient between X and Y; and
i	=	A particular state.

Therefore, when testing the components of equation (2) for significance, the following t-tests are suggested:

- Testing for significance of the difference between the means of two periods:

$$(3)\ t = \frac{[\overline{Y} - \overline{X}]}{\left[\left(\frac{1}{n}\right)(S_X^2 + S_Y^2 - 2rS_XS_Y)\right]^{1/2}}$$

- Testing for significance the national trend contribution to a specific state:

$$(4)\ t = \frac{(b-1)(X_i - \overline{X})}{\left[(b-1)^2 S_X^2\right]^{1/2}} = \frac{(X_i - \overline{X})}{S_X}.$$

- Testing the significance of the residual change for state i:

$$(5)\ t = \frac{(Y_i - Y_i')}{\left[S_Y^2(1 - r^2)\right]^{1/2}}$$

An example for the use of these formulas is provided in Appendix A.

Table 3 portrays the t values of the residuals $(Y_i - Y_i')$ by computations from equation (5) above for the nine sectors. When performance is above the regression line the t-values are positive. They are negative otherwise. The results of phase B in comparison with results in phase A may be used to predict the future economic outlook for each state as well as to examine patterns across states.

A crude validity check of the numbers in Table 3 is provided by the findings of Friedenberg and Tran (1993, 1994) where they name some of the fastest-growing states in income such as Montana, Tennessee, Utah, Colorado, and New Mexico. For Montana, the change in t-values between phase A and B in agriculture moved from -0.74 to 0.32, for mining from -0.15 to 0.26, for construction from -0.96 to -0.17, for manufacturing from -1.42 to 1.32, for transportation from -1.88 to 0.31, for wholesale from -1.76 to 1.25, for retail from -1.57 to -0.95, for finance from -0.99 to -1.18, and for services from -1.43 to -1.15. In all instances but one (finance), the improvement was in the right direction. Similar patterns of behavior are observed for many of the other states for the majority of their industrial sectors. The table also can be checked to validate some of the cases of the slowest-growing states such as Delaware, Maryland, Massachusetts, and Connecticut where a deterioration is observed between phases A and B.

Table 3—Summary Information of t-Values for Differential Change of State Average Annual Growth Rates of Employment for Nine Industrial Sectors (Computed From Equation (5))

	Agriculture		Mining		Construction	
State	A	B	A	B	A	B
Alabama	-0.94	0.16	-0.37	-0.15	0.07	0.03
Alaska	0.80	0.08	1.70*	-0.22	0.74	-0.05
Arizona	0.12	1.03	-0.90	-0.29	1.15	0.98
Arkansas	-1.44*	0.75	0.68	-0.70	-0.56	-0.18
California	-0.62	-0.09	0.66	-0.40	0.99	1.89*
Colorado	0.42	-1.01	0.04	-1.95*	-0.05	0.78
Connecticut	1.14	-0.77	1.11	0.43	0.82	-0.26
Delaware	--	1.25	--	-0.28	0.97	-1.11
Washington DC	--	-3.69*	--	-0.28	-1.91*	0.95
Florida	-0.30	-0.04	0.56	0.57	1.39*	1.19
Georgia	1.30*	-0.36	0.75	1.26	1.22	0.76
Hawaii	--	0.67	--	-0.28	-1.26*	1.52*
Idaho	0.80	0.13	-0.23	0.41	-0.23	0.42
Illinois	0.91	1.09	-0.06	-0.51	-0.81	0.21
Indiana	0.57	-0.05	0.04	0.49	-0.47	0.17
Iowa	0.44	-0.02	-0.14	1.50*	-1.72*	-0.53
Kansas	0.44	0.09	0.72	-0.66	-0.66	-0.84
Kentucky	1.09	-0.64	-0.34	-0.63	-0.80	-0.26
Louisiana	-2.62*	0.48	-0.14	-1.35*	-1.54*	-1.87*
Maine	--	-2.30*	--	-0.28	1.74*	-2.50*
Maryland	1.18	-0.28	0.52	0.09	0.97	-1.39*
Massachusetts	1.04	-1.52*	1.53*	0.43	1.13	0.37
Michigan	0.38	0.56	0.11	0.73	-0.74	0.90
Minnesota	-1.11	0.63	-1.54*	0.07	-0.45	0.08
Mississippi	-1.66*	-0.35	0.09	-0.72	-1.03	0.11
Missouri	-1.16	0.45	-0.55	-0.18	-0.09	0.15
Montana	-0.74	0.32	-0.15	0.26	-0.96	-0.17
Nebraska	-1.38*	0.40	0.43	-0.33	-1.10	-0.39
Nevada	1.73*	2.21*	2.25	1.47*	1.97*	1.77*
New Hampshire	2.04*	-1.70*	--	-0.18	2.16*	-1.50*
New Jersey	0.79	-2.02*	1.01	0.56	0.70	-0.69
New Mexico	-0.12	0.53	-0.84	-1.34*	0.08	0.63
New York	0.10	-0.41	0.69	-0.24	0.57	0.21
North Carolina	-0.01	0.45	0.45	1.35*	0.74	-0.11
North Dakota	-1.54*	1.44*	-0.12	-1.12	0.23	0.83
Ohio	0.68	0.54	-0.36	-0.27	-0.90	0.02
Oklahoma	-0.32	0.18	0.25	-0.90	-1.10	0.52
Oregon	-0.44	-0.50	-0.26	1.40*	-0.77	0.53
Pennsylvania	0.47	-0.13	-0.82	-1.79*	-0.38	-0.06
Rhode Island	--	-1.16	--	-0.28	0.73	0.70
South Carolina	-0.01	0.14	0.35	0.34	0.76	0.05
South Dakota	-0.63	0.42	0.18	0.77	-0.77	-0.62
Tennessee	0.48	-0.03	-0.40	0.56	0.14	0.32
Texas	-1.73*	-0.10	0.59	-1.24	-0.47	-0.41
Utah	0.42	-0.28	-1.36*	0.64	0.04	1.61*
Vermont	-0.01	0.66	-0.41	0.43	1.28*	-2.23*
Virginia	0.61	0.60	-0.34	-0.33	1.13	0.15
Washington	-0.01	0.77	0.76	2.46*	0.04	0.57
West Virginia	-0.50	1.68*	-1.05	-1.54*	-1.57*	-1.20
Wisconsin	0.01	0.06	-4.18*	2.60*	-0.58	0.60
Wyoming	-0.67	-0.32	-0.91	-0.37	-0.83	-2.59*

Table 3—(continued)

State	Manufacturing A	Manufacturing B	Transportation A	Transportation B	Wholesale A	Wholesale B
Alabama	0.49	-0.15	0.00	-1.25	-0.23	-0.32
Alaska	0.51	-3.74*	-1.22	-0.50	0.92	-2.86*
Arizona	2.34*	-0.15	1.62*	2.00*	1.36*	1.68*
Arkansas	0.22	-0.15	0.63	-0.36	-0.60	0.15
California	1.02	-0.59	0.14	1.23	0.92	0.64
Colorado	-0.17	0.15	0.66	1.00	-0.17	1.72*
Connecticut	-0.16	-1.37*	0.85	-1.05	0.41	-1.13
Delaware	0.99	-0.89	0.71	-0.27	0.73	0.57
Washington DC	2.72*	0.43	-0.42	-0.95	-2.20*	-1.38*
Florida	1.78*	-0.60	1.15	-0.33	1.56*	0.62
Georgia	1.33*	-0.36	1.50*	-0.83	1.13	-0.55
Hawaii	0.63	0.14	0.87	1.06	0.29	0.80
Idaho	-0.49	0.64	-1.42*	1.10	-1.68*	2.02*
Illinois	-1.30*	0.62	0.15	-0.18	-0.19	-0.77
Indiana	-0.43	0.69	0.46	-0.08	-0.17	0.34
Iowa	-0.94	0.86	-0.98	0.85	-0.75	-0.46
Kansas	-0.87	0.70	-0.99	-1.28*	-0.44	-0.74
Kentucky	-0.53	0.20	0.08	0.16	-0.50	0.56
Louisiana	-1.74*	0.65	-1.82*	-0.55	-1.81*	-1.14
Maine	0.16	-1.05	0.87	-1.03	0.78	-0.41
Maryland	-0.08	-0.08	0.53	-0.11	1.10	-0.27
Massachusetts	-0.27	-1.64*	0.45	-0.78	1.29*	-1.90*
Michigan	-1.05	-0.50	-0.90	1.18	0.08	0.92
Minnesota	0.84	-0.13	-0.34	0.43	-0.42	-0.07
Mississippi	0.00	0.28	-0.21	1.46*	0.82	0.60
Missouri	0.13	-0.69	-0.10	-0.39	-0.36	-0.37
Montana	-1.42*	1.32*	-1.88*	0.31	-1.76*	1.25
Nebraska	0.19	0.33	-1.33*	-0.27	-0.51	-0.61
Nevada	-0.20	2.23*	0.61	1.77*	1.95*	2.49*
New Hampshire	0.63	-1.48*	2.06*	-1.79*	1.86*	-0.88
New Jersey	-0.34	-1.21	1.21	-1.65*	1.23	-0.79
New Mexico	0.23	0.52	-0.35	0.60	-0.29	0.91
New York	-0.27	-1.21	-0.60	-1.17	-0.08	-1.16
North Carolina	0.91	-0.79	1.15	-0.75	0.83	-0.35
North Dakota	-1.07	1.35*	-0.18	-0.51	-1.42*	-0.41
Ohio	-0.98	0.18	-1.05	0.07	-0.04	-0.64
Oklahoma	-1.32*	0.21	-1.08	1.46*	-1.05	1.31*
Oregon	-0.32	0.51	-0.37*	0.27	-0.25	0.07
Pennsylvania	-1.14	-0.41	-1.06	0.08	0.26	-0.57
Rhode Island	-0.94	-0.79	1.20	-0.25	0.60	-0.48
South Carolina	0.03	0.08	0.38	-0.45	0.20	0.03
South Dakota	0.51	1.46*	-0.79	1.34*	-0.80	-0.23
Tennessee	0.10	-0.06	0.99	1.97*	0.14	-0.05
Texas	-0.60	-0.07	0.01	-0.38	-0.41	-0.45
Utah	0.62	1.37*	0.30	2.00*	-0.31	1.90*
Vermont	0.72	-0.41	0.93	-1.25	1.58*	-0.09
Virginia	0.67	-0.22	1.37*	-1.04	0.94	-0.02
Washington	1.64*	0.26	0.47	0.93	0.14	0.63
West Virginia	-2.51*	1.07	-1.79*	-1.07	-1.04	-0.33
Wisconsin	-0.14	0.42	0.03	-0.36	0.04	-0.22
Wyoming	-0.44	2.04*	-2.05*	-0.37	-2.00*	0.44

Table 3—(continued)

State	Retail A	Retail B	FIRE A	FIRE B	Services A	Services B
Alabama	0.09	-0.64	-0.43	-0.38	-0.08	-0.53
Alaska	0.18	-1.71*	-0.40	-1.17	-0.77	-1.91*
Arizona	1.09	1.31*	2.21*	1.70*	2.02*	0.97
Arkansas	-0.24	-0.24	-0.03	-0.16	-0.37	-0.23
California	0.24	1.73*	0.29	1.27	0.50	1.43*
Colorado	-0.60	1.26	0.26	0.22	0.15	0.76
Connecticut	0.57	-0.20	0.88	-0.96	0.66	-1.28*
Delaware	0.89	-0.05	3.76*	1.34*	1.44*	-0.26
Washington DC	0.09	0.99	-1.21	1.17	-0.02	0.42
Florida	1.84*	0.39	1.16	0.00	2.13*	-0.25
Georgia	1.69*	-0.35	0.93	0.55	1.45*	0.53
Hawaii	-0.21	1.16	-0.98	1.01	-0.59	2.32*
Idaho	-1.54*	1.53*	-0.98	0.63	-1.59	1.67*
Illinois	-0.30	0.52	-0.66	-0.21	0.08	0.03
Indiana	-0.48	0.24	-0.76	0.27	-0.15	0.05
Iowa	-1.32*	0.37	-0.81	0.77	-1.04	1.12
Kansas	-0.50	-0.58	-0.27	-0.56	-0.81	0.05
Kentucky	0.13	-1.23	-0.72	0.34	-0.34	0.01
Louisiana	-1.24	-1.20	-0.84	-1.25	-1.21	-1.24
Maine	1.60*	-0.54	1.26	-1.03	0.06	-0.98
Maryland	1.09	-0.35	0.65	-0.38	1.33*	-0.29
Massachusetts	0.78	-0.19	0.92	-1.22	0.77	-1.44*
Michigan	-0.23	-0.38	-0.72	0.83	-0.45	0.56
Minnesota	-0.52	0.00	-0.02	0.25	-0.43	0.11
Mississippi	-0.45	0.18	-0.25	0.15	-1.96*	1.06
Missouri	0.03	-0.22	-0.41	-0.69	0.22	-0.65
Montana	-1.57*	-0.95	-0.99	-1.18	-1.43*	-1.15
Nebraska	-0.87	0.29	-0.72	-0.12	-0.76	0.42
Nevada	0.08	3.43*	0.33	3.05*	-0.50	2.88*
New Hampshire	2.09*	0.61	1.78*	-1.11	1.95*	-1.61*
New Jersey	0.32	0.29	0.86	-0.26	1.29*	-0.80
New Mexico	-0.27	0.85	-0.01	1.38*	0.20	1.24
New York	0.44	-0.38	-0.30	-1.62*	0.14	-1.89*
North Carolina	1.27	-1.08	0.72	-1.09	0.82	-0.15
North Dakota	-1.36*	0.33	-0.98	0.36	-0.94	-0.20
Ohio	-0.15	-1.09	-0.64	-0.64	-0.35	-0.38
Oklahoma	-1.25	0.76	-0.79	-0.02	-0.74	0.49
Oregon	-0.96	0.18	-1.43*	1.00	-0.44	0.75
Pennsylvania	-0.33	-0.59	-0.41	-0.58	0.04	-0.46
Rhode Island	0.84	-0.76	-0.06	-0.78	-0.01	0.01
South Carolina	1.18	-2.14*	0.95	-0.69	1.02	-0.30
South Dakota	-1.24	0.26	0.07	-0.32	-1.34*	-0.10
Tennessee	0.32	0.05	0.00	0.73	0.53	0.33
Texas	-0.13	-0.23	0.69	-1.26	0.69	-0.37
Utah	-0.27	1.66*	-0.15	2.27*	0.87	1.15
Vermont	1.55*	-1.30*	1.44*	-1.60*	0.37	-0.57
Virginia	1.51*	0.34	0.47	0.47	1.39*	0.22
Washington	0.37	0.64	-0.29	0.91	0.31	0.64
West Virginia	-0.83	-1.76*	-1.15	-0.31	-1.27	-1.53*
Wisconsin	-0.58	-0.19	-0.59	-0.35	-0.85	0.30
Wyoming	-2.65*	-1.02	-1.62*	-0.71	-1.99*	-1.00

A = results of regressing 1979-1988 states' growth rates on corresponding 1969-1979; B = results of regressing 1988-2000 on 1979-1988. Agriculture includes forestry and fisheries; transportation includes communications and public utilities; and FIRE stands for finance, insurance, and real estate; * Significant at .10 level

A comprehensive measure of the relative importance of the components of change of equation (2) is obtained when the sum of the squares of the differences of two observed periods $(Y_i - X_i)$, computed as percentages, is broken down as

$$(6)\ (1/n)\Sigma(Y_i - X_i)^2 = (\overline{Y} - \overline{X})^2 + (b-1)^2 S_X^2 + S_Y^2(1 - r^2),$$

where the symbols are as defined earlier. The derivation of equation (6) and an assessment of the changing structure of growth rates of employment over the periods of time under consideration are provided in Appendix B.

Shift-Share and Analysis of Variance: A Comparison by Regions

Analysis of variance also is proposed as an alternative to shift-share. An appropriate designation for regional application is to view the growth (performance) of each industry of a state in a region as composed of three parts: a national average, a regional factor, and a random factor. In the statistical terminology used in analysis of variance (Ostle and Malone, 1988), a simple linear representation is

$$(7)\ r_{ij} = \mu + t_i + e_{ij} \quad i = 1, \ldots, k; j = 1, \ldots, n_i,$$

where:

r_{ij} = Rate of growth in region i state j;
μ = National average;
t_i = The growth component due to region i;
e_{ij} = The share effect assumed to be random; and
n_i = The number of states in region i.

A distinction between shift-share and analysis of variance is their respective views of the share effect e_{ij} in equation (7), where in the former it is assumed to be systematic while in the latter it is assumed to be random. Differences of growth rates among regions are considered to be probabilistic events. This aspect allows statistical inference in analysis of variance modeling which is done in terms of the parameters in equation (7) by testing the null hypothesis

$$H: t_i = 0 (i = 1, \ldots, k),$$

against an alternative

A: t_is are not all equal.

Furthermore, this formulation of the hypothesis is equivalent to testing an hypothesis of equality of regional average growth rates. In other words, H: $t_1 = t_2 = \ldots = t_k = 0$ is equivalent to H: $\mu_1 = \mu_2 = \ldots = \mu_k$ where $\mu_i = \mu + t_i$. In this case, the test for significance that relies on the F-distribution is an extension of the t-test for the difference between two means. This procedure is applied to the regional employment growth rates for the nine industrial sectors by grouping the states into regions according to the Bureau of Economic Analysis (BEA) classification.[1]

The F test of the null hypothesis versus the general alternative compares a computed F-ratio with the percentage points of an F distribution with $(k - 1)$ degrees of freedom in the numerator and $(n - k)$ degrees of freedom in the denominator. For the research at hand, $k = 8$ (the number of regions), and n = the number of states for which data are available. The significance level of the test, denoted by the P-value, is obtained from the upper tail of the F distribution.

If the conclusion is that the means μ_i are not all equal, the F test does not provide information as to which means differ from each other. This deficiency is overcome by the use of multiple comparisons for which many comparable procedures are available (Miller 1985, 1986). The method chosen here is that of least significant difference. The results of the multiple comparisons and the P-values are contained in Table 4, where the regions are listed according to their sample means ranked in ascending order. Any two regions that are not inside the same parentheses differ in average growth from each other. This presentation provides two types of information regarding industry-specific employment growth. The first identifies the regions that lead or lag, and the second identifies clusters of regions that are similar.

In the agricultural sector, for instance, there was a tendency toward equality in the means of employment annual growth rates evidenced by large P-values, in essence accepting the null hypothesis for this sector for all three periods. The sectors that show the most inequality among the regions are construction and manufacturing. A mixture of results is observed for the other sectors changing from significance of P-value = 5 percent, if this is used as a basis of decision to reject the null hypothesis, to P-values > 5 percent. With some minor exceptions, both the Southwest and the Far West (and to some extent the Rocky Mountain) regions consistently were included in the higher annual growth subsets in the projected period. A noticeable result for the projected period 1988 to 2000 is that the P-values in general were

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[1] Regions of the United States according to the Bureau of Economic Analysis are New England (MA, NH, VT, MA, CT, RI); Mideast (NY, PA, NJ, DE, MD, DC); Southeast (VA, WV, NC, SC, GA, FL, KY, TN, AL, MS, AR, LA); Southwest (OK, TX, AZ, NM); Rocky Mountain (CO, WY, MT, ID, UT); Far West (NV, CA, OR, WA, AK, HI); Plains (MN, IA, MO, ND, SD, NE, KS); Great Lakes (OH, MI, IN, WI, IL).

Table 4—Multiple Comparisons of Regional Industrial Sectors Employment Annual Growth Rates (Percent)

Industry	Comparisons	P-value
Agricultural Services, Forestry, Fisheries, and Others		
1969-1979	[(6,2,5,3,8); (2,5,3,8,4,7,1)]	.1785
1979-1988	[(6,3,7,2,8); (3,7,2,8,4,5,1)]	.1233
1988-2000	[(2,1,6,8,3,7); (1,6,8,3,7,4,5)]	.3029
Mining		
1969-1979	[(2,6,5,4,1,8); (6,5,4,1,8,7,3)]	.3011
1979-1988	[(8,7,6,3,5); (7,6,3,5,2); (2,1,4)]	.0125
1988-2000	[(7,8,2,3,6); (8,2,3,6,5,1); (5,1,4)]	.0325
Construction		
1969-1979	[(2,1,5); (3,6,4); (6,4,7); (8)]	.0000
1979-1988	[(8,6,7); (6,7,5,3,4); (3,4,2); (1)]	.0000
1988-2000	[(1,2); (2,3,6,8,5); (3,6,8,5,7); (8,5,7,4)]	.0017
Manufacturing		
1969-1979	[(2,5,1); (5,1,3); (3,6,4,8,7)]	.0000
1979-1988	[(5,2,1); (2,1,3,6,8); (1,3,6,8,7); (3,6,8,7,4)]	.0202
1988-2000	[(1,2,5); (2,5,3); (3,6,4,7,8)]	.0017
Transportation, Communications, and Public Utilities		
1969-1979	[(2,5,1); (5,1,6); (6,3); (3,7,8,4)]	.0000
1979-1988	[(6,8,5,2,7,4,3); (2,7,4,3,1)]	.0539
1988-2000	[(2,6,5,1,8,3); (5,1,8,3,4,7)]	.1357
Wholesale Trade		
1969-1979	[(2,5); (5,1,3,4); (1,3,4,6,7); (3,4,6,7,8)]	.0007
1979-1988	[(8,6,5,2,7,3); (5,2,7,3,4); (7,3,4,1)]	.0091
1988-2000	[(6,2,5,3,1,8); (2,5,3,1,8,7,4)]	.1726
Retail Trade		
1969-1979	[(2,5,6); (5,6,1); (1,3); (3,7,8); (7,8,4)]	.0000
1979-1988	[(6,8,5,2); (5,2,7); (2,7,4,3)(7,4,3,1)]	.0003
1988-2000	[(6,5,3,8.2,1); (3,8,2,1,7); (2,1,7,4)]	.0881
Finance, Insurance, and Real Estate		
1969-1979	[(2,1,5); (1,5,6,3); (6,3,7); (3,7,8); (7,8,4)]	.0000
1979-1988	[(8,5,6,4,3); (6,4,3,7,2); (3,7,2,1)]	.0134
1988-2000	[(5,6,8,1,3,2,4,7)]	.5293
Services		
1969-1979	[(2,3,5,1,6); (1,6,7); (6,7,8); (8,4)]	.0000
1979-1988	[(6,5,8,3,2,4); (5,8,3,2,4,1,7)]	.1979
1988-2000	[(6,1,5,3,2,8); (1,5,3,2,8,7); (3,2,8,7,4)]	.1428

Note: The numbers in the table refer to regions as follows: (1) New England; (2) Mideast; (3) Southeast; (4) Far West; (5) Great Lakes; (6) Plains; (7) Southwest; (8) Rocky Mountain. P-value is the smallest level for which the test statistic F is significant. P-value ≤ .05 indicates significance at the 5 percent level or less. The regions are ranked in ascending order of regional sample means larger than their counterparts in 1979 to 1988 and 1969 to 1979. This gives credence to a conjecture that regional growth rates in the projected period tend to equality more so than those of the previous periods, substantiated further by the multiple comparisons in grouping more regions in common subsets. Also noticeable from Table 4 is the change of positions of the regions as one examines the various sectors for the different time periods. A case in point is the construction sector. The New England and Mideast regions had the lowest rates in the projected period, while these regions had the highest rates in the preceding period.

Summary

Annual growth rates of employment for nine industrial sectors were investigated using regression and analysis of variance procedures, both of which can supplement shift-share analysis. The regression procedure disaggregates differences in growth rates between two periods of time into two components (structural and differential). The analysis of variance procedure disaggregates growth to detect differences in average growth rates among regions. In both procedures, unlike shift-share, the results can be subjected to statistical testing. The proposed regression model can be used to assess the outcomes of a specific policy initiative on employment undertaken in a region in a former period by observing the differential change. Also, on the assumption that projections reflect the future trends of an economy, the differential change may predict future patterns of employment growth. The results obtained from the analysis of variance can be used in a similar manner to test the regional effect on the stability of growth as well as to test for the continuity of the stability in a projected period.

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Appendix A—Testing the Significance of the Components of Change

As an example for the use of equations (3) to (5) , the following data pertain to employment in the agriculture sector in Arizona, where X and Y refer to data for the annual growth rates between 1969-1979 and 1979-1988, respectively. X and Y, individual state growth rates, are not provided to conserve space. $\overline{X}$ and $\overline{Y}$ are provided in Table 1. S_X^2 and S_Y^2 can be computed from Table 1 by squaring the product of the mean and CV. b and r are provided in Table 2, and Y' can be computed using the regression coefficients in Table 2.

X = 10.20 is the growth rate for Arizona in 1969-1979;

Y = 6.35 is the growth rate for Arizona in 1979-1988;

$\overline{X}$ = 3.64 is the mean of the growth rate for the U.S. between 1969-1979;

$\overline{Y}$ = 5.04 is the mean of the growth rate for the U.S. between 1979-1988;

S_X^2 = 12.21 is the estimate of the variance for 1969-1979;

S_Y^2 = 2.44 is the estimate of the variance for 1979-1988;

b = .15 is the slope of regressing Y on X;

r = .36 is the correlation coefficient between X and Y; and

Y' = 6.18 is the predicted value of the growth rate for 1979-1988 obtained from regressing Y on X.

The tests for components of equation (2) proceed as follows:

- The test for significance of the difference between the overall means of the two periods from equation (3) is

$$t = \frac{(5.04 - 3.64)}{[(1/46)(12.21 + 2.44 - (2)(.36)(3.49)(1.56))]^{1/2}}$$

$= 2.92.$

- The test for significance of national trend contribution to the growth rates in Arizona from equation (4) is

$$t = \frac{(10.20-3.64)}{3.49} = 1.88.$$

- Test for significance of differential change from equation (5) is

$$t = \frac{(6.35-6.18)}{[2.44(1-(.36)^2)]^{1/2}} = .12$$

The above computed t-values are compared with tabular t with (n - 2) degrees of freedom. Note here that n = 46 because five observations are missing. Note also that the only statistically significant result in this example is the test for the difference between the two means in the first test at the 5 percent significance level. This paper provides in Table 3 the computed t-values for the tests given in equation (5).

Appendix B—Relative Importance of Components of Change

The derivation of equation (6) follows from the identity

$$Yi - X_i = (\overline{Y} - \overline{X}) + (b - 1)(X_i - \overline{X}) + (Y_i - Y'_i),$$

established in equation (2) and by squaring, summing, and dividing by the number of observations in both sides. After performing these operations the result is

$$(1/n)\sum_{i=1}^{n} (Y_i - X_i)^2 = (1/n) \sum_{i=1}^{n} (\overline{Y} - \overline{X})^2$$

$$+ (b - 1)^2 (1/n)\sum_{i=1}^{n} (X_i - \overline{X})^2 + (1/n)\sum_{i=1}^{n} (Y_i - Y'_i)^2.$$

Now, in the above expressions

$$\sum_{i=1}^{n} (\overline{Y} - \overline{X})^2 = n(\overline{Y} - \overline{X})^2$$

$$(1/n)\sum_{i=1}^{n} (X_i - \overline{X})^2 = S_X^2, \text{ and}$$

$$(1/n)\sum_{i=1}^{n} (Y_i - Y'_i)^2 = S_Y^2(1 - r^2),$$

where $(1/n)\Sigma_i(Y_i\text{-}Y'_i)^2$, according to Dougherty (1992), is an estimate of that part of the variance unexplained by regression and equals $S_Y^2(1 - r^2)$. Equation (6) results from simplifications and substitutions.

Computations suggested by equation (6) provide (Table B1) the breakdown of the overall relative importance (in percentages) of the three components of change given in equation (2) for phase A (1969-1979/1979-1988) and for phase B (1979-1988/1988-2000) for the nine industrial sectors.

These computations show, for instance, that in the manufacturing sector for phase A, 46.9 percent of the change in growth is due to changes in the mean, while 32.1 percent is due to the influence of national trends on the states and 21.0 percent is due to the differential (competitive) effect. By comparison phase B has the percentages of 29.2, 65.0, and 5.8 which implies that in the projected period 1988-2000 the structural change from 1979-1988 of 94.2 percent (29.2 + 65.0) is much larger than in the previous period 1969-1979 to 1979-1988 where the structural change was 79.0 percent (46.9 + 32.1). This implies that the states are projected to narrow their differences and become more alike in growth rates.

Table B1—Percentage of Component of Change in Employment Annual Growth

	Phase A (1969-1979) and (1979-1988)			Phase B (1979-1988) and (1988-2000)		
	Mean	Trend	Differential	Mean	Trend	Differential
Agriculture	15.2	68.4	16.5	76.9	21.6	1.6
Mining	27.4	22.4	50.2	6.4	92.4	1.2
Construction	12.4	68.6	19.0	4.6	92.6	2.8
Manufacturing	46.9	32.1	21.0	29.2	65.0	5.8
Transportation	4.5	46.6	49.0	10.9	84.5	4.6
Wholesale Trade	56.1	25.8	18.1	1.7	93.8	4.5
Retail Trade	24.8	41.6	33.6	51.2	44.9	3.9
FIRE	12.0	54.5	33.6	72.0	27.1	0.9
Services	14.2	38.3	47.6	86.8	12.0	1.2