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Exports, R&D and Productivity:

A test of the Bustos-model with German enterprise data

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Abstract:

This paper presents the first empirical test with German firm level data of a hypothesis derived by Bustos (AER 2011) in a model that explains the decision of heterogeneous firms to export and to engage in R&D. Using a non-parametric test for first order stochastic dominance it is shown that, in line with this hypothesis, the productivity distribution of firms with exports and R&D dominates that of exporters without R&D, which in turn dominates that of firms that neither export nor engage in R&D. These results are in line with findings for Argentina. The model, therefore, seems to be useful to guide empirical work on the relation between exports, R&D and productivity.

JEL classification: F14

Keywords: Exports, R&D, productivity, Germany

* The data used in this study are confidential but not exclusive; see Zühlke et al. (2004) for a description of how to access the data. All computations were done inside the Research Data Centre of the Statistical Office of Berlin. To facilitate replication the Stata do-file is available from the author on request.

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1. Motivation

Building on the seminal paper by Melitz (2003) a large literature emerged during the past ten years that discusses international trade in models with heterogeneous firms (see Redding (2011) for a survey). At the core of this theoretical literature and the closely related micro-econometric literature on firm performance and international trade is the relation between firm productivity and exports (see Wagner (2012) for a survey). In a recent paper Bustos (2011) makes an important extension to this literature by introducing technology choice in a model of trade with heterogeneous firms. In her model, more productive firms gain higher revenues and therefore are the only ones that find paying the fixed costs that are needed to start exporting profitable (as in the Melitz (2003) model). In addition, only the most productive firms adopt the most advanced technology, because the benefit of adoption is proportional to revenues, while its cost is fixed.

As is proved in detail in Bustos (2011) in the model the underlying productivity differences produce a sorting of firms in three groups: the most productive firms both export and use the advanced technology, the intermediate group exports but still uses the old technology and the least productive firms use the old technology and serve only the domestic market only. In an empirical application the use of advanced technology is represented by spending on research and development (R&D). This leads to the following empirically testable hypothesis:

In a given industry productivity is highest in firms that export and engage in R&D, followed by firms that export and do not engage in R&D and by firms that do neither export nor engage in R&D.

Bustos (2011) finds support for this implication of her model with data from Argentina. This note uses data for a large sample of German manufacturing firms for

a further empirical test of these implications, keeping in mind that 'the credibility of a new finding that is based on carefully analyzing two data sets is far more than twice that of a result based only on one' (Hamermesh, 2000, p. 376). To anticipate the most important finding, results are in line with the theoretical hypothesis for Germany, too.

2. Empirical strategy and data

The empirical strategy used here to test the hypotheses derived by Bustos (2011) uses a familiar t-test for differences in the means of productivity between the three groups of firms. Furthermore, it applies a non-parametric test for first order stochastic dominance of one distribution over another that was introduced into the empirical literature on exports by Delgado, Farinas and Ruano (2002). Let F and G denote the cumulative distribution functions of productivity for two groups of firms (say, exporters with and without R&D activities). First order stochastic dominance of F relative to G is given if F(z) – G(z) is less or equal zero for all z with strict inequality for some z. Given two independent random samples of plants from each group, the hypothesis that F is to the right of G can be tested by the Kolmogorov-Smirnov test based on the empirical distribution functions for F and G in the samples (for details, see Conover 1999, p. 456ff.). Note that this tests not only for differences in the mean productivity of both groups (like in almost all other papers in the literature on trade and productivity) but for differences in all moments of the distribution.

The data used in this study are merged from two surveys conducted by the German statistical offices. One source is the monthly report for establishments in manufacturing industries described in Konold (2007). This survey covers 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. For this project the information collected at the establishment level has been aggregated at the enterprise level to match the unit of observation from the second source of data used here. This survey is the source for information on the location of the firm in West Germany or East Germany, the industry affiliation of the firm and whether a firm is an exporter or not.

The second source of data is the cost structure survey for enterprises in the manufacturing sector. This survey is carried out annually as a representative random sample survey. The sample is stratified according to the number of employees and the industries; all firms with 500 and more employees are covered by the cost structure survey (see Fritsch et al. 2004). This survey is the source for information on value added per employee and whether a firm is actively engaged in R&D (reporting a positive amount of spending for research and development activities).

Productivity is measured by labour productivity defined as value added per employee. Bartelsman and Doms (2000, p. 575) point to the fact that heterogeneity in labor productivity has been found to be accompanied by similar heterogeneity in total factor productivity in the reviewed research where both concepts are measured. In a recent comprehensive survey Chad Syverson (2011) argues that high-productivity producers will tend to look efficient regardless of the specific way that their productivity is measured. Furthermore, Foster, Haltiwanger and Syverson (2008) show that productivity measures that use sales (i.e. quantities multiplied by prices) and measures that use quantities only are highly positively correlated. Therefore, labor productivity can be regarded as a useful measure of productivity at the firm level. To mitigate concerns that performance differences simply reflect differences in the sectoral composition of the three firm types, and following Girma, Görg and Strobl

(2004) and Wagner (2006), value added per employee is calculated relative to the 4-digit industry mean.

Data from the two surveys are matched using the enterprise identifier available in both surveys (see Malchin and Voshage (2009) for details). These data are confidential but not exclusive; they can be used for empirical investigations inside the research data centres of the statistical offices in Germany (see Zühlke et al. 2004 for details). Given that there are large differences between enterprises from West Germany and East Germany even more than ten years after re-unification in 1990 especially with regard to export activities (see Wagner (2008)) all computations are performed for the two parts of Germany separately.

3. Results

The hypotheses from the Bustos (2011) model were tested with data for each year from 2003 to 2009. To economize on space, only the results for the most recent year are reported here in detail in Table 1 for West Germany and in Table 2 for East Germany; results from the other years (that are available from the author on request) are identical.

[Table 1 and Table 2 near here]

The sample for West Germany includes 13,362 firms in 2009. 217 firms (or 1.62 percent) did not export but reported spending on R&D; these few firms were excluded from the empirical investigation because this type of firm is not considered in the theoretical model and in the hypothesis derived from this model. 2,368 firms (17.72 percent of the sample) did not export and did not engage in R&D, these are labelled firms of Type 1 here. 6,330 firms (47.37 percent of the sample) exported

without engaging in R&D, these are labelled firms of Type 2. 4,447 firms (33.28 percent of the sample) were exporters with R&D activities, and these are labelled firms of Type 3. Note that the large share of exporting firms in the sample is due to oversampling of larger firms (discussed above).

According to Table 1 in West Germany the ranking of the mean values for value added per employee is in line with the Bustos hypothesis: Type 3 firms have the highest average productivity, followed by Type 2 firms, and Type 1 firms come last. A t-test for differences in the means (based on productivity values measured as percentages of the 4-digit industry mean) reveals that this ranking is statistically significant at any conventional error level. Results of the two-sample Kolmogorov-Smirnov tests show that not only the means of the productivity distributions are ranked in this way. Using a conventional error level of five percent, we find that in line with the Bustos (2011) hypothesis the productivity distribution of firms with exports and R&D dominates that of exporters without R&D, which in turn dominates that of firms that neither export nor engage in R&D.

Results for East Germany that are reported in Table 2 are fully in line with the results reported for West Germany.

4. Conclusions

This paper presents the first empirical test with German firm level data of a hypothesis derived by Bustos (2011) in a model that explains the decision of heterogeneous firms to export and to engage in R&D. Using a non-parametric test for first order stochastic dominance it is shown that, in line with this hypothesis, the productivity distribution of firms with exports and R&D dominates that of exporters without R&D, which in turn dominates that of firms that neither export nor engage in

R&D. These results are in line with findings from Bustos (2011) for Argentina. The model introduced in Bustos (2011), therefore, seems to be useful to guide empirical work on the relation between exports, R&D and productivity.

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Table I: Results of the empirical investigation, West Germany, 2009

		Type 1	Type 2	Type 3
		Exports: no, R&D: no	Exports: yes, R&D: no	Exports: yes, R&D: yes
Number of enterprises		2,368	6,330	4,447
Value added per employee	mean	41,553	51,485	61,810
	Sd	30,333	37,995	37,521

	Type 1 vs. Type 2	Type 1 vs. Type 3	Type 2 vs. Type 3
t-Test for difference in means of value added per employee (prob-value)[1]	0.000	0.000	0.000
Two-sample Kolmogorov-Smirnov test for stochastical dominance (prob-value)[2]	0.000	0.000	0.000

[1] Test of H_0: mean of first group equal to mean of second group against H_1: mean of first group smaller than mean of second group. Value added per employee is measured as percentage of industry mean. The t-test is a two-sample test with unequal variances.

[2] Test of H_0: distributions are equal against H_1: distribution of value added per employee of the second group stochastically dominates distribution of value added of the first group. Value added per employee is measured as percentage of industry mean.

Table II: Results of the empirical investigation, East Germany, 2009

		Type 1	Type 2	Type 3
		Exports: no, R&D: no	Exports: yes, R&D: no	Exports: yes, R&D: yes
Number of enterprises		853	1,198	796
Value added per employee	mean	37,213	44,875	49,135
	Sd	26,601	36,334	31,495

	Type 1 vs. Type 2	Type 1 vs. Type 3	Type 2 vs. Type 3
t-Test for difference in means of value added per employee (prob-value)[1]	0.001	0.000	0.007
Two-sample Kolmogorov-Smirnov test for stochastical dominance (prob-value)[2]	0.001	0.000	0.000

[1] Test of H_0: mean of first group equal to mean of second group against H_1: mean of first group smaller than mean of second group. Value added per employee is measured as percentage of industry mean. The t-test is a two-sample test with unequal variances.

[2] Test of H_0: distributions are equal against H_1: distribution of value added per employee of the second group stochastically dominates distribution of value added of the first group. Value added per employee is measured as percentage of industry mean.

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