# Exports, R&D and Productivity in German Business Services Firms: A test of the Bustos-model

Vogel, Alexander; Wagner, Joachim

*Publication date:*
2012

*Document Version*
Publisher's PDF, also known as Version of record

WORKING PAPER

# Exports, R&D and Productivity in German Business Services Firms: A test of the Bustos-model

by

Alexander Vogel and Joachim Wagner

University of Lüneburg
Working Paper Series in Economics

**No. 247**

August 2012

www.leuphana.de/institute/ivwl/publikationen/working-papers.html

ISSN 1860 - 5508

# Exports, R&D and Productivity in German Business Services Firms:

# A test of the Bustos-model

**Alexander Vogel and Joachim Wagner***

Leuphana University Lueneburg

[Version: August 23, 2012]

Abstract:

This paper uses newly available data for German business services firms to test 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 firms from manufacturing industries. The model, therefore, seems to be useful to guide empirical work on the relation between exports, R&D and productivity for services firms, too.

*JEL classification*: F14

*Keywords*: Exports, R&D, productivity, business services firms, Germany

* The data used in this study are confidential but not exclusive; see www.kombifid.de for a description of how to access the data. All computations were done inside the Research Data Centre of the Federal Statistical Office. To facilitate replication the Stata do-file is available from the first author on request.

Alexander Vogel
Leuphana University Lueneburg
PO Box 2440, D-21314 Lueneburg, Germany
alexander.vogel@leuphana.de

Joachim Wagner
Leuphana University Lueneburg
PO Box 2440, D-21314 Lueneburg, Germany
wagner@leuphana.de

## 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 (2012a) 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. Using data for a large sample of German manufacturing firms Wagner (2012b) shows that this is the case in Germany, too. This note looks at data from German business services firms for a further empirical test of the implications of the Bustos model, 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 firms from business services industries in 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 taken from two sources. The first source is the German business services statistics panel (described in detail in Vogel (2009)). This data set includes the information whether a firm was an exporter in a year or not. 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 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 2-digit industry mean.

The German business services statistics panel has no information on either the share of employees engaged in research and development (R&D), or on the amount of money spent on R&D activities, or on the introduction of innovative services. Therefore, a second source of data is used, the Establishment History Panel (*Betriebs-Historik-Panel*) described in detail in Spengler (2008). Details aside, this data set is built from individual level information for employees covered by social

security and it is a data set with detailed information about the characteristics of the employees in each enterprise in a year. From these data we do not have any direct information on the number of employees working in R&D. However, information on the composition of the workforce includes, among others, the number of engineers and natural scientists in the firm. These highly qualified employees can be expected to work on the development of innovative solutions that will eventually lead to improved or completely new ways to perform business services. Therefore, the share of engineers and natural scientists in all employees can be viewed as a suitable measure for the R&D intensity and the innovativeness of an enterprise.

Data from both sources were combined in the project KombiFiD (an acronym for combined firm data for Germany) for the years 2003 to 2006. Due to the fact that the German business services statistics do not provide information about the export activities of small firms, only firms with an annual sum of turnover and other operational income greater than or equal to €250,000 are considered for the analyses. Furthermore, due to the very small number of firms located in the former communist East Germany the analysis is limited to firms from West Germany. The 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 www.kombifid.de for details).

## 3. Results

The hypotheses from the Bustos (2011) model were tested with data for each year from 2003 to 2006. To economize on space, only the results for the first year are

reported here in detail in Table I. Results from the other years (that are available from the authors on request) show very similar results.

The sample includes 2,180 firms in 2003. 317 firms (or 14.5 percent) did not export but reported employees that are engaged in R&D; these 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. 1,358 firms (62.3 percent of the sample) did not export and did not engage in R&D, these are labelled firms of Type 1 here. 345 firms (15.8 percent of the sample) exported without engaging in R&D, these are labelled firms of Type 2. 160 firms (7.3 percent of the sample) were exporters with R&D activities, and these are labelled firms of Type 3.

According to Table I 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 a conventional error level for Type 1 firms vs. Type 2 firms only. However, results of the non-parametric two-sample Kolmogorov-Smirnov test that is less sensitive to extreme values reported for some firms 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.

## 4. Conclusions

This paper uses newly available data for German business services firms to test 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 for firms from manufacturing industries in Germany presented in Wagner (2012b). The model introduced in Bustos (2011) and other models with similar predictions, therefore, seems to be useful to guide empirical work on the relation between exports, R&D and productivity for services firms, too.

## References


Bartelsman, E.J. and M. Doms (2000) "Understanding Productivity: Lessons from Longitudinal Micro Data" *Journal of Economic Literature* **38**, 569-594.

Bustos, P. (2011) "Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinian Firms" *American Economic Review* **101**, 304-340.

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.

Girma, S., H. Görg and E. Strobl (2004) “Exports, international investment, and plant performance: evidence from a non-parametric test” *Economics Letters* **83**, 317-324.

Hamermesh, D.S. (2000) “The craft or labormetrics” *Industrial and Labor Relations Review* **53**, 363-380.

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

Redding, S.J. (2011) “Theories of Heterogeneous Firms and Trade” *Annual Review of Economics* **3**, 77-105.

Spengler, A. (2008) “The Establishment History Panel” *Schmollers Jahrbuch / Journal of Applied Social Science Studies* **128**, 501-509..

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

Vogel, A. (2009) “The German Business Services Statistics Panel 2003 – 2007” *Schmollers Jahrbuch / Journal of Applied Social Science Studies* **129**, 515-522.

Wagner, J. (2006) “Exports, foreign direct investment, and productivity: evidence from German firm level data” *Applied Economics Letter* **13**, 347-349.

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) “Exports, R&D and productivity: A test of the Bustos-model with German enterprise data” *Economics Bulletin* **32,** 1942-1948.

**Table I: Results of the empirical investigation, Business Services Firms from West Germany, 2003**

| | | Type 1 | Type 2 | Type 3 |
|---|---|---|---|---|
| | | **E**xports: no, R&D: no | Exports: yes, R&D: no | Exports: yes, R&D: yes |
| Number of enterprises | | 1,358 | 345 | 160 |
| Value added per employee (Euro) | mean | 48,940 | 67,001 | 68,663 |
| | sd | 114,789 | 55,625 | 47,579 |
| | | 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] | | 0.015 | 0.079 | 0.886 |
| Two-sample Kolmogorov-Smirnov test for stochastical dominance (prob-value)[2] | | 0.000 | 0.000 | 0.023 |

[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.

# Working Paper Series in Economics

(recent issues)

No.246: *Alexander Vogel* and *Joachim Wagner*: Innovations and Exports of German Business Services Enterprises: First evidence from a new type of firm data, August 2012

No.245: *Stephan Humpert*: Somewhere over the Rainbow: Sexual Orientation Discrimination in Germany, July 2012

No.244: *Joachim Wagner*: Exports, R&D and Productivity: A test of the Bustos-model with German enterprise data, June 2012 [published in: Economics Bulletin, 32 (2012), 3, 1942-1948]

No.243: *Joachim Wagner*: Trading many goods with many countries: Exporters and importers from German manufacturing industries, June 2012

No.242: *Joachim Wagner*: German multiple-product, multiple-destination exporters: Bernard-Redding-Schott under test, June 2012 [published in: Economics Bulletin, 32 (2012), 2, 1708-1714]

No.241: *Joachim Fünfgelt* and *Stefan Baumgärtner*: Regulation of morally responsible agents with motivation crowding, June 2012

No.240: *John P. Weche Gelübcke*: Foreign and Domestic Takeovers: Cherry-picking and Lemon-grabbing, April 2012

No.239: *Markus Leibrecht* and *Aleksandra Riedl*: Modelling FDI based on a spatially augmented gravity model: Evidence for Central and Eastern European Countries, April 2012

No.238: *Norbert Olah, Thomas Huth* und *Dirk Löhr*: Monetarismus mit Liquiditätsprämie Von Friedmans optimaler Inflationsrate zur optimalen Liquidität, April 2012

No.237: *Markus Leibrecht* and *Johann Scharler*: Government Size and Business Cycle Volatility; How Important Are Credit Contraints?, April 2012

No.236: *Frank Schmielewski* and *Thomas Wein*: Are private banks the better banks? An insight into the principal-agent structure and risk-taking behavior of German banks, April 2012

No.235: *Stephan Humpert*: Age and Gender Differences in Job Opportunities, March 2012

No.234: *Joachim Fünfgelt* and *Stefan Baumgärtner*: A utilitarian notion of responsibility for sustainability, March 2012

No.233: *Joachim Wagner*: The Microstructure of the Great Export Collapse in German Manufacturing Industries, 2008/2009, February 2012

No.232: *Christian Pfeifer* and *Joachim Wagner*: Age and gender composition of the workforce, productivity and profits: Evidence from a new type of data for German enterprises, February 2012

No.231: *Daniel Fackler, Claus Schnabel,* and *Joachim Wagner*: Establishment exits in Germany: the role of size and age, February 2012

No.230: *Institut für Volkswirtschaftslehre*: Forschungsbericht 2011, January 2012

No.229: *Frank Schmielewski*: Leveraging and risk taking within the German banking system: Evidence from the financial crisis in 2007 and 2008, January 2012

No.228: *Daniel Schmidt* and *Frank Schmielewski*: Consumer reaction on tumbling funds – Evidence from retail fund outflows during the financial crisis 2007/2008, January 2012

No.227: *Joachim Wagner*: New Methods for the Analysis of Links between International Firm Activities and Firm Performance: A Practitioner's Guide, January 2012

No.226: *Alexander Vogel* and *Joachim Wagner*: The Quality of the KombiFiD-Sample of Business Services Enterprises: Evidence from a Replication Study, January 2012

No.225: *Stefanie Glotzbach*: Environmental justice in agricultural systems. An evaluation of success factors and barriers by the example of the Philippine farmer network MASIPAG, January 2012

No.224: *Joachim Wagner*: Average wage, qualification of the workforce and export performance in German enterprises: Evidence from KombiFiD data, January 2012 [published in: Journal for Labour Market Research, 45 (2012), 2, 161-170]

No.223: *Maria Olivares* and *Heike Wetzel*: Competing in the Higher Education Market: Empirical Evidence for Economies of Scale and Scope in German Higher Education Institutions, December 2011

No.222: *Maximilian Benner*: How export-led growth can lead to take-off, December 2011

No.221: *Joachim Wagner* and *John P. Weche Gelübcke*: Foreign Ownership and Firm Survival: First evidence for enterprises in Germany, December 2011

No.220: *Martin F. Quaas, Daan van Soest,* and *Stefan Baumgärtner*: Complementarity, impatience, and the resilience of natural-resource-dependent economies, November 2011

No.219: *Joachim Wagner*: The German Manufacturing Sector is a Granular Economy, November 2011 [published in: Applied Economics Letters, 19(2012), 17, 1663-1665]

No.218: *Stefan Baumgärtner, Stefanie Glotzbach, Nikolai Hoberg, Martin F. Quaas, and Klara Stumpf*: Trade-offs between justices , economics, and efficiency, November 2011

No.217: *Joachim Wagner*: The Quality of the KombiFiD-Sample of Enterprises from Manufacturing Industries: Evidence from a Replication Study, November 2011

No.216: *John P. Weche Gelübcke*: The Performance of Foreign Affiliates in German Manufacturing: Evidence from a new Database, November 2011

No.215: *Joachim Wagner*: Exports, Foreign Direct Investments and Productivity: Are services firms different?, September 2011

No.214: *Stephan Humpert and Christian Pfeifer*: Explaining Age and Gender Differences in Employment Rates: A Labor Supply Side Perspective, August 2011

No.213: *John P. Weche Gelübcke*: Foreign Ownership and Firm Performance in German Services: First Evidence based on Official Statistics, August 2011
[forthcoming in: The Service Industries Journal]

No.212: *John P. Weche Gelübcke*: Ownership Patterns and Enterprise Groups in German Structural Business Statistics, August 2011 [published in: Schmollers Jahrbuch / Journal of Applied Social Science Studies, 131(2011), 4, 635-647]

No.211: *Joachim Wagner*: Exports, Imports and Firm Survival: First Evidence for manufacturing enterprises in Germany, August 2011

No.210: *Joachim Wagner*: International Trade and Firm Performance: A Survey of Empirical Studies since 2006, August 2011 [published in: Review of World Economics, 2012, 148 (2), 235-267]

No.209: *Roland Olbrich, Martin F. Quaas, and Stefan Baumgärtner*: Personal norms of sustainability and their impact on management – The case of rangeland management in semi-arid regions, August 2011

No.208: *Roland Olbrich, Martin F. Quaas, Andreas Haensler and Stefan Baumgärtner*: Risk preferences under heterogeneous environmental risk, August 2011

No.207: *Alexander Vogel and Joachim Wagner*: Robust estimates of exporter productivity premia in German business services enterprises, July 2011 [published in: Economic and Business Review, 13 (2011), 1-2, 7-26]

No.206: *Joachim Wagner*: Exports, imports and profitability: First evidence for manufacturing enterprises, June 2011

No.205: *Sebastian Strunz*: Is conceptual vagueness an asset? Resilience research from the perspective of philosophy of science, May 2011

No.204: *Stefanie Glotzbach*: On the notion of ecological justice, May 2011

No.203: *Christian Pfeifer*: The Heterogeneous Economic Consequences of Works Council Relations, April 2011

No.202: *Christian Pfeifer, Simon Janssen, Philip Yang and Uschi Backes-Gellner*: Effects of Training on Employee Suggestions and Promotions in an Internal Labor Market, April 2011

No.201: *Christian Pfeifer*: Physical Attractiveness, Employment, and Earnings, April 2011

No.200: *Alexander Vogel*: Enthüllungsrisiko beim Remote Access: Die Schwerpunkteigenschaft der Regressionsgerade, März 2011

No.199: *Thomas Wein*: Microeconomic Consequences of Exemptions from Value Added Taxation – The Case of Deutsche Post, February 2011

No.198: *Nikolai Hoberg* and *Stefan Baumgärtner*: Irreversibility, ignorance, and the intergenerational equity-efficiency trade-off, February 2011

No.197: *Sebastian Schuetz*: Determinants of Structured Finance Issuance – A Cross-Country Comparison, February 2011

No.196: *Joachim Fünfgelt and Günther G. Schulze*: Endogenous Environmental Policy when Pollution is Transboundary, February 2011

No.195: *Toufic M. El Masri*: Subadditivity and Contestability in the Postal Sector: Theory and Evidence, February 2011

No.194: *Joachim Wagner*: Productivity and International Firm Activities: What do we know?, January 2011 [published in: Nordic Economic Policy Review, 2011 (2), 137-161]

No.193: *Martin F. Quaas* and *Stefan Baumgärtner*: Optimal grazing management rules in semi-arid rangelands with uncertain rainfall, January 2011

No.192: *Institut für Volkswirtschaftslehre*: Forschungsbericht 2010, Januar 2011

No.191: *Natalia Lukomska, Martin F. Quaas and Stefan Baumgärtner*: Bush encroachment control and risk management in semi-arid rangelands, December 2010

No.190: *Nils Braakmann:* The causal relationship between education, health and health related behaviour: Evidence from a natural experiment in England, November 2010

No.189: *Dirk Oberschachtsiek and Britta Ulrich:* The link between career risk aversion and unemployment duration: Evidence of non-linear and time-depending pattern, October 2010

Leuphana Universität Lüneburg
Institut für Volkswirtschaftslehre
Postfach 2440
D-21314 Lüneburg
Tel.: ++49 4131 677 2321
email: brodt@leuphana.de

www.leuphana.de/institute/ivwl/publikationen/working-papers.html