TESTS OF HYPOTHESES RELATING REGIONAL
INDUSTRY LOCATION AND GROWTH TO INPUT
PRODUCTIVITIES IN THE FOOD AND KINDRED
PRODUCTS INDUSTRY GROUP

Richard A. Stanford*
Furman University

Jerry H. Padgett*
Winthrop College

The purpose of this paper is to test with available empirical data hypotheses concerning causative relationships in the regional economic development context. Specifically, empirical ratios based on theoretical propositions are developed to measure the productivities of expenditures on a variety of inputs in the manufacturing process. These ratios are tested with conventional correlation analysis for their ability to explain regional industry location and growth. Industry Group SIC 20, Food and Kindred Products, was chosen for this analysis because it is the most dispersed industry group in the United States, and thus provides the largest number of observations by states.

I. THE INDUSTRY LOCATION LITERATURE

A number of approaches to the empirical analysis of industry location and growth have been suggested in the theoretical literature, and other ad hoc methods have been attempted, including the questionnaire-interview method¹ and the ultra-empirical method.² Proposed means of location analysis have included input-output analysis and mathematical programming, both of which demand more data than are currently available.³ From international-interregional trade literature have come the comparative-cost⁴ and factor-ratio⁵ approaches to industry location, both of which have yielded mixed results.

A possibly more productive approach to the subject of industry location than those described above has been suggested in international trade literature. Stolper and Samuelson postulated that international trade in goods could substitute for international resource mobility in the equilibration of commodity prices, factor prices, and marginal productivities across regions.⁶ The approach of this paper concentrates on interregional productivity differentials resulting from either factor-endowment, production function, demand function, resource quality, or economy (internal or external) differences between regions. Resource productivity differences reflected in differential rates of return across regions theoretically lead to reallocation of resources (thus relocation of industry) among the regions. Consequently, in the static context the industry expands in some regions and contracts in others even though the national industry output may remain constant.

*Richard A. Stanford is Assistant Professor of Economics and Business Administration at Furman University, Greenville, South Carolina. Jerry H. Padgett is Professor of Economics and Dean of the School of Business at Winthrop College, Rock Hill, South Carolina. The authors are indebted to Furman University for providing computer time for the statistical analysis, and to colleagues, Norman J. Wood, James L. Green, and Nicholas A. Beadles, all of the University of Georgia, for numerous helpful comments and suggestions.

It is a short step from the static theory of interregional and international resource allocation to dynamic growth theory if the assumed ceteris paribus conditions (under which given stocks of resources are reallocated) are dropped and time lapse is permitted. In the context of dynamic growth, there may occur not only interregional resource reallocation, but also positive growth of the whole economy. In theory, growth will be most rapid in those regions of highest resource productivity. Thus industry relocation may occur through growth.

In this context George Borts has undertaken an analysis of the Stolper-Samuelson proposition that resource returns tend to be equilibrated across regions:

If we assume that each region produces the same single output with the same production function, those regions with the highest proportion of capital to labor will evidence the highest real wage and the lowest marginal product of capital. In a free market we would observe capital moving from high-wage areas, with rates of growth of capital and of the return of labor. If the regional wage differentials were large enough initially, we might also observe labor migrating from the low-wage to the high-wage areas. This would yield the same equilibrating effect of the return to capital and labor, although the effects on the growth of output in each region would be somewhat different. Whether or not labor migrates, capital movements would produce an eventual elimination of regional differences in resource endowment, in the real wage, and in the marginal product of capital ...⁷

Bort's stated intent in his study is to analyze the degree to which wages converge across regions over time. Yet his approach to that problem suggests a possibly useful approach to the analysis of the regional industry location and growth, i. e., measures of regional marginal productivities of resources.

In a 1958 article, Jerome Stein formulated a method of constructing measures of the marginal productivity of capital across regions for comparative purposes.⁸ He proposed the employment of this device in his 1960 article which concentrated attention on the productivity of the single resource, capital, to explain and predict regional industry growth.⁹ In a joint 1961 article Borts and Stein used the method to construct measures of the marginal productivity of capital for various industries within a single region. These measures were used in a simple correlation context as independent variables to predict the rate of growth:

We are interested in predicting the growth of employment in specific industries from a knowledge of the rate of return on investment in those industries. We calculate this rate of return for both prior and concurrent periods, relying mainly on the former as our predictor. The industries are the 4-digit members of Census Group No. 35, Non-Electric Machinery. We predict the growth for the New England region; but this method could be used for any region or for any industry for which data are available.¹⁰

The present study employs a modification of the procedure suggested by Borts and Stein. They were concerned with relative employment growth between industries, and thus performed correlations for a number of industries within a single region. In contrast, the present study is concerned with industry location and relative growth across regions, and thus employs correlation tests for a single industry across a number of regions.

The general hypothesis tested in this study is that regional industry location, and changes thereof, are significantly associated, after some time lag, with value productivity ratios which can be constructed from available data. Four sub-hypotheses were tested:

- a. Hypothesis I: Industry locates with respect to labor availability and productivity conditions.
- b. Hypothesis II: Decision-makers locate plants so as to maximize their own value productivities and money incomes.
- c. Hypothesis III: Industry is located so as to maximize the productivity of plant and equipment.
- d. Hypothesis IV: Industry is located regionally with respect to tax cost considerations and the dictates of proprietary and creditor interests.

The method of testing the hypotheses is to employ simple and multiple correlation-regression analyses to test for the existence and significance of the relationships. Since data availability does not permit the construction of ratios for all successive years over any period, time series analysis is precluded. However, output/input ratios may be constructed by states for a number of years for which data are available, and correlated as independent variables against industry location coefficients as dependent variable in those or subsequent years. Thus, cross-sectional simple and multiple correlation-regression analyses for varying time lags between independent and dependent variables are the primary tools of analysis. The basic explanatory regression equation is of the linear form

$$Y = c_0 + c_1X_1 + c_2X_2 + \dots + c_nX_n,$$

where X_1 through X_n are productivity ratios for regional industry resource inputs at some time t , and Y is a measure of industry location at some time $t+r$; r may be zero or positive. Logarithmic transformations were employed to determine whether relationships are curvilinear rather than linear.

II. CONSTRUCTION OF OUTPUT-INPUT MEASURES

Available data for the Food and Kindred Products industry group, SIC 20, are sufficiently complete¹¹ for a number of time periods to permit construction of two- and three-digit state industry output/input ratios for non-wage (S_{ij}), wage (W_{ij}), and new capital expenditure (K_{ij}) inputs, where i designates the industry and j the state. Value added by manufacture (V_{ij}) may be used as the measure of output at the two-digit level. Payroll may be subtracted from value added by manufacture to arrive at a measure of the residual expenditure (R_{ij}) made by firms in the industry on all items other than payroll and materials. This residual covers a variety of expenditures, including payments of principle and interest on long-term and short-term financing, taxes to various governments, dividends, and profits paid into retained earnings. It was decided for purposes of this study to keep the analysis at the two-digit level in order to maximize the number of observations by states. Consequently, an analysis of a materials-use productivity hypothesis is precluded. A subsequent extension to the four-digit level would permit such an analysis, but at the expense of a smaller number of observations.

Three types of output/input ratios for each state industry resource input expenditure were constructed for purposes of this study:

- a. Type A output/input ratio: state industry output, Q_{ij} , for the year divided by state industry expenditure on a resource input used during the year, for example, Q_{ij}/W_{ij} . This ratio is a measure of the average value productivity per dollar expenditure on the resource, on average for all firms in the regional industry.
- b. Type B output/input ratio: the increment of state industry output between the ends of specified years divided by the increment of state industry expenditure on a resource input during the same period, for example, $\Delta Q_{ij}/\Delta W_{ij}$. This ratio is a measure of the incremental value productivity per additional dollar expenditure on the resource employed on average for all firms in the regional industry during the period.
- c. Type C output/input ratio: the increment of state industry output between subsequent year-ends which is attributable to increased spending on a resource, divided by that increment of spending. This ratio represents a refinement of Type B ratio. The refinement is an attempt to approximate ceteris paribus conditions for industry output with respect to all resource inputs other than the one for which a ratio is constructed, for example $(\text{net } \Delta Q_w)_{ij} / \Delta W_{ij}$.

It was decided to construct the Type C ratios as refinements of the Type B ratios after the Type B ratios were found to be quite erratic over time and across regions. In the productivity analysis context, variation of output value may be due to variation in any or all of the inputs, or to other than input variation (e.g., demand variation). In lieu of information about other possible causes of variation, and in the absence of data for enough successive time periods to permit construction of an explicit production function for each industry, the simplifying assumption was made that output value varies proportionately with the percentage variation of each input. This assumption is expressed in the ceteris paribus approximating device used in this study. The device is a quantity index designed to deflate the total increase of output by the approximate percentage contribution of resources other than the one for which the ratio is constructed.

Neither Type B nor Type C output/input ratios can be considered as marginal productivity ratios since "marginal productivity" is a term applicable only to per-resource-unit marginal utilization by a single firm at a point in time. However, these ratios may be considered as measures of the average revenue productivity for incremental expenditure on the resource, on average for all firms in the regional industry. If the number of firms in the industry sample could be reduced to one, and if the time period of observation could be shortened to approach that for employing one more dollar's worth of a single resource, the average incremental ratios for the industry would approach the marginal value productivity per resource dollar expenditure by the firm. The calculated Type B and Type C ratios are therefore only approximate measures of marginal productivity conditions within each regional industry.

III. CONSTRUCTION OF COEFFICIENTS OF INDUSTRY LOCATION

There has been some difference of opinion in the professional economics and geography literature over how the location of manufacturing should be measured. Questions center on the choice of variables to indicate industry location and the particular form which the indicator of location should take once the appropriate variables are chosen.¹² Any of a variety of variables for which data are available could be used for the correlation analysis of the present study. Because many of the calculated productivity ratios use value

added by manufacture in their numerators, regional industry employment was selected in order to minimize the possibility of auto-correlation between the dependent and independent variables. Also avoided in the selection of employment data is the necessity of deflating for price changes over time.

A raw measure of absolute regional industry employment was tested as one type of dependent variable in the correlation analyses of this study. However, a raw measure of absolute employment would be satisfactory for purposes of correlation analysis only if the larger area were divided into regions of approximately the same size (i. e., "regionalized" as the term is often used by geographers). Data availability requires the use of states as regions. States, of course, differ in area, population, personal incomes, and stocks of resources, and thus in productive and market potential. As W. R. Thompson has suggested, such data measures are unjustifiably population weighted.¹³ Because states do differ in size, however measured, there would be little reason to suppose that productivity ratio differences should significantly explain interstate differences in absolute industry employment.

The problem may be treated by employing procedures suggested by H. O. Nourse.¹⁴ Each state industry's relative (i. e., percentage) share of the national industry total employment may be adjusted (or "weighted" or "deflated") by an appropriate size factor to approximate a uniform regionalization of the national area. For example, letting e represent regional employment, i the industry, j the state, and n the nation, the ratio $E_{ij} = e_{ij}/e_{in}$ expresses each state industry's relative share of the national industry's total employment. One such ratio may be constructed for each state for which data are available. Each of the E_{ij} ratios may then be adjusted by dividing it by P_j , the state's relative share of national population, p_j/p_n . The adjusted employment coefficient would then be expressed as

$$AE = E_{ij}/P_j = (e_{ij}/e_{in}) / (p_j/p_n).$$

This measure is equivalent to Nourse's location quotient constructed for purposes of indicating regional industry export-import status. The only difference is that the divisions are taken in a different order for purposes of justifying a methodological procedure. When considered in this manner, the collection of location coefficients are state industry location indicators which have been reduced to common size denominators on the basis of population.

The location coefficient which has been adjusted for size as described above may be interpreted as an index of the degree to which the state's population is specialized to the production of the industry's product as compared with the national industry taken as a whole. A state location coefficient greater than unity would indicate a greater degree of manufacturing specialization in the production of the industry's product than for the national industry, or for some other state with a calculated coefficient of lesser value; conversely for a coefficient of value less than unity or smaller in magnitude than the coefficient for another state.

Population, however, is not the only possible size factor which could be used to adjust the employment relative share for each regional industry. Other possible size adjustment candidates for which data are available are personal income (I_j), nonagricultural employment (N_j), all-manufacturing employment (M_j), and value added by manufacture (V_j). Each of these factors represents a different basis of specialization. The ratio E_{ij}/M_j indicates the region's degree of specialization of its manufacturing labor force (excluding unemployment) to the production of the industry's product. The ratio E_{ij}/N_j indicates the region's degree of specialization of its nonagricultural labor force (excluding unemployment) to the industry. The ratio E_{ij}/V_j indicates the percentage of the region's value added by manufacture pro-

duced by the regional industry relative to the industry nationally. The ratio E_{ij}/I_j indicates that net import-export position of the industry product for the region as used by Nourse. It thus expresses the degree of specialization of the region's personal income to the product of the industry.

Since there is no apriori way to determine which size factors described above are more or less appropriate adjusters of employment data, the regional industry relative share of national employment was adjusted separately by each of the possible weighting factors. Data for the various size-adjusted variables were tested as dependent variables against the calculated value productivity ratio independent variable data.

IV. RESULTS OF THE CORRELATION TESTS

Data for the two digit industry SIC 20, Food and Kindred Products, are available for as many as forty-two states over the 1947-66 period. Multiple correlation coefficients for the SIC 20 Type LE (raw employment data) dependent variables and Type A independent variables never exceeded 0.45 in several simultaneous correlation tests. The highest multiple correlation coefficient, 0.4414, occurred for the LE66/A66 test (this notation shall be understood to indicate the dependent variable and its data to the left of the slash, the independent variables and their data to the right of the slash) with log transformation performed on dependent variable data for this test. This coefficient is significant at the 0.90 level for the forty-one state sample. A coefficient of this magnitude indicates the existence of a correlation relationship significantly different from zero, although the relationship indicated is not sufficient for explanatory purposes. The significance level is high enough for the correlation not to be due to random factors. Thus, there appears, to be no useful correlation between raw employment data (Type LE coefficients) and the average productivity ratios (Type A) over the 1947-1966 period for the entire SIC 20 sample.

The gross incremental productivity ratios (Type B) showed little more promise as predictors of location than did the Type A ratios. Statistically significant, non-zero correlation again was indicated, but because of rather unimpressive or erratic results, Type B ratios cannot be accepted as useful for explanation of Type LE industry location coefficients. The net incremental productivity ratios (Type C) were generally not as good as the Type B ratios relative to explanation of raw employment location data.

Because of generally poor results, it must be conceded that there exist no significant or consistent relationships between the raw employment (Type LE) location coefficients and any of the constructed productivity ratios. These poor results, together with the objection that the Type LE coefficients are unjustifiably population weighted, led to the development of the size-adjusted Type AE location coefficients as refinements of the LE coefficients.

W.R. Thompson's criticism (that raw data for industry location are unjustifiably population weighted since no account is taken of the necessity for the productive capacities of different states to produce for different population sizes) would be of little consequence for an industry which is highly localized to a very few states, and which exports the major part of its product to other states. The Thompson criticism is quite relevant, however, to the U.S. Food and Kindred Products Industry since a major portion of each state's production of manufactured or processed food products is consumed locally.

In order to determine whether or not adjustment of state industry employment data for population size differences (i.e., industry employment per

capita of population or labor force) would have any consequence for the explanation of industry location or growth, the Type AE location coefficients were constructed as indicated above. Table 1 presents the multiple correlation coefficients for simultaneous relationships between the various Type AE location coefficients and Type A productivity ratios. The log transformation was performed on data for dependent variables. The multiple correlation coefficients presented in Table 1 were generally much higher and more consistent over time than the relationships between productivity ratios and raw employment data (the Type LE location coefficients). It appears that the Type A productivity ratios explain the AEP and AEN location coefficients at about the same level, the AEM coefficients at a somewhat lower level, and the AEI and AEV ratios at a yet lower level. The AEP/A and AEN/A multiple correlation coefficients all exhibit significance in excess of the 0.99 level. Correlation coefficients of this magnitude and significance indicate the existence of relationships which are useful for explanatory purposes. A comparison of the Types AE and LE correlation results indicates that the calculated productivity ratios could not significantly explain the absolute pattern of industry location, but did with notable success explain the location of manufacturing employment per capita of population in industry SIC 20.

TABLE 1. MULTIPLE CORRELATION COEFFICIENTS FOR SIMULTANEOUS CORRELATION BETWEEN TYPE A PRODUCTIVITY RATIOS AND TYPE AE LOCATION COEFFICIENTS ADJUSTED BY PERSONAL INCOME (I), POPULATION (P), NONAGRICULTURAL EMPLOYMENT (N), ALL-MANUFACTURING EMPLOYMENT (M), AND VALUE ADDED BY MANUFACTURE (V).

Variables	AEI	AEP	AEN	AEM	AEV
AE47/A47	0.5897	0.7672	0.7665	0.6844	0.6139
AE54/A54	0.5794	0.6594	0.6885	0.6970	0.6193
AE58/A58	0.5384	0.6566	0.6454	0.6663	0.6098
AE63/A63	0.5795	0.7417	0.7334	0.6299	0.5934
AE66/A66	0.5129	0.6610	0.6253	0.6538	0.7089

The correlation tests for all of the Type AE location coefficients and Type A productivity ratios consistently showed the salaried (S) and wage (W) productivity ratios to produce the highest simple correlation coefficients. The AE/A-S simple coefficients were always positive, generally between 0.35 and 0.5, and significant above the 0.7 level. The AE/A-W coefficients were always negative, generally between -0.4 and -0.7, and significant above the 0.8 level. The AE/A-K and AE/A-R simple coefficients were all lower and almost insignificant. This may indicate that location decision-makers tended to react positively and significantly to the salaried productivity conditions, which determine the decision-makers' returns, while wage productivity conditions relate to the cost of a resource which the decision-makers would like to minimize.

The AEP, AEN, and AEM location coefficients differ by the size adjustment factors, P including the entire labor force, N the nonagricultural labor force, and M the manufacturing labor force in each state (abstracting from unemployment). The fact that the level of explanation was typically higher for the AEP than AEM coefficients indicates that the industry probably drew broadly from the total labor force of the region rather than narrowly from the manufacturing labor force, and thus that the industry generally employed less technically specialized labor. Because they were explained at significantly lower levels than the AEP, AEN, and AEM coefficients, and AEI and AEV ratios were deleted from further analysis.

The AEP, AEN, and AEM location coefficients were tested as dependent variables for lagged correlation with Type A productivity ratios for two

different years, 1947 and 1954, to check for consistency of results over different time periods. Results are presented in Table 2. Some of the fluctuation of coefficients for successively longer time lags between dependent and independent variables is due to differences in the size and content of samples for the included years. The Department of Commerce failed to report data for some states during some years. Most notably, data for Wyoming were absent for 1950, 1951, 1952, 1953, 1955, and 1956, but were present for all other years. When data for Wyoming were present in the sample, the observation with the largest residual between the observed and estimated values for the dependent variables was consistently that for Wyoming. The impact on the correlation analyses was the appearance of much higher correlation coefficients when data for Wyoming were absent. Because of differences in sample size and content, it is difficult to determine the time lag of highest correlation. However, on the basis of the results for years which contain approximately the same observations, it appears that the level of correlation improved over a time lag of two or three years, and then decreased gradually for successively longer timelags. This seems to be true of results for Types AEP, AEN, and AEM location coefficients.

TABLE 2. MULTIPLE CORRELATION COEFFICIENTS FOR LAGGED RELATIONSHIPS BETWEEN TYPE A INDEPENDENT VARIABLES AND TYPE AE DEPENDENT VARIABLES ADJUSTED BY POPULATION (P), NONAGRICULTURAL EMPLOYMENT (N), AND ALL-MANUFACTURING EMPLOYMENT (M). THE LOG TRANSFORMATION WAS PERFORMED ON DEPENDENT VARIABLES FOR EACH TEST.

	AEP	AEN	AEM
AE47/A47	0.7672	0.7665	0.6844
AE50/A47	0.8105	0.8132	0.6872
AE51/A47	0.8824	0.8141	0.6318
AE52/A47	0.8392	0.7733	0.5749
AE53/A47	0.7465	0.6715	0.5039
AE54/A47	0.6511	0.6591	0.6380
AE55/A47	0.7672	0.6090	0.6191
AE56/A47	0.7602	0.7593	0.6107
AE57/A47	0.6095	0.6582	0.6288
AE58/A47	0.6044	0.5634	0.6331
AE59/A47	0.6066	0.5824	0.5949
AE60/A47	0.5803	0.5496	0.5773
AE61/A47	0.6585	0.5712	0.6036
AE62/A47	0.6343	0.5297	0.5520
AE63/A47	0.6918	0.5210	0.5770
AE64/A47	0.7488	0.5625	0.5604
AE65/A47	0.6590	0.5552	0.6187
AE66/A47	0.5459	0.6682	0.6225
AE54/A54	0.6594	0.6885	0.6970
AE55/A54	0.7997	0.8260	0.7096
AE56/A54	0.7686	0.8167	0.6765
AE57/A54	0.6553	0.6746	0.6836
AE58/A54	0.6386	0.6091	0.7170
AE59/A54	0.6402	0.6321	0.6820
AE60/A54	0.6242	0.6113	0.6673
AE61/A54	0.6590	0.6731	0.7039
AE62/A54	0.6359	0.6306	0.6686
AE63/A54	0.6193	0.5848	0.6441
AE64/A54	0.7068	0.6623	0.6650
AE65/A54	0.6269	0.6326	0.7069
AE66/A54	0.5900	0.5999	0.6252

Correlation results for Type B productivity ratios as predictors of Type AE location coefficients were unimpressive and highly erratic. Multiple correlation coefficients for AE/B relationships rarely exceeded 0.4, and never appeared with any degree of consistency over time for simultaneous or lagged correlations.

Results for Type C productivity ratios as predictors of Type AE location coefficients were similar to Type A results, although the level of explanation by Type C ratios was typically ten percentage points lower than for Type A ratios. Since they exhibited the same general properties and predictive trends as Type A ratios, and Type C results were regarded as supporting the finds for the Type A ratios.

Because the AE refinement of the LE location coefficients resulted in higher levels of correlation, the Type DAE coefficients were calculated as the change of the Type AE coefficients over specified time span. The log transformation performed on all data for the DAE tests consistently gave poorer correlation results than the linear data for Types A, B, and C productivity ratios.

Type A productivity ratios generally explained Type DAE location change at a lower level than the Type C ratios. Since the correlation results for the Type A ratios generally exhibited similar characteristics and time period trends as the Type C ratios, they are regarded as supporting the Type C findings. The Type B ratios again proved to be almost useless as potential predictors of Type DAE location change.

Multiple correlation coefficients for the DAE/C simultaneous and lagged relationships are presented in Table 3. Because results were somewhat mixed in the simultaneous tests, it is difficult to estimate whether the results for the DAE-P or DAE-N coefficients are better, although both appear to be superior to the DAE-M results. The highest multiple correlation coefficient, 0.5341 for the DAE-N47-54/C47-54 test, is significant at the 0.999 level. It appears, however, that for the simultaneous tests the relationship between DAE and C deteriorated as time passed. The results of the time-lag tests presented in Table 3 indicate that Type C explanation of the DAE-N coefficients is superior to both DAE-P and DAE-M results. All of the DAE-N/C multiple correlation coefficients after 1952 are significant at the 0.99 level or above.

TABLE 3. MULTIPLE CORRELATION COEFFICIENTS FOR SIMULTANEOUS AND LAGGED RELATIONSHIPS BETWEEN TYPE C PRODUCTIVITY RATIOS AND TYPE DAE LOCATION COEFFICIENTS ADJUSTED BY POPULATION (P), NONAGRICULTURAL EMPLOYMENT (N), AND ALL-MANUFACTURING EMPLOYMENT (M). DATA FOR ALL TESTS WERE LINEAR.

	DAE-P	DAE-N	DAE-M
DAE47-54/C47-54	0.5341	0.7374	0.6269
DAE54-58/C54-58	0.5394	0.4989	0.1487
DAE58-63/C58-63	0.4540	0.3809	0.2984
DAE63-66/C63-66	0.4791	0.5273	0.3098
DAE47-50/C47-54	0.1768	0.4256	0.4087
DAE47-52/C47-54	0.3180	0.0688	0.2018
DAE47-54/C47-54	0.5341	0.7374	0.6290
DAE47-54/C47-54	0.5123	0.7087	0.6407
DAE47-58/C47-54	0.5525	0.7175	0.5738
DAE47-60/C47-54	0.4803	0.7401	0.6200
DAE47-63/C47-54	0.4600	0.7529	0.6115
DAE47-66/C47-54	0.4376	0.7103	0.6402

The highest simple correlation coefficients for the DAE/C simultaneous and lagged relationships consistently resulted for the Type C wage (W) productivity ratio. The simple correlation coefficients for the DAE-N (W) series were usually positive, between 0.65 and 0.75, and significant above the 0.99 level. Other simple correlation coefficients were much smaller and almost insignificant.

V. CONCLUSIONS FROM THE SIC 20 ANALYSIS

Several tentative conclusions may be drawn from the analysis of relationships for SIC 20 over the 1947-66 period.

- a. Type AE location coefficients (i.e., the relative-share size adjusted employment coefficients) could be explained (simultaneously) and predicted (over time lags) more successfully than could the Type LE location coefficients.
- b. Type B productivity ratios (gross incremental) seldom proved to be useful for explanation or prediction of existing location or location change.
- c. Type A productivity ratios average were generally superior to Type C ratios (net incremental) as explainers and predictors of Type AE location coefficients.
- d. Type A productivity ratios for the salaried (S) and wage (W) input expenditures generally resulted in the highest and most significant simple correlation coefficients.
- e. Type C productivity ratios were generally superior to Type A ratios as explainers and predictors of Type DAE location-change coefficients. Thus Type A productivity ratios best explain existing location patterns at various points in time, but Type C productivity ratios best explain and predict location change over time.
- f. The Type C productivity ratio for the wage input expenditure generally resulted in the highest and most significant simple correlation coefficient in the explanation and prediction of Type DAE location-change coefficients. Thus, the S and W average productivity ratios best explain existing industry location patterns, while decision makers seem to react most strongly to the W incremental productivity ratios in making industry relocation decisions.

The purpose of this study has been to measure the degree to which hypothetically rational economic behavior predicated solely on measurable revenue and cost considerations is a determinant of industry location. Because many possible non-measurable criteria for industry location were omitted from the test model, it must be conceded that a rationality of behavior depending only on revenue-cost conditions is very narrowly defined. Therefore, it was felt that a demonstration of fifty percent or more of the variation in industry location or growth patterns due to productivity considerations would be quite meaningful.

Correlation coefficients calculated in tests for this study never exceeded 0.9, and rarely exceeded 0.8. The fact that the coefficients typically failed to reach these magnitudes only indicates the existence of a significant amount of random variation, imperfectly rational behavior, or behavior predicated upon criteria other than measurable revenue-cost considerations. It is beyond the scope of this study to attempt to measure the extent to which

the non-revenue/cost factors determine location and growth patterns. The fact that correlation coefficients for industry SIC 20 often did exceed 0.7 in magnitude is gratifying, for it indicates that fifty percent or more of the variation of industry location, location change, or growth is explained by the theoretical economic criteria.

The correlation results for industry SIC 20 generally give support to Hypothesis I (i.e., "Industry locates and grows with respect to labor availability and productivity conditions") in the explanation of Types AE and DAE location coefficients. The relationships between the wage productivity ratios and the location pattern coefficients were typically negative, indicating that the industry tended to be more concentrated relative to population in states with lower wage input productivity conditions. These results are not necessarily inconsistent. Interpreted together, these results may indicate that the industry was not optimally located with respect to labor productivity conditions, but was in the process of relocating toward more optimal conditions.

The correlation results for industry SIC 20 give support to Hypothesis II (i.e., "Decision-makers locate plants so as to maximize their own value productivities and money incomes") in the explanation of all types of location coefficients tested. The relationships were all positive for the incremental productivity ratios, indicating that the industry was more concentrated relative to population in states with higher productivity for the salaried inputs, and the relocation and growth tended to occur toward states with higher productivity levels. Taken together, the salaried and wage simple correlation results indicate that the industry tended to be concentrated at any point in time in certain states because of their salaried input productivity, and in spite of their wage input productivity. However, the industry tended to relocate to states where both salaried and wage productivity conditions were better. Thus, salaried productivity conditions appear to override the labor conditions, except where the effect was mutual reinforcement.

The capital and residual productivity ratios rarely were found to be significant in the explanation of the various types of location coefficients for SIC 20. Consequently, little support for these hypothesis was found in the SIC 20 results.

The authors believe that results of this study are significant enough to warrant subsequent incursions into the data. The obvious next step is to extend the analysis to other two digit industry groups, and then to the narrower industry classifications. Although data availability is currently limited, in the future it may be possible to conduct the analysis on the level of Standard Metropolitan Statistical Areas (SMSA) or counties. At the state level of analysis useful results might be attained by decomposing the entire sample of states into sub-samples for correlation testing on the basis of geographical regions or levels of development or industrialization. Ultimately the analysis should be directed toward attempting to identify the factors which determine resource input productivities.

FOOTNOTES

¹Examples of the questionnaire-interview method of industry location analysis are provided by M. L. Greenhut and M. R. Colberg, Factors in the Location of Florida Industry, Florida State University Studies, Number Thirty-Six (Tallahassee: Florida State University, 1962); and R. E. Carrier and W. R. Schriver, "Location Theory: A Empirical Model and Selected Findings," Land Economics, Vol. XLIV (November, 1968), pp. 450-66.

²The method of the ultra empiricist is to test every possible hypothesis, and to accept no hypothesis which is not tested. A study which is reminiscent of this method in terms of the very wide coverage of possible deterministic variables is that by V. R. Fuchs, Changes in the Location of Manufacturing in the United States since 1929 (New Haven: Yale University Press, 1962).

³See J. R. Meyer's discussion of the objections to these approaches in "Regional Economics: A Survey," American Economic Review, Vol. LIII (March, 1963), pp. 35-36.

⁴See Meyer, op. cit., p. 31, on the results of comparative cost analysis of industry location.

⁵An example of the factor-ratio approach is provided by J. R. Moroney and J. M. Walker, "A Regional Test of the Heckscher-Ohlin Hypothesis," Journal of Political Economy, Vol. LXXIV (1966), pp. 573-86, who find only partial support for the Heckscher-Ohlin factor intensity hypothesis. Their procedure is criticized by E. F. Estle, who makes different assumptions about regional factor endowments, "A More Conclusive Test of the Heckscher-Ohlin Hypothesis," Journal of Political Economy, Vol. LXXV (1967), pp. 886-88.

⁶W. F. Stolper and P. A. Samuelson, "Protection and Real Wages," Review of Economic Studies, Vol. IX (November, 1941), pp. 58-73.

⁷G. Borts, "The Equilization of Returns and Regional Economic Growth," American Economic Review, Vol. L (June, 1960), p. 321.

⁸J. L. Stein, "Interregional Comparisons of the Marginal Product of Capital," Southern Economic Journal, Vol. XXV (July, 1958), pp. 24-32.

⁹J. L. Stein, "A Theory of Interstate Differences in Rates of Growth of Manufacturing Employment in a Free Market Area," International Economic Review, Vol. I (May, 1960), pp. 112-28.

¹⁰G. H. Borts and J. L. Stein, "Investment Return as a Measure of Comparative Regional Economic Advantage," in W. Hochwald, ed., Design of Regional Accounts (Baltimore: The Johns Hopkins Press, 1961), p. 83.

¹¹U. S. Department of Commerce, Bureau of the Census, Census of Manufactures, editions from 1947 through 1963 (Washington, D. C.: U. S. Government Printing Office); Annual Survey of Manufactures, editions from 1950 through 1966 (Washington, D. C.: U. S. Government Printing Office).

¹²A Discussion of alternative measures is included in J. W. Alexander and J. B. Lindberg, "Measurement of Manufacturing: Coefficients of Correlation," Journal of Regional Science, Vol. III (1961), pp. 71-81.

¹³W. R. Thompson, "The Coefficient of Localization: An Appraisal," Journal of Political Economy, Vol. LXIII (June, 1958), pp. 320-25.

¹⁴H. O. Nourse, Regional Economics: A Study in the Economic Structure, Stability, and Growth of Regions (New York: McGraw Hill, Inc., 1968), p. 66.

REFERENCES

Alexander, J.W., and Lindberg, J.B., "Measurement of Manufacturing: Coefficients of Correlation," Journal of Regional Science, Vol. III (1961), pp. 71-81.

Borts, G.H., "The Equilization of Returns and Regional Economic Growth," American Economic Review, Vol. L (June, 1960), pp. 319-47.

_____, and Stein, J.L., "Investment Return as a Measure of Comparative Regional Economic Advantage," in Hochwald, W., ed., Design of Regional Accounts, Baltimore: The Johns Hopkins Press, 1961.

Carrier, R.E., and Schriver, W.R., "Location Theory: An Empirical Model and Selected Findings," Land Economics, Vol. XLIV (November, 1968), pp. 450-460.

Estle, E.F., "A More Conclusive Test of the Heckscher-Ohlin Hypothesis," Journal of Political Economy, Vol. LXXV (1967), pp. 886-88.

Fuchs, V.R., Changes in the Location of Manufacturing in the United States Since 1929. New Haven: Yale University Press, 1962.

Greenhut, M.L., and Colberg, M.R., Factors in the Location of Florida Industry. Florida State University Studies, Number Thirty-Three Tallahassee: Florida State University, 1962.

Meyer, J.R., "Regional Economics: A Survey," American Economic Review, Vol. LIII (March, 1963), pp. 19-54.

Moroney, J.R., and Walker, J.M., "A Regional Test of the Heckscher-Ohlin Hypothesis," Journal of Political Economy, Vol. LXXIV (1966), pp. 573-86.

Nourse, H.O., Regional Economics: A Study in the Economic Structure, Stability, and Growth of Regions. New York: McGraw-Hill, Inc., 1968.

Stein, J.L., "A Theory of Interstate Differences in Rates of Growth of Manufacturing Employment in a Free Market Area," International Economic Review, Vol. I (May, 1960), pp. 112-28.

_____, "Interregional Comparisons of the Marginal Products of Capital," Southern Economic Journal, Vol. XXV (July, 1958), pp. 24-32.

Stolper, W.F. and Samuelson, P.A. "Protection and Real Wages," Review of Economic Studies, Vol. IX (November, 1941), pp. 58-73.

Thompson, W.R., "The Coefficient of Localization: An Appraisal," Journal of Political Economy, Vol. LXII (June, 1958), pp. 320-25.

U.S. Department of Commerce, Bureau of the Census, Census of Manufactures, editions from 1947 through 1963. Washington, D.C.: U.S. Government Printing Office. Annual Survey of Manufactures, editions from 1950 through 1966. Washington, D.C.: U.S. Government Printing Office.