Economics Bulletin

Volume 32, Issue 4

Productivity and the extensive margins of trade in German manufacturing firms: Evidence from a non-parametric test

Joachim Wagner
Leuphana University Lueneburg

Abstract

This paper contributes to the literature by comparing the productivity distribution for firms with various numbers of goods traded and various numbers of countries traded with from Germany, one of the leading actors on the world market for goods. It applies a non-parametric test for first-order stochastic dominance of one productivity distribution over another. We find that the larger the number of goods exported or imported, and the larger the number of countries exported to or imported from, the higher is the productivity of the firms – not only on average, but over the whole productivity distribution. This is in line with implications of recent theoretical models of multi-product multi-country trading firms.

All computations were done at the Research Data Centre of the German Statistical Office. I thank Christopher Gürke for preparing the data, running my Stata do-files and checking the results for any violation of privacy. The enterprise level data used are confidential but not exclusive; see http://www.forschungsdatenzentrum.de/nutzungsbedingungen.asp for any details regarding the access to the data. I thank the editor Rod Falvey and an anonymous referee for helpful comments on an earlier version.
Citation: Joachim Wagner, (2012) "Productivity and the extensive margins of trade in German manufacturing firms: Evidence from a non-parametric test", *Economics Bulletin*, Vol. 32 No. 4 pp. 3061-3070.
Contact: Joachim Wagner - wagner@leuphana.de.
Submitted: September 16, 2012. **Published:** November 06, 2012.

1. Motivation

Firms that are engaged in international trade are more productive than firms that do not export or import. This stylized fact has been documented over the past 15 years in a large number of micro-econometric studies that use firm-level data from countries all over the world (see Wagner (2007, 2012a) for surveys). The theoretical rational behind this empirical regularity is that there are extra cost of exporting and importing (including the cost of market studies and finding reliable trading partners, of adapting products for a market in a country they are not produced in, and of familiarization with customs procedures). Most of these extra costs are fixed costs and sunk costs. Only the more productive firms can cover these extra costs of trade and produce profitably (see Melitz (2003) for exports and Castellani et al. (2010) for imports).

While this positive relationship between participation in international trade and productivity has been documented for a long time, only recently researchers used transaction level data that report not only the sum of exports or imports for a firm but that have information on the goods traded and on the countries of the trading partners, too, to look at two extensive margins of trade, namely the number of goods traded and the number of countries traded with. With these data new stylized facts have been uncovered. It is shown that international trade is dominated by a small number of firms that trade many goods with many countries (see Bernard et al. (2007) for the United States and Wagner (2012b) for Germany). Furthermore, there is a positive link between firm productivity and both the number of goods traded and the number of countries traded with. The theoretical rational for this link is similar to the one discussed above for exporting and importing per se: Many costs associated with exports or imports recur when a new country is added as a destination of exports or source of imports of a firm, and many costs recur when a new product is added to the portfolio of products a firm exports or imports. Bernard et al. (2011) present a theoretical model of this link between productivity and both the number of goods exported and of export destinations. In their empirical investigation they find that, on average, productivity of firms from the United States increases with the number of exported goods and destination countries. Wagner (2012c) reports a strikingly similar result for Germany; similar findings from empirical studies for firms from other countries are surveyed in Wagner (2012a).

However, it is well known that firms are highly heterogeneous. Results that point to productivity differences at the (unconditional or conditional) mean might not tell the whole story. As Moshe Buchinsky (1994, p.453) put it: "'On the average' has never been a satisfactory statement with which to conclude a study of heterogeneous populations." An empirical study of heterogeneous firms should look at differences in the whole distribution of the variable under investigation between groups of firms, not only at differences at the mean.

This paper contributes to the literature by comparing the productivity distribution for firms with various numbers of goods traded and numbers of countries traded with from Germany, one of the leading actors on the world market for goods. It applies a non-parametric test for first-order stochastic dominance of one productivity distribution over another. To anticipate the most important result, the larger the number of goods exported or imported, and the larger the number of countries exported to or imported from, the higher is the productivity of the firms – not only on average, but over the whole productivity distribution.

2. Data and descriptive evidence

The empirical investigation uses a newly constructed data set that is based on customs' records about goods traded by German firms with countries outside the European Union and

on information delivered by firms about goods traded with EU member countries.[1] These transaction-level data were aggregated at the level of the exporting enterprise by the German Statistical Office for the first time for the reporting year 2009; data for more recent years are not yet available. The data have, among others, information at the firm level about the number of different goods traded[2] and the number of countries traded with. These firm level data on transactions in foreign trade were linked to the enterprise register system. By linking the aggregated transaction-level data to the enterprise register system it was possible to match these data with information on the number of employees in the firm and total turnover of the firm taken from the regular survey of manufacturing firms.

Productivity is measured as labor productivity (defined as total turnover per employee) because information on the capital stock of a firm is not available, so more elaborate measures of total factor productivity cannot be used in this study. 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 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, we argue that labor productivity is a suitable measure for productivity at the firm level. Furthermore, to control for differences in capital intensity between firms productivity is measured in percentage of the 5digit-industry mean value.

In the empirical investigation four groups of firms are distinguished according to either the number of goods exported or imported and according to either the number of countries exported from or imported to, namely firms with only 1 good traded or country traded with, firms with 2 – 5 goods traded or countries traded with, firms with 6 – 9 goods traded or countries traded with, and firms with 10 or more goods traded or countries traded with. The sample has information on 13,004 firms from West Germany and 2,273 firms from East Germany that traded internationally in 2009.[3] Table I reports the number of firms by number of goods traded and by number of countries traded with and the share of each group of firms in all firms by trade activity. While there are many firms that trade only some goods with some countries, many firms trade 10 or more goods and with 10 or more countries.

3. Productivity distribution and the extensive margins of foreign trade

Table II reports means and selected percentiles of the productivity distribution of the firms in our sample by the number of goods traded and by the number of countries traded with. With a

[1] Note that firms with a value of exports to and imports from EU-countries that does not exceed 400,000 Euro in 2009 do not have to report to the statistic on intra-EU trade. Small exporters and importers that trade with EU-countries only are therefore underrepresented in the sample. For trade with firms from non-member countries all transactions that exceed 1,000 Euro are registered. For details see Statistisches Bundesamt, Qualitätsbericht Außenhandel, Januar 2011.

[2] A good is an eight-digit number from the official nomenclature for the statistics of foreign trade.

[3] The economy still differs considerably between West Germany and the former communist East Germany even many years after the unification in 1990, and this is especially true with regard to international trade and productivity (see Wagner (2008)). Therefore, the analysis is carried out separately for both parts of Germany.

few exceptions that are mainly found at 99th percentile the big picture is in line with the theoretical hypothesis that there is a positive link between firm productivity and both the number of goods traded and the number of countries traded with. The empirical strategy used here to test this hypothesis 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 et al. (2002).[4] Let F and G denote the cumulative distribution functions of productivity for two groups of firms (say, firms that export 1 good and firms that export 2 - 5 goods). Fist 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 but for differences in all moments of the distribution.

Results for the 48 tests that compare the productivity distributions of two groups of firms each are reported in Table III. Results for West Germany are fully in line with the theoretical hypothesis. The hypothesis that the two distributions do not differ is rejected at an error level of less than one percent, and the results clearly indicate that the productivity distribution of firms with a smaller number of goods traded or with a smaller number of trading partners is dominated by the productivity distribution of firms with a larger number of products traded or with a larger number of trading partners in all 24 cases investigated. The big picture for East Germany is the same, although the hypothesis of no difference in the productivity distribution cannot be rejected at an error level of five percent in three out of 24 cases (2 - 5 vs. 6 – 9 goods exported; 1 vs. 2 – 5 and 2 – 5 vs. 6 – 9 countries exported to).

The division of firms into four groups by the number of goods traded and the number of countries traded with used here is in a sense arbitrary. Furthermore, in some of the performed comparisons, the last group concentrates more than 50 percent of the whole distribution of firms. As a robustness check, the investigation was performed for groups of firms defined by the four quartiles of the distribution of firms by the number of goods traded and the number of countries traded with.[5] Results are reported in Table IV and Table V. These results confirm the results reported in Table II and Table III.

The bottom line, then, is that there are statistically significant differences in the productivity distribution as a whole – and not only at the mean – between firms by their extensive margins of trade. The more goods firms trade, and the more countries firms trade with, the higher is the productivity of the firms. This is in line with implications of recent theoretical models of multi-product multi-country traders.

References

Bartelsman, E. J. and M. Doms (2000) "Understanding Productivity: Lessons from Longitudinal Micro Data" *Journal of Economic Literature* **XXXVIII**, 569-594.

Bernard, A. B., J. B. Jensen, S. J. Redding and P. K. Schott (2007) "Firms in International Trade" *Journal of Economic Perspectives* **21** (3), 105-130.

Bernard, A. B., S. J. Redding and P. K. Schott (2011) "Multiproduct firms and trade liberalization" *Quarterly Journal of Economics* **126**, 1271-1318.

[4] Results of t-tests for differences in means of productivity between the groups of firms by the number of products traded and by the number of countries traded with are available on request.

[5] I thank an anonymous referee for suggesting this robustness check.

Buchinsky, M. (1994) "Changes in the U.S. wage structure 1963-1987: Application of quantile regression" *Econometrica* **62**, 405-458.

Castellani, D., F. Serti and C. Tomasi (2010) "Firms in international trade: Importers' and exporters' heterogeneity in the Italian manufacturing industry" *The World Economy* **33**, 424-457.

Conover, W. J. (1999), *Practical Nonparametric Statistics*. Third edition. New York etc.: John Wiley.

Delgado, M. A., J. C. Farinas and S. Ruano (2002) "Firm productivity and export markets: a non-parametric approach" *Journal on International Economics* **57**, 397-422.

Foster, L., J. Haltiwanger and C. Syverson (2008) "Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability?" *American Economic Review* **98**, 394-425.

Melitz, M. J. (2003) "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity" *Econometrica* **71**, 1695-1725.

Syverson, C. (2011) "What determines productivity?" *Journal of Economic Literature* **49**, 326-365.

Wagner, J. (2007) "Exports and Productivity: A Survey of the Evidence from Firm-Level Data" *The World Economy* **30**, 60-82.

Wagner, J. (2008) "A note why more West than East German firms export" *International Economics and Economic Policy* **5**, 363-370.

Wagner, J. (2012a) "International trade and firm performance: A survey of empirical studies since 2006" *Review of World Economics / Weltwirtschaftliches Archiv* **148**, 235-267.

Wagner, J. (2012b) "Trading many goods with many countries: Exporters and importers from German manufacturing industries" *Jahrbuch für Wirtschaftswissenschaften* **63**, 170-186.

Wagner, J. (2012c) "German multiple-product, multiple-destination exporters: Bernard-Redding-Schott under test" *Economics Bulletin* **32**, 1708-1714.

Table I: Number of firms by number of goods traded and number of countries traded with, German manufacturing firms, 2009

	Number of goods traded				Number of countries traded with			
	Exports		Imports		Exports		Imports	
	No. of firms	Share (%)	No. of firms	Share (%)	No. of firms	Share (%)	No. of firms	Share (%)
West Germany								
1	1,698	14.14	903	7.91	975	8.22	1,223	10.93
2 – 5	3,426	28.54	2,301	20.15	1,830	15.42	3,152	28.18
6 – 9	1,595	13.29	1,524	13.35	1,332	11.23	2,289	20.46
10 and more	5,287	44.04	6,689	58.59	7,727	65.13	4,522	40.43
East Germany								
1	384	19.55	242	12.43	250	12.94	283	14.93
2 – 5	707	36.00	434	22.29	479	24.79	571	30.13
6 – 9	297	15.12	281	14.43	257	13.30	444	23.43
10 and more	576	29.33	990	50.85	946	48.96	597	31.50

Source: Research Data Center of the German Statistical Office, Foreign Trade Statistics 2009, own calculations

Economics Bulletin, 2012, Vol. 32 No. 4 pp. 3061-3070

Table II: Labor productivity by number of goods traded and number of countries traded with

	West Germany							East Germany						
	Mean	sd	p1	p10	p50	p90	p99	Mean	sd	p1	p10	p50	p90	p99
Number of goods exported														
1	86.2	56.8	18.7	38.2	73.9	144.5	286.4	86.2	48.0	12.1	35.7	74.4	155.5	233.6
2 – 5	93.8	69.0	21.2	41.3	79.3	157.6	320.1	96.8	59.6	19.1	42.7	86.1	156.2	341.9
6 – 9	97.2	63.3	22.0	44.0	83.4	157.1	371.0	100.6	71.3	13.3	40.9	87.1	168.6	394.9
10 and more	111.8	85.5	26.3	50.8	95.6	182.5	372.0	115.9	74.8	20.3	51.5	100.0	198.3	364.1
Number of goods imported														
1	82.6	81.7	17.1	37.5	68.8	130.5	298.6	87.9	75.7	19.1	37.0	75.4	138.5	289.2
2 – 5	90.4	73.5	18.2	39.5	74.4	152.1	361.4	91.3	53.9	19.7	42.0	80.2	144.4	293.0
6 – 9	96.7	59.9	18.8	43.1	82.9	158.1	315.8	101.7	64.6	15.5	40.2	91.4	167.4	353.7
10 and more	111.8	83.2	24.4	51.0	95.6	184.2	373.8	113.1	71.9	18.1	48.1	100.0	190.4	339.0
Number of countries exported to														
1	79.1	47.5	18.0	36.7	69.5	129.4	254.4	82.5	49.1	13.9	33.6	70.8	143.2	243.1
2 – 5	92.4	101.2	15.4	37.4	75.5	151.5	362.9	93.6	67.3	16.3	36.6	79.8	163.4	291.0
6 – 9	98.8	74.2	22.8	40.7	82.0	166.5	407.3	99.9	74.9	17.8	42.0	86.5	154.8	468.5
10 and more	106.7	70.6	26.5	49.2	91.7	177.0	349.8	110.5	64.0	21.8	49.4	100.0	183.2	334.2
Number of countries imported from														
1	78.5	71.4	18.0	37.0	66.8	124.2	272.8	78.3	40.9	20.1	36.8	73.1	126.9	228.6
2 – 5	92.6	70.5	19.5	40.7	77.4	154.3	344.1	96.9	59.3	16.3	41.1	86.3	158.3	353.7
6 – 9	105.2	69.9	19.5	47.5	88.7	178.7	350.7	104.7	55.8	12.6	42.3	98.9	176.3	288.6
10 and more	117.8	89.0	29.1	54.9	100.0	190.3	418.9	121.5	81.3	21.8	52.3	100.5	208.7	409.1

Note: Labor productivity is calculated as total sales per employee and is in percentage of the 5digit-industry mean value
Source: Research Data Center of the German Statistical Office, Foreign Trade Statistics 2009, own calculations

Economics Bulletin, 2012, Vol. 32 No. 4 pp. 3061-3070

Table III: Test for difference in distribution of labor productivity by number of products traded and number of countries traded with (p-value of Kolmogorov-Smirnov test)

	Number of goods exported			Number of goods imported			Number of countries exported to			Number of countries imported from		
	H1	H2	H3	H1	H2	H3	H1	H2	H3	H1	H2	H3
West Germany												
1 vs. 2 – 5	0.000	0.981	0.000	0.001	0.998	0.000	0.000	0.963	0.000	0.000	0.998	0.000
1 vs. 6 – 9	0.000	0.995	0.000	0.000	0.989	0.000	0.000	0.997	0.000	0.000	0.999	0.000
1 vs. 10 and more	0.000	0.999	0.000	0.000	0.999	0.000	0.000	1.000	0.000	0.000	0.999	0.000
2 – 5 vs. 6 – 9	0.004	0.970	0.002	0.000	0.940	0.000	0.000	0.996	0.000	0.000	0.995	0.000
2 – 5 vs. 10 and more	0.000	1.000	0.000	0.000	0.999	0.000	0.000	0.997	0.000	0.000	0.999	0.000
6 – 9 vs. 10 and more	0.000	1.000	0.000	0.000	1.000	0.000	0.000	0.959	0.000	0.000	0.999	0.000
East Germany												
1 vs. 2 – 5	0.006	0.999	0.003	0.041	0.916	0.020	0.056	0.964	0.028	0.000	0.848	0.000
1 vs. 6 – 9	0.011	1.000	0.005	0.000	0.894	0.000	0.001	1.000	0.001	0.000	0.930	0.000
1 vs. 10 and more	0.000	0.999	0.000	0.000	0.986	0.000	0.000	1.000	0.000	0.000	0.997	0.000
2 – 5 vs. 6 – 9	0.700	0.511	0.368	0.006	0.879	0.003	0.167	0.747	0.084	0.001	0.830	0.001
2 – 5 vs. 10 and more	0.000	0.992	0.000	0.000	0.986	0.000	0.000	0.997	0.000	0.000	0.999	0.000
6 – 9 vs. 10 and more	0.001	0.996	0.000	0.026	0.993	0.013	0.000	0.894	0.000	0.029	1.000	0.014

Note: Labor productivity is calculated as total sales per employee and is in percentage of the 5digit-industry mean value. The hypotheses tested are:
H1: The productivity distributions of the two groups of firms do not differ
H2: The productivity distribution of the first group is first-order stochastically dominated by the productivity distribution of the second group
H3: The productivity distribution of the second group is first-order stochastically dominated by the productivity distribution of the first group

Source: Research Data Center of the German Statistical Office, Foreign Trade Statistics 2009, own calculations

Economics Bulletin, 2012, Vol. 32 No. 4 pp. 3061-3070

Table IV: Labor productivity by number of goods traded and number of countries traded with: Robustness check

	West Germany							East Germany						
	Mean	sd	p1	p10	p50	p90	p99	Mean	sd	p1	p10	p50	p90	p99
Number of goods exported														
Fist quartile of distribution	89.67	66.35	19.51	39.26	76.15	149.74	310.94	89.52	49.88	15.50	38.45	78.91	155.48	250.09
Second quartile of distribution	96.86	62.08	24.14	44.03	82.67	163.87	327.39	97.61	64.09	18.53	44.11	85.86	151.08	353.67
Third quartile of distribution	102.80	86.15	22.50	46.26	86.21	165.18	400.08	100.03	65.29	15.72	42.33	88.57	164.65	341.87
Fourth quartile of distribution	117.29	80.09	28.00	55.07	100.00	188.95	366.46	118.94	78.47	21.63	51.48	100.00	207.78	369.43
Number of goods imported														
Fist quartile of distribution	88.24	76.00	17.39	38.78	72.75	147.98	347.83	87.56	66.55	18.53	36.85	75.49	139.36	355.55
Second quartile of distribution	98.74	66.25	19.63	44.19	84.01	162.79	324.72	99.96	58.53	16.57	43.66	90.21	160.15	304.36
Third quartile of distribution	107.60	91.15	24.40	48.76	90.22	177.64	351.66	107.38	72.60	13.34	46.31	94.24	179.06	369.43
Fourth quartile of distribution	119.99	77.21	27.84	57.22	102.66	193.17	418.92	120.12	72.56	21.63	48.90	102.70	209.98	338.98
Number of countries exported to														
Fist quartile of distribution	88.33	84.05	15.98	37.02	73.62	146.82	339.04	85.41	49.70	16.30	35.76	73.52	147.76	250.09
Second quartile of distribution	99.50	71.88	22.93	44.05	82.73	165.59	349.85	100.65	79.61	16.57	41.44	85.29	167.13	409.08
Third quartile of distribution	105.66	72.70	26.09	49.02	89.81	173.68	336.85	105.16	63.61	21.83	47.78	95.25	174.46	293.01
Fourth quartile of distribution	113.42	69.46	31.76	54.71	98.39	184.42	372.03	115.84	63.94	20.33	51.48	100.66	194.90	338.98
Number of countries imported from														
Fist quartile of distribution	83.79	63.80	17.39	38.38	71.94	137.59	286.40	84.21	47.16	18.12	37.08	75.47	137.70	257.11
Second quartile of distribution	100.17	73.85	20.42	43.45	83.90	167.39	346.94	103.99	62.75	15.50	42.45	93.68	166.14	355.55
Third quartile of distribution	110.26	80.36	23.76	50.64	92.93	184.31	371.01	109.85	59.97	17.53	48.17	100.00	183.36	324.71
Fourth quartile of distribution	123.06	94.06	31.28	59.39	104.06	196.71	436.22	122.87	85.64	20.96	51.89	100.00	217.36	390.33

Note: Labor productivity is calculated as total sales per employee and is in percentage of the 5digit-industry mean value
Source: Research Data Center of the German Statistical Office, Foreign Trade Statistics 2009, own calculations

Economics Bulletin, 2012, Vol. 32 No. 4 pp. 3061-3070

Table V: Test for difference in distribution of labor productivity by number of products traded and number of countries traded with (p-value of Kolmogorov-Smirnov test): Robustness check

	Number of goods exported			Number of goods imported			Number of countries exported to			Number of countries imported from		
	H1	H2	H3	H1	H2	H3	H1	H2	H3	H1	H2	H3
West Germany												
Q1 vs. Q2	0.000	0.997	0.000	0.000	0.986	0.000	0.000	0.999	0.000	0.000	0.999	0.000
Q1 vs.Q3	0.000	1.000	0.000	0.000	1.000	0.000	0.000	0.997	0.000	0.000	0.999	0.000
Q1 vs.Q4	0.000	1.000	0.000	0.000	0.999	0.000	0.000	0.998	0.000	0.000	1.000	0.000
Q2 vs. Q3	0.006	0.966	0.003	0.000	1.000	0.000	0.000	0.983	0.000	0.000	0.995	0.000
Q2 vs. Q4	0.000	0.991	0.000	0.000	0.999	0.000	0.000	0.982	0.000	0.000	0.997	0.000
Q3 vs. Q4	0.000	0.989	0.000	0.000	0.991	0.000	0.000	0.916	0.000	0.000	0.985	0.000
East Germany												
Q1 vs. Q2	0.114	0.915	0.057	0.000	0.974	0.000	0.003	1.000	0.001	0.000	0.975	0.000
Q1 vs.Q3	0.006	0.998	0.003	0.000	0.963	0.000	0.000	1.000	0.000	0.000	0.976	0.000
Q1 vs.Q4	0.000	0.998	0.000	0.000	0.992	0.000	0.000	1.000	0.000	0.000	0.996	0.000
Q2 vs. Q3	0.494	0.835	0.251	0.233	0.916	0.117	0.001	0.740	0.000	0.270	0.974	0.135
Q2 vs. Q4	0.000	0.998	0.000	0.000	0.965	0.000	0.000	0.944	0.000	0.006	0.999	0.003
Q3 vs. Q4	0.000	0.998	0.000	0.000	0.981	0.000	0.012	0.907	0.006	0.350	0.977	0.176

Note: Q1 (Q2, Q3, Q4) indicates the first (second, third, fourth) quartile of the distribution of the number of goods or the number of countries, respectively. Labor productivity is calculated as total sales per employee and is in percentage of the 5digit-industry mean value. The hypotheses tested are:
H1: The productivity distributions of the two groups of firms do not differ
H2: The productivity distribution of the first group is first-order stochastically dominated by the productivity distribution of the second group
H3: The productivity distribution of the second group is first-order stochastically dominated by the productivity distribution of the first group

Source: Research Data Center of the German Statistical Office, Foreign Trade Statistics 2009, own calculations

Economics Bulletin, 2012, Vol. 32 No. 4 pp. 3061-3070