AN EMPIRICAL TEST OF NONSOPHISTICATED EMPLOYMENT PROJECTION TECHNIQUES
AT THE SMSA LEVEL*

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INTRODUCTION

Nonsophisticated employment projection techniques are often utilized by
public and private agencies in lieu of more complex techniques due to limited
resources or time constraints. Nonsophisticated techniques, albeit admittedly
more theoretically crude than intricate methods such as multiple regression,
input/output analysis and econometric models, still serve as viable preliminary
or interim guidelines for future employment. Even though less complicated
techniques have been applied by both private and public agencies, this in
itself does not warrant their usage unless empirical evidence demonstrates
otherwise.

Several empirical studies have been undertaken in order to measure the
precision of nonsophisticated employment projection techniques, Franklin and
Hughes [4], Brown [1], Floyd and Sirman [3], Greenburg [5], Houston [6],
and Zimmerman [9]. The majority of these empirical tests have been employed
to validate or reject the shift-share framework as a viable projection
technique. No conclusive evidence has been formulated thus far as to the
accuracy of nonsophisticated techniques at the SMSA level.

The primary purpose of this paper is to empirically investigate the
overall accuracy of nonsophisticated employment projection techniques at the
SMSA level. Secondary purposes of this paper are to: (1) analyze whether
particular techniques perform better in fast or slow-growing areas; (2)
empirically test Zimmerman's modified shift-share construct, Zimmerman [9];
and (3) denote which techniques are dependable enough to use for preliminary
forecasting.

SOURCES OF DATA AND METHODOLOGY

Six commonly used nonsophisticated employment projection techniques were
selected for empirical testing. They are: (1) Constant Numerical Change;

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*Federated Department Stores does not approve nor reject the techniques contained
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(2) Extrapolation of Aggregate Employment; (3) Ingrow Model; (4) Super Ingrow Model; (5) Ratio Technique; and (6) Shift-Share Analysis. The accuracy of these techniques are to be investigated at the SMSA geographical level. SMSA's were initially chosen based on two criteria: (1) the availability of dis-aggregated Bureau of Labor Statistics (BLS) time series employment data (BLS [7, 8]) previous to 1952; and (2) the uniformity of the SMSA geographical definition over the period of study (1949 to 1974). SMSA's which meet these specifications were then grouped into fast or slow-growing SMSA's. A fast-growing SMSA was defined as an SMSA which surpassed the U. S. average annual compounded rate of employment growth by at least 5 percent between 1949 and 1974 and vice versa for slow-growing SMSA's. By categorizing the SMSA's in this manner, not only do the results signify which techniques were most accurate overall but they also demonstrate which techniques were most accurate in fast or slow-growing SMSA's. After this was completed, ten fast-growing SMSA's and ten slow-growing SMSA's were selected from the appropriate group. Due to the limited amount of SMSA's which have historic employment data back to 1952, only nine fast-growing SMSA's remained after the selection process; thus, the Tampa-St. Petersburg SMSA was added in spite of its minor violation of the geographical area standard.

BLS time series employment data for the years of 1949 (in certain instances 1950, 1951 or 1952) through 1964 were projected to 1974 for each of the 20 SMSA's using alternative projection techniques. It was assumed that the U. S. employ-ment figures for the forecast year of 1974 were known. This assumption favors projections made by techniques which utilize U. S. projection figures as part of their forecasting framework such as the Super Ingrow, Ratio, and Shift-Share Techniques. The amount and direction of error that U. S. projections are subject to in an average ten-year period is generally uncertain. Consequently, it is nearly impossible to tell exactly how this assumption would in actuality effect the results.

The accuracy of each technique was determined by how precisely it represented the actual 1974 figure as reported by the BLS. To make the results clear, comparable, and understandable, the amount of error incurred by each technique was quantified by several simple percentage and numeric error measurements. The <u>actual difference</u> is calculated by simply subtracting total projected 1974 employment from total actual 1974 employment for the SMSA's. <u>Gross difference</u> figures ignore the + or - sign for the differences between individual actual SMSA employment and individual projected SMSA employment. This yields a more realistic view of error than does actual differences since high negative and high positive differences between actual and projected figures cancel each other when + and - are retained. The <u>gross difference</u> <u>percentage</u> is calculated by summing the individual numeric differences for each SMSA without regard to sign then dividing this sum by the actual 1974 employment figure and multiplying the resultant figure by 100. The <u>range of</u> <u>percentage error</u> indicates the breadth of error arising within each projection technique. Finally, the <u>number of + or - deviations</u> from the actual employment figure marks the number of SMSA projections that under-represent (-) or surpass (+) the actual employment figure. For business, a projection which exceeds the employment figure at the target date generally is considered to be more serious than a conservative prediction. A high projection can create a serious surplus of commodities, eventually leading to low sales margins and

and high year-end taxation. In the public sector, the opposite is generally true. A projection which under-represents the employment figure at the target date leads to an overcapacity of public facilities. Thus, the direction of the error is vitally important to the user of the forecast.

FINDINGS

Tables 1, 2, and 3 illustrate the findings of the study. Tables 1 and 2 depict the results for fast and slow-growing SMSA's respectively. Table 3 consolidates the outcomes for Tables 1 and 2 into a summary for all 20 SMSA's. The next six subsections will briefly describe the findings of the study.

Constant Numeric Change

The constant numeric change technique employed in this study can be expressed by the following equation:

$$\frac{E_t - E_{t-x}}{T_x} = PNC$$

$$PNC \times T_f + E_t = E_{t+z}$$

where

E_t = employment at time t

E_{t-x} = employment at a previous year t-x

E_{t+z} = employment in projection year t+z

T_x = time between t and t-x

T_f = time between t and t+z

PNC = past numeric change

This projection technique will only prove fruitful in periods of consistently even employment change. The results show that this assumption is not entirely valid in the projection period.

The constant numeric change technique underestimated the actual 1974 employment figures in both fast and slow-growing SMSA's by more than 10 percent. All but one of the 20 SMSA projections underestimated the actual 1974 employment figures. The technique performed poorly in both fast and slow-growing SMSA's. The gross difference percentage exceeded 10 percent both in fast and slow-growing areas. Compared to other nonsophisticated techniques, this technique performed moderately and should be used only with acknowledged limitations.

TABLE 1: Accuracy of Employment Projection Techniques for Fast-Growing SMSA's*

Technique Applied

Measurement Categories	Constant Numeric Change	Extrapolation of Aggregate Employment	Ingrow Model	Super Ingrow Model	Ratio Technique	Shift and Share Analysis
Total Actual 1974 Employment	6998.4	6998.4	6998.4	6998.4	6998.4	6998.4
Total Projected Employment	6169.3	6156.5	5753.1	6270.9	7750.1	7728.7
Actual Difference						
Numeric	- 829.1	- 841.9	-1245.3	- 727.5	+ 751.7	+ 730.3
Percentage	- 11.9	- 12.0	- 17.8	- 10.4	+ 10.7	+ 10.4
Gross Difference+						
Numeric	900.9	853.3	1245.3	1083.1	997.3	944.9
Percentage	12.9	12.2	17.8	15.5	14.3	13.5
Range of % Error	+1.2 to -30.2	+0.2 to -29.1	-2.6 to -37.3	+5.8 to -32.3	+24.1 to -10.9	+22.6 to -10.9
Number of + or - Deviations	1+, 9-	1+, 9-	0+, 10-	1+, 9-	4+, 6-	5+, 5-

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*SMSA's included are: (1) Tampa - St. Petersburg, (2) Phoenix, (3) Tucson, (4) Anaheim, (5) Los Angeles, (6) Riverside, Calif., (7) San Diego, (8) San Jose, (9) Miami, and (10) Portland, Oregon.

+Gross difference figures ignore minus signs in tabulations. The figures show the total amount of error resulting irregardless of + or - sign.

TABLE 2: Accuracy of Employment Projection Techniques for Slow-Growing SMSA's *

<div align="center">Technique Applied</div>

Measurement Categories	Constant Numeric Change	Extrapolation of Aggregate Employment	Ingrow Model	Super Ingrow Model	Ratio Technique	Shift and Share Analysis
Total Actual 1974 Employment	2544.9	2544.9	2544.9	2544.9	2544.9	2544.9
Total Projected Employment	2185.5	2122.5	2504.1	2725.6	2427.2	2507.5
Actual Difference						
Numeric	- 359.4	- 422.4	- 40.8	+ 180.7	- 117.7	- 37.4
Percentage	- 14.1	- 16.6	- 1.6	+ 7.1	- 4.6	- 1.5
Gross Difference[+]						
Numeric	359.4	422.4	96.8	186.9	172.7	144.4
Percentage	14.1	16.6	3.8	7.3	6.8	5.7
Range of % Error	-9.3 to -27.3	-12.0 to -28.9	+5.5 to -11.6	+15.0 to -2.3	+3.2 to -25.4	+4.4 to -18.3
Number of + or - Deviations	0+, 10-	0+, 10-	2+, 8-	8+, 2-	1+, 9-	2+, 8-

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*SMSA's included are: (1) Baltimore, (2) Providence, (3) South Bend, Ind., (4) Terre Haute, Ind., (5) Spokane, (6) Tacoma, Wash., (7) Springfield, Mass., (8) Worcester, Mass., (9) Buffalo, and (10) New Bedford, Mass.

+Gross difference figures ignore minus signs in tabulations. The figures show the amount of error resulting irregardless of + or - sign.

TABLE 3: Accuracy of Employment Projection Techniques in Aggregate*

Technique Applied

Measurement Categories	Constant Numeric Change	Extrapolation of Aggregate Employment	Ingrow Model	Super Ingrow Model	Ratio Technique	Shift-and Share Analysis
Total Actual 1974 Employment	9543.3	9543.3	9543.3	9543.3	9543.3	9543.3
Total Projected Employment	8354.8	8279.0	8257.2	8996.5	10,177.3	10,236.2
Actual Difference						
Numeric	-1188.5	-1264.3	-1286.1	- 546.8	+ 634.0	692.9
Percentage	- 12.5	- 13.2	- 13.5	- 5.7	+ 6.6	+ 7.3
Gross Difference+						
Numeric	1260.3	1275.7	1342.1	1270.0	1170.0	1083.3
Percentage	13.2	13.4	14.1	13.3	12.3	11.4
Range of % Error	+1.2 to -30.2	-12.0 to -29.1	+5.5 to -37.3	+15.0 to -32.5	+24.1 to -25.4	+22.6 to -18.3
Number of + or - Deviations	1+, 19-	1+, 19-	2+, 18-	9+, 11-	5+, 15-	7+, 13-

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*Figures in Table 3 represent all 20 SMSA's.

+Gross difference figures ignore minus signs in tabulations. The figures show the total amount of error resulting irregardless of + or - sign.

Extrapolation of Aggregate Employment

Aggregate employment was extrapolated through the use of time series linear regression. The equation applied can be expressed as follows:

$$Y = a + bX$$

where

Y = the dependent variable - total employment

a = Y axis intercept

b = slope of the line (rate of change)

X = independent variable - time

The projected employment figure for each SMSA was calculated by multiplying the 1964 total employment figure by b and the desired time period X (10 years). This projection technique is used extensively when historic employment data are linear in nature. As the results show, SMSA's ostensibly do not grow at linear rates over medium-ranged time periods.

The extrapolation of aggregate employment technique understated actual 1974 employment by greater than 10 percent for both fast and slow-growing SMSA's. The technique performs better in fast-growing SMSA's where it registered a mediocre 12.2 percent gross error versus a high 16.6 percent gross percentage error in slow-growing SMSA's. The technique has a strong tendency to underestimate SMSA employment as witnessed by the large number of negative deviations from the actual figure. The technique's performance overall is tantamount to the constant numeric change technique and therefore should be used only under special circumstances.

Ingrow Model

The Ingrow Model projects each subnational industry into the future by that industry's national compounded growth rate over the previous period. It is assumed that future local employment growth will grow analogous to past U. S. growth. For instance, if U. S. manufacturing employment grew at a 2.5 percent compounded annual rate of change over a previous period of time, then local manufacturing employment is projected to grow at 2.5 percent over a desired time period. In this study, total employment was disaggregated into 7 to 11 Standard Industrial Classification (S.I.C.) groupings depending on availability of data.

The outcome indicates that the Ingrow Model was extremely inaccurate in fast-growing SMSA's. Conversely, the Ingrow Model performed exceedingly well in slow-growing SMSA's. Slow-growing SMSA's were only subject to an actual difference error of 1.6 percent and a gross error of 3.8 percent versus a 17.8 percent actual difference error and a 17.8 percent gross error for fast-growing areas. Ostensibly, the Ingrow Model is significantly better suited for slow-growing SMSA's typically located in the Midwest and Northeast

as compared to the fast-growing areas of the West and South. Slow-growing
SMSA's growth rates generally deviate less from the U. S. norm than do rapidly
growing SMSA's which in part accounts for the results contained herein. In
aggregate, the Ingrow Model was slightly less accurate than the previous two
techniques.

Super Ingrow Model

The Super Ingrow Model projects each SMSA industry by that industry's
national projected compounded growth rate. It is assumed the future employment
change within local industry is directly reflective of anticipated change
within U. S. industrial employment. For example, if U. S. manufacturing
employment is projected to grow at 2.0 percent compounded annually, then local
manufacturing employment will also be projected at that same rate. It was
assumed that U. S. employment growth rates were precisely projected for this
study. Total employment was disaggregated into SIC groupings equivalent to
the Ingrow Model.

The results demonstrate that the Super Ingrow Model performs similarly
to the Ingrow Model. The Super Ingrow Model is slightly more accurate in
fast-growing SMSA's and moderately less accurate in slow-growing SMSA's than
the Ingrow Model. The Super Ingrow Model experienced a 15.5 percent gross
difference percentage error in fast-growing SMSA's and a 7.3 percent error
in slow-growing SMSA's equalling an overall error of 13.3 percent. The
Super Ingrow Model has a tendency to underestimate in fast-growing areas
and overestimate in slow-growing areas as illustrated by the number of positive
and negative deviations. In aggregate, the Super Ingrow Model is similar to
other techniques with regard to accuracy. However, the balance of positive
and negative projections relative to the actual employment figures yielded
a low actual difference error. According to the results contained herein,
the Super Ingrow Model should be restricted for use in slow-growing SMSA's
since its performance in fast-growing SMSA's is subject to substantial error.

Ratio Technique

The Ratio Technique interrelates employment changes in an SMSA to employment
changes in the U. S. The ratio between local employment and U. S. employment is
assumed to change in a predictable and consistent fashion. The time series
relationship between SMSA and U. S. employment was extrapolated over time using
linear regression as expressed by the following equation:

$$Y = a + bX$$

where

Y = dependent variable - ratio of SMSA to U. S. employment

a = Y axis intercept

b = slope of the line (rate of change)

X = independent variable - time

Regional Science Perspectives

The employment ratio for the projected year (1974) was calculated by multiplying the actual 1964 employment ratio by b and by the projection period (10 years). The projected employment ratio was then multiplied by the actual 1974 U. S. employment figure in order to gain the projected SMSA employment figure. It was assumed the actual 1974 U. S. employment figure was known.

As the summary tables show, the Ratio Technique was quite accurate in slow-growing SMSA's but extremely inaccurate in fast-growing areas. The gross difference percentage error for fast and slow-growing SMSA's was 14.3 percent and 6.8 percent respectively, yielding an overall gross error of 12.3 percent. Actual difference percentage errors were small relative to the other techniques in both fast and slow-growing SMSA's. In aggregate, the Ratio Technique performed better than the previously discussed methods based on the gross difference error. According to the evidence of this study, the Ratio Technique performs well in slow-growing SMSA's but is subject to larger errors in fast-growing SMSA's.

Shift-Share Analysis

The Shift-Share analysis (S/S) framework used in projecting SMSA employment was tantamount to the one developed by Zimmerman [9]. The S/S framework, as modified by Zimmerman, is expressed in the following manner:

$$E_{ij(t+1)} = \left(\frac{E_{ijt}}{E_{ikt}}\right) E_{ik(t+1)} + \left[\left(\frac{E_{ij(t+1)}}{E_{ik(t+1)}}\right)^* - \frac{E_{ijt}}{E_{ikt}}\right] E_{ik(t+1)}$$

where

  i = industry

  j = region

  k = benchmark economy

  t = time

  E = employment

Zimmerman's modification to the S/S framework permits the shift component (starred term) to be projected using sundry techniques. In this study, the shift component was projected for each SIC grouping by linear regression where the employment share was the dependent variable and time was the independent variable. The number of SIC groupings varied from 7 to 11, and were identical to those used for the two Ingrow Models.

Contrary to other findings, Brown [1] and Floyd and Sirman [3], the S/S projection framework has the potential to produce reasonably accurate forecasts. In fact, S/S proved to be superior overall to the other nonsophisticated techniques tested herein. The S/S framework performed particularly well in slow-growing SMSA's as exemplified by the 5.7 percent gross difference error, the 1.5 percent actual difference error, and the relatively small range of error. In fast-growing areas, the constant numeric change and extrapolation techniques were slightly more accurate than the S/S framework in terms of gross difference error but not actual difference error.

In aggregate, the S/S framework was superior in almost all measurement categories. The gross difference error for the SMSA's combined was only 11.4 percent which is superior to the other nonsophisticated techniques. The number of positive and negative deviations are well balanced relative to the other techniques, accounting for its low actual difference error. Based upon these results, the S/S framework used in this study yields reasonably accurate projections. The technique can be used with a certain degree of confidence when producing preliminary projections except in fast-growing SMSA's.

CONCLUSIONS

Certain techniques were shown to be more accurate in fast-growing SMSA's than slow-growing SMSA's and vice versa. However, none of the techniques performed particularly well in fast-growing SMSA's. The Ratio and S/S methods performed well in slow-growing areas, but the Ingrow Model was found to be superior to them. The remaining techniques were inaccurate in both fast and slow-growing SMSA's. The results demonstrate that particular techniques work better in certain growth situations than others and that no technique is dominant under every circumstance.

Another conclusion reached from the results is that U. S. related projection approaches such as the S/S, Ratio, and Ingrow Model techniques appear to be superior to past trend techniques. Part of this superiority can be attributed to the assumption that U. S. projections were known at the target date. Consequently, this would have a tendency to reduce the amount of error occurring for the U. S. related techniques which depend on U. S. forecasts (i.e., Super Ingrow Model, Ratio Technique, and S/S). Since U. S. forecasting errors could be partially offset by local errors in the opposite direction, the impact of U. S. forecasting errors is not a direct one-to-one relationship. Due to the moderate error margins between the U. S. related techniques and nonrelated techniques, it is doubtful that the U. S. employment assumption seriously hindered the results.

The final conclusion of the study is that the Ratio Technique and S/S projection framework were superior overall to other techniques by a small margin. Preliminary investigations done in conjunction with this paper indicate that if all the SMSA's analyzed were weighted equally, the Ratio and S/S methods would have been subject to gross difference percentage errors of less than 10 percent as opposed to substantially larger errors for the other techniques. This tentative outcome would signify that the Ratio and S/S frameworks work particularly well in smaller fast-growing SMSA's. With certain additional modifications, perhaps such as those suggested by Zimmerman [9], the S/S method could potentially become even more reliable for forecasting. However, at this time, none of the techniques studied are totally suitable for preliminary forecasting in all growth situations.

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