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ECONOMIES OF SCALE AND INTERNATIONAL EXPORTS OF SIC 35 FROM US METROPOLITAN AREAS

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ABSTRACT: *New trade theory emphasizes scale economies as the source of places' international export performances. This paper estimates the functional relationship between scale economies and international export performance using recently released export data reported at the spatial scale of metropolitan areas. First, scale coefficients for metro areas' production in SIC 35 are estimated. Then, metro areas' international export performance in SIC 35 is modeled as a function of the estimated scale coefficients and global demand. Results indicate that scale economies are important determinants of metro areas' international exports of SIC 35.*

INTRODUCTION

International export sales are increasingly important in the economies of regions, states, and metropolitan areas (Howes and Markusen, 1993; Erickson, 1989). This is especially true in terms of places' employment and wage levels, and output. By 1995, 11 million US jobs were supported by international exports, up from 9.9 million in 1993, and 6.8 million in 1986 (Davis, 1997). Between 1993 and 1996, exporting firms grew 20 percent faster than their non-exporting counterparts, were 9 percent less likely to go out of business, paid wages 13 percent higher than the national average, and were more productive (Daley, 1997).

Recent explanations of international export performance have been developed and outlined in New Trade Theory (NTT). In essence, NTT asserts that international performance is largely determined by the extent of scale economies which corresponds to the size of the domestic market, and that gains from specialization can be realized even when trading partners have identical technologies and factor proportions (Krugman, 1980). These assertions rest upon the logic that bigger economies have bigger demand and consequently bigger plants, which in turn have lower marginal costs that confer upon them a competitive advantage.

This paper tests the proposition that metropolitan areas' international export performances are a function of the scale economies they contain. The next section briefly describes the treatment of scale economies in NTT. Section three describes the procedures employed in estimating scale coefficients for metropolitan areas and the model estimating the contribution of scale economies to international export performances. Results are reported in section four along with evidence from large-scale surveys of exporting firms. Conclusions close the paper.

NEW TRADE THEORY AND SCALE ECONOMIES

Unlike neo-classical Factor Proportions and classical Comparative Advantage theories, New Trade Theory considers scale economies as endogenous and treats them in conjunction with relative factor endowments and relative productivity levels. Two market forces lead to specialization, consequent returns and international competitiveness: contestable markets and monopolistic competition. In any given contested market, the threat of entry and increasing returns ensures that there is only one producer of each good, and that each producer prices at average costs. When average production costs fall in unit increments with unit increases in plant size, each good can be most efficiently produced at a single plant, so it makes sense for each trading partner to specialize. Trade effectively creates a single world market and thereby concentrates production of each good in a single firm. Under monopolistic competition, with free entry and average cost pricing and when the number of products is endogenously determined by the interplay between market size and increasing returns, the scale efficiency of individual firms improves and the variety of products in the market expands if trade increases demand elasticities (Ethier, 1982). Thus, Krugman (1980) argues that producers who enjoy large domestic demand are better able to exploit scale economies and are thus more competitive abroad.

Econometric attempts to assess the hypothesis that scale economies generate trade have generally proved uninformative (Tybout, 1993). Studies that analyze scale effects typically regress the Grubel-Lloyd (1975) index of intra-industry trade on characteristics of trading partners or industry-specific scale-economy proxy variables. This may not be the correct test. Helpman and Krugman (1985) show that the Grubel-Lloyd index does not vary sufficiently with variations in scale economies or product differentiation.

There are two central problems, then, for understanding the importance of scale economies in metropolitan areas' international export performance: accurately estimating their extent, and testing for their significance. The next section details the methods for estimating scale economies and assessing their importance in the international export performance of metropolitan areas.

METHODOLOGY AND DATA

The analysis requires a two-step procedure. First scale coefficients are produced for individual metropolitan areas, then the functional relationship between these coefficients and the international export performance from corresponding metropolitan areas is estimated.

Estimating Scale Parameters

Cross-section production function estimations are the preferred method for generating scale parameters because they are considered to be more reflective of firms' actual behavior in international markets, because cyclical effects on value-added data are removed, and because they reflect those conditions which influence firms' production choice (Fujita, 1988).

Estimating returns-to-scale coefficients using standard production functions that assume perfect competition is inappropriate insofar as space itself and the existence of transport costs limit competition (Helpman and Krugman, 1985). Moreover, estimating returns-to-scale coefficients is hindered because data on capital inputs are not available. Dhrymes (1965) provides a generalized form of the CES production function, assuming homogeneity of degree h, which allows a returns-to-scale parameter to be estimated for producers in imperfectly competitive markets, and does not require capital inputs data. It is written as...

$$W_{ij} = A\, Q_{ij}{}^{\beta}\, L_{ij}{}^{\gamma}\, U_{ij} \qquad \textbf{(1)}$$

where W is the wage rate, Q is output, L is labor input, U is a random disturbance term, and subscripts refer to the ith industry in the jth MSA.

Dhrymes assumes the unit whose production function this represents behaves as if it were a profit maximizer, and that the first-order conditions for profit maximization (with respect to capital and labor) are met in a two-stage process. Specifically, Dhrymes (1965:360) assumes that the economic unit optimizes with respect to labor first, that the wage bill is essentially determined by the output elasticity of labor, and that "capital gets what is left over". This assumption ensures that the first-order conditions for profit maximization are identical in both the short- and long-run. Dhrymes then goes on to show that the homogeneity parameter can be written as...

$$h_{ij} = \frac{1+\gamma}{1-\beta} \qquad \textbf{(2)}$$

The h_{ij}'s, the scale parameter, can be estimated by applying OLS to the logarithmic transformation of equation 1. Note that h is an aggregate scale parameter. That is, it does not distinguish between internal and external forces. As such it consists of several factors internal scale economies, agglomeration (localization) economies, and urbanization economies.

Scale and Export Performance

The second step in the analysis estimates the functional relationship between metropolitan areas' calculated scale coefficients and their (metro areas') international export performance. The model used for this analysis estimates metropolitan areas' international export performance as a function of their estimated scale coefficients and Balassa's (1965) world market performance index of their goods which measures market demand for a good from a place relative to world market demand for that good from all places. It is written as...

$$XP_{ij} = f(h_{ij}, D_i) \quad (3)$$

where XP is per worker international export volume, h is the returns-to-scale parameter estimated in the first analysis, D is Balassa's measure of global demand for manufactures from an MSA, and subscripts refer, as above, to the ith industry in the jth MSA. In order to test the responsiveness to changes in scale, the export performance measure is log-transformed and estimated as...

$$\ln(XP_{ij}) = b_0 + b_1(h_{ij}) + b_2D_i \quad (4)$$

In equation 4, estimated coefficients are interpreted as the proportional change in the dependent variable resulting from a unit change in the independent variable. Thus, this model captures the responsiveness of international export performance to changes in the scale of production.

Estimating the international export performance model must take into account the heteroscedasticity in the error term that arises from the fact that the h's are derived from different samples, each assumed to exhibit zero mean and constant variance but with variances that differ from sample to sample. The solution is to estimate the model via weighted least squares, using estimates of the parameters' standard errors as weights (Gujarati 1995).

Data and Sources

Data are taken from several sources. Total employment (production workers), total wages (to production workers), and total output (value added by manufacturing) data are taken from the 1992 economic census MC92A4 (CD-ROM #1i). Table 1 shows the data coverage used in the analysis. MC92A4 provides data at nested spatial scales (CMSA, PMSA, MSA, County and Place). An accounting procedure is employed to avoid double counting. Data for places are subtracted from their home-county data to yield remainder county values. In turn, county data are subtracted from home-MSA data to yield remainder MSA values, and MSA data are subtracted from home-PMSA data to yield remainder PMSA data.

Metropolitan areas are those designated by the Office of Management and Budget (OMB) as Primary Metropolitan Statistical Areas (PMSA's), and Metropolitan Statistical Areas (MSA's). Data availability limits the metropolitan areas used in the analysis to those 29 for which metro-area designation corresponds to SIC-specific exports as reported by the USDOC, ITA (see next paragraph).

International export volume data are taken from the US Department of Commerce, International Trade Administration, Exports from Metropolitan Areas (EMA) tables available via the internet at *www.ita.gov*. Data are limited to total international export volumes for 243 metropolitan areas, and limited to 2-digit SIC-category for 31 metropolitan areas. Further disaggregation of international export data for metropolitan areas is impossible given existing regulations governing federal disclosure of protected business information.

When combining the Census and EMA data, disclosure effects are compounded. A complete set of 2-digit SIC-specific production and export data for metropolitan areas is possible only for SIC 35 (industrial machinery), and that for only 29 metropolitan areas. Thus, both the scale parameters and the export performance model are estimated for the correspondent production and international

Table 1

DATA COVERAGE

Census: MC92A4		
data	percent of US total in data set	percent not in MSA's or withheld
number of establishments	86.26	13.74
number of production workers	82.30	17.70
value added	93.12	5.88
ITA Exports from Metropolitan Areas		
data	unable to allocate	allocated to non-metro zip codes
export volume (in $)	8.7% (e.g. 50.4 billion 1995)	6.9% (e.g. 34.2 billion 1995)

exports of SIC 35 from 29 metropolitan areas.

RESULTS

Estimates of metropolitan areas' scale coefficients are produced in order to be employed in a model of export performance. Hence, this research is more concerned with their suitability for inclusion in a subsequent analysis than with the magnitudes of individual coefficients. Some general statements about their pattern and suitability are offered in the next section before moving on to the results of the export performance model.

Results 1: Estimates of Returns-to-scale Coefficients

Table 2 shows the scale coefficients estimated with equation 1. Table 2 reports the scale coefficient (h), along with summary measures of the estimations' "goodness" (r^2, F, and P_F) and sample size (n). The focus on scale economies in MSA's SIC 35 export performance precludes discussion of individual coefficients estimated for the labor and output variables. A general statement about their values is, however, in order.

The estimate scale coefficients are greater than 1.0 for some metropolitan areas, and less than 1.0 for other. Such a pattern is to be expected. Both metropolitan areas and SIC 35 can be characterized as concentrations of various activities. Metro areas are agglomerations of quite different sorts, offering different economies and diseconomies to any average establishment within a sector. It is not the intent of this study to determine the source of increasing (or decreasing) returns. To do so would require (1) more detailed data on firms' shipments, (2) that firms' cost functions be estimated before metro areas' scale functions, and (3) that both cost functions and input ratios be determined for firms across metro areas. Data to do this are not available.

In terms of their "suitability", this research is focused upon the validity of the scale coefficients, as portrayed in the estimating equations' F-scores. The overall results are very good, 21 of the 29 estimated equations yield statistically significant F-values, others nearly so. Considering that SIC 35 encompasses a wide variety of productive activities, the collective results appear to portray good estimates of scale in metropolitan areas.

Investigations, where possible, of the distribution of observations across 3-digit classifications within the 2-digit SIC 35 category reveal that metro areas with many observations have more diverse product output, and presumably more diverse production relations, than metro areas with fewer observations.

This stems from problems with the Census reporting, which withholds data unless sufficient numbers of observations mask production data for individual companies. Two conditions arise from this: (1) statistical results appear, in general, more robust for metro areas with fewer observations, especially in terms of the r^2; and (2) metro areas with similar magnitudes of (few) observations may have somewhat similar statistical results. For example, Miami and Buffalo have similar & significant returns to scale, but do so for different 3-digit categories within SIC 35 (SIC 355 vs. SIC 358). These conditions may deflate the results of equation 2.

Results 2: Scale and Export Performance

The results from estimating the international export performance model are shown in equation 5. The signs of the coefficients are as expected, and are statistically significant. The equation has good explanatory power, and indicates that metropolitan areas' export performance is positively and substantially responsive to unit increases in their estimated scale of production. The reported r^2 value is likely deflated because of the aggregate character of the scale measure. That is, because it does not distinguish between external or internal or localization or urbanization economies, those scale features particularly important in specific places may well be shadowed by those that are unimportant. Without disaggregating the scale measure, which is the focus of follow-up research, it is probable that the contribution of scale economies is underestimated here.

$$\begin{aligned} \ln(XP)_{ij} &= 10.194 + 1.334(h_{ij}) + 0.233D \\ &\quad\ (6.274)\quad (3.537) \quad\ (3.861) \\ r^2 &= .505 \qquad\qquad\qquad (5) \\ F &= 12.765 \end{aligned}$$

Still, their importance is quite noticeable, with unit scale increases producing a more than 1.3% increase in export performance. Comparing the squares of the standardized scale and demand coefficients (0.249 vs. 0.297) suggests that scale economies are effectively equal to demand in determining metropolitan areas' export performances. If so, links between scale and international export performance must be considered more closely.

Supporting Data and Information

There is scant confirmatory data directly linking returns-to-scale and international exporting activities for individual firms or places, but several exporter profiles at varying levels of resolution indicate that scale matters, and provide support both for the findings reported here and for more explicit treatment of scale economies in geographical research on international trade.

At the most discrete level, survey information produced by the Bureau of Business Research in Austin Texas points to some relationships between metropolitan location, scale, and international exporting (McElreath and Stewart, 1997). The Bureau publishes the Directory of Texas Manufacturers which gathers voluntary data about Texas firms, including the geographical extent of their product distribution. In 1995, 16,663 firms provided data to the Bureau, while 16,305 did so in 1997. Fully 22% (3,673) plants reported exporting activity in 1995, and 24% (3,915) did so in 1997.

Several characteristics of these firms are helpful in understanding the links between metropolitan areas, size of manufacturing operations, and exporting activities. First, these exporters are overwhelmingly located in Texas' metropolitan areas. Nearly 60% are located in either Houston, or Dallas-Fort Worth. Moreover, metropolitan-area manufacturers are significantly more likely to export than their non-metropolitan counterparts.

Table 3 shows the international exporting activity of Texas firms by plant size, including the number and percentage of firms in each size class that report exporting activity to the Bureau. Clearly, larger firms are more likely to be exporters. The greater the number of employees in plant, the greater the percentage of firms in that employment-size class who export. This is consistent with findings reported by Tybout (1993), who is also constrained to examining plant size of exporters as a proxy for scale economies in trade. This is, at best, a crude indication, but is given considerable weight by the

Table 2

RETURNS-TO-SCALE COEFFICIENTS

region	metropolitan area	*h*	r^2	F	P_F	n
north central	chicago	1.109	.155	3.945	.0271	46
	milwaukee	0.965	.313	4.102	.0344	21
	cincinatti	1.013	.002	0.022	.9791	22
	cleveland	1.074	.122	4.235	.0192	35
	dayton	1.126	.197	3.306	.0502	30
	detroit	1.040	.029	1.200	.3067	42
	st. louis	1.028	.248	2.804	.0883	20
	minneapolis	0.897	.171	2.168	.1391	24
middle atlantic	new york	0.962	.266	9.400	.0003	33
	buffalo	1.390	.769	15.032	.0014	13
	philadelphia	1.041	.074	1.786	.1792	24
	washington DC	0.922	.513	4.743	.0392	12
	pittsburgh	1.090	.255	4.273	.0253	24
midwest	memphis	0.914	.221	3.414	.0496	27
	kansas city	0.971	.184	1.063	.3616	26
south central	dallas	1.045	.190	4.437	.0201	21
	houston	1.104	.462	7.295	.0052	19
	new orleans	1.065	.312	2.948	.0880	16
mid-south atlantic	greensboro	1.095	.179	2.187	.1380	22
	atlanta	0.967	.298	7.420	.0021	23
	miami	1.497	.858	45.431	.0000	18
pacific	portland	1.023	.044	0.162	.8531	12
	seattle	1.109	.894	16.938	.0012	11
	san francisco	1.208	.410	6.953	.0051	23
	oakland	1.197	.340	7.223	.0030	31
	los angeles	0.984	.075	3.397	.0382	43
	orange county	0.810	.522	6.016	.0172	19
	san jose	1.113	.489	9.571	.0012	23
northeast	boston	1.061	.184	3.260	.0531	34

fact that the relationship is fairly regular while moving through classes.

The Bureau reports in a separate survey of 1,772 high-tech Texas firms, those in SIC's 35 and 36 and 38 with scientists and engineers comprising more than 6% of their workforce, that small firms were less competitive (Echeverri-Carroll, 1997). Moreover, a Bureau survey of 178 high-tech firms' export linkages showed larger firms to have more international and more asymmetric networks both of which corresponded to greater export activities (Echeverri-Carrol et al., 1997).

At a more geographically widespread resolution, Industry Week's Survey of Manufacturers reports that larger firms in their sample of 2,789 were more productive in terms of output per employee, and more competitive in international markets (Taninecz, 1997).

Table 3

EXPORTING MANUFACTURING PLANTS in TEXAS by EMPLOYMENT SIZE

employment size	number of plants	exporters	exporters as % of total
5,000 & over	6	6	100.0
1,000 to 4,999	101	60	59.4
500 to 999	188	103	54.8
250 to 499	375	202	53.9
100 to 249	1187	465	39.2
50 to 99	1451	860	36.0
20 to 48	2985	860	28.8
10 to 19	2823	601	21.3
1 to 9	6251	887	14.2
not reported	938	206	22.0
total	16305	3912	24.0

Source: Texas Business Review: 1997 Directory of Texas Manufacturers

Finally, US Department of Commerce Profile of Exporting Companies (USDOC, 1997) reported that multiple-location companies accounted for 81% of all export value that could be assigned to specific companies (about $349 billion), that companies with more than 500 workers were responsible for 71% of all known export value, and that companies with fewer than 20 employees exported only 11% of the known value.

Fieleke (1997) reported returns-to-scale effects in employment terms. Firms that increased total employment by 1% typically accompanied this increase with an increase in export-related employment of 1.5%. This can be interpreted to mean that increases in the scale of employment generate more than proportional increases in export orientation, which can be taken to be evidence of returns-to-scale as a determinant of trade.

Thus, the findings reported in this research, that returns-to-scale are important forces in metropolitan areas' export performance of SIC 35 are consistent with, but more systematic than, summary survey information from several sources having widely disparate themes.

CONCLUSIONS

International export performance is important. Export-related employment and wage growth have become ever larger shares of total economic growth in metropolitan areas. Scale economies are important sources of successful export performance, and metropolitan areas whose firms are best able to exploit them have an advantage in the global economy. This paper has shown that aggregate scale economies contribute significantly to metropolitan areas' international export performance.

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