Industrial Diversification and Productivity

——An Empirical Study——

by

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I. Introduction

As an explanation for interregional specialization and trade, the classical doctrine of comparative advantage has been generally accepted. When the doctrine of comparative advantage is viewed in the context of economic development, its applicability to the growing economies is limited by its static framework.[1)]

Recognizing the importance of such dynamic elements as changing technology, external economies, and economies of scale, some authors point out the necessity of reinterpreting the classical doctrine, taking explicit account of dynamic elements---namely, the elements which affect changes in the efficiency of production and divergence between social and private costs and benefits. the theory of economic development centers around the interactions over time among producers, consumers, and investors within a given economy.[2)] Thus some authors, recognizing the importance of complementarity of industries over time, have advanced a dynamic interpretation of external economies.[3)]

The nature and sources of external economies are diverse, and opinions differ

1) An excellent discussion of the classical doctrine of comparative advantage vs. the modern growth theory is presented by H.B. Chenery in "Comparative Advantage and Development Policy," American Economic Review, LI (March, 1961), pp. 18~51.

2) For an exposition of the necessary conditions concerning technology, tastes, and producers' motivations for the correspondence between the competitive equilibrium conditions and the requirements of Paretian efficiency in a static framework, the reader is referred to F.M. Bator, "The Anatomy of Market Failure, "Quarterly Journal of Economies, LXXI (February, 1957), pp. 353~56. See also, J.E. Meade, "External Economies and Diseconomies in a Competitive Situation," Economic Journal, LXII (Karch, 1952), pp. 54~67.

3) Cf. P.N. Rosenstein-Rodan, "Industrialization of Eastern and South-Eastern Europe," Economic Journal, LIII(June-September, 1943), pp. 202~211, T.Scitovsky, "Two Concepts of External Economies," Journal of Political Economy, LXII(April, 1954), pp. 143~51.

among writers. However, external economies are generally associated with the diversification and simultaneous expansion of industries. In the present study, an attempt is made to test a hypothesis concerning such inter-industry dependence by an interregional analysis of the production function.

II. Statistical Models

The nulll hypothesis to be tested in the present study is:

$$(2.1)\quad Q_i^d(X_{ij}) = Q_i^s(X_{ij})$$

$$j=1, 2, \cdots\cdots n$$

where Q_i^d is the production function in n factors for ith industry in industrially diversified regionsand Q_i^S is the production function for the same industry in specialized regions. That is, if technological external economies are associated with the industrial diversification and expansion, the production function differs between two groups of regions---diversified and specialized regions.[1]

To test this hypothesis, regions are divided into two groups, each group consisting of homogeneous regions with respect to the composition of industry outputs. Then the production function is estimated for each industry and compared between the two groups. This test is based on the following assumptions: 1) the two groups of regions are homogeneous in all respects except the composition of industry outputs; 2) the more diversified the region is, the more external benefits accrue to different industries; and therefore 3) the estimates of the parameters of the production function for a given industry are expected to be significantly different between the two groups.

The key variable used in partitioning the sample regions into two sub-groups is the index of specialization.[2] The degree of industrial diversification or specialization is a relative measure and is determined by comparing a given region with some arbitrary standard. In the present study, the composition of industries for the nation is adopted as a standard of measurement. Hence, the degree of specialization is a function of outputs for a region and outputs for the nation.

The formula used in the computation of the index of specialization is:

$$(2.2)\quad S_i = \frac{\sum_{j=1}^{k} \left| \frac{q_{ij}}{q_i} - \frac{Q_j}{Q} \right|}{2} \times 100$$

1) Even though the hypothesis precludes the existence of pecuniary economies, because of the output data(value added), some elements of pecuniary economies are reflected in the test.

2) Walter Isard, Methods of Regional Analysis : An Introduction to Regional Science (New York : John Wiley & Sons, Inc., 1960), pp. 270~71.

where S_i —the coefficient of specialization for ith region.

q_{ij}—value added by jth industry in ith region.

q_i—total value added in ith region, i.e., $\sum_{j=1}^{k} q_{ij}$.

Q_j—national total for jth industry.

Q—total national industrial output, i.e., $\sum_{j=1}^{k} Q_j$.

S_i measures the extent to which the regional distribution of outputs deviates from that of the nation. If a region has an industrial structure identical to that of the nation, the region is considered to be perfectly diversified, and the index is zero. As a region becomes completely specialized in one line of production, the index approaches 100 as a limit.

The index of specialization so computed has been used as a first approximation, and the final partiton is formed by the method of discriminant analysis.[1] The discriminant analysis involves estimating a linear function of a set of variables, value added by various industries in the present case, which discriminates best between two groups. The discriminant function Z is

$$(2.3)\quad Z(x)=\sum_{j=1}^{k} b_j x_j$$

where X_j is jth industry output and b_j is the coefficient to be estimated.

$$\text{If } Z_i(\bar{X})=\sum_{j=1}^{k} b_j x_{ij}<Z(\bar{X})=\sum_{j=1}^{k} b_j \bar{X}_j \text{ for}$$

ith region, where $\bar{X}$ is the general mean, the region is classified as specialized: if $Z_i(\bar{X})>Z(\bar{X})$, then ith region is classified as diversified.

The production function estimated is of the Cobb-Douglas form in two factors–labor and capital. As is well known, the Cobb-Douglas production function is a special case of the more general CES production function.[2] However, because of the computational ease with which the test of hypothesis (2.1) is facilitated, the Cobb-Douglas production function is used. Hence, the production function estimated for individual industries is

$$(2.4)\quad Q=AK^{\alpha}L^{\beta}U$$

where Q—output

K—capital

L—labor

U—random disturbance

1) G. Tintner, Econometrics (New York: John Wiley & Sons, Inc.. 1952), pp. 96~102.

2) K.J. Arrow, H.B. Chenery, B.S. Minhas and R.M. Solow. "Capital-Labor Substitution and Economic Efficiency," Review of Economics and Statistics, XLIII (August, 1961), pp. 225~250.

As is the case with most econometric studies, the problem of least squares bias arises in estimating the production function in a one equation model. The problem of least squares bias in this particular context has long been considered by numerous authors.[1]

In spite of simultaneity which distorts our estimates, the least squares method and its variants are used for a number of reasons. First, under certain restrictive assumptions concerning the behavior of firms, the least squares bias disappears. For example, the firm optimizes its inputs with respect to the future output rather than the actual output, or the firm's behavior is governed by institutional restrictions such as limited access to the capital market or union pressure so that the firm may not be able to optimize as it would under competitive conditions. If these assumptions are reasonably correct, the simultaneity between the variables would disappear. Either one of the assumptions is not unrealistic in the American Economy. Secondly, in the present study, the aggregate production function for the two-digit manufacturing indutries is estimated. On this level of aggregation, it is doubtful if simultaneity would affect estimates as would for micro-functions under competitive conditions.

In the present study, three methods of estimation have been tried---the ordinary least squares method(OLS), restricted least squares method(RLS), and Theil's indirect least squares method. The so-called restricted least squares method is based on the assumption that the true production function is linear and homogeneous.[2] Hence the following relation holds:

(2.5) $Q/L = A(K/L)^{\alpha}$

where Q/L—output-labor ratio

K/L—capital-labor ratio

Since the production function is linear and homogeneous, the output-labor ratio is a function of the capital-labor ratio only and not of scale. But the capital-labor ratio is independent of scale and is determined by relative factor prices. Hence, when the least squares method is applied to the reduced form equation, consistent estimates of α can be obtained.

1) See, for example, J. Marschak and H. Andrews, Jr., "Random Simultaneous Epuation and the Theory of Production," Econometrica, XII (July-October, 1944), pp. 143~205, L. Klein, A Textbook of Econometrics (Evanston: Row, Peterson and Co., 1953), pp. 193~196, Irwin Hock, "Simultaneous Equation Bias in the Context of the Cobb-Douglas Production Function." Econometrica, XXVI (October, 1958), pp. 566~576.

2) The term "restricted least squares" is selected because of the restrictive assumption under which the parameters are estimated. It is, however, different from the least squares estimates under the same constraints which are obtained by the use of the Lagrange Multiplier.

Theil's indirect least squares method was also tried. It involves estimating a set of reduced form parameters under the assumption of non-linearity of the production function.[1] However, this method yields consistently poor estimates not only of the reduced form parameters but estimates of the parameters which are unacceptable on a priori grounds, e.g., negative coefficients. Hence, the statistical results by this method are not presented in this report.

The null hypothesis to be tested is

(2.6) Ho: $(A_j,\ \alpha_j,\ \beta_j)^s=(A_j,\ \alpha_j,\ \beta_j)^d$

where A_j, α_j, β_j are the parameters of the production function for jth industry and the superscripts "s" and "d" denote specialized and diversified regions, respectively. The alternative hypothesis is

(2.7) Ha: $(A_j,\ \alpha_j,\ \beta_j)^s\neq(A_j,\ \alpha_j,\ \beta_j)^d$

By the analysis of covariance as shown by Gregory Chow,[2] the hypothesis has been tested for all two-digit manufacturing industries except Tobacco Products.

III. Description of Data

The 1958 cross-section data for all two-digit manufacturing industries on the state level, except the Tobacco Industry, are used in this study.[3] Value added by manufacture in 1958 is used for output of each industry which has been adjusted for (1) value added by merchandising operations, i.e., the difference between sales value and cost of merchandise sold without further manufacture, processing, or assembly, and (2) the net change in finished goods and work-in-process inventories between the beginning and the end of the year.

Labor input is measured in production man-hours. It represents all man-hours actually worked at the plant. Adjustments have been made for paid vacations, holidays, and sick leave. Non-production workers are assumed to be in a fixed

1) Let the Cobb-Douglas production function in logarithm be $\log Q=\log A+\alpha\log K+\beta\log L$. By subtracting $(\alpha+\beta)\log Q$ from both sides of the equation and collecting terms, we get

$$\log Q=\frac{\log}{1-\alpha-\beta}+\frac{\alpha}{1-\alpha-\beta}\log\frac{K}{Q}+\frac{\beta}{1-\alpha-\beta}\log\frac{L}{Q}$$

Assuming that the capital-output and labor-output ratios are independent of output, consistent estimates of the reduced form coefficients are obtained by the least squares method. See J. Kmenta and M.E. Joseph, "A Monte Carlo Study of Alternative Estimates of the Cobb-Douglas Production Function," Econometrica, XXXI(July, pp. 1963), 363~385.

2) Gregory Chow, "Tests of Equality between Sets of Coefficients in Two Linear Regressions," Econometrica, XXVIII(July, 1960), pp. 595—605.

3) U.S. Dept. of Commerece, Bureau of the Census, U.S. Census of Manufactures: 1958 (Washington, D.C.), Vol. I & III.

proportion to production workers and are excluded. This assumption is made because non-production workers are reported in the Census in number of employees rather than man-hours. Furthermore, production and non-production workers are nonhomogenous inputs and cannot be added.

In the Census, gross book value of depreciable or depletable assets on the books of the establishment at the end of 1957 is reported. The book value represents the actual costs of the assets at the time of purchase including all costs incurred in making the assets usable. From this book value accumulated depreciation and depletion to December 31, 1956 and depreciation and depletion charged in 1957 are subtracted. This gives us an estimate of net capital stock as of December 31, 1957. The amount subtracted from the gross book value of assets represents the allowances for depreciation and depletion through December 31, 1956 and the amount charged in 1957.

In order to estimate the capital stock for the year 1958, total expenditures for plant and equipment for 1958 are added to the estimates of capital stock as of December 31, 1957. Total expenditures for plant and equipment include expenditures made during the year for permanent additions and major alterations to plants, as well as for new machinery and equipment purchases that are chargeable to fixed-asset accounts of manufacturing establishments for which depreciation accounts are ordinarilly maintained. Excluded are costs of maintenance and repairs aharged as current operating expenditures made by owners of plant and equipment leased to reporting manufactures. Value added and capital stock are measured in thousands of dollars; and labor input, in thousands of man-hours.

The states and manufacturing industries included in this study are presented in Appendix A which describes the samples used in estimating the production functions.

IV. Statistical Results

Applying equation (2.2) to the output data on the two-digit level for forty selected states, the index of specialization has been computed. As shown in Table 1, the forty states are then ranked and classified. The initial partition is arbitrarily formed by dividing the forty states into two groups of equal size. Using the twenty two-digit manufacturing outputs for the two groups, the discriminant function $Z(X)$, equation (2.3), has been estimated. The discriminant function is[1]

1) By E notation is meant notation of the form aEb, where a is any decimal number which does not exceed eight digits which is to be multiplied by 10b, e.g., 0.55555555 E 12 is 0.55555555 times 10^{12}.

(3.1)

$$Z=X\begin{pmatrix} 0.10679879 \text{ E } -06 \\ -0.40239220 \text{ E } -08 \\ -0.83853198 \text{ E } -07 \\ 0.13018650 \text{ E } -06 \\ -0.46277328 \text{ E } -07 \\ 0.61641357 \text{ E } -07 \\ -0.14934625 \text{ E } -06 \\ -0.23570246 \text{ E } -06 \\ 0.20962519 \text{ E } -07 \\ 0.48048947 \text{ E } -07 \\ 0.14777216 \text{ E } -06 \\ 0.22350358 \text{ E } -06 \\ -0.24346555 \text{ E } -06 \\ 0.24635604 \text{ E } -07 \\ 0.45621987 \text{ E } -07 \\ 0.38972820 \text{ E } -07 \\ -0.65075780 \text{ E } -08 \\ 0.53950808 \text{ E } -08 \\ 0.10269935 \text{ E } -06 \\ -0.49388830 \text{ E } -07 \end{pmatrix}$$

where X is the row vector(x_{20}, $x_{21}, \cdots\cdots x_{39}$) for twenty manufacturing industry-outputs. The index of specialization and the value of $Z(X)$ evaluated for each state are presented in Table 1.

As shown in Table 1, $Z(X)$ evaluated at the general means is

(3.2) $Z(\bar{X})= \bar{X}B=0.01861678$

where $\bar{X}$ is the row vector of the general means for twenty industries and B is the column vector shown in equation (3.1). Hence, if $Z(X)$ for a region is greater (less) than $Z(\bar{X})$, the state is classified as diversified (specialized). We find seven states which have been misclassified in the initial partitioning. Thus we have twenty-three states in the first group(specialized) and seventeen states in the second group(diversified).

Using this partition, the production function has been estimated for each industry for each subset of the sample and appropriate "F" ratios computed for tests of equality between the two subsets. Presented in Tables 2 and 3 are these estimates obtained by the ordinray least squares method(OLS) and the restricted least squares method (RLS), respectively. If the computed "F" ratio is greater (less) than $F_{.05}$, the null hypothesis (2.6) is rejected(accepted) at a five per cent level of significance.

Index of Specialization and Values of thə Discriminant Function

Table 1. **for Forty Selected States.**

State	Index of Specialization	Z^{b}
Specialized Regions:[a]		
District of Columbia	68.55	−0.02323494
South Carolina	59.38	−0.05894692
North Carolina	54.43	−0.02362352
Maine	53.60	−0.00519377
Oregon	51.70	−0.02816985
West Virginia	51.43	−0.01626303
New Hampshire	47.55	0.00496292
Louisiana	44.79	−0.00441175
Utah	41.74	0.00370226
Nebraska	40.02	0.01863925
Rhode Island	39.44	−0.00169040
Washington	38.30	−0.02795437
Kansas	37.97	0.00620226
Virginia	37.32	−0.01194935
Florida	37.20	−0.02535579
Georgia	36.34	−0.03640406
Alabama	34.20	−0.03931757
Vermont	33.89	−0.00658344
Iowa	32.71	0.03426292
Mississippi	31.67	−0.00085038
Diversified Regions:		
Colorado	31.38	0.00140288
Arkansas	31.18	0.00075688
Oklahoma	30.28	0.00267772
Michigan	29.22	0.07773104
Kentucky	28.91	0.03873593
Minnesota	28.05	0.00352548
Connecticut	27.09	0.04305874
Tennessee	27.00	0.01731899
Massachusetts	26.16	0.08141880
Texas	25.87	0.06612570
Wisconsin	24.88	0.04641561
New York	23.96	0.06952815
Ohio	22.79	0.06720545
Indiana	21.92	0.04920529
California	21.24	0.07377395
Missouri	19.45	0.04284025
Illinois	19.33	0.07528600
Maryland	18.47	0.03029307
New Jersey	17.53	0.08140479
Pennsylvania	17.35	0.05720501
$Z(\bar{X})^{c}$		0.01861678

a) Initial partitioning according to the index of specialization.

b) $Z=\sum_{j=20}^{39} k_j x_j$ for each state. c, Z computed at the general means.

Table 2. **Fstimates of the Cobb-Douglas Production Functions by the Ordinary Least Squrares Method:** Specialized and Diversified Regions

Industry Code	Specialized Regions				Diversified Regions				F
	log A	α	β	R	log A	α	β	R	
Ind. 20	1.00729	0.43370	0.48570	0.98924	0.76928	0.49263	0.48724	0.98698	3.60
	(0.0507)	(0.14492)	(0.14936)	(0.545)	(0.0514)	(0.15789)	(0.16780)	(0.590)	(2.92)
21	NA	NA	NA	NA	NA	NA	NA	NA	NA
22	0.5995	0.03904	0.92987	0.99917	0.93447	0.41622	1.36065	0.99246	12.76
	(0.0333)	(0.08642)	(0.08773)	(0.697)	(0.0677)	(0.26050)	(0.26416)	(0.796)	(3.29)
23	0.64131	0.21304	0.75240	0.99109	0.52944	0.04535	0.95690	0.98917	5.79
	(0.0684)	(0.12773)	(0.09169)	(0.726)	(0.0804)	(0.11653)	(0.10810)	(0.697)	(3.20)
24	0.35990	0.58137	0.42003	0.97466	0.34731	0.21018	0.82667	0.97083	1.93
	(0.1023)	(0.15368)	0.18687)	(0.671)	(.0937)	(0.30192)	(0.44776)	(0.836)	(3.92)
25	0.74257	0.09286	1.03669	0.98840	0.41584	0.32615	0.72516	0.9882	6.63
	(0.0757)	(0.17356)	(0.15098)	(0.726)	(0.0561)	(0.16332)	(0.20480)	(0.726)	(3.24)
26	0.90171	0.44721	0.44765	0.98900	0.34189	0.25360	0.80458	0.99625	2.53
	(0.0556)	(0.13246)	(0.17732)	(0.627)	(0.0390)	(0.06401)	(0.07089)	(0.627)	(3.01)
27	0.08301	0.47378	0.67949	0.98309	0.53143	-0.42195	1.52894	0.99144	4.11
	(0.0549)	(0.15045)	(0.16240)	(0.381)	(0.0558)	(0.25172)	(0.25763)	(0.726)	(3.49)
28	1.39454	-0.01410	0.94019	0.97322	0.94406	0.34362	0.63496	0.98712	4.18
	(0.0911)	(0.13820)	(0.14376)	(0.648)	(0.0663)	(0.11521)	(0.13268)	(0.603)	(3.01)
29	0.98121	0.14981	0.31618	0.96770	1.30003	-0.13140	1.08497	0.97163	0.22b
	(0.1454)	(0.24441)	(0.31846)	(0.881)	(0.1359)	(0.61501)	(0.73012)	(0.758)	(0.11)
30	-0.00372	0.32608	0.87626	0.99773	0.84368	0.43455	0.52699	0.99372	6.37
	(0.0355)	(0.05691)	(0.09322)	(0.975)	(0.0366)	(0.11211)	(0.13589)	(0.758)	(3.86)
31	0.48403	0.17493	0.84284	0.99084	0.41193	0.05431	0.97496	0.99496	0.38b
	(0.0668)	(0.20458)	(0.27263)	(0.930)	(0.0651)	(0.11033)	(0.11825)	(0.836)	(0.11)
32	0.82830	0.29699	0.65088	0.98127	0.80195	0.09069	0.89937	0.99439	1.83
	(0.0606)	(0.07553)	(0.09000)	(0.671)	(0.0469)	(0.09057)	(0.09520)	(0.697)	(3.13)
33	0.60209	0.39745	0.60409	0.99014	0.69954	0.18896	0.81039	0.99883	5.57
	(0.0665)	(0.06509)	(0.09249)	(0.758)	(0.0227)	(0.02463)	(0.02833)	(0.608)	(3.10)
34	0.66326	-0.13360	1.15480	0.95440	0.93624	0.02466	0.94043	0.99617	3.35
	(0,0667)	(0.13429)	(0.17063)	(0.648)	(0.0392)	(0.08867)	(0.09219)	(0.590)	(2.99)
35	0.62361	-0.07897	1.12064	0.90873	0.84197	0.06333	0.92796	(0.9969)	0.49b
	(0.1390)	(0.26650)	(0.33572)	(0.671)	(0.0303)	(0.04637)	(0.04343)	(0.609)	(0.12)
36	0.85065	0.04012	0.94098	0.93922	1.06837	-0.27696	1.23712	0.99299	1.17
	(0.1112)	(0.15843)	(0.23887)	(0.795)	(0.0491)	(0.13027)	(0.13496)	(0.648)	(3.20)
37	0.06472	0.20335	0.94830	0.98737	0.78359	0.14385	0.85872	0.99260	2.15
	(0.0915)	(0.08341)	(0.07594)	(0.726)	(0.0654)	(0.08107)	(0.09210)	(0.608)	(3.07)
38a	0.50468	0.15921	0.90972	0.99927	0.35017	0.05667	1.05300	0.99844	1.17
	(0.0281)	(0.06659)	(0.06931)	(0.758)	(0.0277)	(0.11475)	(0.14821)	(0.795)	(5.99)
39a	-1.32867	0.38837	1.04235	0.98540	-0.40580	0.03188	1.21611	0.99054	4.53
	(0.0734)	(0.19747)	(0.15708)	(0.881)	(0.0649)	(0.30140)	(0.18323)	(0.930)	(10.13)

a) Because of insufficient number of observations for Industries 38 and 39, estimates shown under speecialized regions are those obtained by pulling all observations together, i.e., both diversified and specialized regions combined.

b) Lower tail of F.

Note: (1) Enclosed by Parantheses under log A, α, and β are standard errors.

(2) Enclosed by Parantheses under R and F are the values of R.025 and F·025 for appropriate degrees of freedom.

(3) For Industry Code, see Appendix B.

Table 3. —**Estimates of the Cobb-Douglas Production Functions by the Restricted Least Squares Method:** Specialized and Diversified Regions

Industry Code	Specialized Regions				Diversified Regions				F
	log A	α	$1-\alpha$	R	log A	α	$1-\alpha$	R	
Ind. 20	0.66009	0.42660	0.57340	0.52424	0.67402	0.48566	0.51434	0.63397	2.22
	(0.0572)	(0.16333)		(0.444)	(0.0500)	(0.15297)		(0.482)	(3.30)
21	NA	NA	NA	NA	NA	NA	NA	NA	NA
22	0.46023	0.03418	0.96582	0.10309	0.68514	0.41118	0.58882	0.50304	16.44
	(0.0402)	(0.10430)		(0.576)	(0.0694)	(0.26701)		(0.666)	(3.59)
23	0.51801	0.26499	0.73501	0.73004	0.53922	0.04347	0.95653	0.13329	10.01
	(0.0657)	(0.08269)		(0.602)	(0.0763)	(0.10222)		(0.576)	(3.52)
24	0.36168	0.58049	0.41951	0.77240	0.50171	0.25485	0.74515	0.47437	3.50
	(0.0975)	(0.14392)		(0.553)	(0.0859)	(0.19308)		(0.707)	(3.59)
25	0.51669	0.00980	0.99020	0.02223	0.63893	0.38491	0.61509	0.67560	13.07
	(0.0750)	(0.14683)		(0.602)	(0.0547)	(0.14001)		(0.602)	(3.55)
26	0.59091	0.29324	0.70676	0.60277	0.60172	0.26189	0.73811	0.70822	0.12d
	(0.0599)	(0.10766)		(0.514)	(0.0442)	(0.07241)		(0.514)	(0.05)
27	0.71974	0.42186	0.57814	0.76224	1.03087	-0.41811	1.41811	0.42837	3.20
	(0.0603)	(0.16021)		(0.754)	(0.0651)	(0.29399)		(0.602)	(3.72)
28	1.06690	0.00971	0.99029	0.02035	0.85796	0.33295	0.66705	0.63020	37.68
	(0.0919)	(0.13779)		(0.532)	(0.0644)	(0.10963)		(0.497)	(3.37)
29	0.88204	0.12961	0.87039	0.26898	1.30287	-0.29296	1.29296	0.27946	1.07
	(0.1310)	(0.20755)		(0.754)	(0.1281)	(0.35586)		(0.632)	(3.80)
30	0.75977	0.35901	0.64009	0.88033	0.67785	0.40297	0.59703	0.81069	3.90
	(0.0708)	(0.11169)		(0.878)	(0.0358)	(0.10289)		(0.632)	(3.98)
31	0.56868	0.19474	0.80526	0.54684	0.54053	0.05127	0.94873	0.19544	1.10
	(0.0582)	(0.14908)		(0.811)	(0.0618)	(0.10504)		(0.707)	(4.10)
32	0.61332	0.30529	0.69471	0.77872	0.75699	0.09218	0.90782	0.32035	2.36
	(0.0600)	(0.07416)		(0.553)	(0.0447)	(0.08620)		(0.576)	(3.47)
33	0.60825	0.39762	0.60238	0.91850	0.60646	0.18892	0.81108	0.90510	11.06
	(0.0622)	(0.06052)		(0.632)	(0.0219)	(0.02372)		(0.497)	(3.44)
34	0.74924	-0.13139	1.13139	0.28280	0.77171	0.02058	0.97942	0.05727	5.44
	(0.0640)	(0.12864)		(0.532)	(0.0409)	(0.09263)		(0.482)	(3.35)
35	0.78061	-0.06308	1.06308	0.07623	0.79890	0.06995	0.93005	0.40921	1.73
	(0.1330)	(0.24877)		(0.553)	(0.0293)	(0.04169)		(0.497)	(3.38)
36	0.77920	0.03624	0.93676	0.09468	0.87482	-0.27754	1.27754	0.51883	1.79
	(0.1031)	(0.14403)		(0.666)	(0.0497)	(0.13201)		(0.532)	(3.52)
37	0.70665	0.09891	0.90109	0.36385	0.79584	0.14461	0.85539	0.44615	3.87
	(0.1066)	(0.08440)		(0.602)	(0.0630)	(0.07753)		(0.497)	(3.42)
38a	0.78996	0.17760	0.82240	0.45914	0.77161	0.29735	0.70265	0.74473	7.40
	(0.0513)	(0.12149)		(0.632)	(0.0383)	(0.10071)		(0.666)	(5.59)
39a	0.71074	0.01536	0.98464	0.2683	0.80806	-0.31902	1.31902	0.64933	9.88
	(0.1204)	(0.25593)		(0.754)	(0.0723)	(0.18682)		(0.811)	(7.71)

a) Because of insufficient number of observations for Industries 38 and 39, estimates shown under specialized regions are those obtaine by pulling all observations together, i.e., both diversified and specialized regions combined.

b) Lower tail of F.

Note: (1) Enclosed by parantheses under log A and α are standard errors.

(2) Enclosed by parantheses under R and F are the values of R.025 and F.025 for appropriate degrees of freedom.

(3) For Industry Code, see Appendix B.

V. Evaluation of Statistical Results

As can be seen in Table 2, of the nineteen industries tested for equality of production functoin between industrially diversified and specialized regions, the tests under the OLS method suggest that nine industries have the production function which is different at a five per cent level of significance compared to ten industries for which the difference is not significant. A summary of the test results is presented in Table 4.

Unfortunately, however, when the estimates of the parameters are more closely

Table 4. **A Summary of Statistical Results on the Test of Equality in the Production Function Between Industrially Diversified and Specialized Regions**

Ind. Code	Industry	Test of Equality at F.05 (OLS)	Test of Equality at F.05 (RLS)
20	Food and Kindred Products	S	N S
21	Tbacco Products	N A	N A
22	Textile Mill Products	S	S
23	Apparel and Related Products	S	S
24	Lumber and Wood Products	N S	N S
25	Furniture and Fixtures	S	S
26	Paper and Allied Products	N S	N S
27	Printing and Publishing	S*	N S*
28	Chemicals and Allied Products	S*	S
29	Petrloeum and Coal Products	N S*	N S*
30	Rubber and Plastics Products	S	N S
31	Leather and Leather Products	N S	N S
32	Stone, Clay and Glass Products	N S	N S
33	Primary Metal Industries	S	S
34	Fabricated Metal Products	S*	S*
35	Machinery, except Electrical	N S*	N S*
36	Electrical Machinery	N S*	N S*
37	Transportation Equipment	N S	S
38	Instruments and Related Products	N S	S
39	Miscellaneous Manufacturing	N S	S*

Note: S and NS designate "reject" and "accept" the null hypotheses (2.6) at a five per cent level of significance.

(*) denotes that the estimate *a prior* restrictions imposed on the parameters, *viz.*, negative coefficients.

investigated, the results are not so encouraging. As can be seen in Tables 2 and 3, some of the estimates of α and β are negative which are to be rejected on *a priori* grounds for the Cobb-Douglas production function. In the present study, it is probably due to a high level of aggregation(two-digit manufacturing industries) for the variables, in part due to specification errors on the model, and in part due to insufficient information contained in the sample observations. Hence the test is not conclusive for these industries. Similar results are obtained by the RLS method. The RLS estimates for six industries have to be rejected on *a priori* grounds.

Comparing the two sets of test of test results, we reject five industries as being inconclusive since neither method yields the estimates which are plausible. These industries are printing and Printing and Publishing(Ind. 27), Petroleum and Coal Products(Ind. 29), Fabricated Metal Peoducts(Ind. 34), Machinery, except Electrical(Ind. 35), and Electrical Machinery(Ind. 36).

We also find four industries for which the two sets of tests yield conflicting results. For Food and Kindred Probucts (Ind. 20) and Rubber and Plastics Products(Ind. 30), the difference is significant under the OLS method, while the RLS method points to the contrary. For Transportation Equipment(Ind. 37) and Instruments and Related Products(Ind. 38), the differeece in the production function is not significant under the OLS method while it is significant under the RLS method.

Of the remaining ten industries it is concluded that the production function is not significantly different for five industries between the two groups of regions. For these industries, the two sets of test yield the same results except one industry(Ind. 39) for which the RLS estimates are rejected on *a priori* ground. These industries are Lumber and Wood Products(Ind. 24), Paper and Allied Products(Ind. 26), Leather and Leather Products(Ind. 31), Stone, Clay and Glass Products(Ind. 32), and Miscellaneous Manufacturing(Ind. 39).

The remaining five industries are found to have the production function function which is significantly different between the two groups of regions. These industries are Textile Mill Products(Ind. 22), Apparel and Related Related Products (Ind. 23), Furniture and Fixtures(Ind. 25), Chemicals and Allied Products(Ind. 28), and Primary Metal Industries(Ind. 33).

Thus, all in all, the statistical results for nine industries are not conclusive either because of ahe conflicting results shown by the two models or because of the estimates which violate *a priori* restrictions imposed on the Cobb-Douglas parameters. At least for five of the remaining ten industries, we found some evidence that the productivity of an industry is significantly related to industrial diversification of a region in which the activity is carried out. This, of course, is not to be construed as an evidence of external economies which are often associated with industrial diversification. On the basis of the present study, because of the form of the production function being estimated, it cannot be said whether or not external economies exist for industrially diversified regions. It appears that technical efficency cannot be uniquely compared detween the two groups of regions since the models are not designed to test neutral efficiency. At best, one could conclude that the production function is different and that economic efficiency depends on the relative factor price differences between regions. Further investigation of the implcations of this study by the use of miore refined data and models is much desired.

APPENDIX A

Samples Used in the Estimation of Production Function

Ind. Code / State	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Specialized Regions:																				
Alabama	X		X	X					X	X	X		X	X	X	X	X	X		
Arkansas			X		X	X	X		X	X		X		X						
Colorado	X			X			X	X	X				X			X	X	X	X	
District of Columbia	X							X												
Florida	X	X		X	X	X	X	X	X				X		X		X	X		
Georgia	X		X	X	X	X	X		X			X	X		X		X	X		
Kansas	X								X	X					X			X		
Louisiana	X				X		X		X	X			X	X	X			X		
Maine	X		X	X			X					X				X		X		
Minnesota	X				X		X	X	X	X	X		X	X	X	X		X		
Mississippi				X	X	X	X		X						X		X			
New Hampshire			X			X	X					X	X			X	X			
North Carolina	X		X	X	X	X	X		X		X		X		X		X			
Oklahoma	X				X	X				X			X	X	X	X	X	X		
Oregon	X				X		X									X				
Rhode Island	X		X					X			X			X	X	X				X
South Carolina	X		X	X	X	X	X													
Tennesse	X		X	X	X	X	X	X	X		X	X	X	X	X					
Utah	X									X			X			X				
Vermont	X		X													X				
Virginia	X	X	X	X	X	X	X		X			X	X	X	X	X				
Washington	X				X	X	X	X	X					X	X	X		X		
West Virginia	X	X	X	X					X				X	X	X	X	X	X		
m	20	3	12	11	13	11	15	7	14	7	5	6	13	10	14	13	9	11	1	1

(cont.)

APPENDIX A

Samples Used in the Estimation of Production Function

(cont.)

State \ Ind. Code	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Diversified Regions:																				
California	X		X	X	X	X	X	X	X	X	X			X	X	X	X	X		X
Connecticut	X		X	X			X	X	X		X	X	X	X	X	X	X	X		
Illinois	X		X			X	X	X	X	X	X		X	X	X	X	X	X	X	X
Indiana	X			X	X	X	X		X	X	X		X	X	X	X	X	X	X	X
Iowa	X							X	X					X	X	X		X		
Kentucky	X	X			X	X	X		X	X			X	X	X	X	X	X		
Maryland	X		X			X	X		X		X	X	X	X	X	X	X	X		
Massachusetts	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Michigan	X			X		X	X		X		X		X	X	X	X		X	X	
Missousi	X			X	X		X	X	X	X		X	X	X	X	X	X	X		
Nebraska	X														X					
New Jersey	X		X	X			X	X	X	X				X	X	X	X	X	X	X
New York	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ohio	X		X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X
Pennsylvania	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	
Texas	X			X	X	X	X	X	X	X				X	X	X	X	X		
Wisconsin	X			X	X		X		X		X	X	X	X	X	X	X	X	X	
n	17	2	9	12	8	11	15	11	16	10	10	8	12	16	17	16	14	16	9	6

Note: m, n—the numbers of observations for specialized and diversified regions, respectively.
(X)—denotes states used in estimating the crresponding(columns) industry production function.

APPENDIX B

Standard Industrial Classification for Manufacturing Industries

Ind Code	Industry
20	Food and Kindred Products
21	Tobacco Products
22	Tastile Mill Products
23	Apparel and Relatad Products
24	Lumber and Wood Products
25	Furniture and Fixtures
26	Paper and Allied Products
27	Printing and Publishing
28	Chemicals and Allied Products
29	Petroleum and Coal Products
30	Rubber and Plastics Products
31	Leathe and Leather Products
32	Stone, Clay and Glass Prodcuts
33	Primary Metal Industries
34	Fabricated Metal Products
35	Machinery, except Electrical
36	Electrical Machinery
37	Transportion Equipment
38	Instruments and Related Products
39	Miscellaneous Manufacturing