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ABSTRACT

Using quantile regression and a rich cross section data set for German manufacturing plants this paper documents that the impact of plant characteristics on export activities varies along the conditional size distribution of the export/sales ratio.

Keywords: Exports, quantile regression, heterogeneous firms
JEL classification: F10, D21, L60

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1 INTRODUCTION

During the past decade a new literature emerged that deals with the microeconometrics of international trade. Based on large sets of data at the plant or firm level, instead of country or industry level data, these studies investigate various aspects of the causes and consequences of exporting (see, e.g., *Bernard* and *Jensen*, 1995, and *Wagner*, 1995, for early contributions, and *Wagner*, 2002, and *Bernard* and *Jensen*, 2004, for recent studies). One striking finding in this literature is the enormous amount of heterogeneity between plants or firms within narrowly defined industries and size classes. A case in point is the diversity of patterns in the exporting behavior of manufacturing firms from one German federal state during the time span from 1995 to 2002, documented in detail in *Wagner* (2004). This again illustrates what *James Heckman* (2001, 674) in his Nobel lecture named the most important discovery from microeconometric investigations – the evidence on the pervasiveness of heterogeneity and diversity in economic life. Based on these findings from empirical studies with microdata it is argued that there is no such thing as a representative exporting firm. Trade theorists recently took this stylized fact as a starting point for the construction of exiting new models of heterogeneous exporting firms (see *Melitz*, 2004, and *Bernard*, *Redding* and *Schott*, 2004).

If we acknowledge that exporters in an industry are heterogeneous, we have reasons to suspect that the effects of the variables explaining the behavior of firms with regard to foreign markets do not need to be the same for all firms. For example, it might be the case that an increase in the use of highly skilled labor has a different impact on the international competitiveness, and, therefore, on the share of exports in total sales, for plants that export only a small fraction of their products compared to plants that have an export/sales ratio of 70 percent. If we are interested in the relationship between the export/sales ratio on the one hand and a set of plant characteristics (like size, skill intensity, R&D intensity, etc.) on the other hand, and if we regress the export/sales ratio on these independent variables using ordinary least squares (OLS), there is no room for plant heterogeneity of this kind. OLS assumes that the conditional distribution of the export/sales ratio, given the set of plant characteristics, is homogeneous. This implies that no matter what point on the conditional distribution is analyzed, the estimates of the relationship between the export/sales ratio (the dependent variable) and the plant characteristics (the independent variables) are the same. If one wants to test the empirical validity of this rather restrictive assumption, and if one is interested in the evaluation of the relative importance of the variables viewed as determining export behaviour at different points of the conditional distribution of the share of exports in total sales, one has to apply a different estimation technique that is tailor-made for this – quantile regression.

A discussion of technical details of quantile regression is beyond the scope of this paper; canonical references are the pioneering paper by *Koenker* and *Bassett* (1978) and the survey by *Buchinsky* (1998), while *Koenker* and *Hallock* (2001) provide a non-technical introduction. Suffice it to say here that in contrast to OLS (that gives information about the effects of the regressors at the conditional mean of the dependent variable only) quantile regression can provide parameter estimates at different quantiles. Therefore, it gives information on the variation in the effect of independent variables on the dependent variable at different quantiles. The estimated regression coefficients can be interpreted as the partial derivative of the conditional quantile of the dependent variable (here: the share of exports in total sales) with respect to a particular regressor (e.g., skill intensity), i.e. the marginal change in the export/sales ratio at the k^{th} conditional quantile due to a marginal change in skill intensity. For each quantile it can be shown whether the effect of a particular independent variable is positive or negative, and how large this effect is compared to other quantiles. This provides information about the heterogeneity of plant behavior. Note that quantile regression is not the same as applying OLS to subsets of the data produced by dividing the complete data set into different percentiles of the dependent variable. This would mean that not all of the data are being used for each estimate, and it would introduce the familiar type of sample selection bias. For each quantile regression estimate all of the data are being used; some observations, however, get more weight than others.

This paper contributes to the literature on the microeconometrics of international trade by applying quantile regression to the study of the relationship between the export/sales ratio and a set of plant characteristics for the first time.[1] The rest of the paper is organized as follows: Section 2 gives information on the plant level data set and the empirical model used; section 3 reports and comments on the findings from the econometric investigation; section 4 concludes.

1 To the best of my knowledge, there are only two other papers dealing with exports that apply quantile regression: Fugazza (2004) looks at the determinants of export performance of countries using macro data; Yasar, Nelson and Rejesus (2003) investigate the relationship between productivity (as the independet variable) and export status (as one of the independent variables). For applications of quantile regression in other areas of economics see Koenker and Hallock (2001).

2 DATA AND EMPIRICAL MODEL

The data used in this note were collected in interviews conducted as part of a panel study, Das Hannoveraner Firmenpanel, investigating various aspects of firm behavior and firm performance. The population covered encompasses all manufacturing establishments with at least 5 employees (including the owner and members of his family) that were active in 1994 in the state of Lower Saxony, one of the 'old' German federal states. The data were collected in personal interviews with the owner or top manager of the firm. Detailed information on the data set and how it can be accessed by researchers is given in *Gerlach, Hübler* and *Meyer* (2003).

The dependent variable in the empirical model is the share of exports in total sales, the export/sales ratio. Note that information on direct exports only was collected in the survey. Besides firm size (measured by the number of employees in an establishment in 1994) and its squared value the model includes information on the branch plant status of the establishment (small branch plants can use certain resources from their larger mothers), whether it belongs to the crafts sector (and is more or less orientated to local or regional demand), human capital intensity (measured by the percentage of jobs demanding a university or polytech degree), research and development (R&D) intensity (three dummies for various groups using firms without R&D as the reference group), and patents (whether or not a firm registered at least one patent). Furthermore, a set of dummy variables indicating the industry affiliation of the plant is included to control for industry effects. According to international trade theory we expect a positive sign of human capital intensity, R&D, and patents, because firms from a highly industrialized country should have a comparative advantage in new and advanced products made by highly qualified people using advanced technology. Due to economies of scale and the fixed costs related to exports a positive influence of firm size on the export/sales can be expected that might be non-linear and decreasing due to limits to the advantage of size (*Wagner*, 1995).

3 RESULTS OF THE ECONOMETRIC INVESTIGATION

In this study we focus on the relationship between variations in the export/sales ratio and in plant characteristics. Therefore, we look at exporting firms only and do not investigate the decision to export or not; furthermore, the issue of the direction of causality between exporting and plant characteristics is not considered (see *Wagner*, 2002). As a benchmark, in a first step of the econometric investigation the empirical model was estimated by OLS. Results are reported in the first column of table 1. These results are in line with the priors, and with findings from earlier studies on the plant level determinants of exporting in Germany.

[Table 1 near here]

Application of OLS implies that no matter what point on the conditional distribution is analyzed, the estimates of the relationship between the export/sales ratio and the plant characteristics are the same. To test the empirical validity of this rather restrictive assumption, and to uncover the relative importance of the variables viewed as determining export behaviour at different points of the conditional distribution of the share of exports in total sales, quantile regression is applied in a second step at five quantiles, namely .10, .25, .50, .75, and .90 quantiles.[2] Results are reported in columns two to six of table 1.

The point estimates and the statistical significance of the estimated coefficients differ widely across the regressions for the various quantiles, and compared to the benchmark results from the OLS regression. For example, firm size is statistically significant at a conventional level for the .25 quantile only; branch plant status, which is highly significant in the OLS regression, matters at the upper tail of the conditional distribution of the export/sales ratio only; the craft shop dummy is only significant for the very top quantile; the percentage of jobs demanding a university or polytech degree that is an important determinant of plant level export behavior according to the OLS results has no influence according to the quantile regressions results; the impact of the R&D intensity variables differ between quantiles; and patents do not matter at the very lower end of the conditional distribution of export over sales. Heterogeneity abounds.

The null hypothesis that the coefficients are equal between pairwise quantiles and across all quantiles is tested based on the variance-covariance matrix of the coefficients of the system of quantile regressions reported in table 1. Table 2 gives the prob-values for the computed F-statistics. The null hypothesis is rejected at an error level of 5 percent or lower for some of the pairwise comparisons for the craft shop dummy, the dummy variable indicating plants with an R&D intensity that is greater than zero but less than 3.5 percent, and for the patents dummy. The joint test for all quantiles rejects the null hypothesis for the dummy variable indicating plants with an R&D intensity that is greater than zero but less than 3.5 percent, and for the patents dummy.

[Table 2 near here]

2 All computations are done using Stata/SE 8.2. To facilitate replication the do-file is available on request.

4 CONCLUDING REMARKS

Using quantile regression and a rich cross section data set for German manufacturing plants this paper documents that the impact of plant characteristics on export activities varies along the size distribution of the export/sales ratio. This points to the need to supplement OLS (or any other econometric method that focuses on the conditional mean of a dependent variable) by quantile regression when investigating the behavior of heterogeneous plants. To put it differently, and to quote *Moshe Buchinsky* (1994, p. 453): "'On the average' has never been a satisfactory statement with which to conclude a study on heterogeneous populations."

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Table 1: Estimation Results for the Export/Sales Ratio

Independent Variables	OLS Estimates	Quantile Regression Estimates 0.10	0.25	0.50	0.75	0.90
Firm size	.005	.006	.009	.010	.007	.004
(Number of employees)	(.092)	(.106)	(.022)	(.156)	(.447)	(.746)
Firm size squared	-1.85e-7	-1.94e-7	-3.73e-7	-5.27e-7	-3.82e-7	-1.71e-7
	(.310)	(.916)	(.819)	(.903)	(.903)	(.979)
Branch plant status	7.137	-.464	2.416	5.342	12.295	10.573
(Dummy; 1 = firm is a branch plant)	(.014)	(.778)	(.161)	(.216)	(.037)	(.079)
Craft shop	-4.433	-.135	-1.323	.011	-3.527	-12.214
(Dummy; 1 = firm belongs to crafts sector)	(.110)	(.924)	(.493)	(.997)	(.385)	(.046)
Percentage of jobs demanding a university	.360	-.038	.143	.307	.320	-.001
or polytech degree	(.027)	(.700)	(.401)	(.270)	(.279)	(.998)
R&D/sales ratio greater zero and less	5.003	-.705	-.115	3.291	8.307	15.968
than 3.5 percent (Dummy; 1 = yes)	(.014)	(.503)	(.905)	(.143)	(.018)	(.005)
R&D/sales ratio between 3.5 percent and	9.061	4.238	5.545	8.499	8.967	13.687
less than 8.5 percent (Dummy; 1 = yes)	(.003)	(.029)	(.019)	(.003)	(.055)	(.062)
R&D/sales ratio equal to 8.5 percent	4.569	3.492	9.926	4.938	11.347	-.034
or more (Dummy; 1 = yes)	(.318)	(.549)	(.084)	(.537)	(.138)	(.997)
Patents (Dummy; 1 = firm	10.352	2.745	6.630	10.100	18.363	13.410
registered at least one patent)	(.000)	(.170)	(.003)	(.005)	(.001)	(.032)
Constant	22.170	3.537	4.918	18.243	29.419	60.059
	(.000)	(.000)	(.045)	(.000)	(.000)	(.000)
Number of cases	458	458	458	458	458	458
R-square	.275					
Pseudo R-Square		.065	.118	.163	.203	.298

Notes: (1) Prob-values reported in parenthesis; the prob-values for quantile regressions are based on standard errors bootstrapped with 100 replications.
(2) All regressions include dummy variables for 15 manufacturing industries; results are omitted to economize on space, but are available on request.

Table 2: Tests for Coefficient Equality between Pairwise Quantiles and across all Quantiles

	Quantiles being tested	Firm size	Firm size squa.	Branch plant status	Craft shop	Percent univers. jobs	R&D/sales > 0 and < 3.5%	R&D/sales >= 3.5% and < 8.5%	R&D/sales >= 8.5%	Patents
A:	Pairwise									
	0.10 vs. 0.25	.511	.925	.108	.442	.220	.543	.562	.211	.096
	0.10 vs. 0.50	.601	.943	.177	.957	.200	.088	.198	.858	.024
	0.10 vs. 0.75	.928	.972	.030	.411	.228	.011	.338	.401	.003
	0.10 vs. 0.90	.843	.998	.067	.043	.913	.003	.206	.744	.102
	0.25 vs. 0.50	.781	.965	.421	.605	.461	.098	.315	.440	.224
	0.25 vs. 0.75	.875	.998	.075	.595	.564	.015	.492	.863	.021
	0.25 vs. 0.90	.676	.974	.170	.068	.680	.005	.294	.332	.280
	0.50 vs. 0.75	.658	.959	.223	.361	.968	.143	.915	.447	.076
	0.50 vs. 0.90	.509	.947	.399	.039	.450	.030	.466	.658	.584
	0.75 vs. 0.90	.753	.966	.751	.071	.344	.153	.468	.185	.371
B:	Joint test for all quantiles	.923	.999	.189	.273	.568	.019	.649	.405	.038

Note: The null hypothesis is that the coefficients are equal between pairwise quantiles (panel A) and across all quantiles (panel B). Tests statistics are based on the variance-covariance matrix of the coefficients of the system of quantile regressions reported in table 1. The table reports the prob-values for the F-values; if the prob-value is less than the level of significance, the null hypothesis of equal coefficients is rejected.