DISCUSSION PAPER SERIES

IZA DP No. 5244

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October 2010

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

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Discussion Paper No. 5244
October 2010

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IZA Discussion Paper No. 5244
October 2010

# ABSTRACT

## Exports and Firm Characteristics in German Manufacturing Industries*

Reliable information on the characteristics of exporting and non-exporting firms is important to guide theorists and policy makers in an evidence based way. This holds true especially for Germany, a leading actor on the world markets for goods and services. This paper makes three contributions towards this aim: (1) It provides a synopsis and a critical assessment of 51 empirical studies on exports and firm characteristics that use data for German establishments or enterprises, arguing that this literature is not suited to extract the stylized facts needed. (2) It uses recently released rich high quality data for a large representative panel of enterprises from German manufacturing industries to investigate the links between firm characteristics and export activities, demonstrating the decisive role of human capital intensity for exporting. (3) It links these findings to the recent literature from the *new new trade theory* on international activities of heterogeneous firms that emphasises the role of productivity for exporting. It shows that productivity *is* important for exporting as is hypothesized in the formal theoretical models, but that contrary to the assumption made in these models productivity is not (only) the result from a random draw from the productivity distribution – it is strongly positively related to human capital intensity.

JEL Classification: F14

Keywords: exports, firm characteristics, Germany

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* I thank Jeff Wooldridge and Leslie Papke for sharing their Stata code to estimate fractional probit panel models, and Nils Braakmann and Alexander Vogel for extremely helpful discussions. The data used 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-files are available from the author on request.

## 1. Motivation

Germany is one of the leading actors on the world market for manufactured goods, and exports play a key role in shaping the development of the economy. Contrary to what many people (especially people from other countries) think, however, not every firm from a manufacturing industry in Germany is an exporter. In 2006 the share of exporters in all enterprises was 75.7 percent in West Germany and 60.4 percent in East Germany.[1]

How do these exporting firms differ from firms that sell their products on the national market only? What makes a successful exporter? Are there easily observable characteristics of a firm that are closely related to success on international markets? If this is the case, policy measures might be designed that either target firms with these characteristics to foster export activities, or that help firms that do not yet have these characteristics to build them up and to become the successful exporters of the future. If there are no such characteristics, this casts doubts on the adequacy of specially targeted export promotion programs with a focus on selected groups of firms.

Characteristics of exporting firms from Germany have been investigated before in a number of studies using micro data at the establishment or enterprise level. Table 1 summarizes important aspects of 51 studies published between 1991 and 2011.[2]

[Table 1 near here]

[1] All figures refer to enterprises (legal units) with at least 20 employees and are based on the author's own computations; a detailed descriptive table is available on request.

[2] The studies are listed in chronological order by year of publication; purely descriptive studies are not included.

The synopsis shows that many studies use data for a part of Germany only. These data may or may not be representative for the German economy as a whole. Furthermore, many studies are based on small samples, and often only cross section data are investigated (that in some cases are taken from a panel data set). Some of the studies that are based on panel data that can be considered to be representative for the German economy (like the IAB establishment panel) use rather small sub-samples due to the limited availability of information needed. Most of the studies use data at the level of the local production unit (establishment, plant), and this is problematic when the link between firm characteristics and export activities is investigated and when the local production unit is part of a multi-plant enterprise (which is often the case), because in a multi-plant enterprise plants may have different roles, and exports might be concentrated in one unit (or a small number of units) while other units deliver their products to these units and do not report any export activities. The usual approach to include a dummy variable for plants that are part of a multi-plant enterprise cannot take care of this appropriately. The studies that are based on nationally representative and large panel data sets for enterprises usually suffer from a lack of information on important firm characteristics – physical capital is not reported in the surveys, and information on activities related to innovation is lacking.[3] Furthermore, only a small number of studies uses an econometric method that is suited to model empirically the share of exports in total sales which is a proportion variable with a probability mass at zero due to a large

[3] For details of the information available in the most often used data sets see Wagner (2000) for the monthly report of establishments from manufacturing industries, Kölling (2000) for the IAB Establishment Panel, Gerlach, Hübler and Meyer (2003) for the Hannover Firm Panel, Janz et al. (2001) for the Mannheim Innovation Panels and Vogel (2009) for the German Business Services Statistics Panel.

share of non-exporting firms[4], and among these studies only two attempt to control for unobserved heterogeneity by using a fixed effects model for panel data

That said, the 51 empirical studies summarized in table 1 cannot be considered to form a solid basis to extract stylized facts that can be used to inform researchers and policy makers in an evidence based way. This paper contributes to the literature by using recently released rich high quality data for a large representative panel of enterprises from German manufacturing industries to investigate the links between firm characteristics and export activities.

The rest of the paper is organised as follows. In section 2 the data and the definition of the variables used are discussed. Section 3 documents the links between observed firm characteristics and exports. Section 4 investigates the role of unobserved characteristics of the enterprises for the decision to export or not and for the share of exports in total sales. Section 5 links these findings to the recent literature from the *new new trade theory* on international activities of heterogeneous firms that emphasises the role of productivity for exporting. Section 6 concludes.

## 2. Data and definition of variables

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. This survey is the source for information on the location of the firm in West Germany or East Germany, the industry affiliation, the export activities, the number of employees (used to measure

[4] See Wagner (2001) for a discussion of this point and section 3.3 below.

firm size) and the average wage per employee (used as a proxy for human capital intensity).[5] In this data set, export refers to the amount of sales to a customer in a foreign country plus sales to a German export trading company; indirect exports (for example, tires produced in a plant in Germany that are delivered to a German manufacturer of cars who exports some of his products) are not covered by this definition. 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.

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 (stratified according to the number of employees and the industries) of around 18.000 enterprises (see Fritsch et al. 2004). This survey is the source for information on the R&D intensity of the firm (measured as the relation of spending for research and development activities to total sales) and the share of employees working in R&D. While firms with 500 and more employees are covered by the cost structure survey in each year, the sample of smaller firms is part of the survey for four years in a row only. In this study we use the data from the most recent complete sample period available that cover the years from 2003 to 2006.

Data on the stock of physical capital is neither available from the monthly report for establishments in manufacturing industries nor from the cost structure survey for enterprises in the manufacturing sector. The cost structure survey, however, has

[5] The data used in this study do not have any information on the qualification of the workforce (e.g. on the share of employees with a university degree or on the share of skilled blue collar workers). The average wage per employee is used as a proxy variable to measure human capital input in a firm. Obviously, qualification of the work force is not the only determinant of wages, but it can be expected to be highly positively correlated with it. Furthermore, in the empirical model linking wage per employee to exporting both firm size and industry affiliation are included and, and, therefore, both firm-size wage differentials and inter-industry wage differentials are controlled for.

information on the amount of depreciation in an enterprise. Together with information on the average life span of capital goods (for equipments, and for buildings) and information in the composition of the capital stock at the level of two-digit industries these figures for depreciation can be used to estimate the capital stock in an enterprise (see Wagner 2010b for details). The capital stock per employee is used as a measure for the physical capital intensity in the enterprise.

Data from the two surveys are matched using the enterprise identifier available in both surveys.[6] 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). The balanced panels[7] used cover 10,038 enterprises in West Germany and 1,852 enterprises in East Germany. 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[8] all computations are performed for the two parts of Germany separately.

Firm size, human capital intensity, physical capital intensity and R&D intensity are standard firm characteristics used in empirical studies of export activities of firms (see the synopsis for studies with German data in table 1). In line with theoretical

[6] For a description of the matched data from various surveys from official statistics see Malchin and Voshage (2009).

[7] Note that by construction there are no entries into the sample covered by the cost structure survey during a four year period. Enterprises exit the survey if they close down, relocate to services industries or agriculture, or to another country, or shrink below the threshold of twenty employees. Given that one estimator for panel data models used in section 4 is only available for balanced panels all computations use the data from the balanced panel to facilitate comparisons between analyses based on cross section data and on panel data.

[8] See Wagner (2008a) for a discussion of the difference in exporting between firms from West Germany and East Germany.

considerations[9] all these characteristics have been found to be positively related to exporting in a large number of studies for Germany (and many other highly industrialized countries).

## 3. Observed firm characteristics and export activity

In the balanced panels used in this study the share of exporting firms increased slightly over the years covered. In West Germany this share was 80.4 percent in 2003, 80.6 percent in 2004, 80.9 percent in 2005 and 81.4 percent in 2006. The corresponding figures for East Germany were 62.5 percent (2003), 62.8 percent (2004), 63.7 percent (2005) and 65.1 percent (2006), considerably lower than in West Germany. The export participation patterns reported in table 2 demonstrate that this overall net increase in export participation is not only the result of entry of firms into exporting – from year to year firms enter and exit the export market, some of them more than once. The share of permanent exporters in all firms, therefore, is lower than the share of firms that exported in a single year.

[Table 2 near here]

[9] These theoretical considerations are standard in the literature (see e.g. Wagner 1998). The positive relation of exports and firm size is due to fixed costs of exporting and efficiency advantages of larger firms due to scale economies, advantages of specialization in management and cost advantages on credit markets and markets for inputs. Given that Germany is relatively rich in physical and human capital and one of the technologically leading countries, firms that use physical and human capital intensively and that are active in R&D can be expected to have a comparative advantage on the international market.

### 3.1 Unconditional differences between exporters and non-exporters

Exporting and non-exporting firms are different in a number of ways. Table 3 shows that on average exporters are larger (measured by the number of employees), employ more physical capital per employee, pay higher wages per employee (and, therefore, can be viewed as more human capital intensive), and are more intensively engaged in research and development activities. These differences in the means are statistically highly significant with the exception of physical capital intensity in some years. Furthermore, the differences are very large from an economic point of view for R&D activities, and rather high for firm size and wage per employee.

[Table 3 near here]

These findings are in line with evidence from earlier empirical studies summarized in table 1. Furthermore, given that Germany is one of the most highly developed countries we expect that firms using human capital and new technology intensively to produce new products have a comparative advantage and, therefore, are the more successful exporters.

Everybody who is familiar with firm level data knows that firms tend to be heterogeneous. Some exporters are very large and well known firms like Volkswagen, Daimler or Siemens. In 2006 the share of the three largest exporters in total exports[10] was 16.7 percent in West Germany and 17.8 percent in East

[10] These figures refer to all enterprises (legal units) with at least 20 employees and not to the samples used in this study. They are based on the author's own computations; a detailed descriptive table is available on request. Note that the names of these large exporters are confidential like all information from official statistics that relates to a single firm.

Germany; the respective shares of the largest 50 exporters were 44.5 percent and 56.6 percent. Many exporting firms, however, were small firms, and each of them contributed only a tiny share to total exports. This heterogeneity of exporting firms with regard to size is illustrated in column two of table 4. In 2003 the smallest exporters in West Germany had less than 20 employees, the median size is 115 employees (far below the average value of 398 employees), and the three largest exporting firms had on average more than 100,000 employees.

[Table 4 near here]

Heterogeneity of exporting firms is not limited to size. As shown in table 4 successful exporters can be found among firms that produce goods with a very high capital to labour ratio, but there are exporters who manufacture goods with nearly no physical capital. Many exporters have a high share of highly qualified employees, while human capital intensity is rather low in other firms. Some exporters are very active in research and development, others not at all. And heterogeneity is not limited to exporting firms, it is found in non-exporting firms too. This illustrates what James Heckman (2001, p. 674) pointed out In his Nobel-lecture, namely that "(t)he most important discovery [from micro-econometric investigations, *J.W.*] was the evidence on the pervasiveness of heterogeneity and diversity in economic life."

A test for differences in the mean values, therefore, can only be a first step in a comparison of exporters and non-exporters. As Moshe Buchinsky (1994, p. 453) put it: "'On the average' has never been a satisfactory statement with which to conclude a study on heterogeneous populations." An empirical study of heterogeneous firms should look at differences in the whole distribution of the

variables under investigation between groups of firms, not only at differences at the mean.

The hypothesis that the distribution of firm size, physical capital intensity, human capital intensity and R&D intensity for exporters stochastically dominates the respective distribution of non-exporters can be tested by the Kolmogorov-Smirnov test. This non-parametric test for first order stochastic dominance of one distribution over another was introduced into the empirical literature on exports by Delgado, Farinas and Ruano (2002). Let F and G denote the cumulative distribution functions of a variable for two groups of firms, exporters and non-exporters. 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 firms 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.).

[Table 5 near here]

The results for the Kolmogorov-Smirnov test are reported in table 5. The test indicates that the distributions of all variables differ between exporters and non-exporters in each year in West Germany and in East Germany, and that the difference is in favour of the exporters in all 40 cases considered. These results are highly significant statistically. The bottom line, then, is that exporters are larger (measured by the number of employees), employ more physical capital per employee, pay higher wages per employee (and, therefore, can be viewed as more human capital intensive), and are more intensively engaged in research

and development activities not only on average but over the whole distribution of these characteristics.

### 3.2 Conditional differences between exporters and non-exporters

So far only the unconditional differences between one observed characteristic of exporters and non-exporters at a time has been investigated. In the next step the link between a characteristic and the export activity will be looked at conditioning on the industry of the firm and on the effects of the other characteristics. To do so empirical models are estimated that include the firm characteristics (number of employees, physical capital per employee, wage per employee, and R&D intensity) plus a full set of 4digit industry dummy variables as exogenous variables.[11] The endogenous variables is either a dummy variable that takes the value one if the firm is an exporter (and zero otherwise) or the share of exports in total sales.

Results for export participation are reported in table 6. For each year from 2003 to 2006 results for two empirical models are given. Model 1 measures R&D activity by the share of R&D expenditures in total sales, model 2 uses the share of employees in R&D. Both R&D measures are highly positively correlated (the correlation coefficient lies between 0.75 and 0.81 in the four years). Table 6 reports the estimated marginal effects from a probit regression.

[11] It might be argued that the firm characteristics should not be treated as exogenous because exporting might cause firms to grow, to invest in physical or human capital, or to increase the level of R&D activities. To justify the approach taken here it should be pointed out that a large literature finds support for the hypothesis that “better” (larger, more productive, more innovative etc.) firms tend to self-select into exporting, while positive effects of exports on firm characteristics are only rarely found (see Wagner 2007a for a survey of this literature). Note that the use of lagged value of firm characteristics in the empirical models is no convincing strategy to deal with a potential endogeneity problem here because the firm characteristics are highly positively correlated over time (the correlation coefficients in the sample used in this study are around 0.9 for two adjacent years).

[Table 6 near here]

Ceteris paribus the probability that a firm is an exporter is higher for larger firms,[12] firms that pay higher wages per employee (and that can be considered to be more human capital intensive) and firms that are more actively engaged in R&D both in West Germany and in East Germany. While these results are in line with the results reported above for unconditional differences in firm characteristics between exporters and non-exporters the result for physical capital intensity is different. Controlling for industry affiliation and the other firm characteristics included in the empirical model physical capital intensity and exporting are not positively related. For all but one year and one part of Germany the estimated regression coefficient is not statistically significant at the usual error level of five percent – and the results indicate a negative relation for this case (West Germany in 2004).

While the statistical significance and the direction of the relationship between the firm characteristics included in the model and the probability that a firm is an exporter can be seen from table 6 at a glance, the relevance of a specific firm characteristic for the probability of being an exporter – the significance from an economic point of view – cannot. Table 6 reports the marginal effects, that is, the change in the probability of being an exporter for an infinitesimal change in the firm characteristic, measured at the mean of the variable. While marginal effects can in a

[12] Note that the sign pattern of the estimated coefficients for the number of employees and the squared value of the number of employees points to an inversely u-shaped relation between firm size and the probability of exporting. From the estimated coefficients (not reported here to economize on space) the estimated maximum value of this inversely u-shaped relation can be computed. This value is very large. The maximum value from the estimated coefficients for model 1 in 2003 in West Germany is 55,488 – this is much larger than the 99$^{th}$ percentile of the distribution of the number of employees for both exporters and non-exporters (see table 4). The same holds for East Germany where the estimated maximum value is 3,950. Therefore, the estimated coefficients indicate that the probability to export increases with the number of employees in a firm, but at a decreasing rate.

sense be more easily interpreted than the estimated coefficients from the probit regression (that are not reported here to economize on space), it is still difficult to see which of the statistically significant effects can be considered to be important. If, for example, an increase in the annual wage per employee by 10.000 Euro would increase the probability that a firm is an exporter by 0.01 percent, we would consider this effect as negligible and we would argue that human capital intensity does not matter for the probability that a firm is an exporter, regardless of the prob-value of the estimated coefficient.

To elaborate on this let us look at model 1 for West Germany in 2003.[13] From the reported marginal effect for wage per employee per year we see that an increase of this measure for human capital intensity (evaluated at the sample mean of this variable) by 10.000 Euro has an estimated effect of +0.0521 - the estimated probability that a firm is an exporter is 5.21 percent higher than before ceteris paribus. This indicates an important link between human capital intensity and export participation. The same holds for the R&D variables. An increase of the share of R&D expenditures in total sales by 2.0 percentage points (again evaluated at the sample mean of this variable) has an estimated effect of 4 percentage points on the probability that a firm is an exporter. Firm size is important, too. An increase of the number of employees (again evaluated at the sample mean of this variable) by 100 persons has an estimated effect of 1.9 percent.

Another way to understand which firm characteristics are important for becoming an exporter uses the estimated results from the probit models to perform simulation exercises by looking at hypothetical firms and computing the estimated

[13] Given that the estimated results are very similar for the various models the conclusions from looking at this particular model hold for the other models, too.

probability that these firms are exporters. Results for such exercises are reported in table 7.

[Table 7 near here]

Based on the estimation results for model 1 in 2005[14] the probability to be an exporter is estimated for nine hypothetical firms from an arbitrarily chosen manufacturing industry[15] in either West Germany or East Germany. Firm 1 is a very small firm with low physical and human capital intensity and no R&D activity. For West Germany the estimated probability of being an exporter is 73% – well below the share of exporters in the sample (80.9%). A ceteris paribus increase in employment from 20 to 100 increases the export probability only slightly to 75.1 % (firm 2), and a ceteris paribus increase in physical capital intensity decreases it slightly to 74.5% (firm 3). Doubling the human capital intensity leads to a large increase in the probability of exporting to 85.7 percent (firm 4). If a firm that is identical to firm 4 is active in R&D and spends one percent of its total sales for R&D we see a small increase in the export probability of 1 percentage point (firm 5). A ceteris paribus increase in the number of employees by 400 increases the probability to export by nearly 6 percentage points (firm 6). While a huge ceteris paribus increase in physical capital intensity lowers this probability by two percentage points (firm 7), a huge increase in human capital intensity increases it by eight percentage points (firm 8).

[14] This model is used because it is the only model for which results using a full set of 4digit industry dummy variables could be computed for the share of exports in total sales (see table 8 below).

[15] This industry is the industry of the first observation in the data set for West Germany and East Germany, respectively. Note that due to strict data protection rules neither this industry nor the industry used as a reference group in the estimation of the probit model can be revealed.

The large firm that uses physical capital and human capital intensively and that spends a large share of total sales for R&D 8 (firm 9) is for sure an exporter.

For East Germany, the pattern is rather similar, though at a lower level. Firm 1, firm 2 and firm 3 have estimated export participation probabilities that are below the share of exporters in the sample (which is 63.7% in 2005). Firm size and human capital intensity turn out to be important again, while R&D activity increases the probability to export only slightly. Like in West Germany in East Germany the large firm that uses physical capital and human capital intensively and that spends a large share of total sales for R&D 8 (firm 9) is for sure an exporter.

### 3.3 Firm characteristics and the share of exports in total sales

The share of exports in total sales varies widely among exporting firms (see the evidence reported in table 4 for 2003 and the sample of firms used in this study). The next step in the investigation of the links between firm characteristics and export activities, therefore, looks at the role of firm characteristic for the relative importance of exports. To do so empirical models are estimated that include the firm characteristics (number of employees, physical capital per employee, wage per employee, and R&D intensity) plus a full set of 4digit industry dummy variables as exogenous variables. The endogenous variable is the share of exports in total sales. This share of exports in total sales is a percentage variable that is by definition limited between zero and 100 percent, and that has a lot of observations at the lower bound because many firms do not export at all (see table 2 for the sample used in this study). Papke and Wooldridge (1996) showed that for a fractional response

variable of this type, and using cross section data, a fractional logit estimator is appropriate.[16]

The estimated coefficients from fractional logit regressions are reported in table 8.[17] In West Germany all estimated coefficients are statistically highly significant and all firm characteristics included in the empirical models are positively related to the share of exports in total sales. Export intensity tends to increase with the number of employees[18] and the intensity of physical capital, human capital and R&D. The big picture is broadly the same in East Germany.[19] Larger firms with a higher intensity of human capital and R&D are more export intensive here, too. However, physical capital intensity does not play a role in three out of four years.

[Table 8 near here]

[16] Wagner (2001) introduced this estimation strategy into the literature on the determinants of exporting activities of firms, and discussed the flaws related to alternative approaches like Tobit or two-step estimators. For a comprehensive recent discussion of estimation strategies for fractional response variables with a non-ignorable probability mass at zero see Ramalho, Ramalho and Murteira (2010).

[17] Computations were done with Stata 11 using the glm routine with a logit link. Like in the case of the determinants of export participation for each year from 2003 to 2006 results for two empirical models are given. Model 1 measures R&D activity by the share of R&D expenditures in total sales, model 2 uses the share of employees in R&D.

[18] The sign pattern of the estimated coefficients for the number of employees and the squared value of the number of employees points to an inversely u-shaped relation between firm size and the share of exports in total sales. From the estimated coefficients the estimated maximum value of this inversely u-shaped relation can be computed. This value is very large; in model 1 and for 2003 it is 63.172. This value is much larger than the number of employees in the exporting firm at the 99$^{th}$ percentile (see table 4). Therefore, the estimated coefficients indicate that the share of exports in total sales increases with the number of employees in a firm, but at a decreasing rate.

[19] Note that model 1 for 2005 was the only model that could be estimated with a full set of 4digit industry dummy variables for East Germany; in all other cases Stata reported that the variance matrix is non-symmetric or highly singular. All other models for East Germany were estimated with a full set of 2digit industry dummy variables. The results for model 1 for 2005 do not differ qualitatively between the two variants for all estimated coefficients but the number of employees that has a p-value of 0.043 in the model with two-digit industry dummy variables.

While the statistical significance and the direction of the relationship between the firm characteristics included in the model and the share of exports in total sales can be seen from table 8 at a glance, like in the case of the results from the probit regressions for the probability of being an exporter the relevance of a specific firm characteristic for export intensity – the significance from an economic point of view – cannot. The estimated coefficients form the fractional logit model reported in table 8 cannot be interpreted directly in a straightforward way. To understand which firm characteristics are important for the share of exports in total sales the estimated results from the fractional logit models are used to perform simulation exercises by looking at hypothetical firms and computing their estimated share of exports in total sales. Results for such exercises are reported in table 9.

[Table 9 near here]

Like in the case of the empirical models for the participation in exporting discussed above we use the estimation results for model 1 in 2005 to estimate the share of exports in total sales for nine hypothetical firms from an arbitrarily chosen manufacturing industry in either West Germany or East Germany. Firm 1 is a very small firm with low physical and human capital intensity and no R&D activity. For West Germany the estimated share of exports in total sales is only 11.1%. A ceteris paribus increase in employment from 20 to 100 does not increases the estimated export share (firm 2), and a large ceteris paribus increase in physical capital intensity has no effect, too (firm 3). Doubling the human capital intensity leads to an increase in the share of exports in total sales by 6.5 percentage points (firm 4). If a firm that is identical to firm 4 is active in R&D and spends one percent of its total sales for R&D

we see a small increase in the export share of less than 1 percentage point. A ceteris paribus increase in the number of employees by 400 increases the share of exports in total sales only marginally (firm 6). While a huge ceteris paribus increase in physical capital intensity leads to an increase of the export share by more than three percentage points (firm 7), a huge increase in human capital intensity increases it by 23 percentage points (firm 8). The large firm that uses physical capital and human capital intensively and that spends a large share of total sales for R&D 8 (firm 9) has an estimated share of exports in total sales of 56.3 percent.

For East Germany, the estimation results reported for model 1 in 2005 indicate that firm size is only weakly significant, and physical capital intensity does not play a role. Firms with a higher intensity of human capital and R&D, however, are more export intensive in East Germany, too. Simulation results for East Germany that use the same hypothetical firms as for West Germany are reported in the lower panel of table 9. Given that only the estimated coefficients for human capital intensity and R&D are statistically significantly different from zero at a usual error level, we focus on the role of these two firm characteristics. A ceteris paribus increase in human capital intensity turns out to have a large effect – see firm 3 compared to firm 4 and the increase from 23 percent to 37 percent, and firm 7 compared to firm 8 and the increase from 41.5 percent to 73.4 percent. The estimated effect of R&D spending, on the other hand, is tiny according to a comparison of firm 4 and firm 5, and firm 8 and firm 9.

The bottom line, then, is that according to the empirical models estimated so far in this paper human capital intensity is the most important firm characteristic in both parts of Germany for the probability to be an exporter and for the share of exports in total sales.

## 4. Unobserved firm characteristics and export activity

The proof that certain characteristics of a firm are closely related to its export activity is all but easily delivered. In section 3 of this paper exporters and non-exporters (or firms that export different shares of their total product) are compared with respect to firm size, physical capital intensity, human capital intensity, or R&D activities. Such comparisons, however, are only based on observed firm characteristics. They cannot deal with the role of unobserved (and sometimes unobservable) characteristics – like a unique product, or superior quality of the management of a firm - that might be correlated with the observed characteristics. If these unobserved characteristics are correlated with the observed characteristics included in the empirical model, the estimates for the coefficients of these observed firm characteristics are biased. The workhorse in empirical studies faced with this problem is an empirical model estimated with panel data that includes fixed effects to control for time invariant unobserved firm characteristics that might be correlated with the variables in that empirical model.

One crucial problem in any application of the fixed effects strategy is that in the estimation of the coefficients only the within variation of variables over time is used. Therefore, the empirical model for export participation that includes fixed firm effects is estimated using only observations on firms that changed their exporter status between 2003 and 2006 at least once. We know from table 2 that this is a small group of firms only – in West Germany 95 percent of all enterprises had a stable exporter status over the years, and in East Germany 89 percent of the firms did not switch into or out of exporting. Firms that start or stop exporting are known to differ from firms that continue (not) to export.[20] This means that an empirical model tor export participation with fixed firm effects is estimated using a sample of firms that

[20] See Wagner (2008b) for evidence on this for Germany.

is different from the population of firms (or a representative random sample of this population).

Another problem related to using only the variation over time within observations in fixed effects models for firm level data is the high ratio of between to within variation that is often observed, at least over short periods of time (like four years in our case). While enterprises differ widely from each other in all characteristics considered in this study at a point in time (as is demonstrated in table 4), differences from year to year tend to be much smaller. Evidently, there are firms that jump up and down with regard to the share of exports in total sales, or the number of employees, or other firm characteristics. But usually year-to-year changes in firm characteristics tend to be small on average.

For the sample of firms investigated in this study this point is illustrated in Table 10. The total variation of the variables is decomposed into variation over time for a given firm (within variation) and variation across firms (between variation).[21] For all variables the within variation is much smaller than the between variation (especially for the share of exports in total sales, the number of employees, and the wage per employee). This is important to see, because in an empirical model with fixed effects the coefficient of a regressor with little within variation will be imprecisely estimated.

[Table 10 near here]

Usually, the within variation that is needed to identify the coefficient of a regressor in a fixed effects model tends to increase with the length of the panel used in the estimation. A long panel covering many years, therefore, might be considered

[21] See Cameron and Trivedi (2010, p. 244f.) for a discussion and formulas.

to be a better basis for empirical investigations than a short panel for only some years. However, the fixed effects that control for unobserved firm heterogeneity are by assumption time invariant, and this assumption seems more appropriate in shorter than in longer panels. A case in point is the quality of the management of a firm mentioned to motivate the application of fixed effects regression methods in this study. The assumption that management quality does not vary over time seems more convincing in the short run than in the long run (if only because bad management quality can be expected to lead to either market exit or to a new and better, or at least, different group of in the longer run). The empirical researcher, therefore, is facing a trade-off – usually, the longer the panel, the larger is the within variation in the regressors, but the less appropriate is the assumption of time invariant unobserved heterogeneity.

The panel used in this study seems to be short enough to justify the assumption that important unobserved firm characteristics can indeed be considered as time-invariant. But as demonstrated in table 10 the within variation of the regressors might well be too small over this short time period to estimate their effect precisely.

Furthermore, any attempt to apply a fixed effects strategy to the estimation of a model for the share of exports in total sales is confronted with a problem that is due to the nature of the variable to be explained. If the number of panels (i.e., firms) in a population (an industry, or a country) is finite and each panel is represented in the data set, an unconditional fixed-effects fractional logit model can be used which simply includes an indicator variable for each firm (see Hardin and Hilbe 2001, p. 195).[22] This unconditional fixed-effects approach, however, can only be used when

[22] Wagner (2003) applied this modelling strategy using information on all firms in three manufacturing industries from one German federal state.

information for the population of firms is available for a number of periods, and that is rarely the case.

In a recent paper Papke and Wooldridge (2008) introduce a method that can be applied to estimate fractional response models for panel data with a large cross-sectional dimension and relatively few time periods while explicitly allowing for time-constant unobserved effects that can be correlated with explanatory variables. The data need not cover the whole population, but they must form a balanced panel data set with complete information on all variables in each year for each firm. Papke and Wooldridge proof that time-constant unobserved effects that can be correlated with explanatory variables are controlled for by adding the time averages of the explanatory variables to an empirical model.

That said, empirical models for the export participation of firms and for the share of exports in total sales that use the same specification as the empirical models for cross section data used in section 3[23] and that include firm fixed effects were estimated for pooled data from 2003 to 2006, using fixed effects logit and the fractional probit panel estimator introduced by Papke and Wooldrige (2008). Results are reported in table 11.

[Table 11 near here]

The big picture from the models with fixed firm effects differs completely from the results reported for models without fixed effects in table 6 and table 8 above. The decision to participate in the export market that is strongly positively influenced by a higher human capital intensity and a more intensive engagement in R&D according

[23] The models with fixed firm effects do not include 4digit industry dummy variables. Changes between industries are rare (see table 10), and any industry specific effects are included in the firm fixed effects. All models include time dummy variables for the years 2004 to 2006.

to the empirical models based on cross section data in both West Germany and East Germany is no longer related to these firm characteristics in the empirical models with fixed firm effects. Contrary to results reported in table 8 for models without fixed effects, results in table 11 show that neither firm size, nor physical capital, nor R&D intensity matter for the share of exports in total sales in West Germany, and that R&D intensity is (if anything) negatively related to export intensity in East Germany.

Does this really indicate that in German manufacturing industries human capital intensity and R&D intensity are irrelevant for the decision to export, and that a higher R&D intensity *per se* does not make a successful exporter, but that unobserved time-invariant characteristics that are correlated with these observed characteristics matter a lot and shape the results of empirical models estimated with cross section data that ignore these unobserved characteristics?[24] The results reported in table 10 on relatively low within variation over the four years under investigation cast doubts on this conclusion, because in an empirical model with fixed effects the coefficient of a regressor with little within variation will be imprecisely estimated. This might well be the reason for the somewhat strange results reported in table 11 that contradict the findings from empirical models estimated with cross section data.

The bottom line, then, is that the results reported in section 3 that are based on empirical models without fixed firm effects and without control for unobserved heterogeneity seem to be more reliable. This does not mean to deny the role of unobserved firm characteristics like quality of management. These factors matter for export activities. A recent study by Bloom and Van Reenen (2010) that relates management practices to productivity shows, among others, that firms that export are better-managed than domestic non-exporters. Syverson (2010, p. 14) points out that

[24] See Wagner (2003, 2008d) for papers arguing in this direction.

economists have long proposed that managers drive differences between firms, and cites a paper by Walker (1887) published more than 120 years ago. But in the data used in this study (and in many other empirical studies using comparable firm level data for Germany or other countries as well) there is simply not enough variation in the observed firm characteristics to control for unobserved time invariant firm characteristics like management quality in empirical models for export activity with fixed firm effects.

## 5. Productivity and exports

While the links between exporting on the one hand and firm size, physical and human capital intensity, and R&D activity on the other hand have been explored empirically for quite a long time[25] the more recent literature dealing with the export activity of firms focuses on the role of productivity. The reason for this switch in emphasis is the central role played by productivity in the literature that is labeled the *new new trade theory*. Canonical theoretical papers in this literature include Melitz (2003) and Helpman, Melitz and Yeaple (2005). In this theoretical literature that was motivated by earlier empirical studies on exports and productivity (including the seminal Brookings paper by Bernard and Jensen (1995) for the United States and the paper by Bernard and Wagner (1997) for Germany) it is argued that only firms with a productivity that lies above a critical point in the productivity distribution can cover the extra (fixed) costs of exporting and make profits simultaneously.

These theoretical papers kicked off a large empirical literature that deals with the existence, statistical significance, and size of productivity differentials between exporters and non-exporters, and with the direction of causality between exports and

[25] For Germany, see the synopsis of empirical studies in table 1.

productivity. A recent review of 45 empirical studies (published between 1995 and 2006) using firm level panel data from 33 countries concludes that exporters are indeed more productive than non-exporters of the same size from the same narrowly defined industry, and that the more productive firms self-select into export markets, while exporting does not necessarily improve productivity (see Wagner 2007a).[26]

In this study productivity is measured by value added per employee. [27] Table 12 shows that for the sample of German manufacturing enterprises investigated in this study exporters have higher values of labour productivity than non-exporters at the mean in each year and in both parts of Germany. These productivity differentials are statistically highly significant and large from an economic point of view – in 2006, for example, exporters were 31 percent more productive than non-exporters at the mean in West Germany, and 28 percent more productive in East Germany.

[Table 12 near here]

[26] Recent evidence for Germany on productivity and exports is reported in Wagner (2007b) and Vogel and Wagner (2009); for comparable evidence from 14 countries see International Study Group on Exports and Productivity (2008).

[27] Note that 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 (2010, p. 9) argues: "Simply put, high-productivity producers will tend to look efficient regardless of the specific way that their productivity is measured." See International Study Group on Exportrs and Productivity (ISGEP) (2008) for a comparison of results for productivity differentials between exporting and non-exporting firms based on sales per employee, value added per employee and total factor productivity. Results proved remarkably robust. 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.

Like in the case of firm size, physical and human capital intensity and R&D activity both exporters and non-exporters are rather heterogeneous with regard to labor productivity. As is shown in table 13 there are firms that have very small (or even negative) values of value added per employee while other firms have very large values.

[Table 13 near here]

A test for differences in the mean values, therefore, can only be a first step in a comparison of exporters and non-exporters. In a second step we look at differences in the whole productivity distributions and test whether the distribution for exporters stochastically dominates the productivity distribution of non-exporters using the Kolmogorov-Smirnov test (discussed in section 3.1). Results are reported in table 14. The test indicates that the distributions differ between exporters and non-exporters in each year in West Germany and in East Germany, and that the difference is in favour of the exporters in all eight cases considered. These results are highly significant statistically.

[Table 14 near here]

So far only the unconditional difference between productivity of exporting and non-exporting enterprises has been investigated. In the next step the link between exporting and productivity will be looked at conditioning on the industry of the firm. To do so empirical models are estimated that include value added per employee and a

full set of 4digit industry dummy variables as exogenous variables.[28] The endogenous variable is a dummy variable that takes the value one if the firm is an exporter (and zero otherwise). Results for these empirical models for export participation are reported in table 15.

[Table 15 near here]

The results indicate that more productive firms do have a higher probability to participate in exporting when the detailed industry affiliation of the enterprise is controlled for. The reported marginal effect at the mean of productivity is always positive and it is statistically significantly different from zero in all cases with the exception of East Germany in the first year investigated.

These empirical findings of a positive link between exporting and productivity are in line with the predictions of the theoretical models from the *new new trade theory*. In these theoretical models productivity of a firm is modeled as a random draw from a given distribution of productivity. While this is for sure an appropriate approach to build a theoretical model for trade with heterogeneous firms, it is far from satisfactory from an empirical point of view. Obviously there is a role for random shocks, or good or bad luck, in shaping the productivity level of a firm, but we have good reasons to believe that a high or low level of productivity is not a matter of luck alone. Productivity can be expected to be related to the amount and the quality of

[28] From the literature on exports and productivity we have ample empirical evidence that firms with a higher productivity self-select into exporting and that exporting does not tend to increase productivity; see Wagner (2007a) for a survey and Wagner (2007b) and Vogel and Wagner (2009) for Germany. Therefore, productivity can be regarded to be exogenous with respect to the decision to export. Note that the data at hand cover only four years due to the sampling frame used (detailed in section 2). Therefore, an empirical test of the self-selection and learning-by-exporting hypotheses is not possible with these data.

inputs used in the production process, and to the way these production factors are combined.

How are the characteristics of a firm that are investigated in section 3 and section 4 related to labor productivity (measured as value added per employee) in our sample? To investigate this question empirical models are estimated with value added per employee as the endogenous variable and firm size, physical capital per employee, human capital intensity, and R&D activities plus a full set of detailed dummy variables for the industry a firm is active in as exogenous variables. Results are reported in table 16.[29]

[Table 16 near here]

The big picture that arises from the regression results reported in table 16 can be sketched as follows:

- *Firm size is unrelated to productivity*. This finding fits with the evidence available from numerous reports on very small German firms that are highly successful in exporting.[30]

- Both physical capital intensity and human capital intensity are positively related to labor productivity, and the estimated regression coefficients are highly significant. Human capital intensity, however, is much more important for value added per employee than physical capital intensity. To see this, consider the case of

[29] Note that these regression equations are not meant to be an empirical model to explain labour productivity at the enterprise level; the data set at hand here is not rich enough for such an exercise. They are just a vehicle to test for, and estimate the size of, the relation between one firm characteristic and labor productivity controlling for other plant characteristics.Furthermore, note that productivity differences at the firm level are notoriously difficult to explain empirically. “At the micro level, productivity remains very much a measure of our ignorance.” (Bartelsman and Doms 2000, p. 586)

[30] See the examples mentioned in Wagner (2003).

West Germany in 2003.[31] The mean value of physical capital per employee was about 92.000 € (see table 4), and the mean value added per employee was about 57.000 € (see table 13). Using the regression results reported for model 1 in table 16 a ten percent increase in the physical capital intensity leads to an estimated increase in labor productivity by 690 € (9.200 * 0.075), a tiny amount. If physical capital increases by 50 percent, the related estimated increase in value added per employee is still small – 3.450 €, or six percent. Results for human capital intensity are much different. The mean value of wages per employee was about 34.000 € (see table 4), and the mean value added per employee was about 57.000 € in West Germany in 2003 (see table 13). Using again the regression results reported for model 1 in table 16 a ten percent increase in human capital intensity leads to an increase in labor productivity by 4.250 € (3.400 * 1.250) or 7.5 percent. If the human capital intensity increases by 50 percent, the related estimated increase in value added per employee is 21.250 €, or 37.3 percent. The bottom line, then is: *Human capital intensity is strongly positively related to labor productivity, while physical capital intensity matters only marginally.*

- *R&D activity is not related to labor productivity*. The estimated regression coefficient for one measure of R&D activity, the share of employees in a firm that is active in R&D, is never statistically significantly different from zero. As regards the other measure of R&D activity, the share of R&D expenditures in total sales, the estimated regression coefficient points to a negative and statistically significant relation in three out of four years in West Germany and in East Germany. The estimated effect, however, is tiny. From table 4 it can be seen that in West Germany the median firm has no R&D at all. The share of R&D expenditures in total sales is 1.20 for the exporting firm at the 75$^{th}$ percentile of the distribution of R&D intensity.

[31] Results for other years and for East Germany are of a similar order of magnitude.

According to the results for model 1 in 2003 this switch from no R&D expenditure to an R&D expenditure of 1.20 percent of total sales is related to a decrease in value added per employee by 597.43 € (-497.86 * 1.2) – a tiny amount compared to the average amount of value added in exporting firms that was 56,699 € in 2003 according to table 13. Results for East Germany are of the same order of magnitude.

The bottom line, then, is that productivity *is* important for exporting as is expected from the formal models from the *new new trade theory*, but contrary to the assumption made in these theoretical models productivity is not only the result from a random draw – it is strongly positively related to human capital intensity.

## 6. Concluding remarks

Reliable information on the characteristics of exporting and non-exporting firms is important to guide theorists and policy makers in an evidence based way. This holds true especially for Germany, a leading actor on the world markets for goods and services. This paper makes three contributions towards this aim:

- A synopsis and a critical assessment of 51 empirical studies on exports and firm characteristics that use data for German establishments or enterprises is provided, and it is argued that this literature is not suited to extract the stylized facts needed.

- Recently released rich high quality data for a large representative panel of enterprises from German manufacturing industries are used to investigate the links between firm characteristics (firm size, physical and human capital intensity, and R&D activities) and export activities, and the decisive role of human capital intensity for exporting is documented.

- The findings are linked to the recent literature from the *new new trade theory* on international activities of heterogeneous firms that emphasises the role of

productivity for exporting. It is shown that productivity *is* important for exporting as is hypothesized in the formal theoretical models, but that contrary to the assumption made in these models productivity is not (only) the result from a random draw from the productivity distribution – it is strongly positively related to human capital intensity.

The bottom line, then, is that human capital plays a central role for the (international) competitiveness of firms. Therefore, human capital intensity is important for the (international) competitiveness and the growth of industries and regions, and of the economy as a whole. This points out the decisive role of policy measures that focus on improvements in the qualification of employees, both young and older, and to an immigration policy that can help to overcome a shortage of skilled labor as a consequence of an ageing population and demographic change.

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Table 1: Synopsis of empirical studies on firm characteristics and export activities in Germany[1]

| Study | Data | Method | Core findings |
|---|---|---|---|
| Wagner (1991) | Sample of firms from three industries in Lower Saxony, 1986 (N = 133) | Two-limit Tobit ML | Firm characteristics only weakly related to share of exports in total sales; statistically significant coefficients are rare |
| Wagner (1995) | All establishments with at least 20 employees in manufacturing industries in Lower Saxony, 1978 - 1989 (N = ca. 4,300 / year) | Tobit ML, cross section only | Share of exports in total sales increases with firm size at a decreasing rate; human capital intensity (wage per employee), market share at home and technological intensity (measured at the industry level) positively related with export intensity |
| Wagner (1996) | Hannover Firm Panel, wave 1 (1994); sample of establishments in manufacturing industries in Lower Saxony (N = 942) | Tobit ML | Share of exports in total sales increases with firm size at a decreasing rate; human capital intensity (share of employees on jobs demanding a university degree) and product innovations positively related with export intensity. No role of firm age and use of state of the art production technology found. |
| Bernard and Wagner (1997) | All establishments with at least 20 employees in manufacturing industries in Lower Saxony, 1978 – 1992 (N = ca. 4,300 / year) | Descriptive statistics; OLS | Exporters are larger, more productive, have a higher capital intensity, pay higher wages, and have a higher share of non-production workers than non-exporters. Evidence for self-selection of “better” firms into exporting; no evidence that exporting improves firms. |
| Wagner (1998) | Hannover Firm Panel, wave 1 and 2 (1994/95); sample of establishments in manufacturing industries in Lower Saxony (N = 768) | Tobit ML | Share of exports in total sales increases ceteris paribus with number of employees, human capital intensity (share of employees on jobs demanding a university degree), technological intensity (R&D spending), patents and product innovations. |
| Ebling and Janz (1999) | Mannheim Innovation Panel in the Service Sector, wave 1997 (N = 1,010) | Probit; simultaneous Probit | Innovation activities and human capital positively related to exports; export activities do not enforce innovation activities |

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|---|---|---|---|
| Bernard and Wagner (2001) | All establishments with at least 20 employees in manufacturing industries in Lower Saxony, 1978 – 1992 (N = ca. 4,300 / year) | Descriptive statistics; OLS, Probit; panel estimatates (fixed effects, random effects) | Probability of entry into exporting much higher for plants that are larger, more productive and more intensive in skilled workers; evidence for substantial sunk costs of export entry. |
| Loose and Ludwig (2001) | IAB Establishment Panel wave 1998 and 1999; sample of establishments for Germany (N = 502, only East Germany) | Descriptive statistics; stepwise logistic regression | Innovation and R&D positively related to exporting; larger firms have higher probability of exporting. |
| Wagner (2001) | Hannover Firm Panel, wave 1 and 2 (1994/95); sample of establishments in manufacturing industries in Lower Saxony (N = 768) and for four industries | OLS; Tobit ML; Beta regression; fractional logit regression | Share of exports in total sales increases ceteris paribus with number of employees, human capital intensity (share of employees on jobs demanding a university degree), technological intensity (R&D spending), patents and product innovations for all plants; big picture independent of method used to estimate the empirical model. Results differ between industries. |
| Leber (2002) | IAB Establishment Panel wave 2000; sample of establishments for Germany (N = 2,226 for West Germany and 1,645 for East Germany) | Descriptives; Probit; Tobit ML | Firm size, human capital intensity and technology intensity positively related to exports |
| Roper and Love (2002) | Product Development Survey, sample of plants for Germany and UK, collected in 1994. (N = 1,118 / 842 for Germany) | Probit; truncated regression model | Product innovation strong effect on probability to export and share of exports in total sales |
| Wagner (2002) | All establishments with at least 20 employees in manufacturing industries in Lower Saxony, 1978 – 1989 (N = 186 for export starters, N = 9,239 for non-exporters) | Propensity-score matching<br><br>. | Self-selection of “better” plants into exporting. Positive effect of starting to export on growth of employment and wages. |

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|---|---|---|---|
| Loose und Ludwig (2003) | All establishments with at least 20 employees in manufacturing industries in East Germany, 1992 - 2000 (N = 6,444 (1995), 7,546 (2000)) | Descriptive statistics;Logit | Firm size and technology intensity of the industry positively related to exporting |
| Wagner (2003) | All establishments with at least 20 employees in three manufacturing industries in Lower Saxony, 1978 – 1989 (N= 208, 212, 291) | Fractional logit for pooled data and for unconditional fixed effects model | Number of employees not related to share of exports in total sales when fixed plant effects are included in the empirical model |
| Arnold and Hussinger (2005) | Mannheim Innovation Panel; sample for Germany, 1992 – 2000. Highly unbalanced panel, N = 2,149 observations for 389 enterprises | Descriptive statistics; Probit; Granger causality test; propensity-score matching | Exporters are more productive, larger, more R&D intensive. Evidence for self-selection of more productive firms into exporting, no evidence for learning-by-exporting |
| Lachenmaier and Wößmann (2006) | Ifo Innovation Survey 2002 and Ifo Business Climate Survey (N = 981) | IV regression to identify Local Average Treatment Effects; OLS; Tobit | Causal effect of innovation on exports |
| Loose and Ludwig (2006) | IAB Establishment Panel waves 1999 to 2004; sample of establishments for Germany (N = 430 / 418; only East Germany) | Descriptive statistics; binary and multinomial logit | Exporters are larger, more innovative, have higher qualified employees, and are more often foreign owned firms than non-exporters |
| Wagner (2006a) | Hannover Firm Panel, wave 1 (1994); sample of exporting establishments in manufacturing industries in Lower Saxony (N = 458) | OLS; Quantile regression | Impact of plant characteristics on share of exports in total sales varies along the size distribution of the export/sales ratio |
| Wagner (2006b) | Hannover Firm Panel, wave 2 (1995); sample of establishments in manufacturing industries in Lower Saxony (N = 531) | t-test for difference in means; Kolmogorov-Smirnov test for first-order stochastic dominance of distribution | Productivity distribution of foreign direct investors dominates that of exporters, which in turn dominates that of national market suppliers |

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| Schank, Schnabel and Wagner (2007) | Linked employer-employee data combining plant-level data from the IAB establishment panel and information at the individual level from employment statistics of the German Labor Services (1995 – 1997); N = 1,855,034 observations of 918,149 employees in 1,262 plant | OLS; fixed effects for plants, for persons, and for spells of persons in plants | Wages increase with the share of exports in total sales (after controlling for observable and unobservable individual and plant characteristics in the most comprehensive way possible) |
| Wagner (2007b) | All establishments in German manufacturing industries with at least 20 employees; 1995 – 2004 (N = ca. 44,000 / year) | t-test for difference in means; Kolmogorov-Smirnov test for first-order stochastic dominance of distribution; OLS; propensity-score matching | Labor productivity (sales per employee), human capital intensity (wage per employee) and number of employees are higher in exporting firms than in non-exporting firms. Evidence for self-selection of "better" firms into exporting for West German firms. No evidence for learning by exporting. |
| Wagner (2007c) | All establishments in German manufacturing industries with at least 20 employees; 2004 (N = 44,600) | t-test for difference in means; Kolmogorov-Smirnov test for first-order stochastic dominance of distribution | Firms that export to countries inside the euro-zone are more productive than firms that sell their products in Germany only, but less productive than firms that export to countries outside the euro-zone, too. |
| Engelmann und Fuchs (2008) | IAB Establishment Panel waves 2004 - 2005; sample of establishment for Germany (N = max. 1,380 in West Germany and max. 1,239 in East Germany) | Probit; Tobit ML; Oaxaca-Blinder Decomposition | Results differ for West Germany and East Germany (empirical model for share of exports in total sales estimated for exporters only). State of the art technology and R&D positive for exports; firm size only relevant in West Germany. |
| Fryges and Wagner (2008) | All establishments with at least 20 employees in manufacturing industries in Lower Saxony, 1995 – 2005 (N = 21,856) | Fractional logit; generalized propensity score; dose response function | Causal effect of firms' export activity on labor productivity growth; but exporting improves labor productivity growth only within a sub-interval of firms' export-sales ratios. |
| Kaiser and Kongsted (2008) | Mannheim Innovation Panel wave 1 – 13 (1993 – 2004) Sample for Germany, highly unbalanced panel (N = 25,335 observations on 7,278 firms) | Fixed effects and random effects models | State dependence in the current export status of firms; sunk costs in export market entry are important, knowledge and experience in export markets depreciate |

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| Kirbach and Schmiedeberg (2008) | Mannheim Innovation Panel 1993 – 2003; Sample for Germany, highly unbalanced panel (N = 12,500 observations) | Probit; Tobit ML | East German firms less likely to export than West German firms. Strong positive relation between innovation and exports. Labor productivity more important in East Germany. |
| Wagner (2008a) | All establishments in German manufacturing industries with at least 20 employees; 2004 (N = 44,600) | Probit; decomposition of differences in export participation | In West Germany and in East Germany exporters were larger, more productive, and more often from technology intensive industries than non-exporters. Only small share of difference in export participation between West and East Germany can be explained by difference in size and productivity |
| Wagner (2008b) | All establishments in German manufacturing industries with at least 20 employees; 1995 – 2004 (N = ca. 44,000 / year) | t-test for difference in means; Kolmogorov-Smirnov test for first-order stochastic dominance of distribution | Firms that stop exporting in year t were in t-1 less productive than firms that continue to export in t. Firms that start to export in year t are less productive than firms that export both in year t and in year t-1. Firms from a cohort of export starters that still export in the last year were more productive in the start year than firms from the same cohort that stopped exporting before |
| Wagner (2008c) | Hannover Firm Panel, wave 2 (1995); sample of establishments in manufacturing industries in Lower Saxony (N = ca. 820) | t-test for difference in means; Probit; Fractional logit | Exporters generate more new knowledge than non-exporers. Differences not only due to larger firm size, use of more researchers, or different industries, but also due to more learning from external sources by exporters. |
| Wagner (2008d) | Sample of enterprises from manufacturing industries in Germany; balanced panel for 1999 - 2002 | Fractional probit panel with fixed enterprise effects | Human capital intensity and R&D intensity not related to share of exports in total sales when fixed enterprise effects are included in the fractional probit panel model |
| Arndt, Buch and Mattes (2009) | IAB Establishment Panel waves 2004 – 2006; sample of establishments for Germany (N = 3,705 – 5,864) | Two-step Heckman selection model for export decision and share of exports in total sales; Probit, OLS | Self-reported financial constraints do not affect exports; cash flow has effect on exports. Coverage by collective bargaining lowers probability of exporting, domestic shortages in terms of qualified personnel increase it. Wage cost problems lower volume of exports. Larger, more productive firms and firms with R&D are more likely to export. |

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| Buch, Döpke and Strotmann (2009) | All establishments with at least 20 employees in manufacturing industries in Baden-Württemberg, 1980 – 2001 ( N = ca. 21,000) | Fixed effects regression, two-step GMM estimation | Exporters have lower volatility of sales than non-exporters; higher export share in total sales reduces volatility |
| Fryges (2009) | Small sample of technology-oriented firms founded between 1987 and 1996, surveyed 1997/ 1998 and 2003 (N = 173) | Fractional logit; generalized propensity score; dose-response function | Inversely u-shaped relationship between 1997 export intensity and subsequent sales growth rate with maximum at 60 percent |
| Girma, Görg and Wagner (2009) | Sample of manufacturing enterprises with at least 20 Employees, 1999 – 2002 (N = ca. 16,000 / year) | OLS; propensity-score matching | Subsidized enterprises are more often exporters and have a higher share of exports in total sales compared to non-subsidized firms. No impact of subsidies on propensity to start exporting. Some evidence for positive impact of subsidies on share of exports in total sales in West Germany but not in East Germany |
| Vogel and Wagner (2009) | All manufacturing enterprises with turnover that exceeds 17,500 €/year, 2001 – 2005 (N = ca. 160,000 / year) | t-test of difference in mean; Kolmogorov-Smirnov test for first-order stochastic dominance of distribution; OLS; propensity-score Matching | Compared to enterprises that do not trade at all, firms that export and import have the highest productivity, followed by firms that only export, and then by firms that only import. |
| Arnold and Hussinger (2010) | Mannheim Innovation Panel; sample for Germany, 1996 – 2002. Highly unbalanced panel, N differs per year, max. ca. 1,250 | Kolmogorov-Smirnov test for first-order stochastic dominance of distribution; Quantile regression | Exporters outperform non-exporters over the entire productivity distribution |
| Becker and Egger (2010) | Survey data from Ifo Institute of Economic Research (Innovation Survey, Business Survey) 1994 – 2004 (N = 3,401 observations for 1,212 firms) | Bivariate probit, propensity-score matching | Firms that perform both product and process innovation have higher probability to export than firms that do not innovate; product innovation more important |
| Buch, Kesternich, Lipponer and Schnitzer (2010) | Dafne data base merged with Deutsche Bundesbank data from Midi data base (2002 – 2006) | Bivariate probit | Productivity and financial constraints have significant impact on firms‘ intensive and extensive margins of foreign activities (exports, FDI) |

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|---|---|---|---|
| Fryges and Wagner (2010) | Sample of manufacturing enterprises with at least 20 Employees, 1999 – 2004 (N = ca. 16,000 / year) | t-test of difference in mean; Kolmogorov-Smirnov test for first-order stochastic dominance of distribution; OLS; fixed enterprise effects; Fractional logit; generalized propensity score; dose response function | Exporters show positive profitability differential compared to non-exporters that is statistically significant but rather small. No evidence for self-selection of more profitable firms into exporting. Exporting has positive causal effect on profits almost over the whole domain of the export-sales ratio. |
| Hansen (2010) | Data from a survey of German and Austrian firms investing in Central and Eastern European countries collected 1997 – 2001, augmented with information from Amadeus data base etc.. (N =367 German firms, unbalanced panel for 1994 to 2003) | OLS; IV regression; 2SLS | Exporters are more productive than non-exporters; evidence for self-selection is found, and being active in foreign markets boosts firm-level productivity |
| Kelle and Kleinert (2010) | Transaction level data set of trade in services merged with MIDI data from Deutsche Bundesbank for 2005. Comprehensive data for Germany. (N = 209,060 observations for 33,756 firms | Descriptive statistics | Rather few firms from all sectors trade services. Bulk of exports and imports concentrated in few global and diversified firms. |
| Lejpras (2010) | Survey of 3,063 small and medium sized enterprises in East Germany 2004 | Descriptive statistics, Probit | Firm size and innovation activities positively related to exporting |
| Schultz (2010) | IAB Establishment Panel waves 2000 and 2008; sample of establishments for Germany (N = 2,089 / 1,147; only East Germany) | Descriptive statistics; Tobit ML | Firm size, foreign ownership, human capital intensity and R&D positively related to share of exports in total sales |
| Vogel and Wagner (2010) | Sample of business services firms with annual turnover over 250,000 €, 2003 – 2005 (N – ca. 20,000 / year) | OLS; fixed enterprise effects; Fractional logit; generalized propensity score; dose response function | Negative profitability differential of services exporters compared to non-exporters that is statistically significant but small. Self-selection of less profitable firms into exporting. No positive causal effect of exporting on profitability in services firms. |

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|---|---|---|---|
| Schank, Schnabel and Wagner (2010) | Linked employer-employee data combining plant-level data from the IAB establishment panel and information at the individual level from employment statistics of the German Labor Services (1994 – 2006); N = 70 export starters; N = 3,517 Non-exporters; N = ca. 240,000 employees | t-test for difference in mean; OLS; propensity-score matching | Exporters pay higher wages than non-exporting firms, ceteris paribus. This exporter wage premium does already exist in the years before firms start to export, and it does not increase in the following years. |
| Verardi and Wagner (2010a) | All manufacturing enterprises from West Germany with at least 20 employees, 1995 – 2006 N = 303,294 observations from 34,570 enterprises | Standard fixed effects regression and robust fixed effects regression | Exporter productivity premium statistically significant and large in standard fixed effects model, but results are driven by three percent of observations (outliers) – when these are dropped the exporter productivity premium is still statistically significant but small (0.997 percent instead of 13.43 percent) |
| Verardi and Wagner (2010b) | All manufacturing enterprises from West Germany with at least 20 employees, 2003 – 2006 (N = ca. 24,000 / year) | Standard fixed effects regression and robust fixed effects regression | Estimates of exporter productivity premium by destination driven by small share of outliers. Without outliers the premium of firms exporting to Euro-area only no longer much smaller than the premium of firms that export beyond Euro-area, too, and premium over firms that serve the German market only is tiny. |
| Powell and Wagner (2010) | All manufacturing enterprises from West and East Germany with at least 20 employees, 1995 – 2006 (N = 65,052 observations from West Germany and 57,610 from East Germany) | Fixed effects quantile regression | In West Germany exporter productivity premium declines over productivity distribution, is large at the lower end, and significant in the first two-thirds only. In East Germany the premium is significant over nearly the complete distribution. |
| Wagner (2010a) | All manufacturing enterprises from West and East Germany with at least 20 employees, 1995 – 2006 (N = ca. 24,000 / year) | t-test for difference in mean; Kolmogorov-Smirnov test for first-order stochastic dominance of distribution | No evidence found that firm size or productivity in the start year is systematically related to survival on export market. Survival probability in exporting higher for firms with larger share of exports in total sales in start year |
| Eickelpasch and Vogel (2011) | German business services statistics panel 2003 – 2005 (N = ca. 20,000 / year) | Descriptive statistics; t-test for difference in mean; Probit; fractional probit with and without fixed firm effects | Positive relationship between export performance and size, productivity and human capital intensity in models without fixed firm effects; with fixed effects only firm size significant |

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|---|---|---|---|
| Vogel (2011) | German business services statistics panel 2003 – 2005 (N = ca. 20,000 / year) | Descriptive statistics; OLS; fixed effects regression | Exporting firms are larger, more productive and pay higher wages, but have lower turnover profitability, in models without fixed firms effects. Evidence for self-selection of larger , more productive firms paying higher wages into exporting. |

[1] The studies are listed chronologically by the date of publication and in alphabetical order of the (first) author within a year. Purely descriptive studies are not listed.

Table 2: Export participation patterns 2003 – 2006

West Germany

| Pattern | Frequency | Percent | Cumulated |
|---|---|---|---|
| 0000 | 1,658 | 16.52 | 16.52 |
| 0001 | 99 | 0.99 | 17.50 |
| 0010 | 23 | 0.23 | 17.73 |
| 0011 | 56 | 0.56 | 18.29 |
| 0100 | 25 | 0.25 | 18.54 |
| 0101 | 10 | 0.10 | 18.64 |
| 0110 | 12 | 0.12 | 18.76 |
| 0111 | 80 | 0.80 | 19.56 |
| 1000 | 74 | 0.74 | 20.29 |
| 1001 | 11 | 0.11 | 20.40 |
| 1010 | 7 | 0.07 | 20.47 |
| 1011 | 19 | 0.19 | 20.66 |
| 1100 | 31 | 0.31 | 20.97 |
| 1101 | 12 | 0.12 | 21.09 |
| 1110 | 41 | 0.41 | 21.50 |
| 1111 | 7,880 | 78.50 | 100.00 |
| Total | 10,038 | 100.00 | |

East Germany

| Pattern | Frequency | Percent | Cumulated |
|---|---|---|---|
| 0000 | 565 | 30.51 | 30.51 |
| 0001 | 45 | 2.43 | 32.94 |
| 0010 | 8 | 0.43 | 33.37 |
| 0011 | 26 | 1.40 | 34.77 |
| 0100 | 8 | 0.43 | 35.21 |
| 0101 | 7 | 0.38 | 35.58 |
| 0110 | 8 | 0.43 | 36.02 |
| 0111 | 28 | 1.51 | 37.53 |
| 1000 | 25 | 1.35 | 38.88 |
| 1001 | 5 | 0.27 | 39.15 |
| 1010 | 3 | 0.16 | 39.31 |
| 1011 | 12 | 0.65 | 39.96 |
| 1100 | 12 | 0.65 | 40.60 |
| 1101 | 6 | 0.32 | 40.93 |
| 1110 | 17 | 0.92 | 41.85 |
| 1111 | 1,077 | 58.15 | 100.00 |
| Total | 1,852 | 100.00 | |

Note: Frequency is the number of enterprises with a pattern. A zero indicates that an enterprise did not export in a year, a one indicates that it did export. A firm with the pattern 0000 did never export between 2003 and 2006, a firm with the pattern 0001 exported only in the last year (2006), etc.

Table 3: Differences between exporters and non-exporters: Mean Values

| | | Number of employees | Physical capital per employee (Euro) | Wage per employee per year (Euro) | Share of R&D expend. in total sales (percent) | Share of employees in R&D (percent) |
|---|---|---|---|---|---|---|
| West Germany | | | | | | |
| 2003 | | | | | | |
| Exporter | mean | 398.1 | 91,666.3 | 33,783.9 | 1.25 | 2.60 |
| | sd | 2,725.2 | 109,625.3 | 9,246.3 | 2.97 | 5.68 |
| Non-export. | mean | 116.0 | 82,553.9 | 28,436.2 | 0.18 | 0.41 |
| | sd | 212.0 | 120,346.5 | 10,117.7 | 1.22 | 2.47 |
| t-test (p-value) | | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 |
| 2004 | | | | | | |
| Exporter | mean | 395.2 | 88,966.3 | 34,612.7 | 1.23 | 2.61 |
| | sd | 2,720.2 | 107,519.2 | 9,570.1 | 3.06 | 5.70 |
| Non-export. | mean | 109.7 | 81,768.8 | 28,654.8 | 0.20 | 0.41 |
| | sd | 182.2 | 124,986.2 | 9,570.1 | 1.34 | 2.36 |
| t-test (p-value) | | 0.000 | 0.019 | 0.000 | 0.000 | 0.000 |
| 2005 | | | | | | |
| Exporter | mean | 388.2 | 88,100.9 | 35,035.7 | 1.26 | 2.67 |
| | Sd | 2,705.1 | 104,426.4 | 9,944.6 | 3.26 | 5.72 |
| Non-export. | mean | 114.2 | 81,202.9 | 28,607.0 | 0.21 | 0.44 |
| | Sd | 217.1 | 119,153.2 | 10,356.5 | 1.57 | 2.75 |
| t-test (p-value) | | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 |
| 2006 | | | | | | |
| Exporter | mean | 385.2 | 92,477.0 | 35,631.0 | 1.19 | 2.69 |
| | Sd | 2,733.9 | 209,687.0 | 10,484.8 | 2.81 | 5.73 |
| Non-export. | mean | 114.2 | 84,441.1 | 28,871.3 | 0.18 | 0.38 |
| | Sd | 215.5 | 125,666.2 | 10,684.9 | 1.34 | 2.57 |
| t-test (p-value) | | 0.000 | 0.031 | 0.000 | 0.000 | 0.000 |
| East Germany | | | | | | |
| 2003 | | | | | | |
| Exporter | mean | 196.5 | 150,654.3 | 24,816.2 | 1.63 | 3.75 |
| | Sd | 542.2 | 248,688.2 | 8,073.6 | 4.74 | 8.07 |
| Non-export. | mean | 115.0 | 129,388.6 | 21,437.8 | 0.28 | 0.79 |
| | Sd | 277.7 | 417,982.4 | 7,841.4 | 1.26 | 3.54 |
| t-test (p-value) | | 0.000 | 0.224 | 0.000 | 0.000 | 0.000 |
| 2004 | | | | | | |
| Exporter | mean | 196.5 | 150,553.5 | 25,687.0 | 1.58 | 3.41 |
| | Sd | 532.8 | 279,337.0 | 8,212.2 | 4.45 | 7.99 |
| Non-export. | mean | 115.1 | 113,970.4 | 22,117.7 | 0.34 | 0.76 |
| | Sd | 272.3 | 164,268.3 | 7,796.2 | 1.59 | 3.22 |
| t-test (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2005 | | | | | | |
| Exporter | mean | 194.9 | 151,016.2 | 25,964.2 | 1.61 | 3.41 |
| | Sd | 513.8 | 274,276.4 | 8,340.7 | 4.48 | 7.92 |
| Non-export. | mean | 114.0 | 111,159.0 | 22,289.2 | 0.27 | 0.71 |
| | Sd | 240.4 | 156,757.1 | 8,154.4 | 1.29 | 3.24 |
| t-test (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | | | | | |
| 2006 | | | | | | |
| Exporter | mean | 194.2 | 147,077.9 | 26,465.8 | 1.46 | 3.36 |
| | Sd | 497.4 | 233,062.8 | 8,928.9 | 3.81 | 7.74 |
| Non-export. | mean | 111.7 | 107,526.3 | 22,400.6 | 0.25 | 0.77 |
| | Sd | 240.2 | 233,062.8 | 8,117.3 | 1.16 | 3.10 |
| t-test (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Note: sd is the standard deviation. The t-test is for $H_0$: equality of mean values, assuming unequal variances for the two groups.

Table 4: Distribution of characteristics of exporters and non-exporters in 2003

| | | Share of exports in total sales (percent) | Number of employees | Physical capital per employee (Euro) | Wage per employee per year (Euro) | Share of R&D expend. in total sales (percent) | Share of employees in R&D (percent) |
|---|---|---|---|---|---|---|---|
| West Germany | | | | | | | |
| Exporters | mean | 31.62 | 398.1 | 91,666.3 | 33,783.9 | 1.25 | 2.60 |
| (N = 8075) | sd | 24.79 | 2725.2 | 109,625.3 | 9,246.3 | 2.97 | 5.68 |
| average of 3 smallest | | 0.003 | 18.37 | 53.33 | 5,266.8 | 0 | 0 |
| | p1 | 0.11 | 22.1 | 1,766.4 | 13,023.8 | 0 | 0 |
| | p5 | 0.97 | 26.8 | 10,462.5 | 19,456.5 | 0 | 0 |
| | p25 | 10.39 | 53.7 | 35,994.9 | 27,742.4 | 0 | 0 |
| | p50 | 26.89 | 114.8 | 65,327.0 | 33,486.6 | 0 | 0 |
| | p75 | 49.54 | 293.1 | 112,178.7 | 39,255.3 | 1.20 | 2.83 |
| | p95 | 78.98 | 1,214.4 | 247,795.2 | 49,028.8 | 6.45 | 13.02 |
| | p99 | 93.46 | 3,599.0 | 474,227.8 | 60,201.5 | 13.81 | 26.91 |
| average of 3 largest | | 100.00 | 117,365.5 | 2,430,620 | 94,453.1 | 48.09 | 74.3 |
| Non-exporters | mean | 0 | 116.0 | 82,553.9 | 28,436.2 | 0.18 | 0.41 |
| (N = 1963) | sd | 0 | 212.0 | 120,346.5 | 10,117.7 | 1.22 | 2.47 |
| average of 3 smallest | | 0 | 9.3 | 100.6 | 1,780.1 | 0 | 0 |
| | p1 | 0 | 18.6 | 870.6 | 6,510.9 | 0 | 0 |
| | p5 | 0 | 22.5 | 5,384.0 | 12,447.4 | 0 | 0 |
| | p25 | 0 | 32.8 | 22,804.9 | 21,823.5 | 0 | 0 |
| | p50 | 0 | 53.7 | 47,360.5 | 28,334.2 | 0 | 0 |
| | p75 | 0 | 108.8 | 100,118.6 | 34,314.9 | 0 | 0 |
| | p95 | 0 | 442.0 | 252,575.8 | 45,433.1 | 0.43 | 1.49 |
| | p99 | 0 | 1,081.3 | 570,090.8 | 55,445.1 | 5.76 | 13.79 |
| average of 3 largest | | 0 | 2,959.2 | 1,590,138 | 79,413.2 | 19.1 | 36.8 |

East Germany

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Exporters | mean | 25.78 | 196.5 | 150,654.3 | 24,816.2 | 1.63 | 3.75 |
| (N = 8075) | sd | 24.87 | 542.2 | 248,688.2 | 8,073.6 | 4.74 | 8.07 |
| average of 3 smallest | | 0.009 | 19.9 | 421.5 | 3,913.6 | 0 | 0 |
| | p1 | 0.03 | 21.6 | 2,596.9 | 9,680.9 | 0 | 0 |
| | p5 | 0.35 | 25.0 | 14,230.4 | 13,637.4 | 0 | 0 |
| | p25 | 5.04 | 42.7 | 46,213.8 | 19,587.9 | 0 | 0 |
| | p50 | 17.83 | 82.6 | 92,230.0 | 23,788.6 | 0 | 0 |
| | p75 | 40.43 | 165.3 | 160,483.1 | 29,179.4 | 1.04 | 3.45 |
| | p95 | 77.43 | 613.3 | 466,558.1 | 39,957.3 | 9.35 | 22.04 |
| | p99 | 96.51 | 2,073.7 | 981,023.6 | 49,785.8 | 21.08 | 36.84 |
| average of 3 largest | | 100.00 | 7,753.1 | 3,333,004 | 65,104.0 | 58.74 | 57.46 |
| Non-exporters | mean | 0 | 115.0 | 129,388.6 | 21,437.8 | 0.28 | 0.79 |
| (N = 695) | sd | 0 | 277.7 | 417,982.4 | 7,841.4 | 1.26 | 3.54 |
| average of 3 smallest | | 0 | 16.6 | 497.6 | 2,731.6 | 0 | 0 |
| | p1 | 0 | 19.3 | 1,765.0 | 7,885.9 | 0 | 0 |
| | p5 | 0 | 23.2 | 8,934.4 | 11,235.2 | 0 | 0 |
| | p25 | 0 | 32.8 | 29,930.2 | 16,128.5 | 0 | 0 |
| | p50 | 0 | 54.8 | 60,471.3 | 20,434.8 | 0 | 0 |
| | p75 | 0 | 101.9 | 135,825.8 | 25,030.7 | 0 | 0 |
| | p95 | 0 | 367.1 | 408,884.1 | 37,297.0 | 1.48 | 5.00 |
| | p99 | 0 | 1,372.3 | 863,976.2 | 46,042.3 | 7.37 | 18.18 |
| average of 3 largest | | 0 | 3,126.6 | 4,353,952 | 53,759.8 | 11.15 | 33.90 |

Note: sd is the standard deviation; p1 is the first percentile, etc. The mimima and maxima are confidential because they are information for single enterprises; therefore, the average values of the three smallest and the three largest values are reported.

Table 5: Differences between exporters and non-exporters: Distributions of variables

| West Germany | Year (t) | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|
| Number of employees | | | | | |
| K-S-Test H0: equality of distributions (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for non-exporters (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for exporters (p-value) | | 1.000 | 1.000 | 1.000 | 1.000 |
| Physical capital per employee (Euro) | | | | | |
| K-S-Test H0: equality of distributions (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for non-exporters (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for exporters (p-value) | | 0.735 | 0.694 | 0.581 | 0.610 |
| Wage per employee per year(Euro) | | | | | |
| K-S-Test H0: equality of distributions (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for non-exporters (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for exporters (p-value) | | 0.999 | 1.000 | 1.000 | 1.000 |
| Share of R&D expenditures in total sales (percent) | | | | | |
| K-S-Test H0: equality of distributions (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for non-exporters (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for exporters (p-value) | | 1.000 | 1.000 | 1.000 | 1.000 |
| Share of employees inR&D (percent) | | | | | |
| K-S-Test H0: equality of distributions (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for non-exporters (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for exporters (p-value) | | 1.000 | 1.000 | 1.000 | 1.000 |

| East Germany | Year (t) | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|
| Number of employees | | | | | |
| K-S-Test H0: equality of distributions (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for non-exporters (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for exporters (p-value) | | 1.000 | 1.000 | 1.000 | 1.000 |
| Physical capital per employee (Euro) | | | | | |
| K-S-Test H0: equality of distributions (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for non-exporters (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for exporters (p-value) | | 0.997 | 0.997 | 0.999 | 0.998 |
| Wage per employee per year(Euro) | | | | | |
| K-S-Test H0: equality of distributions (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for non-exporters (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for exporters (p-value) | | 1.000 | 0.999 | 0.997 | 0.999 |
| Share of R&D expenditures in total sales (percent) | | | | | |
| K-S-Test H0: equality of distributions (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for non-exporters (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for exporters (p-value) | | 1.000 | 1.000 | 1.000 | 1.000 |
| Share of employees inR&D (percent) | | | | | |
| K-S-Test H0: equality of distributions (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for non-exporters (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for exporters (p-value) | | 1.000 | 1.000 | 1.000 | 1.000 |

Note: K-S-Test is the Kolmogorov-Smirnov test for first-order stochastic dominance.

Table 6: Determinants of export participation: Probit-estimates

| | | 2003 Model 1 | Model 2 | 2004 Model 1 | Model 2 | 2005 Model 1 | Model 2 | 2006 Model 1 | Model 2 |
|---|---|---|---|---|---|---|---|---|---|
| West Germany | | | | | | | | | |
| Number of | ß | 0.000193 | 0.000198 | 0.000228 | 0.000229 | 0.000171 | 0.000172 | 0.000161 | 0.000161 |
| employees | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Number of | ß | -1.74e-9 | -1.78e-9 | -1.63e-9 | -1.63e-9 | -1.22e-9 | -1.23e-9 | -1.21e-9 | -1.21e-9 |
| employees (squared) | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Physical capital per | ß | -3.73e-8 | -3.74e-8 | -7.89e-8 | -7.777e-8 | -7.10e-8 | -7.22e-8 | -4.92 | -6.55e-9 |
| employee (Euro) | p | 0.403 | 0.399 | 0.033 | 0.034 | 0.106 | 0.097 | 0.789 | 0.715 |
| Wage per employee | ß | 5.21e-6 | 5.08e-6 | 5.37e-6 | 5.15e-6 | 5.78e-6 | 5.60e-6 | 5.18e-6 | 4.96e-6 |
| per year (Euro) | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Share of R&D expend. | ß | 0.019979 | | 0.01461 | | 0.01212 | | 0.01532 | |
| in total sales (%) | p | 0.000 | | 0.000 | | 0.010 | | 0.001 | |
| Share of employees | ß | | 0.01014 | | 0.00879 | | 0.00722 | | 0.00847 |
| in R&D (%) | p | | 0.000 | | 0.000 | | 0.001 | | 0.002 |
| Number of cases | | 9,357 | 9,357 | 9,424 | 9,424 | 9,410 | 9,410 | 9,353 | 9,353 |

East Germany

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Number of employees | ß | 0.000287 | 0.000298 | 0.000307 | 0.000304 | 0.000369 | 0.000370 | 0.000334 | 0.000338 |
| | p | 0.009 | 0.007 | 0.006 | 0.007 | 0.002 | 0.002 | 0.005 | 0.005 |
| Number of employees (squared) | ß | -3.75e-8 | -3.79e-8 | -3.87e-8 | -3.79e-8 | -4.43e-8 | -4.40e-8 | -4.17e-8 | -4.18e-8 |
| | p | 0.014 | 0.009 | 0.011 | 0.014 | 0.006 | 0.007 | 0.010 | 0.011 |
| Physical capital per employee (Euro) | ß | -7.09e-8 | -6.87e-8 | -2.89e-8 | -2.35e-8 | 7.80e-9 | 1.15e-8 | 1.21e-8 | 1.47e-8 |
| | p | 0.079 | 0.087 | 0.650 | 0.711 | 0.903 | 0.857 | 0.870 | 0.844 |
| Wage per employee per year (Euro) | ß | 0.000011 | 0.000011 | 0.000012 | 0.000012 | 9.10e-6 | 9.38e-6 | 0.000011 | 0.000011 |
| | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Share of R&D expend. in total sales (%) | ß | 0.03668 | | 0.02491 | | 0.0378 | | 0.0446 | |
| | p | 0.000 | | 0.002 | | 0.000 | | 0.000 | |
| Share of employees in R&D (%) | ß | | 0.01527 | | 0.01524 | | 0.01601 | | 0.01699 |
| | p | | 0.000 | | 0.000 | | 0.000 | | 0.000 |
| Number of cases | | 1,624 | 1,624 | 1,610 | 1,610 | 1,579 | 1,597 | 1,609 | 1,609 |

Note: ß is the estimated marginal effect at the mean of the independent variable; p is the prob-value. All models include a full set of 4digit industry-dummies plus a constant. The number of cases differs between years because firms from industries were all or no firms exported were dropped before the probit estimates were computed.

Table 7: Firm characteristics and export participation: Simulations[1]

| Case Number | Number of Employees | Number of employees (squared) | Physical capital per employee (€) | Wage per employee per year (€) | Share of R&D expenditures in total sales (%) | Estimated probability for being an exporter |
|---|---|---|---|---|---|---|
| West Germany | | | | | | |
| 1 | 20 | 400 | 2,000 | 15,000 | 0 | 0.730 |
| 2 | 100 | 10,000 | 2,000 | 15,000 | 0 | 0.751 |
| 3 | 100 | 10,000 | 55,000 | 15,000 | 0 | 0.745 |
| 4 | 100 | 10,000 | 55,000 | 30,000 | 0 | 0.857 |
| 5 | 100 | 10,000 | 55,000 | 30,000 | 1.0 | 0.870 |
| 6 | 500 | 250,000 | 55,000 | 30,000 | 1.0 | 0.926 |
| 7 | 500 | 250,000 | 400,000 | 30,000 | 1.0 | 0.908 |
| 8 | 500 | 250,000 | 400,000 | 60,000 | 1.0 | 0.984 |
| 9 | 500 | 250,000 | 400,000 | 60.000 | 10.0 | 0.996 |
| East Germany | | | | | | |
| 1 | 20 | 400 | 2,000 | 15,000 | 0 | 0.474 |
| 2 | 100 | 10,000 | 2,000 | 15,000 | 0 | 0.505 |
| 3 | 100 | 10,000 | 55,000 | 15,000 | 0 | 0.505 |
| 4 | 100 | 10,000 | 55,000 | 30,000 | 0 | 0.645 |
| 5 | 100 | 10,000 | 55,000 | 30,000 | 1.0 | 0.681 |
| 6 | 500 | 250,000 | 55,000 | 30,000 | 1.0 | 0.797 |
| 7 | 500 | 250,000 | 400,000 | 30,000 | 1.0 | 0.799 |
| 8 | 500 | 250,000 | 400,000 | 60,000 | 1.0 | 0.940 |
| 9 | 500 | 250,000 | 400,000 | 60.000 | 10.0 | 0.993 |

[1] The simulations are based on the estimated model 1 for 2005

Table 8: Determinants of the share of exports in total sales: Fractional logit estimates

| | | 2003 Model 1 | Model 2 | 2004 Model 1 | Model 2 | 2005 Model 1 | Model 2 | 2006 Model 1 | Model 2 |
|---|---|---|---|---|---|---|---|---|---|
| West Germany | | | | | | | | | |
| Number of employees | ß | 0.000094 | 0.000107 | 0.000092 | 0.000098 | 0.000098 | 0.000095 | 0.000105 | 0.000109 |
| | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Number of employees (squared) | ß | -7.44e-10 | -8.38e-10 | -7.24e-10 | -7.60e-10 | -7.39e-10 | -7.44e-10 | -8.27e-10 | -8.53e-10 |
| | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Physical capital per employee (Euro) | ß | 4.65e-7 | 4.69e-7 | 5.92e-7 | 5.89e-7 | 6.26e-7 | 6.16e-7 | 2.34e-7 | 2.26e-7 |
| | p | 0.004 | 0.004 | 0.000 | 0.000 | 0.0.00 | 0.000 | 0.002 | 0.003 |
| Wage per employee per year (Euro) | ß | 0.000034 | 0.000033 | 0.000035 | 0.000033 | 0.000035 | 0.000033 | 0.000034 | 0.000033 |
| | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Share of R&D expend. in total sales (%) | ß | 0.05553 | | 0.05039 | | 0.04783 | | 0.05439 | |
| | p | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| Share of employees in R&D (%) | ß | | 0.02888 | | 0.02953 | | 0.02835 | | 0.02913 |
| | p | | 0.000 | | 0.000 | | 0.000 | | 0.000 |
| Number of cases | | 10,038 | 10,038 | 10,038 | 10,038 | 10,038 | 10,038 | 10,038 | 10,038 |

East Germany[1]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Number of employees | ß | 0.00057 | 0.00062 | 0.00044 | 0.00046 | 0.00034 | 0.00038 | 0.00047 | 0.00047 |
| | p | 0.003 | 0.001 | 0.015 | 0.011 | 0.090 | 0.039 | 0.014 | 0.015 |
| Number of employees (squared) | ß | -5.05e-8 | -5.58e-8 | -3.63e-8 | -3.83e-8 | -3.82e-9 | -3.03e-8 | -4.45e-8 | -4.38e-8 |
| | p | 0.050 | 0.032 | 0.145 | 0.124 | 0.890 | 0.243 | 0.105 | 0.112 |
| Physical capital per employee (Euro) | ß | 1.80e-8 | 3.22e-8 | 2.16e-7 | 2.31e-7 | 1.08e-7 | 3.30e-7 | 5.67e-7 | 5.70e-7 |
| | p | 0.887 | 0.803 | 0.309 | 0.286 | 0.537 | 0.220 | 0.033 | 0.032 |
| Wage per employee per year (Euro) | ß | 0.000039 | 0.000035 | 0.000044 | 0.000041 | 0.000045 | 0.000038 | 0.000041 | 0.000040 |
| | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Share of R&D expend. in total sales (%) | ß | 0.0278 | | 0.0325 | | 0.0203 | | 0.0530 | |
| | p | 0.025 | | 0.000 | | 0.022 | | 0.000 | |
| Share of employees in R&D (%) | ß | | 0.0274 | | 0.0261 | | 0.0255 | | 0.0274 |
| | p | | 0.000 | | 0.000 | | 0.000 | | 0.000 |
| Number of cases | | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 |

Note: ß is the estimated regression coefficient; p is the prob-value. All models include a full set of 4digit industry-dummy variables plus a constant.

[1] Model 1 for 2005 was the only model that could be estimated with a full set of 4digit industry dummy variables for East Germany; in all other cases Stata reported that the variance matrix is non-symmetric or highly singular. All other models for East Germany were estimated with a full set of 2digit industry dummy variables. The results for model 1 for 2005 do not differ qualitatively between the two variants for all estimated coefficients but the number of employees that has a p-value of 0.043 in the 2digit dummies model.

Table 9: Firm characteristics and share of exports in total sales: Simulations[1]

| Case Number | Number of Employees | Number of employees (squared) | Physical capital per employee (€) | Wage per employee per year (€) | Share of R&D expenditures in total sales (%) | Estimated share of exports in total sales (%) |
|---|---|---|---|---|---|---|
| West Germany | | | | | | |
| 1 | 20 | 400 | 2,000 | 15,000 | 0 | 0.111 |
| 2 | 100 | 10,000 | 2,000 | 15,000 | 0 | 0.111 |
| 3 | 100 | 10,000 | 55,000 | 15,000 | 0 | 0.115 |
| 4 | 100 | 10,000 | 55,000 | 30,000 | 0 | 0.179 |
| 5 | 100 | 10,000 | 55,000 | 30,000 | 1.0 | 0.186 |
| 6 | 500 | 250,000 | 55,000 | 30,000 | 1.0 | 0.192 |
| 7 | 500 | 250,000 | 400,000 | 30,000 | 1.0 | 0.228 |
| 8 | 500 | 250,000 | 400,000 | 60,000 | 1.0 | 0.456 |
| 9 | 500 | 250,000 | 400,000 | 60.000 | 10.0 | 0.563 |
| East Germany | | | | | | |
| 1 | 20 | 400 | 2,000 | 15,000 | 0 | 0.223 |
| 2 | 100 | 10,000 | 2,000 | 15,000 | 0 | 0.228 |
| 3 | 100 | 10,000 | 55,000 | 15,000 | 0 | 0.229 |
| 4 | 100 | 10,000 | 55,000 | 30,000 | 0 | 0.370 |
| 5 | 100 | 10,000 | 55,000 | 30,000 | 1.0 | 0.374 |
| 6 | 500 | 250,000 | 55,000 | 30,000 | 1.0 | 0.406 |
| 7 | 500 | 250,000 | 400,000 | 30,000 | 1.0 | 0.415 |
| 8 | 500 | 250,000 | 400,000 | 60,000 | 1.0 | 0.734 |
| 9 | 500 | 250,000 | 400,000 | 60.000 | 10.0 | 0.768 |

[1] The simulations are based on the estimated model 1 for 2005

Table 10: Decomposition of overall variation into between and within variation

| | West Germany | | East Germany | |
|---|---|---|---|---|
| Variable | Standard deviation | | Standard deviation | |
| Exporter (Dummy; 1 = yes) | overall | 0.39 | overall | 0.48 |
| | between | 0.38 | between | 0.46 |
| | within | 0.10 | within | 0.15 |
| Share of exports in total sales | overall | 26.10 | overall | 23.87 |
| | between | 25.67 | between | 23.18 |
| | within | 4.72 | within | 5.71 |
| Number of employees | overall | 2450.34 | overall | 445.60 |
| | between | 2447.71 | between | 443.66 |
| | within | 115.59 | within | 42.54 |
| Physical capital per employee (€) | overall | 137,056 | overall | 257,072 |
| | between | 112,443 | between | 246,653 |
| | within | 78,369 | within | 72,615 |
| Wage per employee per year (€) | overall | 10,224 | overall | 8,450 |
| | between | 9,932 | between | 8,226 |
| | within | 2,427 | within | 1,940 |
| Share of R&D expend. in total sales (%) | overall | 2.82 | overall | 3.63 |
| | between | 2.60 | between | 3.33 |
| | within | 1.08 | within | 1.44 |
| Share of employees in R&D (%) | overall | 5.32 | overall | 6.75 |
| | between | 5.06 | between | 6.37 |
| | within | 1.66 | within | 2.24 |
| 4-digit industry Identifier | overall | 591.3 | overall | 634.0 |
| | between | 590.5 | between | 633.4 |
| | within | 31.1 | within | 30.2 |
| Number of observations | 40,152 | | 7,408 | |
| Number of firms | 10,038 | | 1,852 | |
| Number of years | 4 | | 4 | |

Table 11: Determinants of export participation and the share of exports in total sales: Fixed effects panel estimates

| | | Export participation (Fixed effects logit) | | Share of exports in total sales (Fractional probit panel) | |
|---|---|---|---|---|---|
| | | Model 1 | Model 2 | Model 1 | Model 2 |
| West Germany | | | | | |
| Number of employees | ß | 0.010 | 0.010 | 0.00002 | 0.00002 |
| | p | 0.000 | 0.000 | 0.304 | 0.303 |
| Number of employees (squared) | ß | -1.55e-6 | -1.49e-6 | -7.90e-11 | -7.69e-11 |
| | p | 0.000 | 0.001 | 0.213 | 0.217 |
| Physical capital per employee (Euro) | ß | -3.75e-6 | -3.76e-6 | 1.29e-8 | 1.27e-8 |
| | p | 0.004 | 0.004 | 0.169 | 0.171 |
| Wage per employee per year (Euro) | ß | -0.00002 | -0.00002 | 1.23e-6 | 1.25e-6 |
| | p | 0.234 | 0.279 | 0.006 | 0.006 |
| Share of R&D expend. in total sales (%) | ß | -0.006 | | -0.0005 | |
| | p | 0.913 | | 0.799 | |
| Share of employees in R&D (%) | ß | | -0.076 | | -0.001 |
| | p | | 0.115 | | 0.137 |
| Number of observations | | 2,000 | 2,000 | 40,152 | 40,152 |
| Number of firms | | 500 | 500 | 10,038 | 10,038 |

East Germany

| | | | | | |
|---|---|---|---|---|---|
| Number of employees | ß | 0.035 | 0.035 | 0.0005 | 0.0006 |
| | p | 0.000 | 0.000 | 0.001 | 0.001 |
| Number of employees (squared) | ß | -0.00002 | -0.00002 | -3.29e-8 | -3.32e-8 |
| | p | 0.001 | 0.001 | 0.083 | 0.078 |
| Physical capital per employee (Euro) | ß | -2.09e-7 | -2.07e-7 | -8.12e-8 | -8.21e-8 |
| | p | 0.569 | 0.572 | 0.233 | 0.223 |
| Wage per employee per year (Euro) | ß | -3.51e-6 | -2.64e-6 | 4.54e-6 | 4.39e-6 |
| | p | 0.915 | 0.936 | 0.047 | 0.060 |
| Share of R&D expend. in total sales (%) | ß | -0.005 | | -0.004 | |
| | p | 0.950 | | 0.046 | |
| Share of employees in R&D (%) | ß | | -0.016 | | -0.0002 |
| | p | | 0.527 | | 0.867 |
| Number of observations | | 840 | 840 | 7,408 | 7,408 |
| Number of firms | | 210 | 210 | 1,852 | 1,852 |

Note: ß is the estimated regression coefficient; p is the prob-value. All models include a full set of year-dummies; the fractional probit panel models include a full set of mean values of the exogeneous variables plus a constant, too.

Table 12: Productivity differences between exporters and non-exporters: Mean Values

| | | Value added per employee (Euro) | |
|---|---|---|---|
| | | West Germany | East Germany |
| 2003 | | | |
| Exporter | mean | 56,690 | 47,237 |
| | sd | 29,988 | 33,255 |
| Non-export. | Mean | 45,165 | 40,644 |
| | sd | 25,038 | 35,027 |
| t-test (p-value) | | 0.000 | 0.000 |
| 2004 | | | |
| Exporter | mean | 59,307 | 49,616 |
| | sd | 31,988 | 47,473 |
| Non-export. | Mean | 46,263 | 40,578 |
| | sd | 26,745 | 30,347 |
| t-test (p-value) | | 0.000 | 0.000 |
| 2005 | | | |
| Exporter | mean | 60,032 | 50,933 |
| | sd | 35,683 | 47,243 |
| Non-export. | Mean | 46,533 | 40,719 |
| | sd | 28,863 | 28,884 |
| t-test (p-value) | | 0.000 | 0.000 |
| 2006 | | | |
| Exporter | mean | 62,689 | 52,845 |
| | sd | 45,195 | 41,529 |
| Non-export. | Mean | 47,834 | 41,289 |
| | sd | 29,917 | 37,626 |
| t-test (p-value) | | 0.000 | 0.000 |

Note: sd is the standard deviation. The t-test is for $H_0$: equality of mean values, assuming unequal variances for the two groups.

Table 13: Distribution of productivity of exporters and non-exporters in 2003

| | | Value added per employee (Euro) | |
|---|---|---|---|
| | | West Germany | East Germany |
| Exporters | Number of enterprises | 8,075 | 1,163 |
| | mean | 56,699 | 49,616 |
| | sd | 29,988 | 47,473 |
| | average of 3 smallest | -120,821 | - 14,665 |
| | p1 | 12,956 | 6,358 |
| | p5 | 25,259 | 18,255 |
| | p25 | 40,686 | 30,435 |
| | p50 | 52,054 | 41,627 |
| | p75 | 65,789 | 57,331 |
| | p95 | 102,111 | 97,904 |
| | p99 | 155,097 | 172,254 |
| | average of 3 largest | 616,678 | 405,536 |
| Non-exporters | Number of enterprises | 1,963 | 689 |
| | mean | 45,165 | 40,578 |
| | sd | 25,038 | 30,347 |
| | average of 3 smallest | -15,413 | - 3,378 |
| | p1 | 7,930 | 9,172 |
| | p5 | 15,925 | 16,145 |
| | p25 | 28,937 | 24,613 |
| | p50 | 41,791 | 33,560 |
| | p75 | 55,623 | 46,354 |
| | p95 | 87,770 | 86,132 |
| | p99 | 122,148 | 171,095 |
| | average of 3 largest | 289,533 | 376,785 |

Note: sd is the standard deviation; p1 is the first percentile, etc. The mimima and maxima are confidential because they are information for single enterprises; therefore, the average values of the three smallest and the three largest values are reported.

Table 14: Differences in the distribution of productivity between exporters and non-exporters

| | Year (t) | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|
| West Germany | | | | | |
| Value added per employee (Euro) | | | | | |
| K-S-Test H0: equality of distributions (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for non-exporters (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for exporters (p-value) | 0.998 | 0.987 | 0.992 | 0.987 | |
| East Germany | | | | | |
| Value added per employee (Euro) | | | | | |
| K-S-Test H0: equality of distributions (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for non-exporters (p-value) | | 0.000 | 0.000 | 0.000 | 0.000 |
| K-S-Test H0: differences favourable for exporters (p-value) | 0.945 | 0.957 | 0.937 | 0.887 | |

Note: K-S-Test is the Kolmogorov-Smirnov test for first-order stochastic dominance.

Table 15: Productivity and export participation: Probit-estimates

| | | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|
| West Germany | | | | | |
| Value added per Employee (Euro) | ß | 2.30e-6 | 1.99e-6 | 1.37e-6 | 7.33e-7 |
| | p | 0.000 | 0.000 | 0.000 | 0.029 |
| Number of cases | | 9,357 | 9,424 | 9,410 | 9,353 |
| East Germany | | | | | |
| Value added per Employee (Euro) | ß | 1.11e-6 | 1.47e-6 | 2.06e-6 | 1.76e-6 |
| | p | 0.116 | 0.039 | 0.003 | 0.012 |
| Number of cases | | 1,624 | 1,610 | 1,597 | 1,609 |

Note: ß is the estimated marginal effect at the mean of the independent variable; p is the prob-value. All models include a full set of 4digit industry-dummies plus a constant. The number of cases differs between years because firms from industries were all or no firms exported were dropped before the probit estimates were computed.

Table 16: Labor productivity and firm characteristics: OLS estimates for value added per employee

| | | 2003 Model 1 | Model 2 | 2004 Model 1 | Model 2 | 2005 Model 1 | Model 2 | 2006 Model 1 | Model 2 |
|---|---|---|---|---|---|---|---|---|---|
| West Germany | | | | | | | | | |
| Number of | ß | 0.322 | 0.017 | 0.295 | 0.046 | 0.609 | 0.354 | 2.691 | 2.285 |
| employees | p | 0.275 | 0.953 | 0.349 | 0.886 | 0.296 | 0.529 | 0.142 | 0.190 |
| Number of | ß | -3.05e-6 | -6.61e-7 | -3.26e-6 | -1.28e-6 | -5.30e-6 | -3.33e-6 | -0.00002 | -0.00002 |
| employees (squared) | p | 0.157 | 0.747 | 0.133 | 0.558 | 0.127 | 0.317 | 0.091 | 0.133 |
| Physical capital per | ß | 0.075 | 0.075 | 0.098 | 0.098 | 0.086 | 0.085 | 0.004 | 0.004 |
| employee (Euro) | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.845 | 0.855 |
| Wage per employee | ß | 1.250 | 1.207 | 1.314 | 1.276 | 1.384 | 1.348 | 1.463 | 1.420 |
| per year (Euro) | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Share of R&D expend. | ß | -497.86 | | -649.83 | | -735.03 | | -1103.42 | |
| in total sales (%) | p | 0.001 | | 0.000 | | 0.019 | | 0.165 | |
| Share of employees | ß | | 137.72 | | -5.547 | | -45.627 | | -93.910 |
| in R&D (%) | p | | 0.175 | | 0.960 | | 0.788 | | 0.795 |
| $R^2$ | | 0.395 | 0.394 | 0.445 | 0.442 | 0.373 | 0.370 | 0.228 | 0.225 |
| Number of cases | | 10,038 | 10,038 | 10,038 | 10,038 | 10,038 | 10,038 | 10,038 | 10,038 |

East Germany

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Number of employees | ß | 8.912 | 9.419 | 4.529 | 4.931 | 1.049 | 1.325 | -1.393 | -0.977 |
| | p | 0.052 | 0.041 | 0.439 | 0.399 | 0.852 | 0.814 | 0.801 | 0.860 |
| Number of employees (squared) | ß | -0.00095 | -0.0011 | -0.00065 | -0.00074 | -0.000095 | -0.00016 | 0.00028 | 0.00019 |
| | p | 0.135 | 0.094 | 0.478 | 0.407 | 0.913 | 0.848 | 0.701 | 0.793 |
| Physical capital per employee (Euro) | ß | 0.065 | 0.065 | 0.128 | 0.128 | 0.121 | 0.121 | 0.103 | 0.103 |
| | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Wage per employee per year (Euro) | ß | 1.350 | 1.311 | 1.314 | 1.286 | 1.442 | 1.411 | 1.794 | 1.771 |
| | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Share of R&D expend. in total sales (%) | ß | -414.81 | | -531.09 | | -249.51 | | -532.62 | |
| | p | 0.005 | | 0.031 | | 0.247 | | 0.032 | |
| Share of employees in R&D (%) | ß | | 33.694 | | -97.540 | | 61.239 | | -92.567 |
| | p | | 0.701 | | 0.459 | | 0.666 | | 0.466 |
| $R^2$ | | 0.715 | 0.713 | 0.764 | 0.763 | 0.726 | 0.726 | 0.616 | 0.615 |
| Number of cases | | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 |

Note: ß is the estimated regression coefficient; p is the prob-value. All models include a full set of 4digit industry-dummy variables plus a constant.