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REGIONAL ECONOMIC FORECAST SYSTEM FOR RESOURCE DEVELOPMENT PLANNING*

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Introduction

Forecasts of regional employment, income and population are prepared for a variety of public and private purposes. With increasingly severe limitations on the availability and use of public funds for construction of new facilities, reliable forecasts and forecasting methods are sought by local and state agencies in efforts to better anticipate needs and set priorities. Private organizations seek the same information as a basis for private investment decisions, particularly in areas of rapid population growth and change.

The focus of this paper is on the preparation and use of regional economic forecasts for water and land resource development and planning. Its primary purpose is to present a forecast method and related data for deriving alternate forecast series based on explicit changes in important production and consumption relationships. This purpose stems from the expressed need for readily available and quickly updated economic forecast series covering a state and its sub-state regions or a major river basin and its water resources planning areas [7, 9, 10]. To meet this need a simple model is used, of the form

$$(1) \quad x_{in} = x_{i0}(1 + r_i)^n,$$

where the industry-specific forecast variable, x_{in} is determined by its initial value x_{i0} , the annual rate of industry growth r_i and the length of the forecast period, n .

In the use of this simple shift-and-share model, coefficient r_i is partitioned, first, into several change sources. In this model, the annual change in the forecast variable, say, industry employment, is determined by a national-growth coefficient A , an industry-mix coefficient B_i and a region-specific regional-share coefficient C_{ir} .

While the part of industry employment change in a region due to national-growth and industry-mix is readily derived from national industry employment forecasts, the part which is due to the regional-share effect is difficult to determine. As noted in the abundant literature on shift-and-share models, the regional-share coefficient is extremely difficult to forecast with high degree of reliability because of its interwoven effects and extreme variability [2, 4, 9].

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A modification of the conventional model is presented in this paper in which the regional-share coefficient is partitioned into additional change sources representing the consumption and production activities in a region. These include an internal component representing local production and consumption relationships and an external component representing export and market relationships.¹

The modified shift-and-share method provides a new application of several forecast methods. These include the use of certain economic and demographic variables and relationships, such as total personal consumption expenditures, industry gross output, and industry employment shares. Thus, a rather simple, but widely used, forecast model is significantly strengthened as a principal source of multi-purpose economic indicators for resource development planning.

Analytical Framework

An analytical framework for small-area employment forecasting is presented which builds on several of the forecasting methods cited in the review of literature. This framework extends the conventional shift-and-share analysis by incorporating the location quotient and economic base approaches in a new allocation-type employment forecasting model. This procedure makes use of U.S. industry employment trends and projections. It is supplemented by an "excess" employment technique which identifies an "export-producing" and a "residential" component for each industry in terms of its total employment[5].

So-called export-producing employment is engaged in producing goods in "excess" of the region's requirements. In this study, "excess" employment is determined statistically as that employment in a given industry which is in excess of the national average for this industry. The ratio of total employment to excess employment is a measure of a region's economic base. The larger the ratio, the larger the total employment supported by each "export-producing" worker and, also, the larger the inter-industry linkages and, hence, the smaller the region's dependency on imports.

The proposed regional economic forecasting model is identical to the conventional shift-and-share model, except for the reformulation of the regional-share coefficient C_r into the internal change coefficient CIN_{ir} and external change coefficient CEX_{ir} . In this reformulation,

$$(2) \quad CIN_{ir} = ISC'_i \left(\frac{e_i g (1 + pchpcepi) (1 + pchpepi) (1 + pchpop)}{(1 + pchoutpw_i) ISC'_i} + 1 \right)$$

$$(3) \quad CEX_{ir} = ISC'_i \left(\frac{aesc'_i}{iesc_i} 1q'_i - 1 \right)$$

¹ Esteban-Marquillas [2] proposed a partitioning of the regional-share coefficient into an homothetic and an allocative component to deal with the well-known difficulties of using the conventional shift-and-share model in small-area forecasting. The modifications proposed in this paper follow the general thrust of the Esteban-Marquillas proposal. They focus, however, on the development of the shift-and-share model as an integral part of a more comprehensive economic impact simulation and forecasting system [8].

where

e_i = expenditure coefficient for personal consumption expenditures of i -th industry output in region

g = aggregate growth indicator to denote expected change in the composite growth ratios for personal consumption expenditures, personal income and population from the preceding period to the current period²

$pchpcepi$ = annual rate of change in ratio of personal consumption expenditures to personal income in region

$pchpcpi$ = annual rate of change in per capita personal income in region

$pchpop$ = annual rate of change in total population in region

$pchoutpw_i$ = annual rate of change in i -th industry output per worker in region

ISC'_i = U.S. industry shift coefficient EMP'_i / EMP_i (i.e., ratio of i -th industry employment in forecast year $t + 1$ to i -th industry employment in base year t)

$aesc'$ = area employment share coefficient in forecast year $t + 1$ (i.e., ratio of total area employment in year $t + 1$ to total U.S. employment in year $t - 1$)

$iesc_i$ = industry employment share in base year t (i.e., ratio of i -th industry employment in region in base year t to i -th industry employment in U.S. base year, t)

$1q'_i$ = industry location quotient in forecast year, $t + 1$ (i.e., $aesc' / iesc'$)

For location quotients of less than one, the external effect is derived by use of the internal regional-share coefficient CIN_{ir} in place of the external regional-share coefficient CEX_{ir} . A negative external effect denotes lack of industry output to meet local requirements; hence the region is, in effect, dependent on imports to satisfy deficit demand.

A special calibration procedure is required in the allocation of the internal regional-share effect to individual change components, which are the industry-specific expenditure elasticity coefficient e_i , the aggregate growth indicator k , and annual rates of change in the ratio of personal consumption expenditure to personal income ($pchpcepi$), per capita personal income ($pchpcpi$), total population ($pchpop$), and industry-specific output per worker ratio ($pchoutpw_i$). Each coefficient is based on the annual change in its corresponding variable which is obtained from the annual forecast series. For the calibration period, however, historical data are used, with the residual internal adjustments being allocated to the industry-specific expenditure elasticity coefficient and the industry-specific output per worker ratio. Thus, unique regional (or subregional) values of the two coefficients are derived in the calibration procedure.

The calibration procedure is initiated with the derivation of the difference, if any, between the regional-share coefficient and the sum of the weighted values of the internal and external components of the regional-share coefficient with the form,

² In the calibration procedure with historical data series, the annual growth rates are for the current period and, hence, $g = 1$. For subsequent periods, this coefficient denotes the composite expected change in relative values of the three growth ratios, i.e., $(1 + pchpcepi)$, $(1 + pchpcpi)$ and $(1 + pchpop)$; hence, the coefficient may be more or less than one depending on the direction of change of the ratios from their lagged values.

$$(4) \text{ DIFF}_i = C_i - \text{CIN}_i \frac{1}{1q_i} - \text{CEX}_i \left(1 - \frac{1}{1q_i}\right)$$

A correction term ct_i is then derived with the form,

$$(5) \text{ ct}_i = \text{DIFF}_i \left(\frac{1q_i}{\text{ISC}_i} \right)$$

The correction term is used to adjust the initial value of the two industry-specific coefficients with the form,

$$(6) \text{ r}_i^* = r_i + \left(\frac{\text{ct}_i}{\text{ISC}_i} \right) K (1 + \text{pchpcepi}) (1 + \text{pchpcpi}) (1 + \text{pchpop})$$

where

r_i^* = corrected value of the ratio, $e_i / (1 + \text{pchoutpw}_i)$

r_i = initial (uncorrected) value of ratio, $e_i / (1 + \text{pchoutpw}_i)$

Finally, the corrected values of the two coefficients — e_i^* and $(1 + \text{pchoutpw}_i)^*$ — are selected from the pairs of values which satisfy the condition,

$$(7) \text{ r}_i^* = e_i^* / (1 + \text{pchoutpw}_i)^*$$

One strategy is to select the corrected pair of values which represents the mid-point of the allowable range of each of the two coefficients. The allowable range of each coefficient is set at a pre-specified percentage of its mean value.

The new formulation of a shift-and-share forecasting model is an improvement over the conventional model on empirical and conceptual grounds. Empirical confirmation of period-to-period changes in the regional-share effects is readily achieved by the use of location quotient and industry employment-share forecasts for a region. The industry employment-share coefficient, while not necessarily more stable than the conventional regional-share coefficient, is more accurately and completely specified as a planning or policy variable. The location quotient also is readily specified as a policy variable, for example, as the ratio of the industry employment and total regional employment share coefficients. All other ratios are lagged one period, or obtained from external forecasts for the nation and, hence, pre-determined in the regional forecasting equation.

The reformulation of the shift-and-share model is conceptually attractive with its melding of location quotient, economic base and shift-and share forecast methods. In addition, it provides for a separation of the influence of the internal (i.e., residentiary) and external (i.e., export-producing) components on the total regional-share effect. If no export-producing employment were present, and if no change occurred in the location quotient, then the regional-share effect would equal zero. With a positive external regional-share, or a change in the location quotient, the excess employment is shown as a measurable regional-share effect. This effect is positive only if the location quotient times the total employment share ratio is greater than one, given a lagged industry employment share ratio equal to or less than one.

Principal data sources used in implementing the forecasting models are the U.S. Census of Population, the Regional Economic Information System, and the periodic and occasional reports from the U.S. Department of Commerce and individual state departments of Employment Security or their equivalent [13, 14, 19, 20, 21, 22].

Various industry classification lists are used in compiling employment and earnings statistics, by industry, from the two data sources. The 25-industry classification system used in this study differs from other frequently used classification systems in the level of industry detail, particularly in manufacturing. It compares with the 1972 OBERS projection series in its industry breakdown and thus makes possible an updating of OBERS projections to the new employment levels indicated by revised state and local population forecasts. Further industry breakdown is possible, of course, by use of various county-level data series [9].

In this study, estimated total earnings were obtained from the Regional Economic Information System while projected post-1975 total earnings were obtained from the 1972 OBERS-E projections. The total earnings projections were used to derive an employed work force projection series. This series is comparable with the U.S. Bureau of Labor Statistics employed work force projections to 1985 and 1990, and the industry earnings projections prepared for the U.S. Water Resources Council [1, 3, 4, 11, 14, 15, 16, 18]. However, published OBERS-E projections are available for only the water resources subareas and economic areas in the United States, including the portion of a subarea in a single-county or multi-county Standard Metropolitan Statistical Area. All county-level series are compiled from current data sources.

Forecasting System

The modified shift-and-share model is the central part of the regional economic forecasting system presented here. The several system components are listed under three topical headings, starting with industry employment and extending to labor force, population, total earnings, and income. Place of work and place of residence differences in the measurement of employment and income are accounted for in the forecast procedures. Thus, while the employment forecasts are usually presented by place of work, they also are available by place of residence, given the adjustment for commuting.

Industry Employment. Each of the three change sources in the basic shift-and-share model can be viewed as additive rates of change in employment in a particular industry. Variations in industry growth rates are unique to the industry while variations in regional growth rates are unique to the region, given the industry mix in the region. The unique regional variations in employment change patterns are accounted for by the individual change components in the corrected internal regional-share effect CIN^*_{ir} and the external regional-share effect CEX_{ir} . The new shift-and-share model is now represented by the form

$$(8) \quad emp'_{ir} = \left[1 + A + B_i + CIN^*_{ir} \frac{1}{1q_i} + CEX_{ir} \left(1 - \frac{1}{1q_i} \right) \right] emp_{ir}$$

Labor Force and Population. Additional forecast system components are represented by the labor force and population relationships. These relationships are given (with region-specific subscripts deleted) by the forms

$$(9) \text{ ecom}' = \text{ecc}' \times \text{empr}'$$

$$(10) \text{ empw}' = \text{empr}' + \text{ecom}'$$

$$(11) \text{ empl}' = \text{ewlc}' \times \text{empw}'$$

$$(12) \text{ pop}' = \text{epc}' \times \text{empl}'$$

where

ecom' = total employed work force commuting to place of work in year $(t + 1)$

ecc' = employed work force commuting ration in year $(t + 1)$

empr' = total employed work force by place of work in year $(t + 1)$

empw' = total employed work force by place of residence in year $(t + 1)$

empl' = total employed labor force by place of residence in year $(t + 1)$

ewlc' = employed work force to employed labor force ratio in year $(t + 1)$

pop' = total population by place of residence in year $(t + 1)$

epc' = employed labor force to total population ratio in year $(t + 1)$

Employment is represented also in total hours worked in each industry by the form,

$$(13) \text{ hour}'_i = \text{hpwc}'_i \times \text{emp}'_i$$

where

hour_i = total hours worked annually in i -th industry in year $(t + 1)$

hpwc_i = average hours worked annually by employed work force in i -th industry in year $(t + 1)$

The series of five equations thus converts the outputs of the employment-based shift-and-share model into a set of intervening variables for deriving a region's total earnings and total personal income levels. The four employment relationships — ecc' , ewlc' , epc' , and hpwc'_i — are derived from the data sources cited earlier and related sources [3, 20, 21, 22].

Total Earnings and Income. Total earnings and total income of the resident population are derived with the use of earnings and income equations, as follows:

$$(14) \text{ earn}' = \sum_i \text{ephc}'_i \times \text{hour}'_i$$

$$(15) \text{ percon}' = \text{perc}' \times \text{earn}'$$

$$(16) \text{ nearn}' = \text{earn}' - \text{percon}'$$

$$(17) \text{ resadj}' = \text{ecc}' \times \text{earn}'$$

$$(18) \text{ nearp}' = \text{nearn}' + \text{resadj}'$$

$$(19) \text{ prop}' = \text{pipc}' \times \text{pop}'$$

$$(20) \text{ tran}' = \text{tppc}' \times \text{pop}'$$

$$(21) \text{ perinc}' = \text{nearp}' + \text{prop}' + \text{tran}'$$

$$(22) \text{ pcinc}' = \text{perinc}' \div \text{pop}'$$

$$(23) \text{ pcpce}' = \text{pceb}' + \text{pcc}' \times \text{pcinc}'$$

$$(24) \text{ pce}' = \text{pcepc}' \times \text{perinc}'$$

where

ephc' = total earnings per hour of employed work force in i-th industry in year $(t + 1)$

earn' = total earnings of employed labor force by place of work in year $(t + 1)$

percon' = total personal contributions of employed work force in year $(t + 1)$

perc' = personal contribution ratio in year $(t + 1)$

nearn' = net earnings of employed work force by place of work in year $(t + 1)$

resadj' = residence adjustment for total earnings of work force commuting to place of work

nearp' = net earnings of employed work force by place of residence in year $(t + 1)$

prop' = total property income by place of residence in year $(t + 1)$

pipc' = property income per capita in year $(t + 1)$

pop' = total population by place of residence in year $(t + 1)$

tran' = total transfer payments by place of residence in year $(t + 1)$

tppc' = transfer payments per capita in year $(t + 1)$

perinc' = total personal income by place of residence in year $(t + 1)$

pcinc' = personal income per capita in year $(t + 1)$

pcepc' = personal consumption expenditures per capita in year $(t + 1)$

pceb' = personal consumption expenditures per capita when $\text{pcinc}' = 0$ in year $(t + 1)$

ppc = total personal consumption expenditures per \$1 total personal income in year $(t + 1)$

pce = total personal consumption expenditures by place of residence in year $(t + 1)$

This series of 11 equations completes the forecast system by linking the total earnings of the employed work force to the total personal consumption expenditures of the resident population. The four earnings relationships — ephc' , perc' , pipc' , and tppc' — also are derived from the previously cited data sources.

Thus, the 16 equations form the regional economic forecast system for resource development planning. Additional relationships are needed to convert the employment, earnings, income, expenditure, and population forecasts into resource and industrial development variables, such as land and water requirements of each industry and sector represented in the economic forecasts.

Summary and Conclusions

An economic forecast system for deriving regional and subregional forecasts is presented in this report. This system makes use of the 1972 OBERS-E projections prepared by the former Office of Business Economics in the U.S. Department of Commerce for the U.S. National Water Resources Council. The OBERS earnings and income projections were used in the building of a baseline series of regional employment forecasts for calibrating the forecast system.

This system is based on a shift-and-share model where the rate of change is the sum of the four shift-and-share coefficients — the national-growth coefficient A , the industry-mix coefficient B_i and the two regional-share coefficients CIN_{ir} and CEX_{ir} . Modified and expanded regional-share components of the shift-and-share forecast method were developed to facilitate the preparation of small-area employment and income forecasts. The regional-share component was first partitioned into an internal effect and an external effect, with the internal effect representing the local consumption and production impacts on industry employment and earnings levels and the external effect representing the corresponding export market impacts on the local economy.

The modified shift-and-share model provides the core module in a 16-equation regional forecast system. Besides industry employment, the system forecasts total earnings of the employed work force, total and per capita personal income, total and per capita personal consumption expenditures, and total population.

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