RETURNS TO SCALE BEHAVIOR AND MANUFACTURING AGGLOMERATION ECONOMIES IN U.S. URBAN AREAS

Neal Duffy

Introduction

The returns to scale (RTS) parameter of urban production functions has often been used to test for the existence of agglomeration economies in urban areas. The underlying rationale is seen most clearly in a statement by Kaldor [17], who referred to agglomeration economies as:

> "Nothing else but the existence of increasing returns to scale — using that term in the broadest sense — in processing activities. These are not just the economies of large-scale production, commonly considered, but the cumulative advantages accruing from the growth of industry itself . . ."

Thus the production function has been viewed as a convenient device for bridging the gap between the theory of agglomeration — laid down by Hoover [15], Isard [16], Richardson [25], and Weber [32] — and its measurement. Though the studies in this area have recently become much more refined, additional research has been needed in some of the more basic methodological and procedural issues connected with the empirical implementation of the production function approach. The principal objective of this sutdy is to obtain a more accurate estimate of RTS for the manufacturing sector of urban agglomerations in the U.S.

One of the principal shortcomings of previous studies is that almost exclusively they have been forced to use homogenuous production functions, due to the lack of information concerning capital.[1] Recent examples include studies by Moomaw [21], Carlino [3, 5], Nakamura [22], and Greytak and Blackley [13]. These have differed from the earlier genre (i.e., [23, 29, 30, 18]) in that the latest attempts have concentrated on separating out localization and urbanization economies from the basic scale parameter by including auxiliary variables in the production model. While most of these approaches have been quite imaginative and not without merit, it would also be instructive

---

[1] The few exceptions have been very limited in scope. Fogarty and Garofalo [11] obtained RTS estimates for two cities, Philadelphia and Pittsburgh in a time-series study that used a Vinod production function, while Schaefer [27] investigated urban areas in Saskatchewan using a translog production function.

to use a nonhomogeneous production function as a modeling tool in order to determine if RTS change with the size of the urban agglomeration. This study, which uses a capital stock series developed by Fogarty and Garofalo [11], will employ a nonhomogeneous production function, though there will be no attempt to isolate localization from urbanization economies in the process.

Background

In the literature four basic methods have been used to measure agglomerà-tion economies. They have included (1) using city size variables in conjunction with the Hicks — neutral shift parameter of a homogeneous cross-sectional urban production function [13, 21, 22, 29]; (2) estimating separate homogeneous production functions for large and small cities [27, 28, 29] or individual cities [3,4]; (3) using a nonhomogeneous urban production function [27, 28, 10, 11] and (4) employing state level data and then including urban agglomeration variables in an estimating equation [23, 1]. Only in methods 2 and 3 are RTS estimates used to test for the existence of agglomeration economies. In this paper a combination of these two methods will be implemented to determine the behavior of RTS as a function of agglomeration in the manufacturing sector.

The theoretical basis for using a production function approach to measure agglomeration economies has itself already been summarized by Kaldor [17], Carlino [5], Greytak and Blackley [13] and others, and will not be repeated here. Though the method itself is theoretically supportable, its empirical implementation has been subject to several limitations: (1) The choice of production has usually been limited to homogeneous forms, though several studies have shown directly or have implied that the parameters of the production function (especially RTS) may change with city size. (2) Studies of U.S. SMSAs have had to resort to using one-factor models such as the well-known Dhrymes variant of the CES function [3, 30] or a variation of the Cobb Douglas function [21] that does not use direct information on capital at all, but infers it by subtracting labor payroll from value added.[2] (3) Measurement errors or omission of variables errors related to biased or missing capital data may inflict an uncertain amount of bias on results. Studies that have attempted to separate out localization and urbanization economies from RTS face the additional problem of collinearity among most of the auxiliary variables that are usually incorporated into the estimating equation. Only in studies by Moomaw [1986, 1981] have any of these econometric problems been adequately addressed.

---

2 Three non-U.S. studies have used direct capital data — Schaefer (1979), Nakamura [22] and Henderson [14]. However, only Schaefer eventually employed a nonhomogeneous production function. Segal [29], in a study of U.S. SMSAs used direct capital data but his collection method and results were severly criticized by both Moomaw [21] and Fogarty and Garofalo [11]. Greytak and Blackley [13] used firm level capital data for industries in the Cincinnati SMSA.

In the presence of such potential shortcomings, when SMSA level capital data is unavailable a better route would seem to be that taken by Nicholson [23], or more recently by Beeson [1]. In these studies state level data was used to estimate either cross-section (Nicholson) or time-series (Beeson) production functions, and then measures of urbanization within a state were used to capture potential agglomeration effects. The disadvantage with this approach is that the study becomes essentially regional, rather than urban, in nature and therefore is not able to measure agglomeration economies directly. So in the absence of capital one is left with a choice between an indirect measure and a direct one that is potentially biased.

A capital series for urban areas (SMSAs) was available in this study and therefore some of these common pitfalls could be avoided. One major problem, choice of functional form, was solved in an earlier paper [8] using the same data base. By applying the statistical techniques of Pesaran and Deaton [24] and of Davidson and MacKinnon [6], it was there determined that the most appropriate manufacturing production function at the urban level is one that incorporates nonhomogeneity, with elasticity of substitution (EOS) being a relatively minor factor. The results pointed to the use of the Ringstad [26] and Vinod [31] specifications, which have the properties of constant EOS and nonhomogeneity. They also have unique RTS functions which together will be able to lend some insight into the nature and measurement of manufacturing agglomeration economies in the U.S.

Sources and Methodology

Data

The observations consist of labor, capital, and output for the manufacturing sector for the years 1975, 1976 and 1977 for forty-nine of the largest U.S. SMSAs. For labor and output the data was obtained from the *Census/Survey of Manufacturers* using manhours of production workers for labor and value added for output. Table 1 lists the sample SMSAs and their average real value added in the manufacturing sector for the three years of the study. Since value added was in current dollars it has been converted to real dollars by using an appropriate deflator, which is the producer price index for all industrial commodities, obtained from the *U.S. Statistical Abstract.* There was no attempt to adjust the labor inputs for quality differences or to include a labor composition variable in the production functions. Both Henderson [14] and Svelkauskas (1975) found that labor quality indices were not statistically significant in their urban production/productivity models.

Capital inputs are measured by capital stock and were provided by Fogarty and Garofalo [10]. They utilized the perpetual inventory/book value method of estimation, which is outlined as follows: First, a 50-year investment series for the manufacturing sector of each SMSA was derived, called the 'built-up' series, for the years 1904-1953. In some cases this was obtained by apportioning a state's investment among SMSAs on the basis of the percentage of

TABLE 1

Classification Of SMSAs By Size Of Output*

SMSA	Output (billions)	SMSA	Output (billions)
Erie	1.2	Atlanta	3.5
Tulsa	1.2	Kansas City	3.6
Lancaster	1.3	Greensboro	3.7
Tampa	1.4	Lousiville	3.9
Miami	1.5	Seattle	3.9
New Orleans	1.5	Buffalo	4.0
San Bernardino	1.5	Anaheim	4.4
Nashville	1.6	Baltimore	4.7
Reading	1.6	San Jose	4.7
Canton	1.6	Cincinnati	5.0
Birmingham	1.6	Minneapolis	5.5
Richmond	1.7	Milwaukee	5.7
Akron	1.8	San Francisco	5.7
Memphis	1.8	Rochester	6.1
Grand Rapids	1.9	Pittsburgh	6.3
Jersey City	1.9	Dallas	6.7
San Diego	1.9	Newark	6.9
Phoenix	2.1	St. Louis	7.2
Allentown	2.4	Cleveland	7.2
Columbus	2.5	Philadelphia	11.7
Denver	2.5	Detroit	14.8
Portland	2.5	New York	17.0
Youngstown	2.5	Los Angeles	21.1
Dayton	2.6	Chicago	23.7
Indianapolis	3.4		

*Output is an average of real value added for the years 1975, 1976 and 1977.

value added in the SMSA compared to the state. Discard and depreciation functions were used to adjust gross investment for obsolescence and depreciation.

Census book value of plant and equipment for 1957 were then used as benchmarks to adjust the built-up series. Capital stock in any one year is the sum of the previous years' undiscarded, undepreciated investments. Since the pre-1954 investment series consisted of estimates *derived* from national data, while the post 1953 series used *direct* Survey data, the 1975-1977 estimates used in this study are presumably the least biased of Fogarty and Garofalo's 1957-1977 capital stock series. The use of the stock rather than the flow concept can be justified on the basis of early studies by Diwan [7] and Lovell [19] and more recently by Greytak and Blackley [13]. They each determined that capacity utilization adjustments did not significantly alter their production function estimates.

Production Functions

As stated above, and shown in a previous study [8], statistical tests have shown that nonhomogeneity is a better representation of the production characteristics of this sample than homogeneity. For this reason two nonhomogeneous forms of the production function, developed by Ringstad [26] and Vinod [31] were estimated, along with the homogeneous Cobb-Douglas function. The homothetic Ringstad function (Equation 1) has a unitary elasticity of substitution (EOS) and also possesses a rather unique and useful RTS function. As shown in Equation 2, RTS is a quadratic function of output, which allows for the possibility of 'turning points', i.e. maxima and minima.

$$\ln Q + c_0 Q + c_1(\ln Q)^2 = d_0 + d_1 \ln(K/L) + d_2 \ln L \quad (1)$$

$$RTS = d_2/(1 + c_0 Q + 2c_1 \ln Q) \quad (2)$$

where K = capital
L = labor
Q = output

Because of the computational difficulties in estimating the Ringstad production function [33], requiring an iterative maximum likelihood procedure, a second simpler nonhomogeneous specification was also used. This is the Vinod form (Equation 3) which is not homothetic and which possesses a nearly constant EOS.[3] As shown in Equation 4, RTS for the Vinod function depends on both of the inputs, capital and labor. Since output is closely correlated to

$$\ln Q = b_0 + b_1 1nK + b_3 1nL + b(1nK)(1nL) \quad (3)$$

$$RTS = b_1 + b_2 + b_3(\ln K + \ln L) \quad (4)$$

the factors of production, and because this sample has a rather large overall variation in output, RTS will tend to exhibit monotonicity with respect to output, except for the smallest cities in the sample. The Cobb-Douglas function (Equation 5) has received much attention in the literature. Its properties include an EOS of inputs, capital and labor. Since output is closely correlated

$$\ln(Q/L) = a_0 + a_1 \ln(K/L) + a_2 \ln L \quad (5)$$

to unity and a constant RTS of 1+a. This is included for the purposes of comparison since several previous studies have used such a specification, detailed above.

Testing For Separate Production Functions

Following the approaches of Segal and Schaefer, an F-test was used to determine if separate production functions are warranted for different size ranges of output. Since several different partitions of the sample may indicate the necessity of separate production functions, the demarcation points se-

[3] Some authors have made the mistake of labeling this a "VES" production function. However, the variation in the EOS is invariably never more than 1% — not great enough, in my opinion, to warrant such a designation.

lected should be the ones that produce the highest significant F-statistic, given by:

$$F = \frac{(RRSS - URSS) / k}{URSS / (n\text{-}ik)} \tag{6}$$

where
RRSS = restricted residual sum-of-squares
URSS = unrestricted residual sum-of-squares
k = # of estimated parameters
n = total # of observations
I = the # of separate functions tested

The F-test assumes that there is neither contemporaneous correlation nor heteroscedasticity.

Having tried both a two-group and a three-group partition of the sample, it was decided to use three groups for all three production functions. The F-statistic tended to be larger using three groups than for two groups, as expected, since there was one less restriction. In order to reduce the computational burden the demarcation points which were tested for the Cobb-Douglas and Vinod functions consisted only of integer values of the dependent variable, value added. However, the F-test is used only for the Cobb-Douglas and Vinod functions. Because the Ringstad function requires a long and very arduous estimation procedure it was necessary to select a single set of demarcation points arbitrarily.

Empirical Results

The results of the F-test for the *Cobb-Douglas* function indicated optimum demarcation points of $4 and $7 billion. This partition produced the highest significant value of the F-statistic, 28.2, compared to a critical value of 3.78 (.01 level of significance). The production function estimates for the individual groups as well as the overall sample are shown in Table 2. The rather low R in three of the four categories, including the overall sample, suggests that the Cobb-Douglas function is not a very good representation of the existing production structure. From the smallest to the largest sub-group the RTS estimates are 1.06, .42, and .93 with respective t-statistics of 1.2, 7.0, and 2.0. At the .05 level the null hypothesis of unitary RTS is accepted for the smallest cities and rejected for the two larger city categories. the usefulness of these results is minimized by the overall poor explanatory power of the function.

The F-statistic for the *Vinod* function indicated that the optimum demarcation points occur at $2 and $6 billion value added. With this partition the F-statistic attained its highest value, 29.6, compared to the critical value of 3.32 (.01 level of significance). The production function estimates are reported in Table 3. Because multicollinearity may be a problem in Vinod production functions, the correlation between capital and labor is also reported. For the medium-sized cities multicollinearity did seem to be present. This is indicated by the high R^2 and the absence of significant coefficients. It is also noted that the R^2 for the under-$2 billion category is significantly lower than for the other

TABLE 2

Cobb-Douglas Production Function Estimates (t-statistics in parentheses)*

Output (Billions)	a_1	a_2	a_3	n	R^2	$\hat{\sigma}^2$	RTS
A11Q	1.84(10.0)[a]	.38(6.7)[b]	.04(2.3)[d]	147	.25	.0258	1.042
Q<4	1.71(5.6)[a]	.39(5.6)[b]	.06(1.2)	90	.25	.0201	1.06
4<Q<7	5.79(10.8)[a]	.20(2.4)[b]	-.58(7.0)[b]	36	.64	.0147	.42
Q>7	3.28(9.9)[a]	.09(1.2)	-.07(2.0)[d]	21	.26	.0047	.93

*a - significant at .01 level, two-tail test
b - significant at .01 level, one-tail test
d - significant at .05 level, one-tail test

TABLE 3

Vinod Production Function Estimates (t-statistics in parentheses)*

Output (Billions)	b_0	b_1	b_2	b_3	n	r^2	$\hat{\sigma}^2$	ρ^{kl}
AllQ	-.70(0.8)	.67(5.8)[a]	1.19(6.2)[a]	-.06(2.9)[a]	147	.96	.0245	.91
Q<2	-20.40(2.1)[c]	3.81(2.7)[a]	5.70(2.6)[a]	-.78(2.4)[c]	51	.63	.0110	.37
2<Q<6	4.61(0.8)	-.10(0.1)	.43(0.4)	.05(0.4)	63	.82	.0195	.84
Q>6	32.1(10.8)[a]	-3.09(8.9)[a]	-3.91(8.3)[a]	.52(9.7)[a]	33	.92	.0059	.68

*a - Significant at .01 level, two-tail test
c - Significant at .05 level, two-tail test

TABLE 4

Ringstad Production Function Estimates (t-statistics in parentheses)*

Output	c_0	c_1	d_0	d_1	d_2	n	$\bar{R}^2$	$\hat{\sigma}^2$
AllQ	.000022	-.022	2.07(18.9)	.25(8.2)	.80(62.0)	147	.96	.0134
Q<2	.000200	-0.78	2.85(34.6)	.04(4.3)	.11(7.4)	51	.50	.0004
2<Q<7.6	.000034	-.067	3.64(384.6)	.01(4.1)	.03(21.1)	81	.85	.00002
Q>7.6	-.000010	-.030	4.79(36.7)	.70(4.5)	.26(8.5)	15	.97	.0004

groups. One explanation of this recurring phenomenon may be that the smaller cities in the sample comprise a more diverse group than the other categories. In this case a single production function could never adequately describe all production within the group, even though there are 51 observations. Above $2 billion value added the observations are made more widely scattered, leading to a much better 'fit'.

FIGURE 1
RTS, Vinod Production Function

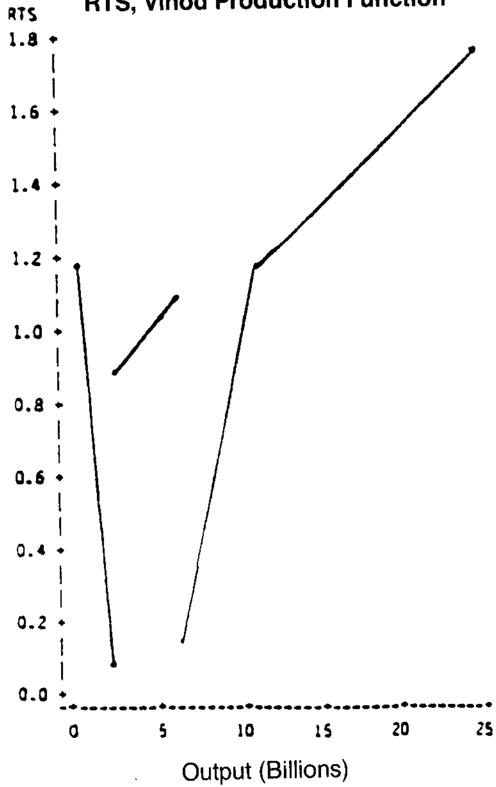
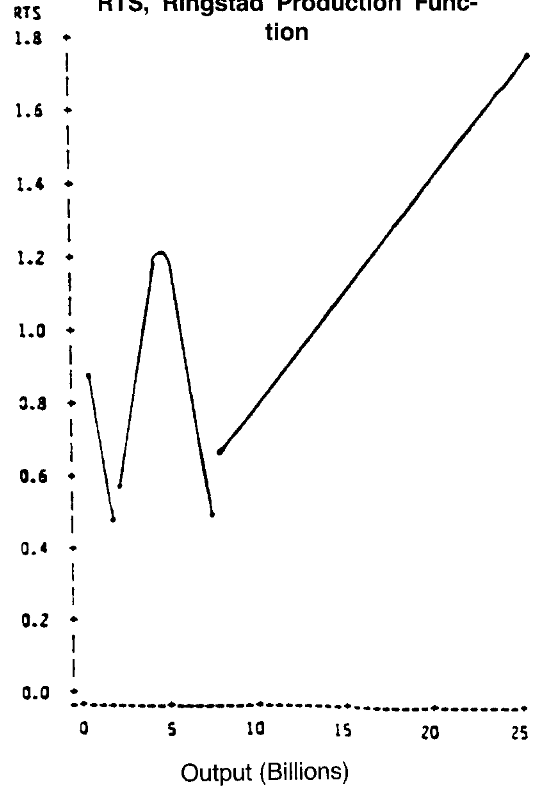


FIGURE 2
RTS, Ringstad Production Function



The RTS estimates for the three sub-groups are plotted in Figure 1. There appears to be a distinct cyclincal trend — RTS first decrease and then increase sharply to approximately unity. In the third sub-group RTS begin quite low and finally increase to a miximum of about 1.75. With the exception of the second group there are clearly some questionable individual magnitudes of RTS. It is unlikely that any city could exist with an RTS close to zero or 1.7, which occur in the first and third groups respectively. In the case of the small-city group there is probably a connection between the unlikely values of RTS and the relatively low $\bar{R}^2$. Another important feature of this group is the low correlation between capital and labor (.37). It is likely that there is much less industrial diversity in these cities, with each city characterized by very distinct capital/labor ratios.

The foregoing discussion suggests that either the Vinod function is an inaccurate representation or that a different interpretation of the RTS estimate is necessary. Having obtained such high $\bar{R}^2$ for three of the four groupings, as shown in Table 3, and having verified the suitability of the nonhomogeneous function in the study referred to above, it woulld seem that the former statement is not a correct one. If a different interpretation is then required it may be the following: that the *absolute* levels of RTS are not as important as the *relative* levels. Thus we should be more concerned with the direction of change, which is easily discernible: Alternate periods of decreasing, increasing, decreasing and then increasing RTS.

Further analysis withthe Ringstad function leads to a similar conclusion. Demarcation points for the *Ringstad* function were arbitrarily chosen to be $2 and $7.6 billion value added. These were selected because a scatter diagram of the output data showed discernible 'breaks' at these points. The calculated F-statistic of 2,133 was significant at the .01 level. As shown in Table 4 all coefficients were significant at the .01 level and the $\bar{R}^2$ is very high in three cases, but not for the under-$2 billion category. As shown in Figure 2, the RTS behavior is remarkably similar to that of the Vinod function. RTS decrease, increase, decrease and increase as output expands. The quadratic nature of the RTS function is seen in the middle grouping ($2 < Q < 7.6$) in which RTS exhibits a parabolic behavior, reaching a maximum at approximately $Q=5$ before falling off. The group estimates of RTS are also consistent with each other. That is, the three groups can be spliced together almost perfectly to produce a nearly continuous graph. As in the case of the Vinod function, it appears that a 'relative' interpretation of the RTS behavior may be more realistic than an 'absolute' interpretation.

Interpretation Of Results

In order to place these results into perspective it is necessary to first point out the fundamental differences between this and earlier studies. Apart from the usage of an urban capital series and the use of more flexible forms of the production function that it allowed, there are a couple of interrelated aspects of the study that are potentially the main points of controversy. These concern (1) the level of aggregation used, (2) its implications towards the interpretation of the RTS parameter estimates vis-a-vis agglomeration economies and (3) the rationale for not placing agglomeration economies into an external, rather than internal, scale economy framework.

At first glace the level of aggregation would seemingly dictate how we should interpret the estimates of RTS. As a point of reference the only comparable studies that used the same level of aggregation are that of Shefer and Nicholson. To Shefer, increasing RTS meant the existence of "urbanization" economies, while Nicholson merely labeled them "urban agglomeration" economies. Since there was no attempt here to decompose RTS into urbanization or localization economies, and neither was "controlled" for in any statistical sense, the safest interpretation of these results is probably Nicholson's. Shefer's interpretation in fact did not even follow the spirit of Hoover's original definition of urbanization economies, since Hoover considered them to be related not just to the size of **all** sectors inclusive.

It would be tenuous at best to conclude that there are internal scale, localization, clustering[4], or urbanization economies to any specific degree. Most likely they are each present to some extent, as several studies have shown, though their exact influence on the derived RTS cannot be determined. If there were a direct linear relation between any of these types of agglomeration economies and the overall size of agglomeration we could attempt further speculation, but that has not been proven. The complicating factor is that industry mix is somewhat haphazard across regions, due to the principal of comparative advantage.

Regardless of what the level of aggregation is, since a straightforward production function approach is used here there is no explicit vehicle for measuring what some would call "external" effects. Any "external" economies are assumed to be captured by the internal scale parameter (i.e., RTS). Is this justifiable? Based on a recent study by Meyer [20], yes.

In his effort to clarify the concept of agglomeration economies he states:

> "once expansion of an industry has led to external economies urban growth resulting from expansion of local industry may not necessarily be due to external economies, although localization economies will be present."

He then went on to give two examples in which:

> "localization economies exist but there are no external economies so long as the low cost of production in athe agglomeration is mediated through the market mechanism . . ."

and concluded that:

> "urban growth can be based on industrial linkage without the presence of external economies."

---

4 The term "clustering economies" is used to refer to agglomeration economies that arise because of industry mix. Henderson [14] attempted to empirically measure the extent of cluster economies, but without much success.

He was very critical of using the term "external economies" in the context of agglomeration economies because he considered it to be "so imprecise as to be meaningless." He found that most examples of external economies for industrial firms were in fact quickly internalized by the market, so that the more appropriate way of thinking about urban agglomerations economies would be as economies of scale, internal to the production function. Thus he substantiated the view that the RTS parameter in a macro/urban production function could be a useful device for measuring the extent of agglomeration economies.

Conclusion

Economists have always assumed that there existed some kind of efficiency advantages that accrued to firms located in cities. What else could explain the historical growth of jobs and people in urban areas? The purpose of this study, and several previous studies as well, was to quantify the extent of these efficiency advantages, or agglomeration economies, from the industrial point of view. However, up until now data limitations did not allow a full appraisal of the changing nature of agglomeration economies with respect to differences in city size.

Using a conventional production function approach, and couching the measurement problem in terms of the identification of scale economies, a rather startling result was obtained: Returns to scale were seen to be cyclical in nature, rather than constant, as previously thought. Only one other study has hinted that such a phenomena might exist. Schaefer [28] chose to interpret his results in terms of an urban hierarchy after he arbitrarily arranged his sample into seven layers, based on city size. As shown in his table 2, RTS were variable and also exhibitied a sinusoidal pattern, just as they did in this study.

Of course the obvious implication of such behavior in both cases is that there may exist not one, but two threshold sizes that a city must reach before "taking off." On the other hand this study, unlike those of Carlino and Kawashima, purposefully avoids the temptation of determining an "optimal" city size, since the natural diversity of cities almost certainly precludes such vain speculation. Instead, it concludes that there seems to be certain empirical regularities causing there to be efficiency advantages of a cyclical nature in our system of cities.

Admittedly, questions concerning causality remain unanswered at this point. The research suggests, however, that economies of agglomeration may be more complex than originally thought and that it may be fruitful for urban economists to next examine more closely some of the underlying factors involved. It is the complex interaction of such size-adjustable factors related to agglomeration that must be responsible for the rather surprising results obtained here. The identification and quantification of these factors would be a good area for future research.

REFERENCES

1. Beeson, P. "Total Factor Productivity Growth and Agglomeration Economies in Manufacturing, 1959-73," *Journal of Regional Science,* Vol. 27 (1987), No. 2, 183-199.
2. Blitch, C.P. "Allyn Young on Increasing Returns," *Journal of Post-Keynesian Economies.* Spring 1983, 359-371.
3. Carlino, G.A. "Declining City Productivity and the Growth of Rural Regions: A Test of Alternative Explanations," *Journal of Urban Economies*, Vol 18 (1985), 11-27.
4. Carlino, G.A. "Increasing Returns to Scale in Metropolitan Manufacturing," *Journal of Regional Science,* Vol. 19 (1979), 363-374.
5. Carlino, G.A. "Manufacturing Agglomeration Economies as Returns to Scale: A Production Function Approach," *Papers of the Regional Science Association,* Vol. 50 (1982), 89-108.
6. Davidson, R. and MacKinnon, J.F. "Several Tests for Model Specification in the Presence of Alternative Hypotheses," *Econometrica*, Vol. 49 (1981), 781-793.
7. Diwan, R.K. "An Empirical Estimate of the Elasticity of Substitution Production Function," *Indian Economic Journal*, Vol. 12 (1965), 347-366.
8. Duffy, N.E. "The Determination of an Appropriate Urban Production Function: A Statistical Approach," *Review of Regional Studies,* Vol. 16 (1986), No. 3, 42-49.
9. Edel, M. "Land Values and the Costs of Urban Congestion," *Social Science Information* (Land Values and City Size), Vol 10 (1971), 12-23.
10. Fogarty, M.S. and Garofalo, G.A. "Capital Stock Estimates for Metropolitan Areas, 1957-1977," Proceedings of the Thirteenth Annual Pittsburgh Conference on Simulation and Modeling, University of Pittsburgh, School of Engineering (1982).
11. Fogarty, M.S. and Garofalo, G.A. "The Life Cycle of Cities and the Urban Capital Stock," Working Paper WP-3, Regional Research Institute, West Virginia University, April 1980.
12. Garofalo, G.A. and Fogarty, M.S. "A Note on the Measurement of Agglomeration Economies with Compensation for Urban Disamenities," *Journal of Environmental Economics and Management,* Vol. 10, (1983), 383-387.
13. Greytak, D. and P. Balckley. "Labor Productivity and Local Industry Size: Further Issues in Assessing Agglomeration Economies," *Southern Economic Journal,* Vol. 51 (1985), No. 4, 1121-1129.
14. Henderson, J.V. "Efficiency of Resource Usage and City Size," *Journal of Urban Economics,* Vol. 19 (1986), No. 1, 47-70.
15. Hoover, E.M. *The Location of Economic Activity,* New York: McGraw Hill, 1948.

16. Isard, W. *Location and Space Economy.* Cambridge, MA: The MIT Press, 1956.

17. Kaldor, N. "The Case for Regional Policies," *Scottish Journal of Political Economy,* Vol. 17 (1970), 337-347.

18. Kawashima, T. "Urban Agglomeration Economies in Manufacturing Industries," *Papers, Regional Science Association,* Vol. 34 (1975), 157-175.

19. Lovell, C.A.K. "Capacity Utilization and Production Function Estimation in Postwar American Manufacturing," *Quarterly Journal of Economics,* Vol. 82 (1968), 219-239.

20. Meyer, D.R. "Agglomeration Economies and Urban-Industrial Growth: A Clarification and Review of Concepts," *Regional Science Perspectives,* Vol. 7 (1977), 80-91.

21. Moomaw, R.L. "Firm Location and City Size: Reduced Productivity Advantages as a Factor in the Decline of Manufacturing in Urban Areas," *Journal of Urban Economies,* Vol. 17 (1985), 73-89.

22. Nakamura, R. "Agglomeration Economies in Urban Manufacturing Industries: A Case of Japanese Cities," *Journal of Urban Economies,* Vol. 17 (1985), 108-124.

23. Nicholson, N. "Differences in Industrial Production Efficiency Between Urban and Rural Markets," *Urban Studies,* Vol. 15 (1978), 91-95.

24. Pesaran, M.H. and Deaton, A.S. "On the General Problem of Model Selection," *Review of Economic Studies*, Vol. 41 (1974), 153-170.

25. Richardson, H.W. *Regional Growth Theory,* New York: Halsted Press, 1973.

26. Ringstad, V. "Some Empirical Evidence on the Decreasing Scale Elasticity," *Econometrica,* Vol. 42 (1974), 87-101.

27. Schaefer, G.P. "Returns to Scale and Income Distribution in Urban Areas in Saskatchewan," *Journal of Regional Science,* Vol. 18 (178), No. 3, 357-371.

28. Schaefer, G.P. "The Urban Hierarchy and Urban Area Production Function: A synthesis," *Urban Studies,* Vol. 14 (1977), 315-326.

29. Segal, D. "Are There Returns to Scale in City Size?" *Review of Economics and Statistics,* Vol. 58 (1976), 339-350.

30. Shefer, D. "Localization Economies in SMSA's: A Production Function Analysis," *Journal of Regional Science,* Vol. 12 (1973), 55-64.

31. Vinod, H.D. "Nonhomogeneous Production Functions and Applications to Telecommunciations," *The Bell Journal of Economics and Management Science,* Vol. 3 (Autumn 1972), 531-543.

32. Weber, A. *Theory of the Location of Industries*, Trans. C.J. Friedrich, Chicago: University of Chicago Press, 1929.

33. Zeliner, A. and Revankar, N.S. "Generalized Production Functions," *Review of Economic Studies*, Vol. 36 (1969), 241-250.