AN ECONOMETRIC MODEL OF MANUFACTURING EMPLOYMENT GROWTH IN RURAL TENNESSEE COUNTIES FROM 1962 TO 1976

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Modeling local and regional manufacturing activity is an important component of economic research. Models that explain the levels of local aggregates, such as employment, aid the efforts of state and local governments to influence the future course of economic activity. Such models also aid private decision makers in their efforts to develop feasibility studies of projects representing different investment alternatives. Input-output and economic base studies are the most common means of modeling local economic activity. These studies, though useful in assessing the multiplier effects of changes in local manufacturing activity, do not capture the temporal influence of national economic trends or the specific community characteristics responsible for varying levels of manufacturing activity. Econometric models, being more flexible and less expensive, may better serve the latter purposes.

Several econometric models have addressed the roles of national trends and community characteristics separately. Glickman [2] used United States aggregate data to explain local manufacturing output in the Philadelphia Standard Metropolitan Statistical Area (SMSA) and used local manufacturing output to recursively explain local manufacturing employment. Dorf and Emerson [1] incorporated 16 orthogonal factors from a factor analysis of 136 community characteristics to explain changes in plant numbers and employment in states comprising the West North Central Region of the United States. Gunter [4] explained plant expansions in rural Tennessee counties by employing a factor analysis in which orthogonal factors represented 30 community characteristics. Smith, Deaton, and Kelch [8] made an important contribution to public policy by using a set of modifiable community characteristics as independent variables in a model explaining plant locations in Tennessee and Kentucky.

The model described in this article accounts for the effect of national economic trends on the level of total manufacturing employment in Tennessee and the influence of modifiable and nonmodifiable community characteristics on the distribution of total manufacturing employment among rural counties.

CONCEPTUAL MODEL

A positive relationship is hypothesized between the total manufacturing employment level of all counties in Tennessee and (1) that of the national economy and (2) the difference between the average costs of manufacturing production nationwide and those in Tennessee. This cost differential is assumed to decrease over time and to have a negative correlation with the secular expansion of the national economy so that its influence is assumed to be picked up by the national level of manufacturing employment.

Economies of localization and urbanization are hypothesized to influence the distribution of total manufacturing employment among rural counties because of their effects on costs and revenues. *Localization economies* result from a concentration of firms creating "... a research institute, marketing organizations, and other collective facilities that individual manufacturers would be unable to provide for themselves [5, pp. 83-87]. Localization economies may also result from access to higher quality labor, specialized educational institutions, and input and output markets. *Urbanization economies* arise from the agglomeration effects associated with a highly developed infrastructure and large population base. The components of these economies are assumed to provide services to a finite set of factors and to function as complements to one another. For example, the services provided by market availability are dependent on a complementary set of services provided by other components.

A common factor model is used in deriving the set of orthogonal factors because it develops factors which explain the proportion of variance in the raw data that is shared

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The author thanks, in alphabetical order, Merton Badenhop, Mike Cuskaden, Tom Klindt, Maurice Landes, and William Sanders for their helpful comments on drafts of the article. The usual caveats apply.

among all variables and represents the provision of complementary services. Manufacturing employment in rural counties is hypothesized to be a function of these factors and total manufacturing employment in the state.

OPERATIONAL MEASURES OF LOCALIZATION AND URBANIZATION ECONOMIES[1]

The literature on the urban-industrial impact hypothesis [7] implies that the distribution of current employment among the 76 rural Tennessee counties may be influenced largely by the magnitude and diversity of their past economic structure. Therefore, observations on the variables localization and urbanization economies are taken at two points in time in order to develop factors for testing the hypothesis of causation between the past distribution of location and urbanization economies and subsequent levels of manufacturing. Data for 1960 are used to measure the effect of the past distribution of these economies on manufacturing employment between 1962 and 1970, and data for 1970 are used in measuring their effect on rural manufacturing employment thereafter. The factor analyzed raw data consist of two observations for each variable.

Localization Economies

The size and diversity of the economic base in the county and contiguous counties, in terms of employment levels (variables 1-19), are used as a measure of all facets of localization economies.[2] Employment levels in the manufacturing industries (variables 4-14) measure the availability of product markets, specialized labor, and organizations that provide services to the manufacturing sector. Employment levels in the secondary industries (variables 15-20) are used to measure the magnitude and diversity of consumer markets, which are assumed to reflect the relative desirability of rural counties as permanent residences for consumers and therefore to assure the availability of a plentiful labor force. The availability of local capital (variable 20) and distance to the nearest SMSA (variable 21) are also components of the market facet of localization economies, and the latter is assumed to pick up the extraregional influences not measured by variables 1 to 19.

Population levels in the county and contiguous counties (variable 22) are used to measure the portion of higher quality labor supply available in the county or commuting from outside the county. This variable also measures the availability of markets for manufacturing industries engaged in the production of consumer goods. Other variables representing the quality of labor are intended to capture the influences of intracounty commuting costs (variables 23-24), the absolute size of the county work force (variable 26), and the associated slack in the local labor force (variables 25 and 27).

Higher labor quality is also generally hypothesized to be associated with a more highly educated (variables 29 and 33) and experienced (variable 30) labor force, aware of its opportunity cost and compensated by a higher wage (variable 27). The literature on human capital suggests that greater female participation (variable 28) may be associated with a higher quality labor force.[3] Last, the availability of health care facilities (variables 31-32) also is used to measure a facet of labor quality.

Urbanization Economies

An infrastructure includes such items as utilities, transportation and communication facilities, educational institutions, public health and safety protection, and the excess of sewage and water capacity. Variables 33-40 are used to measure the availability of those facets of the infrastructure most readily modifiable by government expenditures. In addition, Gunter [4, p. 55] has shown that the excess capacity of sewage and water systems is correlated positively with population levels (variable 22), population density (variable 23), and the percentage urban population of a county (variable 24). Therefore, these variables are also used to measure urbanization economies.

THE EMPIRICAL MODEL

The f orthogonal dimensions of localization and urbanization economies are estimated by first extracting the f significant eigenvectors, w, from

$$(1) \qquad (R - \lambda I) \quad w = 0$$

where R is a nonsingular 40 by 40 correlation matrix of the original variables containing final communality estimates on the diagonal, I is a 40 by 40 identity matrix, and λ is the i^{th}

[1]See Table 1 for the definitions of these variables. The data were obtained from the *Tennessee Statistical Abstract.*

[2]The county and contiguous counties was selected arbitrarily as the relevant region for the sources of localization economies.

[3]Schultz [6] discusses in detail the concepts of human capital theory.

extracted eigenvalue.[4] The significant eigenvectors then are combined into an unrotated factor pattern matrix of correlations between variables and significant factors. Next, the structure of the factor pattern matrix is simplified by a varimax rotation which spreads the extracted variance among many factors, rather than on a single one as would the quartimax rotation procedure but not evenly among all factors as would the equimax procedure. A varimax rotated factor pattern matrix is constrained such that some variables have very high loadings (i.e., correlations close to 1.0 or −1.0) on only one factor, whereas the rest of the variables have very low loadings (i.e., correlations close to zero) on the same factor but high loadings on another factor. The use of varimax is in keeping with the conceptual notion that portions of the variance associated with each variable represent complementary facets of each dimension (factor) of urbanization and localization economies.[5] Finally, the 152 by f matrix of significant factor scores, F, is computed by

$$F = Z(R^{-1}P), \tag{2}$$

where Z is a 152 by 40 matrix of normalized variables with each of the 76 rural counties having two observations—one for 1960 and one for 1970—and P is the 40 by f rotated factor pattern matrix.

Results of the Factor Analysis

The varimax rotated factor pattern matrix of correlations between the variables and factor scores and the final communality estimates indicating the percentage variation contributed to the significant factors by each variable, which are computed as the sum of the squared factor loadings across factors, are given in Table 1. A common nonstatistical method of determining the number of significant factors is to choose a number between the minimum provided by the scree test after the first iteration and the maximum number that are easily interpretable [3, pp. 151-156]. Four significant factors accounting for 58.8 percent of the total variance in the data, and having initial eigenvalues of 13.3, 5.9, 3.5, and 2.4, respectively, are extracted by using this criterion.

Factor 1 is highly correlated with the population and employment levels of most industries in each county and contiguous counties (variables 22, 3-19). Factor 1 appears to represent

TABLE 1. ROTATED FACTOR PATTERN MATRIX OF THE FOUR FACTORS EXTRACTED BY A COMMON FACTOR METHOD

Variable name	Factor 1 Availability of localization economies	Factor 2 Availability of infrast.	Factor 3 Income & labor quality	Factor 4	Communality
Total employment in the co. and contiguous cos., by type:					
1. Agric., forestry & fisheries	0.11	0.01	−0.76	0.23	0.64
2. Mining	0.11	−0.10	0.03	−0.68	0.49
3. Construction	0.92	0.21	−0.01	−0.06	0.89
4. Furniture, lumber, & wood products	0.60	0.11	−0.20	−0.34	0.52
5. Metal products	0.58	0.16	0.14	0.08	0.39
6. Nonelectrical machinery	0.79	0.31	0.25	0.17	0.75
7. Electrical machinery	0.48	0.48	0.23	0.09	0.52
8. Transportation equipment	0.24	0.14	0.26	0.40	0.31
9. Other durable goods	0.83	0.23	0.21	−0.04	0.79
10. Food processing	0.92	0.06	−0.24	0.01	0.92
11. Textiles and apparel	0.51	0.27	0.24	−0.12	0.42
12. Printing	0.79	0.24	−0.10	−0.21	0.73
13. Chemical	0.58	0.20	0.01	−0.54	0.67
14. Other nondurables	0.71	0.32	0.25	0.31	0.75
15. Communications and transport services	0.87	−0.01	−0.05	0.08	0.76
16. Wholesale trade	0.96	0.04	−0.01	0.04	0.93
17. Retail trade	0.99	0.13	−0.03	−0.01	0.99
18. Financial services	0.97	0.06	0.05	0.04	0.96
19. Other industries	0.95	0.11	0.02	−0.03	0.91
20. Bank deposits	0.12	0.89	0.16	0.09	0.85
21. Distance from the co. seat to the nearest SMSA	−0.39	−0.10	0.11	0.36	0.30
22. Population of co. & continguous cos.	0.92	0.08	−0.18	−0.17	0.92
23. Population density	0.20	0.66	−0.18	−0.26	0.58
24. Percent urban population	0.02	0.76	−0.09	0.07	0.59
25. Employment rate	0.04	0.19	0.41	0.29	0.29
26. Size of the civilian labor force	0.14	0.77	−0.40	0.05	0.77
27. Per capita income	0.12	0.60	0.68	0.19	0.88
28. % females in the civilian labor force	0.05	0.06	0.41	−0.06	0.18
29. % of the civilian labor force over 25 yrs. of age	0.20	0.76	0.37	0.16	0.77
30. Median age of population	−0.30	0.09	0.23	0.40	0.31
31. No. M.D.s/1000 population	−0.04	0.14	−0.49	−0.04	0.26
32. No. of hospital beds/1000 pop.	0.01	0.27	−0.30	−0.01	0.16
33. Educational expenditures per pupil	−0.05	0.17	0.67	0.17	0.51
34. Hwy. expenditure[1]	0.15	0.71	0.06	0.09	0.54
35. Public welfare expend.	0.11	0.51	0.01	0.01	0.28
36. Health & hosp. expend.	0.08	0.50	0.15	0.15	0.30
37. Expend. on public protection	0.12	0.78	0.10	−0.10	0.64
38. Expenditures on parks & natural resources	0.06	0.58	0.03	0.04	0.34
39. Financial expend.	0.15	0.58	0.01	−0.01	0.36
40. Property tax rate	−0.17	−0.06	0.17	−0.55	0.37

[1]All expenditures except those on education by local government are total expenditures.

[4]The principal axes method of using squared multiple correlations as initial communality estimates in equation 1, calculating a second set of communality estimates from the initial factor solution, using these to estimate a second factor solution, and iterating toward a final set of communality estimates and factor solution, by means of the PA2 procedure in the *Statistical Package For the Social Sciences* (SPSS), was used in estimating the final factor scores. This method is discussed by Gorsuch [3, pp. 92-103]. Convergence was achieved after six iterations.

[5]The three principal methods of orthogonal rotation are varimax, quartimax, and equimax. Gorsuch [3, pp. 189-195] discusses the mathematical and conceptual reasons for using each method.

most of the dimensions of localization economies. Factor 2 is primarily correlated with the modifiable facet of urbanization ecnomies (variables 34-39), the relatively fixed facet (variables 23-24), the availability of capital (variable 20), the size of the labor force (variable 26), and a variable measuring labor quality (variable 29), and shows these to be associated with high wage rates (variable 27). Factor 3 represents a facet of localization economies associated with a skilled labor force (variables 1, 33) and a high wage rate (variable 27). Note that this factor is modifiable by the educational expenditure per pupil (variable 33). Factor 4 is difficult to interpret as it correlates moderately with a number of variables.

The Recursive Model of Rural Manufacturing Employment

The recursive model of rural manufacturing growth can be represented as:

$$(3) \quad E_t^T = a_1 + b_{11}E_t^N + b_{12}X_{70} + e_t \ (t = 1,\ldots, 15)$$

$$(4) \quad E_{ct}^C = a_2 + b_{21}F_{1c} + b_{22}F_{2c} + b_{23}F_{3c} + b_{24}F_{4c} + b_{25}E_t^T + e_{ct} \ (c = 1,\ldots, 76; \ t = 1,\ldots, 15)$$

where

- E_t^T is national manufacturing employment in period t
- E_t^T is total manufacturing employment in Tennessee in period t
- E_{ct}^C is total manufacturing employment in county c and period t
- F_{ic} is the factor score for county c in period t, with the 1960 factor scores used as observations for the first 9 periods and the 1970 factor scores used for the last 6 periods
- X_{70} is a variable that takes the value of 0 up to 1970 and 1 thereafter; it is used to adjust for an apparent rachetlike decline in Tennessee manufacturing employment during 1970-71 recession before the prerecession trend was reestablished.

For reasons already explained, positive coefficients are hypothesized for b_{11}, b_{12}, b_{21}, b_{22}, and b_{25}. Although particular industries may be relatively intensive in their use of skilled labor, a common hypothesis in rural industrialization research is that industries which tend to be located in rural areas are generally intensive in the use of less expensive and less skilled labor. Therefore, the hypothesized sign of b_{23} is negative. No hypothesis is advanced for the influence of factor 4 because of its ambiguity.

The random influences are assumed to be uncorrelated within and between equations. Ordinary least squares is the method of estimation.

SUMMARY OF RESULTS

The results are summarized in Table 2. The coefficient of determination in equation 4 is considerably better than the coefficients of similar studies (0.3 to 0.63 for Dorf and Emerson, 0.02 to 0.2 for Gunter, and 0.22 to 0.43 for Smith, Deaton, and Kelch). It should be noted that these studies are characterized by a higher proportion of explanatory variables in relation to the number of observations than is the present one. Results from the present study seem relatively more powerful. Greater explanatory power can be obtained from equation 4 by postulating a more sophisticated structural form. However, the present state of theory for so doing is considered weak.

TABLE 2. RESULTS OF REGRESSION ANALYSIS[1]

Equation 3

$$E_t^T = -283468.0 + 36.8\, E_t^N + 55078.7X_{70} \qquad R^2 = 0.994$$

Standard error (1.63) (4024.01) $n = 15$

Equation 4

$$E_{ct}^C = 786.1 + 361.6F_{1c} + 1983.1F_{2c} - 469.6F_{3c} - 286.2F_{4c} + 0.0042E_t^T$$

Standard error (49.1) (54.9) (59.3) (52.5) (0.0011)

$R^2 = 0.61$ $n = 1053$

Independent variable with a 1% change	Percent change in employment/percent change in independent variables evaluated at the mean: Factor 1	Factor 2	Factor 3	Factor 4	Net percent, and employment change (in parentheses)
33. Educational exp. per pupil $4.08	-0.0564	-0.1047	0.0600	0.01552	-0.0856 (-2.28)
34. Highway exp. $3748	-0.0082	0.0949	0.0081	-0.0069	0.0879 (2.341)
35. Public welfare exp. $512.2	0.0019	0.0081	0.0023	0.0034	0.0157 (0.418)
36. Health & Hosp. exp. $3540	0.0004	0.0129	0.0066	0.0062	0.0261 (0.695)
37. Exp. on public protection $282.4	0.0068	0.0557	-0.0094	0.0042	0.0573 (1.526)
38. Exp. on parks & nat. resources $112.4	-0.0092	0.0562	0.0029	-0.0009	0.0490 (1.305)
39. Financial exp. $1038	0.0061	0.0060	-0.0131	-0.0042	-0.0052 (0.139)

[1]The employment data were taken from *County Business Patterns* which includes data covering only the employment in the first three months of the year. Annual average data for 1963 were taken from the *City and County Data Book*. Eighty-seven missing values were excluded from the analysis. All parameters except the intercept terms in both equations were significant at the $\alpha = 0.0005$ level.

The results are generally as hypothesized. For purposes of public policy, the high statistical significance of factor 2, which correlates highly with variable expenditures by local governments, should be noted. One logical implication is that the absence of *localization economies* may be compensated for by government expenditures on *urbanization economies.* An implication of the negative parameter of factor 3 is that industries which have located in rural Tennessee during the period of the study tended to locate in counties with relatively low educational expenditures per pupil. However, this implication should be interpreted cautiously because the continued attraction of these types of industries may not be compatible with the income objectives of all counties in the future.

A rough measure of the effect of changes in local government expenditures on the level of manufacturing employment is derived by computing elasticities of the percentage change in employment divided by the percentage change in each type of government expenditure (variables 33-39) evaluated at the means. The absolute magnitude of these changes is also included. The elasticities are derived by combining $R^{-1}P$ into a 40 by 4 weight matrix, W, where w_{ij} represents the weight associated with the i^{th} normalized variable and the j^{th} factor, and computing

$$(5)\quad \frac{dE^{C}_{ct}}{dX_i}\frac{\bar{X}_i}{\bar{E}^{C}_{ct}} = b_{21}\frac{\bar{X}_i}{\bar{E}^{C}_{ct}}\frac{w_{i1}}{a_i} + b_{22}\frac{\bar{X}_i}{\bar{E}^{C}_{ct}}\frac{w_{i2}}{a_i} - b_{23}\frac{\bar{X}_i}{\bar{E}^{C}_{ct}}\frac{w_{i3}}{a_i} - b_{24}\frac{\bar{X}_i}{\bar{E}^{C}_{ct}}\frac{w_{i4}}{a_i}$$

where $\bar{X}_i$ is the mean of the i^{th} policy variable and a_i is its standard deviation, and $\bar{E}^{C}_{ct}$ is the mean value of employment.

The elasticities suggest that expenditures on highways may be the most efficient means of increasing employment in the manufacturing sector, followed by expenditures on public protection, and on parks and natural resources. Expenditures on these items appear to have the potential of offsetting the unattractiveness to industry of a county with a higher quality and hence more expensive labor force.

In summary, the study supports the need for further research on the short-term effects of local government expenditures on manufacturing employment. The statistical significance of factor 1, however, suggests that these expenditures may have longer term influences through the type of economic structure they create. In view of the importance of the four factors, more research on the definition and measurement of urbanization and location economies and the manner in which they affect rural employment appears appropriate.

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