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DISCUSSION PAPER

Unobserved firm heterogeneity and the size - exports nexus: Evidence from German panel data

Joachim Wagner

HWWA DISCUSSION PAPER

194

Hamburgisches Welt-Wirtschafts-Archiv (HWWA)
Hamburg Institute of International Economics
2002
ISSN 1616-4814

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Special thanks go to Uwe Rode and the Statistical Office of Lower Saxony for providing access to the data and running my Stata jobs. Comments from a referee helped to improve the paper; the usual disclaimer applies.

The discussion paper is assigned to the HWWA research programme "International mobility of firms and labour". The author is research fellow in this programme.

HWWA DISCUSSION PAPER

Edited by the Department
EUROPEAN INTEGRATION
Head: Dr. Konrad Lammers

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Abstract

This paper starts from the stylized fact that firm size and exporting tends to be positively related. Using large sets of establishment panel data for three different industries from official statistics evidence is presented that the familiar picture of an export/sales ratio that ceteris paribus increases (at a decreasing rate) with firm size vanishes if unobserved firm heterogeneity is controlled for in a fixed effects fractional logit regression model. This finding is well in line with the fact that many small firms are 'hidden export champions'.

Zusammenfassung

Das Papier geht von dem stilisierten Faktum aus, dass Unternehmensgröße und Exportorientierung positiv miteinander zusammenhängen. Auf der Grundlage eines umfangreichen Betriebsdatensatzes der amtlichen Statistik für drei Zweige des Verarbeitenden Gewerbes wird dieser Zusammenhang in einem fraktionalen logit Regressionsmodell mit fixed effects näher untersucht. Dabei verschwindet das gewohnte Bild einer degressiv mit der Betriebsgröße steigenden Exportquote, wenn die unbeobachtete Heterogenität der Betriebe kontrolliert wird. Dies Ergebnis stimmt gut mit der Tatsache überein, dass viele kleinere Firmen als "hidden export champions" anzusehen sind.

JEL-Code: F10, D21, L60
Keywords: Exports, firm size, establishment panel data, fractional logit regression

1 MOTIVATION

It is a truism that firm size and export activities are positively related. "That exporting tends to be concentrated in the larger production units in an industry has been found for several countries ..." (*Caves* 1989, p. 1236) On average, both the propensity to export and the share of exports in total sales tend to increase with firm size (for Germany, see *Wagner* 1995).

Formal microeconomic analysis of this firm size - exports nexus often refers to a model of a firm that faces a downward sloping demand curve at the home market that is steeper than the demand curve abroad. This firm will export a larger fraction of total sales when production increases due to, e.g., a positive cost shock. This textbook model of a price discriminating monopolist has been introduced into the literature on the microeconomics of the exporting firm by *Hirsch* and *Zvi Adar* (1974). A closer look at it, however, reveals that it does not form a firm ground for any conclusion regarding a positive relationship between firm size and exports in a cross section of firms. Given the assumptions of the model, we can expect a positive linkage of firm growth and growth of exports for each firm, and this is what *Wagner* (1993) finds in an econometric study using longitudinal data for German establishments. However, this model does not lead to any clear cut conclusion regarding the firm size - exports relationship in a sample of firms that produce different products under different cost conditions and sell these products on markets with different demand curves (see, e.g., *Sterlacchini* 2001).

Informal reasoning about the positive relationship between firm size and exports points to economies of scale in production, a more fully utilization of (specialized) executives, the opportunity to raise financing at a lower cost, benefits from bulk purchasing, own marketing department plus own sales force, and a higher capacity for taking risks (e.g., development of new products) due to internal diversification in larger compared to smaller firms. Furthermore, at least some of the costs related to exporting are fixed in nature (e.g., retooling and redesigning products for foreign markets, doing market studies abroad), and firms with a large sales volume can keep unit costs low by spreading fixed costs over a large number of units sold (see *Hirsch* 1971, pp. 64, for a good discussion along these lines). Obviously one can expect limits to the advantages of size because of mounting coordination costs with an increasing scale of operation, and at some

point further expansion will cease to be profitable. Therefore, one can expect a positive relationship between firm size and exports, at least up to a point.

Studies from the emerging literature on the microeconometrics of German exports tend to back this reasoning. Firm size (usually measured by the number of employees) turns out to be positively related to the share of exports in total sales ceteris paribus after controlling for a number of other firm level variables. If the squared value of the size variable is included the estimated coefficient has a negative sign, pointing to an inversely u-shaped relationship between size and exports. A closer look at the data reveals that only some firms are larger than the maximum value of this quadratic curve, so the estimates show that the fraction of exports in total sales increases with firm size at a decreasing rate (see *Wagner* 1998). From studies using longitudinal data we have some evidence that causality here runs in both ways - a larger firm size has a positive influence on the propensity to start to export, and starting to export tends to promote firm growth (see *Bernard* and *Wagner* 1997, and *Wagner* 2001a).

This evidence from descriptive and microeconometric studies plus the theoretical arguments summarized above could lead towards centering the discussion of any questions related to exporting on large firms. A case in point might be policy measures to foster exporting, or the consequences of barriers to trade. However, reading beyond professional journals and looking at evidence reported in the business press or trade journals reveals lots of counter examples as regards the necessity of largeness for success in exporting. There are many small firms, often with less than hundred employees, which are highly successful on the world market. Three examples may suffice to illustrate this point:[1]

- *Dr. Rolf Hein KG, Tuebingen*, is the producer of soap bubble material sold under the brand name *Pustefix*; the firm exports one third of its production in more than 50 countries. In 1998 the firm had 28 employees.

- *Sattlerei G. Passier und Sohn, Hannover*, makes high-class saddles with less than 100 employees (in 2000), selling more than half of the production in Europe and overseas.

1 See Frankfurter Allgemeine Zeitung, 21.10.1998, p. 30; Hannoversche Allgemeine Zeitung, 25.1.2000, p. 12; and Unsere Wirtschaft - Industrie- und Handelskammer Lüneburg-Wolfsburg, 1/2002, pp. 23., respectively.

- *Dr. Kaiser Diamantwerkzeuge, Celle,* is active in diamond precision tools, has 104 employees (in early 2002), and sells 35 percent of its production in foreign markets all over the world.

Looking at the evidence from descriptive and microeconometric studies plus the theoretical arguments summarized above one may wonder how these small firms (and many other 'hidden export champions') can be that successful. The case studies mentioned point to the role of a unique product (due to secret ingredients as in the case of *Pustefix*, patents, or top-quality rooted in a long tradition of craftsmanship), combined with an attitude of the management that is favorable to selling in foreign markets. Therefore, one can argue that while not all large firms are successful exporters, and not all successful exporters are large, factors that make a successful exporter seem to be found more often in larger firms. If these success-factors which are positively correlated with firm size are not controlled for in regression studies, the estimated coefficient of the firm size variable is biased upwards, and controlling for these factors should lead to a diminishing or even vanishing size - exports nexus. Given that these factors can only be described rather vaguely ("unique product", "attitude of management", etc.), however, a straightforward test of this hypothesis by estimating regression models including both firm size and variables that measure (or at least proxy) these factors convincingly is not possible.

This paper contributes to the literature on the microeconometrics of exports by suggesting and implementing an empirical approach that allows to control for unobserved (and often unobservable) firm heterogeneity caused by such factors in investigating the firm size - exports nexus. It is based on a large set of panel data for establishments from manufacturing in Germany, and it applies a new econometric method tailored to deal with endogenous variables that are limited by zero and one (like the share of exports in total sales), with many observations at the lower limit. The rest of the paper is organized as follows: Section 2 introduces the data; section 3 discusses the empirical modelling strategy; section 4 reports the estimation results; and section 5 concludes.

2 DATA

The empirical investigation uses data from an unbalanced panel of establishments (local production units, plants) built from cross section data collected in regular surveys by the Statistical Office of Lower Saxony, one of the 'old' federal states of Germany. The sur-

veys cover all establishments from manufacturing industries that employ at least twenty persons in the local production unit or in the company that owns the unit. Participation of firms in the survey is mandated in official statistics law, and the firms have to report the true figures. The panel starts in 1978, and in this paper annual data for 1978 (the first year data are available for) to 1989 (the year prior to the German re-unification) are used. Note that the data are strictly confidential and for use inside the Statistical Office only, but not exclusive. Further information on the content of the data set and how to access it is given in *Wagner* (2000).

The **export/sales ratio** is computed as the amount of (direct) sales in foreign countries over the sum of sales at home and abroad. **Firm size** is measured by the number of employees. To check whether results are affected by the choice of a measure of size based on an input rather than an output variable, the amount of total sales (normalized by the average amount of total sales in a given year in the four-digit industry to take care of price level changes over the years) was used in an alternative specification. In the model described in the next section below, two further variables are used: A **branch plant** dummy that takes on the value one if an establishment is part of a multi-establishment enterprise, zero otherwise. And the **average wage per employee** to proxy human capital intensity and to reflect different levels of labor productivity. This variable is normalized by the average wage in a given year in the four-digit industry the plant belongs to and, therefore, measures the deviation of the average wage in an establishment from the industry average at a point in time. Note that the data do not contain any information about the quantity or quality of physical capital, nor information about research and development spending, innovative activities, or patents.

Data were pooled over the years 1978 to 1989. Given the potential role played by technology in determining the firm size - export relationship, and that economies of scale as well as transaction cost efficiencies may vary considerably from one industry to another, the existence or not of an inversely u-shaped relation between the number of employees and the export/sales ratio should be examined in specific industries. For the empirical investigation all four-digit industries (the finest classification available in the data set) were selected that fulfilled two conditions: First, on average, there was information for at least 100 establishments in the pooled data set in every year between 1978 and 1989 (leading to a sufficiently large number of cases for the econometric study); eleven four-digit industries met this criterion. Second, the average share of exports in total sales in the industry as a whole was at least 20 percent, excluding five industries

where exporting plays no role (average share of exports in total sales below four percent in, e.g., 1983) or a much smaller role (average share of exports in total sales between 8.4 and 12.5 percent) only. Three four-digit industries met this criteria, viz. **manufacturing of steel- and light metal constructions** (SYPRO 3111 - Stahl- und Leichtmetallbau), **other mechanical engineering** (SYPRO 3280 - sonstiger Maschinenbau), and **manufacturing of plastic goods** (SYPRO 5800 - Herstellung von Kunststoffwaren). In 1984, the mid-year of the period under consideration, the average share of exports in total sales in these industries was 22 percent, 24.5 percent, and 21.4 percent, respectively.

3 EMPIRICAL MODELLING STRATEGY

In the literature on the microeconometrics of exporting various approaches have been used to model the export/sales ratio. This issue is somewhat tricky because the endogenous variable is a proportion, or percentage variable, whose values must by definition lie between zero and one (or zero and one hundred percent) including the limits, with usually many observations at the lower limit. *Wagner* (2001b) discusses various econometric methods to deal with this special nature of the export/sales ratio in cross-section estimations, and he shows that the standard approaches (two-step sample selection models, and application of tobit estimators) are flawed for both theoretical and econometric reasons.

A solution comes from an estimator specifically constructed to deal with proportions data that was developed by *Papke* and *Wooldrige* (1996) in a paper on 401(k) plan participation rates; a textbook treatment of this fractional logit regression model can be found in *Wooldridge* (2002, pp. 661). *Wagner* (2001) introduced this estimator into the microeconometrics of exporting. Based on a rich cross-section data set he reports that the "usual" ceteris paribus inversely u-shaped relationship between firm size and exports is statistically significant at a conventional level for the whole sample of firms from all industries, and for firms from two (out of three) broadly defined industries.

The application of the fractional logit regression model to modelling the export/sales ratio in *Wagner* (2001) was limited to cross section data because in the data set used in that study, viz. the **Hannover Firm Panel Study**, information needed to estimate the model is not available from a sufficiently large number of waves. With cross section

data, unobserved firm heterogeneity cannot be controlled for, and the problem discussed in the introductory section above arises: If unobserved factors that make a successful exporter (like a unique product, or an attitude of the management that is favorable towards taking the extra risks of selling in foreign markets) are positively correlated with firm size and not controlled for in regressions using cross section data, the estimated coefficient of the firm size variable is biased upwards.

Panel data can be used to control for unobserved heterogeneity (see, e.g., *Baltagi* 2001). The application of the fractional logit regression model to panel data is straightforward in the situation we are facing here: If the number of panels (i.e., establishments) in a population (i.e., in an industry) is finite and each panel is represented in our sample, an unconditional fixed-effects model can be used which simply includes an indicator variable for each panel (see *Hardin* and *Hilbe* 2001, p. 195). The survey data from official statistics used in this study fulfill both conditions. Therefore, a fixed effects version of the fractional logit regression model is applied; to see the effects of controlling for unobserved heterogeneity, a simple fractional logit regression model based on pooled data is computed, too.[2]

4 ESTIMATION RESULTS AND INTERPRETATION

The central aim of this study is to test whether unobserved firm specific factors which make a successful exporter and which are positively correlated with firm size bias the estimated coefficient of the firm size variable upwards in models estimated with cross section data. To put it differently, we want to test whether the usual picture that the export/sales ratio increases (at a decreasing rate) with firm size is weakened or even vanishing when panel data are used to control for unobserved firm heterogeneity.

Using unbalanced panels made of pooled data for all establishments from three industries that had to report to official statistics at least in one year between 1978 and 1989 two empirical models were estimated for each industry: A model based on pooled data without establishment dummies, and a fixed effects model with an indicator variable for each unit. Both models were estimated using the fractional logit regression approach.

2 Computations were done using the glm program of Stata 7 (StataCorp 2001); details are available from the author on request.

The endogenous variable is the fraction of total sales that is exported; exogenous variables in both models include the size of the establishment (measured either by the number of employees or by the amount of total sales) and its squared value, a dummy variable indicating whether or not the establishment is part of a multi-plant enterprise, the average wage per employee (normalized by the industry average in the respective year) to proxy human capital intensity and to reflect different levels of labor productivity, and a set of year dummies to control for macroeconomic conditions. Note that limitations of the data (discussed above) prevent inclusion of further control variables, e.g. physical capital intensity, or research and development activities.

Results for models using the number of employees as an indicator for firm size are reported in table 1. When pooled data without fixed effects for all three industries are used the familiar picture is found: The export/sales ratio increases (at a decreasing rate) with firm size and with the average wage per employee. Note that the branch plant dummy is negative and statistically significant in 'manufacturing of steel- and light metal construction' and in 'other mechanical engineering', while it is positive and statistically significant in 'manufacturing of plastic goods'. The positive firm size - exports nexus vanishes completely when unobserved plant heterogeneity is controlled for in fixed effects models. None of the estimated coefficients of the establishment size variables is statistically significant at an error level of five percent or better. The same holds for the average wage per employee included as a proxy variable for human capital and to reflect different levels of labor productivity (and for the branch plant dummy in two of the three industries considered here).

Results for models using the amount of total sales instead of the number of employees as an indicator for firm size are reported in table 2. Given that total sales and the number of employees tend to be highly correlated in an industry (in 1984, the mid-year of the period under consideration, the correlation coefficient for number of employees and total sales was 0.88 in industry 3111, 0.90 in industry 3280, and 0.96 in industry 5800) it comes as no surprise that the big picture is very similar to the one reported in table 1 above. The positive firm size - exports nexus vanishes completely in two industries when unobserved plant heterogeneity is controlled for in fixed effects models. Only one of the estimated coefficients of the establishment size variables is statistically significant at an error level of slightly better than five percent (see the coefficient of the total sales variable in model B for industry 3111).

These results are in line with the hypothesis stated at the beginning of this paper: It is not firm size *per se* that makes a successful exporter. There are other factors that cannot be measured in a straightforward way, and that tend to be correlated positively with firm size. Controlling for these unobserved "export success factors" by adding fixed effects to a fractional logit regression model for the share of exports in total sales helps to understand why there is no contradiction between the bulk of findings from descriptive and econometric studies pointing to the positive relationship between firm size and exports on the one hand, and the many stories told about small firms which are highly successful on the world market on the other hand.

5 CONCLUDING REMARKS

This paper starts from the stylized fact that firm size and exporting tend to be positively related. Using large sets of establishment panel data for three different industries from official statistics evidence is presented that the familiar picture of an export/sales ratio that ceteris paribus increases (at a decreasing rate) with firm size vanishes if unobserved firm heterogeneity is controlled for in a fixed effects fractional logit regression model. This finding is well in line with the fact that many small firms are 'hidden export champions'. And it should be noted when measures to support export activities of firms are tailored.

What, however, are these "success factors" that are treated as fixed effects to control for unobserved firm heterogeneity? The survey data we are used to work with in the microeconometrics of exporting are highly unlikely to tell us. Whoever has been engaged in doing a survey of firms knows that it is difficult if not impossible to collect information on such 'hard' facts like amounts of physical capital, investment and depreciation, or R&D outlays, without a large fraction of interviewees refusing to answer because this information is considered to be strictly confidential, let alone information on strategies and attitudes of the management. Maybe, we should follow *Blinder's* (1990) advice and start **learning by asking those who are doing**, i.e. supplement theoretical and econometric research with evidence from carefully performed case studies telling stories of success and failure on export markets.

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Table 1: Results for firm size measured by number of employes (fractional logit regressions)

Endogenous variable: Fraction of exports in total sales (1978-89)

Industry: 3111 (Manufacturing of steel- and light metal constr.)

Model		A	B
Number of employees	ß	0.016	-0.010
	p-value	0.000	0.216
Number of employees (squared)	ß	-1.82e-5	1.88e-5
	p-value	0.006	0.106
Branch plant dummy	ß	-1.261	0.757
	p-value	0.000	0.005
Average wage per employee	ß	1.367	-0.171
	p-value	0.000	0.826
Fixed effects		no	yes
Number of observations		1299	1299
Number of establishments		208	208

Industry: 3280 (Other mechanical engineering)

Model		A	B
Number of employees	ß	0.008	0.003
	p-value	0.000	0.484
Number of employees (squared)	ß	-6.86e-4	-3.34e-6
	p-value	0.000	0.456
Branch plant dummy	ß	-0.756	-0.054
	p-value	0.000	0.789
Average wage per employee	ß	0.797	0.347
	p-value	0.000	0.314
Fixed effects		no	yes
Number of observations		1332	1332
Number of establishments		212	212

Industry: 5800 (Manufacturing of plastic goods)

Model		A	B
Number of employees	ß	0.001	0.001
	p-value	0.000	0.382
Number of employees (squared)	ß	-2.76e-7	-1.49e-7

	p-value	0.000	0.394
Branch plant dummy	ß	-0.297	-0.122
	p-value	0.000	0.427
Average wage per employee	ß	-0.981	0.185
	p-value	0.000	0.531
Fixed effects		no	yes
Number of observations		2046	2046
Number of establishments		291	291

Note: All models include a set of year dummies for 1979 to 1989. For further details, see text.

Table 2: Results for firm size measured by total sales (fractional logit regressions)

Endogenous variable: Fraction of exports in total sales (1978-89)

Industry: 3111 (Manufacturing of steel- and light metal constr.)

Model		A	B
Amount of total sales	ß	0.457	0.375
	p-value	0.000	0.049
Amount of total sales (squared)	ß	-0.007	-0.003
	p-value	0.000	0.580
Branch plant dummy	ß	-2.186	0.101
	p-value	0.000	0.738
Average wage per employee	ß	1.539	-0.553
	p-value	0.000	0.406
Fixed effects		no	yes
Number of observations		1299	1299
Number of establishments		208	208

Industry: 3280 (Other mechanical engineering)

Model		A	B
Amount of total sales	ß	0.528	0.234
	p-value	0.000	0.224
Amount of total sales (squared)	ß	-0.031	-0.020
	p-value	0.000	0.122
Branch plant dummy	ß	-0.585	-0.063
	p-value	0.000	0.751
Average wage per employee	ß	0.469	0.237
	p-value	0.000	0.472
Fixed effects		no	yes
Number of observations		1332	1332
Number of establishments		212	212

Industry: 5800 (Manufacturing of plastic goods)

Model		A	B
Amount of total sales	ß	0.179	0.124
	p-value	0.000	0.123
Amount of total sales (squared)	ß	-0.005	-0.003

	p-value	0.000	0.139
Branch plant dummy	ß	0.273	-0.118
	p-value	0.000	0.453
Average wage per employee	ß	0.783	0.147
	p-value	0.000	0.614
Fixed effects		no	yes
Number of observations		2046	2046
Number of establishments		291	291

Note: All models include a set of year dummies for 1979 to 1989. For further details, see text.