A RE-EXAMINATION OF THE KENDRICK-JAYCOX METHOD OF ESTIMATING GROSS STATE PRODUCT

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Recently, there have been several attempts to estimate gross state product by using the method developed by John W. Kendrick and C. Milton Jaycox [1].[1] The Kendrick-Jaycox method involves estimating gross product originating for each of the one digit major industries and summing the total to yield gross state product. Since the Kendrick-Jaycox procedure provides the gross state product figure on an industry breakdown, it is extremely useful for comparative state and regional analysis. A large part of the method's popularity is based on this industry disaggregation.[2]

The basic assumption required by the Kendrick-Jaycox method for industries in the private nonfarm sector is that factor proportions are similar within industry groups for the various states and the nation for given years. This assumption is required due to the fact that the estimates of gross state product originate on the basis of labor payroll data, namely income received by persons for participation in current production.[3] For each private nonfarm industry, the income received figure is inflated by a series of national coefficients to yield an estimate of output originating. The procedure for a given year for each private nonfarm industry works as follows;

$$\frac{YO_n^a}{YR_n^a} \cdot YR_s^a = YO_s^a \tag{1}$$

$$\frac{KC_n^a}{YO_n^a} \cdot YO_s^a = KC_s^a \tag{2}$$

$$\frac{IBT_n^a}{YO_n^a} \cdot YO_s^a = IBT_s^a \tag{3}$$

where YO = income originating, YR = income received, KC = capital consumption, IBT = indirect business taxes, a represents industry a, and the subscripts n and s represent nation and state respectively. The sum of equation (1), (2), and (3) yields gross product originating in the particular industry.

The purpose of this paper is twofold: first, a test is made for the reliability of assuming similarity of factor proportions in the private nonfarm industries between the individual states and the nation; second, an analysis is made of several sources of state and regional variation in factor proportions. It is possible to test the assumption of similarity for the leading industry of the private nonfarm group, manufacturing, through the use of value

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added and labor payroll data collected by the U.S. Department of Commerce in the Annual Survey of Manufactures.[4] Value added is conceptually equivalent to gross product originating and labor payroll is conceptually equivalent to income received. On the basis of these figures it is possible to construct annual estimates of an output-labor ratio in manufacturing for each state during the postwar period.[5]

The ratio of value added to labor payroll was computed for each state and the nation for four sample years: 1950, 1955, 1960, and 1965. For each sample year, the mean output-labor ratio of all states was computed and compared to the national average. It was found that in each year the mean of all states was in the neighborhood of the national average; the percentage variation in each year was as follows: 1950, 6.8%; 1955, 7.7%; 1960, 5.4%, and 1965, 6.0%.[6] However, despite this close conformity of the mean of all states to the national average, the deviation around the state mean was very large. The 90% confidence intervals around the state means were as follows:

1950 1.52-2.58 ($\bar{x}$ = 2.05, σ = .315)

1955 1.42-2.50 ($\bar{x}$ = 1.96, σ = .321)

1960 1.59-2.33 ($\bar{x}$ = 1.96, σ = .222)

1965 1.62-2.62 ($\bar{x}$ = 2.12, σ = .295)

A number of states were reasonably well represented by the national output-labor ratio in each sample year. (See Table 1). Generally, however, use of the national average output-labor ratio would have led to a bias in excess of 5% in 70% or more of the states. Kendrick and Jaycox and others who have used the Kendrick-Jaycox method have suggested that the assumption of similarity of factor proportions between the states and the nation is most appropriate for the economically more developed and diversified states. Per capita income was taken by this author as indicative of general levels of development and the percentage share of manufacturing employment of the private nonfarm total was used to reflect diversification away from primary economic activity. A review of Table 1 does not suggest much in the way of homogeneity of levels of development or extent of diversification among those states most conformable to national factor proportions; in fact, the suggestion is that a broad spectrum of states were represented by the national output-labor ratio.

For example, in 1950 those states in which the use of the Kendrick-Jaycox procedure for estimating gross product originating in manufacturing would have resulted in an error of 5% or less included a number of high ranking per capita income states: California (5), New Jersey (6), Illinois (7), Michigan (8), and Washington (9). However, a number of low per capita income states were equally well represented: Georgia (41), Mississippi (47), North Carolina (40), and South Carolina (44). The pattern of extremely high and low per capita income states both approximating the national output-labor ratio was characteristic of the other sample years. In 1955 the per capita income ranking of the states best represented by the national output-labor ratio ranged from California (4) to North Carolina (42); in 1960 the range was from New Jersey (7) to Idaho (34); and in 1965 the range was from Illinois (4) to Mississippi (50).

Similarly, a group of different industrial structures approximated national factor proportions. In 1965 several high ranking industrial states demonstrated factor proportions closely approximating those of the nation: Indiana (5), Michigan (6), Ohio (7), and Rhode Island (8). On the other hand, several non-industrialized states also demonstrated a close proximity to the national output-labor ratio: South Dakota (46), Colorado (42), Minnesota (32), and Maryland (40). In the other sample years there were extremes on both sides that were well represented by the national output-labor ratio; the range of extremes was as follows: 1950, Michigan (3) to North and South Dakota (46); 1955, Michigan (2) to New Mexico (47); and 1960, Indiana (5) to New Mexico (48).

Linear regression analysis was used to further test the relationship between state-national variation in factor proportions and levels of development and diversification. The variables were specified as follows: Y = the ratio of value added/labor payroll in each state minus the ratio of value added/labor payroll in the nation; X_1 = per capita income in each state minus per-capita income in the nation; and X_2 = the percentage share of manufacturing employment in total private nonfarm employment in each state minus the percentage share of manufacturing employment in total private nonfarm employment in the nation. Using this model for the four sample years yields the following results.

$$1950 \quad Y = 7.401 + \underset{(.0123)}{.0066X_1} - \underset{(.0306)}{.1312X_2} \qquad R^2 = .295 \tag{4}$$

$$1955 \quad Y = 6.312 - \underset{(.0114)}{.0082X_1} - \underset{(.0348)}{.1182X_2} \qquad R^2 = .238 \tag{5}$$

$$1960 \quad Y = 3.248 - \underset{(.0062)}{.0202X_1} - \underset{(.0226)}{.0864X_2} \qquad R^2 = .359 \tag{6}$$

$$1965 \quad Y = 4.796 - \underset{(.0082)}{.0198X_1} - \underset{(.0332)}{.0998X_2} \qquad R^2 = .255 \tag{7}$$

Several significant conclusions are obtained from the regression analysis. First, it appears that the variables chosen to reflect economic development levels and diversification away from primary economic activity do not explain much of the state-national variation in output-labor ratios. Second, the significant relationships that do show up in the regression are the opposite of what has been suggested by those who have developed and used the Kendrick-Jaycox method. It appears that states with relatively high concentration in manufacturing are characterized by relatively labor intensive production. The same type of positive relationship has developed recently between the relative level of per capita income and the relative factor share going to labor. In short, there does not appear to be any reason to expect the more developed and diversified states to have factor proportions in line with those in the nation. The results here indicate that states with above average levels of per capita income or above average development in manufacturing tend to have below average output-labor ratios.

After reviewing the application of the Kendrick-Jaycox method to the manufacturing sector, the conclusion reached is that the method may not be useful for large numbers of states.[8] With respect to levels or types of development within the select group of states which best fit the crucial assumption of similarity to national factor proportions, there does not appear to be

any homogeneity. However, it should be reiterated that this author's appraisal only concerns the manufacturing sector and the value added/labor payroll weight devised by Kendrick can correct for the bias in manufacturing.

TABLE 1
STATES MOST REPRESENTATIVE OF THE NATIONAL OUTPUT-LABOR RATIO

State	Percentage Error Using National Output-Labor Ratio[a]	Rank According to Per Capita Income	Rank According to Percentage of Private Nonfarm Employment in Manufacturing[c]
		1950	
Georgia	0.00	41	17
Ohio	0.52	13	9
New Jersey	2.08	6	6
Illinois	2.08	7	16
North and South Dakota	2.08	33	46
Mississippi	2.08	47	25
California	2.08	5	32
North Carolina	2.60	40	8
Indiana	3.12	18	6
Michigan	3.12	8	3
South Carolina	3.12	44	6
Washington	3.64	9	26
Wisconsin	4.16	22	12
Nebraska	4.16	19	38
Pennsylvania	4.68	17	14
		1955	
Illinois	0.55	7	15
Nebraska	0.55	30	37
Wyoming	0.55	17	45
Ohio	1.10	9	6
Washington	1.10	10	30
Oregon	1.10	14	22
Vermont	1.65	36	16
New Jersey	2.20	5	8
Indiana	2.20	15	3
Maryland	2.20	12	21
California	2.20	4	26
Wisconsin	2.75	19	11
Michigan	3.30	8	2
Pennsylvania	3.85	16	12
Missouri	4.95	21	23
New Mexico	4.95	35	47
North Carolina	4.95	42	8

TABLE 1
STATES MOST REPRESENTATIVE OF THE NATIONAL OUTPUT-LABOR RATIO
Continued

State	Percentage Error Using National Output-Labor Ratio[a]	Rank According to Per Capita Income	Rank According to Percentage of Private Nonfarm Employment in Manufacturing[c]
		1960	
Ohio	0.54	12	9
Illinois	0.54	8	15
New Mexico	0.54	32	48
Indiana	1.62	19	5
Wisconsin	1.62	20	11
Rhode Island	2.16	18	7
Oregon	2.16	17	24
New Jersey	2.70	7	9
Minnesota	2.70	23	32
Idaho	2.70	34	35
Colorado	4.32	14	39
Michigan	4.32	13	6
		1965	
Vermont	0.00	35	17
Mississippi	0.00	50	19
New Jersey	0.50	7	10
Maryland	0.50	11	30
South Dakota	1.00	39	46
Illinois	1.00	4	15
Rhode Island	1.50	16	8
Michigan	1.50	10	6
Minnesota	1.50	22	32
Ohio	2.50	15	7
Missouri	2.50	23	22
Colorado	3.00	20	42
Wisconsin	3.50	19	11
Oregon	4.00	17	27
Indiana	4.50	14	5

[a]Only those states are shown in which use of the national output-labor ratio would have resulted in error of 5.0% or less.

[b]The per capita income ranking was made on the basis of the revised personal income figures published in the August, 1969 issue of the Survey of Current Business, U.S. Department of Commerce.

[c]The ranking according to shares of private nonfarm employment contributed by manufacturing was made on the basis of data obtained from Employment and Earnings Statistics for States and Areas, 1939-65, U.S. Deptment of Labor.

The bias resulting from the assumption of similar factor proportions within industries in the nation and all states is likely to be much lower in those industries with high relative labor inputs and those industries producing services. The private nonfarm industries in which the bias cannot be eliminated (transportation, communication and public utilities, finance, insurance and real estate, wholesale and retail trade, services, construction, and mining) generally fall into one of these two categories. Therefore, the modified Kendrick-Jaycox method may yield useful results for the researcher concerned with regional economic growth. However, one must recognize the limitation and biases incorporated in the method in order to interpret the results in a meaningful way.

FOOTNOTES

[1]The basic method was developed by John W. Kendrick and C. Milton Jaycox, "The Concept and Estimation of Gross State Product," Southern Economic Journal, October, 1965, pp. 153-168. Recently, W. L. L'Esperance, G. Nestel, and D. Fromm, "Gross State Product and an Econometric Model of a State," Journal of the American Statistical Association, September, 1969, pp. 787-807, estimated gross state product for Ohio using the Kendrick-Jaycox procedure. The Federal Reserve Bank of Boston published estimates of gross state product in the New England states, also based on the Kendrick-Jaycox method, which appeared in the New England Business Review, July, 1966, pp. 7-11. This author wrote his dissertation, New England: Gross State Product and Productivity, 1948-65, University of Connecticut, 1969, under the direction of John Kendrick and prepared estimates for Georgia, Georgia: Gross State Product and Productivity, 1950-68, Division of Research, College of Business Administration, University of Georgia, 1970; in both instances the modified Kendrick-Jaycox method outlined in this paper was used.

[2]Recently, an attempt to estimate gross state product from the income side has been developed by Harold K. Charlesworth and William Herzel, The Gross State Product of Kentucky: 1968, Office of Development Services and Business Research, College of Business and Economics, University of Kentucky. This approach avoids the simplifying assumptions involved in the Kendrick-Jaycox approach and provides the most direct estimation technique developed to this date.

[3]The estimates of income received are generally published by the U. S. Department of Commerce in the August issue of the Survey of Current Business as a supplement to the state personal income series.

[4]Of the private nonfarm group of industries, output figures are only available for manufacturing; therefore, the tests performed in this paper are restricted to manufacturing. All data used in this paper to construct output-labor ratios has been taken from the appropriate volumes of the Annual Survey of Manufactures, U. S. Department of Commerce.

[5]During the preparation of his dissertation, this author was advised by John Kendrick to use the Commerce manufacturing data to weight his estimates of gross product originating in manufacturing in the New England states. The weight was designed by Kendrick to eliminate the influence of national factor proportions on the state output estimates and was contructed as the ratio of value added per unit of labor payroll in each state to value added per unit of labor payroll in the nation.

[6]The following output-labor ratios were computed for the nation and for the average of all states:

	1950	1955	1960	1965
Nation	1.92	1.82	1.86	2.00
States	2.05	1.96	1.96	2.12

[7]This suggestion is found in Kendrick and Jaycox, p. 157, and in L'Esperance et. al, p. 789.

[8]The modifications of the model of estimating gross product originating in manufacturing developed by Kendrick and used by this author partially overcome the problems involved in assuming similarity of factor proportions among states and the nation. In defense of Kendrick and Jaycox, it should also be pointed out that they never claimed that the method would yield exact results. They viewed their contribution as a temporary device to be used to provide interim estimates of gross state product and to provoke further thought and analysis concerning regional economic growth.

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