DISCUSSION PAPER SERIES

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IZA DP No. 3798

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October 2008

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

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October 2008

ABSTRACT

Exports and Profitability: First Evidence for German Manufacturing Firms*

Using unique recently released nationally representative high-quality longitudinal data at the enterprise level for Germany, this paper presents the first comprehensive evidence on the relationship between exports and profitability. It documents that the positive profitability differential of exporters compared to non-exporters is statistically significant, though rather small, when observed firm characteristics and unobserved firm specific effects are controlled for. In contrast to nearly all empirical studies on the relationship between productivity and exports we do not find any evidence for self-selection of more profitable firms into export markets. Due to the sampling frame of the data used we cannot test the hypothesis that firms which start exporting perform better in the years after the start than their counterparts which do not start. Instead, we use a newly developed continuous treatment approach and show that exporting improves the profitability almost over the whole range of the export-sales ratio. Only firms that generate 90 percent and more of their total sales abroad do not benefit from exporting in terms of an increased rate of profit. This means, that the usually observed higher productivity of exporters is not completely absorbed by the extra costs of exporting or by higher wages paid by internationally active firms.

JEL Classification: F14, D21

Keywords: exports, profitability, micro data, Germany

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* All computations for this study were done inside the Research Data Centre of the Statistical Office of Berlin. A first version of this paper was presented at the workshop of the International Study Group on Exports and Productivity at Nottingham University in February 2008. Furthermore, this paper was presented at the Applied Micro Workshop at Pennsylvania State University in September 2008, while Helmut Fryges was visiting Penn State University during the fall semester 2008. Helpful suggestions by Mark Roberts, James Tybout and other participants of the Applied Micro Workshop are highly acknowledged.

1. Motivation

A huge and emerging literature on the micro-econometrics of international trade demonstrates that exporting firms are more productive than otherwise identical firms that sell on the national market only (see Bernard et al. (2007) for the U.S., Mayer and Ottaviano (2007) for European countries, Wagner (2007a) for a survey of studies from countries all over the world, and The International Study Group on Exports and Productivity (2008) for strictly comparable results from 14 countries). Exporting firms have to bear extra costs due to, among others, market research, adoption of products to local regulations, or transport costs. These extra costs are one reason for a self-selection of the more productive firms on international markets. Furthermore, exporting firms tend to pay higher wages than non-exporting firms (see Schank, Schnabel and Wagner (2007) for a survey). Germany, one of the leading actors on the world market for goods, is a case in point: After controlling for observable and unobservable firm characteristics, productivity is significantly and substantially higher in exporting than in non-exporting firms (Wagner 2007b), and compared to identical non-exporting firms exporting firms pay significantly and substantially higher wages to workers with the same observable and unobservable characteristics (Schank, Schnabel and Wagner 2007).

A question that has (to the best of our knowledge) not been investigated in this literature is whether the productivity advantage of exporting firms does lead to a profitability advantage of exporters compared to otherwise identical non-exporters even when exporters are facing extra costs and pay higher wages. Profitability is a performance dimension that is not investigated empirically in the literature dealing with the micro-econometrics of international trade (see the recent survey papers by Bernard et al. (2007) and by Mayer and Ottaviano (2007)).[1]

The situation differs when the literature on international management is considered. Here empirical investigations of the relationship between internationalisation (measured by the percentage of exports in total sales, or by various other indicators including foreign assets to total assets, or the number of foreign subsidiaries) and firm performance (measured by various accounting indicators like return on assets, or return on equity) have a long tradition lasting at least 40 years. This literature has produced a great number of studies based on various methods. Glaum and Oesterle (2007, p. 308) recently argued that these empirical studies have come to heterogeneous and sometimes contradictory results. Similarly, Ruigrok, Amann and Wagner (2007, p. 350) state that the findings generated by this research stream have been inconclusive and contradictory. In a meta-analysis that covers 36 studies Bausch and Krist (2007) find a positive and statistically significant overall relationship between internationalisation and firm performance, although the effect size is small in magnitude. Furthermore, they find evidence that this relationship is highly context-dependent, and that R&D intensity, product diversification, country of origin, firm age, and firm size significantly affect performance gains attributable to internationalisation (see Bausch and Krist (2007), p. 337).

Given that the samples used in these studies from the literature on international management tend to be small cross-section samples that do not allow to control for unobserved heterogeneity by including fixed firm effects, and that various measures of both internationalisation and performance are used (see Bausch and

[1] Note that the recent paper by Asiedu and Freeman (2007) has a different focus – it examines the within-region effect of globalisation, i.e. the extent to which the level of globalisation in the region in which a firm operates affects its performance.

Krist (2007), p. 332), we cannot find an answer to our question – whether the productivity advantage of exporting firms does lead to a profitability advantage of exporters compared to otherwise identical non-exporters even when exporters are facing extra costs and pay higher wages – from this literature.

This paper contributes to the literature by using unique recently released nationally representative high-quality longitudinal data for German enterprises to conduct the first comprehensive empirical study on the relationship between exports and profitability. We document a positive profitability differential of exporters compared to non-exporters that is statistically significant, though rather small, when observed firm characteristics and unobserved firm specific effects are controlled for. In contrast to nearly all empirical studies on the relationship between productivity and exports we do not find any evidence for self-selection of more profitable firms into export markets. Due to the sampling frame of the data used we cannot test the hypothesis that firms which start exporting perform better in the years after the start than their counterparts which do not start. Instead, we use a newly developed continuous treatment approach and show that exporting improves the profitability almost over the whole range of the export-sales ratio. This means, that the usually observed higher productivity of exporters is not completely absorbed by the extra costs of exporting or by higher wages paid by internationally active firms. This evidence presented here for Germany, a leading actor on the world market for manufactured goods, is interesting on its own, and it can serve as a benchmark for future studies using comparable data from other countries.

The rest of the paper is organised as follows: Section 2 introduces the newly available data set. Section 3 presents results from descriptive comparisons of exporting and non-exporting firms. Section 4 reports estimations of exporter profitability premia after controlling for observed and unobserved differences between exporters and non-exporters. Section 5 investigates the causal effect of exporting on profitability using the recently developed generalised propensity score (GPS) methodology.

2. Data

The data used in this study are merged from two surveys conducted by the German Statistical Offices. One source is a monthly report for establishments in manufacturing industries that covers all local production units that have at least 20 employees itself or that belong to an enterprise with a total of at least 20 employees. Information from the monthly surveys is either summed up for a year, or average values for a year are computed, and a panel data set is build from annual data. A detailed description of these data is given in Konold (2007). 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 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. While all enterprises with 500 or more employees are included in each survey, a stratified random sample of smaller firms with 20 to 499 employees is drawn that remains in the survey sample for four years in succession and that is replaced by a new stratified random sample afterwards. Therefore, data from the cost structure survey can be used to build an unbalanced panel containing all enterprises with at least 500 employees (in a year) plus a sample of smaller firms with a rotating panel design. A detailed description of the cost structure survey can be found in Fritsch et al. (2004).

Data from the two sources are matched using the enterprise identifier available in both surveys. The resulting panel used in this study covers the years from 1999 to 2004.[2] These data are confidential but not exclusive. They can be used by researchers on a contractual basis via controlled remote data access inside the research data centres of the German Statistical Offices (see Zühlke et al. (2004) for details).[3]

3. Descriptive analysis

As a first step in our empirical investigation we compare the profitability of exporting and non-exporting firms. Information on exports is based on data taken from the monthly report for establishments in manufacturing industries, and an enterprise is considered to be an exporter in a year if at least one of its establishments (or, in case of single-establishment enterprises, the enterprise itself) reported a positive amount of sales to a customer in a foreign country or to a German export trading company. Using information from the cost structure surveys, the rate of profit of a firm is computed as a rate of return, defined as gross firm surplus (computed as gross value added at factor costs – gross wages and salaries – costs for social insurance paid by the firm) divided by total sales (net of VAT) minus net change of inventories.[4]

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[2] The data are available for 1995 to 2004. Due to the introduction of a new industry classification new samples were drawn after two years in 1997 and in 1999. This leads to a highly unbalanced panel when data for 1995 to 2004 are used (see Brandt et al. (2008), p. 221), and these data are not useful for the empirical investigation performed here. Furthermore, information on employees in R&D is available from 1999 onwards only.

[3] To facilitate replication the Stata do-files used in the computations are available from the authors upon request.

[4] Note that the data set does not have any information on the capital stock, or the sum of assets or equity, of the firm, so that it is not possible to construct profit indicators based thereon like return on assets or return on equity.

Our profit measure is a measure for the price-cost margin which, under competitive conditions, should on average equal the required rental on assets employed per money unit of sales (see Schmalensee (1989), p. 960f.). Differences in profitability between firms, therefore, can follow from productivity differences, but also from different mark-ups of prices over costs and from differences in the capital intensity. Given that our data set does not have information on the capital stock employed by the firms in our econometric investigations we control for differences in the capital intensity by including a complete set of industry dummy variables at the most disaggregated (4-digit) level.

Table 1 reports the mean and selected percentiles of the distribution of the rate of profit for exporting and non-exporting enterprises for each year between 1999 and 2004. The mean and the median is higher for exporters compared to non-exporters in every year, and with the exception of the first percentile in three of the six years this holds for the other percentiles of the distribution of the rate of profit reported here, too.

[Table 1 and Table 2 near here]

According to the results from a t-test (that does not assume equal variances for both groups of enterprises) reported in Table 2 the difference in the mean value is highly statistically significant in five years. Note, however, that this difference in the rate of profit is rather small; it rarely exceeds one percentage point with a mean of the rate of profit for exporters around 12 percent.

If one looks at differences in the mean value for two groups only, one focuses on just one moment of the profitability distribution. A stricter test that considers all moments is a test for stochastic dominance of the profitability distribution for one group over the profitability distribution for another group. More formally, let F and G denote the cumulative distribution functions of profitability for exporters and for non-exporters. Then first order stochastic dominance of F relative to G means that F(z) – G(z) must be less or equal zero for all values of z, with strict inequality for some z. Whether this holds or not is tested non-parametrically by adopting the Kolmogorov-Smirnov test (see Conover (1999), p. 456ff.). Furthermore, exporters and non-exporters are not equally distributed over the industries, and the level of the rate of profit might vary across industries due to, for example, differences in the degree of competition or regulation. To control for the different industries, for the Kolmogorov-Smirnov test the rate of profit of a firm is calculated as the deviation from the mean value in the 4-digit industry.

The Kolmogorov-Smirnov test is used here to test three hypotheses, i.e., that the distributions of the rate of profit are different for exporting and non-exporting enterprises, that the distribution of the rate of profit for exporting enterprises first order stochastically dominates the distribution of the rate of profit for non-exporting enterprises, and that distribution of the rate of profit for non-exporting firms first order stochastically dominates the distribution of the rate of profit for exporting firms. Results reported in Table 2 show that the first two hypotheses cannot be rejected at a five percent level, while the third hypothesis is clearly rejected.

A comparison of the rate of profit between exporting and non-exporting firms neglects that exporters distinguish from each other with respect to the share of total sales they generate abroad (the so-called export-sales ratio or export intensity). Fryges and Wagner (2008) showed that the relationship between labour productivity growth and the export-sales ratio is nonlinear. Thus, it can be expected that similar to the relationship between the export-sales ratio and labour productivity growth the firms' profitability also varies between firms with different export intensities. Table 3 displays the rate of profit for enterprises within different classes of the export-sales ratio. The descriptive results demonstrate that enterprises that exhibit a higher export-sales ratio tend to have higher levels of the rate of profit. However, for all years covered by our data set the mean profitability of firms that export only a small share of their total sales (less than 5 percent) falls below that of non-exporting firms. For the two years 1999 and 2004, firms that export more than 5 percent and not more than 10 percent of their total sales also show a mean rate of profit smaller than the comparable rate of non-exporting firms. Enterprises with an export-sales ratio of more than 10 percent exhibit a rate of profit that, on average, exceeds the profitability of firms without any exports and that increases with the export intensity. Moreover, Table 3 shows that the standard deviation of the rate of profit also tends to increase with the export-sales ratio. In four out of six years in our sample the first percentile of the rate of profit of those enterprises that sell more than half of their total sales abroad is smaller than the first percentile of non-exporters. This points out that intense export activities are not only associated with a higher mean rate of profit but also with a higher risk of losses.

[Table 3 near here]

The results from the descriptive comparison of exporters and non-exporters reported here indicate that exporting enterprises are more profitable than non-exporting enterprises not only on average but over the whole distribution of the rate of profit. The statistically significant difference, however, is small from an economic point of view. Moreover, the rate of profit tends to increase with the firms export-sales ratio. However, firms that export only a very small share of their total sales exhibit a rate of profit that falls below that of non-exporting firms.[5]

[5] Results reported in the appendix in Tables A.1, A.2 and A.3 show that the exclusion of the enterprises with the one percent lowest and highest values for the rate of profit leads to the same conclusions.

4. Exporter profitability premia

The next step in our empirical investigation consists of the estimation of so-called exporter profitability premia that indicate the ceteris paribus difference in profitability between exporting and non-exporting enterprises, controlling for other characteristics of the enterprises. In analogy with the now standard approach in the micro-econometric literature on exports and productivity (see The International Study Group on Exports and Productivity (2008)) pooled data are used to regress the rate of profit on the export activity of the enterprise plus a set of control variables including firm size (measured as the number of employees and its squared value), share of employees in R&D, and a full set of interaction terms of the year of observation and the 4-digit industry the enterprise is active in.[6]

Export activity of an enterprise is measured in four different ways, i.e. by a dummy variable that takes on the value of one if an enterprise is an exporter (and zero otherwise), by the share of exports in total sales, by the share of exports in total sales and its squared value, and by the share of exports in total sales plus its squared and its cubic value. While the dummy variable for exporting firms tests for the presence or not of an exporter profitability premium per se, the estimated coefficient of the share of exports in total sales shows whether or not this premium increases with an increase in the relative importance of exports for an enterprise. The quadratic terms test for the presence or not of a so-called threshold of internationalisation – whether the positive effects vanish and become even negative

[6] The set of control variables used is motivated by the evidence reported by Bausch and Krist (2007, p. 337) from their meta-analysis of results from the literature in international management. The authors find that the relationship between firm performance and internationalisation is highly context-dependent, and that R&D intensity, product diversification, country of origin, firm age, and firm size significantly affect performance gains attributable to internationalisation. While country of origin does not matter in our study using data for Germany only, information on firm age and product diversification in exporting is not available in the data at hand.

when the optimal share of exports in total sales is exceeded because increasing costs of exporting exceed the extra benefits. The cubic term tests for an s-shaped relationship between profitability and the share of exports in total sales that is suggested in recent studies from the international management literature.[7]

Results for empirical models using pooled data without fixed enterprise effects are reported in columns 1 to 4 of Table 4. According to the results in column 1 exporting firms have a rate of profit that is one percentage point higher ceteris paribus than in non-exporting firms (a difference that matches the order of magnitude showing up in the descriptive analysis that does not control for firm size, R&D intensity, and industry and time effects reported in Table 1), and from column 3 we see that the pattern of the relationship between export intensity and profitability is inversely u-shaped with an estimated maximum at a level of exports to sales of 65 percent. According to column 4, there is no evidence for an s-shaped relationship.[8]

When unobserved firm heterogeneity is controlled for by including fixed enterprise effects a different picture emerges. From column 5 we see that exporting *per se* is not accompanied by higher profits – the estimated coefficient of the exporter dummy variable is statistically insignificant at any conventional level. Column 6 shows that there is a statistically significant relationship of exporting and profitability that increases with a rise in the share of exports in total sales. According to this result, an increase in the exports to sales ratio of ten percentage points is accompanied by an increase in the profit rate by 0.3 percentage points. Therefore, a

[7] See Contractor (2007) for a discussion of this s-shaped relationship in a longitudinal perspective that investigates the relationship between internationalisation and performance when a firm increases its international activities over time.

[8] The conclusions are identical when the enterprises with the one percent lowest and highest values for the rate of profit were excluded from the calculations; see Table A.4, columns 1 to 4, in the appendix. Descriptive statistics for the samples used in the regressions for Tables 4 and A.4 are reported in Table A.5 in the appendix.

firm that exports 50 percent of its products has on average a rate of profit that is 1.5 percentage points higher than a firm from the same industry and size, and with the same share of employees in R&D, that does not export at all.[9]

[Table 4 near here]

According to the results reported in columns 1 to 4 compared to the results given in columns 5 to 8 in Table 4 unobserved enterprise characteristics that are correlated with the level of export activity of the firm do matter.[10] This leads to the conclusion that exporting *per se* is not positively related to profitability. Therefore, the results reported in columns 1 to 4 should be interpreted in a way that the positive effect of the export activities on profitability encompasses the influence of unobserved firm characteristics that are correlated with firms' export activities.

The exporter premia detected by estimating regression models using pooled data for exporters and non-exporters cannot be interpreted as indicators for a positive causal effect of exporting on profitability. On the one hand, it might well be the case that there is self-selection of more productive and, net of any higher costs related to exporting, more profitable firms into exporting. On the other hand, exporting might increase profitability by learning from foreign customers and competitors, by realising scale effect on markets larger than the national market, or by earning monopoly rents from firm specific advantages on more than one market. Obviously, for any given firm both directions of causality might be important.

[9] From the models with fixed enterprise effects we do not have any evidence that the relationship between the share of exports in total sales and profitability is nonlinear. While the estimated coefficient for the quadratic term in column 7 and for the cubic term in column 8 are both statistically different from zero at an error level of five percent (pointing to non-linearity), this does not hold when the enterprises with the one percent lowest and highest values for the rate of profit were excluded from the calculations; see Table A.4, columns 7 and 8, in the appendix.

[10] These characteristics may include such factors as the age of the firm, the geographical scope of exports, financial constraints, or the degree of risk aversion and international orientation of the managers.

Again following the now standard approach in the micro-econometric literature on exports and productivity (see The International Study Group on Exports and Productivity (2008)) the next step in our empirical investigation, therefore, consists in testing whether we can document any self-selection of more profitable firms into exporting. To do so, we identify a group of firms that did not export over a time span of the three years t-3 to t-1. Some of these firms started to export in year t (these are called export starters of cohort t), some did not (these are called non-starters of cohort t). We then compare the export starters and the non-starters of cohort t

- in the year t
- three years back in year t-3.

Given that our data set covers the year 1999 to 2004, we can investigate three cohorts for t = 2002, 2003, and 2004. Results are reported in Table 5. It turns out that export starters are not more profitable than non-starters in t, the year of start. For the cohort 2002 we even have (although somewhat week) evidence from both the t-test and the Kolmogorov-Smirnov test that the non-starters have a higher level of the rate of profit than the starters.

The ex-ante profitability premia in year t-3 is the estimated regression coefficient of a dummy variable (taking the value one for export starters in t, and zero for non-starters) from an OLS-regression of the rate of profit in t-3 on this dummy, controlling for firm size (number of employees and number of employees squared), share of employees in R&D, and the 4-digit industry, all measured in year t-3.[11] This coefficient is never significantly different from zero. Therefore, we conclude that in contrast to nearly all empirical studies on the relationship between productivity and exports we have no evidence for self-selection of more profitable firms into exporting.

[11] At first sight it might confuse that we regress the rate of profit in t-3 on a dummy variable measured later in year t. Note, however, that this regression is not meant to “explain” past profits by today’s exports – it is just a way to test whether or not profits did differ between today’s starters and today’s non-exporters three years before the start.

However, as a caveat we add that the number of starters in the cohorts tends to be small, and that this may contribute to imprecise estimates of any profitability differences.

[Table 5 near here]

When the rate of profit between exporting and non-exporting firms does differ at a point in time – and this is the case according to both the descriptive evidence reported in section 3 and the results of the econometric investigation presented in Table 4 – and when there is no evidence for self-selection of more profitable firms into export activities, this points to positive effects of exporting on the rate of profit. However, due to the sampling frame of the data used we cannot test the hypothesis that firms which start exporting perform better in the years after the start than their counterparts which do not start. As pointed out in section 2, the cost structure survey that is the basis for the computation of the profit rate is a survey based on a stratified random sample with a rotating panel design, and all but the largest firms with 500 and more employees in the sample usually are replaced every four years. Therefore, it is not possible to follow the cohorts of starters from 2002 or 2003 over the next year(s).

5. Causal effect of exports on profitability

In the last step of our analysis we examine whether there is a causal effect of a firm's export activity on its rate of profit. As stated in the previous section, we cannot evaluate post-entry differences in profitability between export starters and non-starters due to the panel design of the German cost structure survey. Nonetheless, the question of whether exports improve profitability is crucial for our analysis. Since we demonstrated that there is no evidence for self-selection of more profitable firms into the export market, the absence of a causal effect of exports on profitability would suggest that a firm’s international business activities and its rate of profit are unrelated. In this case, exporting may result in a higher labour productivity but this increase is then completely absorbed by higher wages and higher costs related to exporting.

The hypothesis of a positive causal effect of exporting on profitability is tested using a newly developed econometric technique, the generalised propensity score (GPS) methodology recently developed by Imbens (2000) and Hirano and Imbens (2004). The GPS methodology was introduced to the literature examining the export-performance relationship by Fryges (2008) and applied by Fryges and Wagner (2008) who estimated the relationship between exports and labour productivity growth using a sample of German manufacturing firms.

The GSP methodology has a number of advantages compared to other econometric techniques. Firstly, the GPS method allows for continuous treatment, i.e., different levels of the firms’ export-sales ratio. In this way, we are able to determine the causal relationship between profitability and the export-sales ratio (the treatment) at each value of firms’ export intensity in the interval from zero to one. Thus, the second important advantage of the GPS method is that it enables us to identify the entire function of the rate of profit over all possible values of the continuous treatment variable. This property of the GPS methodology might be important in our case. The OLS regression of the determinants of the rate of profit in Table 4 pointed out that there might be a nonlinear relationship between profitability and the share of exports in total sales – at least if we restrict ourselves on the estimations without unobserved heterogeneity. Fryges and Wagner (2008) showed that the relationship between the export-sales ratio and labour productivity growth is nonlinear and that exporting causally affects labour productivity growth only within a sub-interval of the domain of the share of exports in total sales. The GPS methodology is flexible allowing to test how the causal impact of exporting on profits varies along the range of the export-sales ratio from zero to one.

Thirdly, the continuous treatment approach allows us to analyse the level of the export intensity at which profitability is maximised (or minimised) or whether the relationship between the export-sales ratio and the rate of profit exhibits turning points or discontinuities (cf. Flores 2004). A detailed description of the GPS methodology is presented in appendix A.1.

Using the GPS methodology, we do not compare export starters versus non-starters. Export starters that have entered the foreign market during the previous year generally show a very small export-sales ratio. Thus, restricting the analysis to export starters precludes a reliable estimation of the causal effect of medium-sized and large export-sales ratios on profitability. Our causal analysis in this section therefore includes export starters as well as firms that export for decades. In this way, the GPS method is an appropriate econometric technique that provides an analysis of the causal effect of exporting on profitability despite, due to data restrictions, we cannot follow cohorts of starters over the next years after foreign market entry.

Hirano and Imbens (2004) suggest a three-stage approach to implement the GPS method. In the first stage, the conditional distribution of the treatment variable given the covariates is estimated. In our case, the distribution of the treatment variable, i.e. the export-sales ratio, is highly skewed. In particular, it has many limit observations at the value zero, representing firms without any exports. The latter group of firms decided that their optimal volume of exports was zero. Following Wagner (2001, 2003), we apply the fractional logit model developed by Papke and Wooldridge (1996) to estimate the export intensity of the firms in our sample.[12] In the second stage of the GPS method the conditional expectation of outcome (rate of

[12] Hirano and Imbens (2004) use a normal distribution for (the logarithm of) the treatment variable of their model. However, they emphasise that more general models may be considered.

profit in our case) is modelled as a function of the treatment and the (estimated) generalised propensity score. In the last stage, we estimate a dose-response function that depicts the conditional expectation of profitability given the continuous treatment (export-sales ratio) and the GPS, evaluated at any level of the continuous treatment variable in the interval from zero to one.

As stated above, we first estimate the conditional distribution of the export-sales ratio given the covariates, applying the fractional logit model. The exogenous covariates of the fractional logit model include firm size (measured as the log of number of employees and its squared value), the log of wages and salaries per employee, the share of employees in R&D, and the log of the firms' lagged labour productivity (measured as sales per employee in t-1). The average wage per employee is used to proxy differences in firms' human capital. A firm with a highly qualified human capital and with extensive R&D activities is likely to generate intangible assets (e.g., a technologically superior product) leading to a competitive advantage of the firm over its (international) rivals and enabling the firm to realise a high export intensity. The lagged labour productivity is included as a covariate in order to account for self-selection of more productive firms into the international market. While we did not find any evidence for a self-selection effect of more profitable firms (see section 4), most studies in the literature confirm the self-selection hypothesis of firms with higher labour productivity (cf. Wagner (2007a) for a survey and The International Study Group on Exports and Productivity (2008) for an international comparison). Thus, firms with a higher labour productivity in t-1 are expected to generate a higher share of total sales abroad. The set of covariates finally contains a full set of interaction terms of the year of observation and the 4-digit industry the enterprise is active in.

The results of the fractional logit model are presented in Table 6. Firm size has a significantly positive effect on the export-sales ratio. The significantly negative sign of the squared value of the number of employees, however, shows the familiar picture that the export-sales ratio tends to increase with firm size at a decreasing rate.[13] As hypothesised, firms with a higher average wage per employee and a higher share of employees in R&D realise a higher export intensity, reflecting the importance of a firm's intangible assets by which a firm is able to create a competitive advantage over its international rivals. The lagged labour productivity is also positively correlated with the share of exports in total sales: Firms that exhibited a higher labour productivity in the past are able to bear the additional costs of exporting and to extend their international business activities. It can also be argued that more productive firms have a competitive advantage when compared with their (foreign) counterparts. Thus, more productive firms are more likely to generate a higher share of total sales abroad.

[Table 6 near here]

The fractional logit model is estimated in order to calculate the generalised propensity score (GPS). As Imbens (2000) shows, adjusting for the GPS removes all the bias associated with differences in covariates between treated (exporting) and non-treated (non-exporting) firms. This allows us to identify a possibly causal influence of the export-sales ratio on profitability. This is done by calculating pairwise treatment effects: we compare the expected rate of profit at one deliberately chosen export-sales ratio with the estimated value of profitability at another deliberately chosen export intensity. If the difference in these two expected rates of profits is

[13] The negative sign of the squared value of the number of employees actually points out to an inversely u-shaped relationship between the export-sales ratio and the number of employees. However, the estimated maximum of this relationship lies at 3,148 employees. Since only few firms in Germany (less than one percent) have a number of employees that exceeds the estimated maximum, our results should better be interpreted to indicate that the export-sales ratio increases with firm size but with a decreasing rate.

significantly positive (negative) a hypothetical switch between the two deliberately chosen export-sales ratios at which the rate of profit is measured increases (decreases) firms' profitability. Since the GPS methodology controls for differences in covariates, the increase (decrease) in the rate of profit can be interpreted as a causal effect of the varying export-sales ratio on profitability (see appendix A.1 for more details). The dose-response function that represents the expected profitability conditional on the export-sales ratio and the GPS is depicted in Figure 1.

[Figure 1 near here]

Overall, the estimated dose-response function shows an inversely u-shaped relationship between profitability and firms' export-sales ratio. The maximum value of the rate of profit is reached at an export-sales ratio of 49 percent, where the expected value of the rate of profit amounts to 13.5 percent. Establishments that do not export show an expected rate of profit of 11.2 percent. Calculating the pairwise treatment effect reveals that at an export-sales ratio of 49 percent profitability is significantly larger than at an export intensity of zero (p-value: 0.000). In other words, at an export-sales ratio of 49 percent a firm's export activities have a causal effect on the rate of profit. The difference in the expected rate of profit accounts for 2.3 percentage points.

In order to find out whether profitability is positively improved by a firm's export activities over the whole range of the export-sales ratio or whether the effect is restricted to a sub-interval of the domain of the share of exports in total sales, we calculated pairwise treatment effects at each export intensity from one to 100 percent, always comparing the expected value of the rate of profit in the case of exporting with the respective value of non-exporting firms. According to conventional t-tests at the 5 percent level of significance, exporting increases profitability almost over the whole range of the export-sales ratio. Even firms that generate a very small share of their total sales in the international market do show a rate of profit that exceeds that of non-exporting firms.[14] This result corresponds to that obtained by Fryges and Wagner (2008) who demonstrate that exporting increases labour productivity growth even for firms with very small export-sales ratios. Thus, learning from foreign customers and competitors is relevant and the positive effect of learning-by-exporting is not completely absorbed, e.g. by higher wages or by the costs of entry into a foreign market, even if firms carry out only limited export activities.[15]

As already discussed above, the rate of profit is maximised at an export-sales ratio of 49 percent. Beyond this threshold of internationalisation, firms exhibit a decrease in profitability compared to firms with lower export intensities. This decrease might be a result of additional costs of exporting, for instance due to rising costs of coordination and control of a firm's export activities or higher transportation costs due to the increasing geographical distance of the foreign markets a firm has entered. Nevertheless, the rate of profit for firms of which the export intensity exceeds the threshold of internationalisation is still significantly higher than the profitability of non-exporting firms – provided that the firms realise an export-sales ratio of less than 90 percent. Firms that generate an export intensity of at least 90 percent do not benefit from a higher rate of profit if compared with non-exporting firms. Thus, there is a sub-interval of the domain of the export-sales ratio where exporting does not significantly improve profitability. However, there are only very few exporters in our sample (less than three percent) that realise an export intensity that

[14] Firms that realise an export intensity of only one percent do not show a significantly positive effect of exporting on profitability.

[15] As discussed in section 2, differences in the rate of profit might also be explained by varying mark-ups of prices over costs. Firms that possess a competitive advantage over their (international) rivals, due to, for instance, intense R&D activities or a highly qualified human capital, might be able to realise a higher mark-up. However, differences in profitability that result from intense R&D activities or a highly qualified human capital (and consequently from a higher mark-up) have been eliminated since we included these variables in the vector of covariates of the fractional logit model estimated in the first step of GPS methodology. Thus, the different rates of profit depicted by the estimated dose-response function can primarily be interpreted as an effect of differences in labour productivity resulting from learning-by-exporting.

lies in the range between 90 and 100 percent. Therefore, we can conclude that almost all exporters in the German manufacturing sector benefit from their international business activities in terms of an increased rate of profit.

The results we obtained in this section are very similar to those described in section 4. At least the estimation results without fixed enterprise effects as reported in columns 1 to 4 of Table 4 show an inversely u-shaped relationship between profitability and the export-sales ratio. Based on the results in Table 4, the estimated threshold value of internationalisation amounts to 65 percent whereas according to the estimated dose-response function the rate of profit reaches its maximum at an export-sales ratio of 49 percent. According to the results in section 4, the difference in profitability between exporting and non-exporting firms is rather small. The analysis based on the estimated dose-response function can confirm this result: the maximum difference in the rate of profit is 2.3 percentage points. The advantage of the continuous treatment approach applied in the section is that we can prove that differences in profitability are caused by differences in the share of exports in total sales. Furthermore, the dose-response function shows that firms with very high export intensities do not benefit from their export activities – at least not in terms of an increase in the rate of profit.

6. Conclusion

The relationship between productivity and a firm's export activities has been studied extensively in the literature on the micro-econometrics of international trade. Stylised facts point out that exporting firms exhibit a higher productivity and higher wages. Econometric analyses proved that there is a self-selection of the more productive firms into the international market. A question that has not been investigated so far is whether the productivity advantage of exporting firms does lead to a profitability advantage of exporters compared to non-exporting firms even when exporters are facing extra costs and pay higher wages.

Looking at profitability instead of productivity is more appropriate from a theoretical point of view, too. Even if productivity and profitability are positively correlated (which tends to be the case) productivity is, as was recently pointed out by Foster, Haltiwanger and Syverson (2008, p. 395), only one of several possible idiosyncratic factors that determine profits. Success of firms in general, and especially survival, depends on profitability. Often profitability is viewed both in theoretical models of market selection and in empirical studies on firm entry and exit as a positive monotonic function of productivity, and selection on profits then is equivalent to selection on productivity. In empirical studies the use of productivity instead of profitability is usually due to the fact that productivity is easily observed in the data sets at hand while profitability is not. Fortunately, our data set is rich enough to allow to measure profitability.

Our findings illustrate that using profitability sheds new light on the relationship between exports and firm performance. Using a unique recently released data set on German manufacturing firms, we demonstrate that exporters show a positive profitability differential compared to non-exporters and that this differential is statistically significant, though rather small. However, in contrast to nearly all empirical studies on the relationship between productivity and exports we find no evidence for self-selection of more profitable firms into export activities. Conversely, exporting has a positive causal effect on profitability almost over the whole domain of the export-sales ratio from zero to one. The only exceptions are firms that realise an export-sales ratio of 90 percent and more.

The maximisation of the rate of profit is one of the main objectives of a firm. This paper shows that exporting leads to a higher rate of profit. This means that the higher productivity usually observed in the group of exporting firms is not completely absorbed by higher wages and higher costs related to exporting. However, the positive effect of exporting on profitability varies along the range of the export-sales ratio. The effect reaches its maximum for firms that generate 49 percent of their total sales abroad and it is zero for firms with very high export intensities. As a rule, therefore, we conclude that exporting pays for German manufacturing firms.

References

Asiedu, Elizabeth and James A. Freeman (2007), The Effect of Globalization on the Performance of Small- and Medium-Sized Enterprises in the United States: Dos Owners' Race/Ethnicity Matter? *American Economic Review Papers and Proceedings* 97, 2, 368-372.

Bausch, Andreas and Mario Krist (2007), The Effect of Context-Related Moderators on the Internationalization-Performance Relationship: Evidence from Meta-Analysis. *Management International Review* 47, 3, 319-347.

Bernard, Andrew B., Bradford J. Jensen, Stephen J. Redding and Peter K. Schott (2007), Firms in International Trade. *Journal of Economic Perspectives* 21, 3, 105-130.

Brandt, Maurice, Stefan Dittrich and Michael Konold (2008), Wirtschaftsstatistische Längsschnittdaten für die Wissenschaft. *Wirtschaft und Statistik* 3/2008, 217-224.

Conover, William J. (1999), *Practical Nonparametric Statistics*. Third Edition. New York etc.: Wiley.

Contractor, Farok J. (2007), Is International Business Goof for Companies? The Evolutionary or Multi-Stage Theory of Internationalization vs. the Transaction Cost Perspective. *Management International Review* 47, 3, 453-475.

Flores, Carlos A. (2004), *Estimation of Dose-Response Functions and Optimal Doses with a Continuous Treatment*. Job Market Paper, University of California, Berkeley.

Foster, Lucia, John Haltiwanger and Chad Syverson (2008), Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability? *American Economic Review* 98, 1, 394-425.

Fritsch, Michael, Bernd Görzig, Ottmar Hennchen and Andreas Stephan (2004), Cost Structure Surveys for Germany. *Schmollers Jahrbuch / Journal of Applied Social Science Studies* 124, 4, 557-566.

Fryges, Helmut (2008), The Export-Growth Relationship: Estimating a Dose-Response Function. *Applied Economics Letters*, forthcoming.

Fryges, Helmut and Joachim Wagner (2008), Exports and Productivity Growth – First Evidence from a Continuous Treatment Approach. *Review of World Economics / Weltwirtschaftliches Archiv*, forthcoming.

Glaum, Martin and Michael-Jörg Oesterle (2007), 40 Years of Research on Internationalization and Firm Performance: More Questions than Answers? *Management International Review* 47, 3, 307-317.

Hennart, Jean-Francois (2007), The Theoretical Rationale for a Multinationality-Performance Relationship. *Management International Review* 47, 3, 423-452.

Hirano, Keisuke and Guido W. Imbens (2004). *The Propensity Score with Continuous Treatments*. in: Gelman, A. and X.-L. Meng (eds.). Applied Bayesian Modeling and Causal Inference from Incomplete-Data Perspectives, Chichester: Wiley, 73-84.

Imbens, Guido W. (2000). The Role of the Propensity Score in Estimating Dose-Response Functions. *Biometrika*, 83, 706-710.

Konold, Michael (2007), New Possibilities for Economic Research through Integration of Establishment-level Panel Data of German Official Statistics. *Schmollers Jahrbuch / Journal of Applied Social Science Studies* 127, 2, 321-334.

McCullagh, Peter and John A. Nelder (1989), *Generalized Linear Models*, second edition. New York: Chapman and Hall.

Mayer, Thierry and Gianmarco I. P. Ottaviano (2007), The Happy Few: The internationalisation of European firms. New facts based in firm-level evidence. Brussels: Bruegel.

Papke, Leslie E. and Jeffrey M. Wooldridge (1996), Econometric Methods for Fractional Response Variables with an Application to 401(K) Plan Participation Rates. *Journal of Applied Econometrics* 11, 4, 619-632.

Rosenbaum, Paul R. and Donald B. Rubin (1983), The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika* 70, 1, 41-55.

Ruigrok, Winfried, Wolfgang Amann and Hardy Wagner (2007), The Internationalization-Performance Relationship at Swiss Firms: A Test of the S-Shape and Extreme Degree of Internationalization. *Management International Review* 47, 3, 349-368.

Schank, Thorsten, Claus Schnabel and Joachim Wagner (2007), Do exporters really pay higher wages? First evidence from German linked employer-employee data. *Journal of International Economics* 72, 1, 52-74.

Schmalensee, Richard (1989), Inter-Industry Studies of Structure and Performance, in: Richard Schmalensee and Robert D. Willig (Ed.), Handbook of Industrial Organization, Volume II, Amsterdam etc.: North-Holland, 951-1009.

The International Study Group on Exports and Productivity (2008), Understanding Cross-Country Differences in Exporter Premia – Comparable Evidence for 14 Countries. *Review of World Economics / Weltwirtschaftliches Archiv*, forthcoming.

Wagner, Joachim (2001), A Note on the Firm Size – Export Relationship. *Small Business Economics* 17, 4, 229-237.

Wagner, Joachim (2003), Unobserved Firm Heterogeneity and the Size-Exports Nexus: Evidence from German Panel Data. *Review of World Economics* 139, 1, 161-172.

Wagner, Joachim (2007a), Exports and Productivity: A Survey of the Evidence from Firm Level Data. *The World Economy* 30, 1, 60-82.

Wagner, Joachim (2007b), Exports and Productivity in Germany. *Applied Economics Quarterly* 53, 4, 353-373.

Zühlke, Sylvia, Markus Zwick, Sebastian Scharnhorst and Thomas Wende (2004), The research data centres of the Federal Statistical Office and the statistical offices of the *Länder*. *Schmollers Jahrbuch / Journal of Applied Social Science Studies* 124, 4, 567-578.

Table 1: Rate of profit (percentage) in exporting and non-exporting enterprises (1999 – 2004)[1]

Year		Number of enterprises	Mean	Standard deviation	p1[2]	p25[2]	p50[2]	p75[2]	p99[2]
1999	Exporters	11726	12.84	13.88	-21.06	5.06	11.22	19.24	55.20
	Non-Exporters	5049	12.42	13.90	-20.58	4.76	10.98	19.11	54.28
2000	Exporters	11744	12.90	13.64	-17.89	5.04	11.03	19.15	54.80
	Non-Exporters	4890	11.76	13.60	-20.05	4.22	10.17	18.04	53.07
2001	Exporters	11241	12.29	13.70	-19.39	4.55	10.49	18.55	54.35
	Non-Exporters	4412	11.24	13.04	-19.42	3.66	9.81	17.26	51.50
2002	Exporters	10885	11.84	13.52	-20.09	4.05	10.07	17.95	53.25
	Non-Exporters	4098	10.56	12.94	-21.48	3.17	8.97	17.01	49.94
2003	Exporters	11911	11.82	14.13	-20.20	4.29	10.08	18.18	52.90
	Non-Exporters	4005	11.14	12.86	-18.27	3.77	9.76	17.67	49.69
2004	Exporters	11776	12.37	14.03	-20.50	4.76	10.64	18.51	52.59
	Non-Exporters	3954	11.53	12.60	-18.84	4.13	9.97	17.67	49.69

[1] For definition of the rate of profit see text.
[2] p1, p25, p50, p75 and p99 are the first, 25th, 50th, 75th and 99th percentile of the distribution of the rate of profit.

Table 2: Tests for differences in the rate of profit between exporting and non-exporting enterprises (1999 – 2004)[1]

Year	t-test for difference in the mean (p-value)[2]	Kolmogorov-Smirnov test (p-value)[3] Difference: yes	Exporters > Non-Exporters	Non-Exporters > Exporters
1999	0.075	0.044	0.023	0.997
2000	0.000	0.021	0.011	0.997
2001	0.000	0.016	0.009	0.911
2002	0.000	0.004	0.002	0.992
2003	0.005	0.015	0.008	0.961
2004	0.000	0.007	0.004	0.955

[1] For definition of the rate of profit see text.
[2] The t-test does not assume equal variances for both groups. A p-value of 0.05 (or smaller) indicates that the null hypothesis of equal mean values for exporters and non-exporters can be rejected at an error level of five percent (or less).
[3] The rate of profit is measured as the deviation from the mean value in the 4-digit industry; see text. A p-value of 0.05 (or smaller) indicates that the hypothesis mentioned in the header of the column cannot be rejected at an error level of five percent (or less), meaning that
- the distributions of the rate of profit differ between exporting and non-exporting enterprises.
- the distribution of the rate of profit for exporting enterprises first order stochastically dominates the distribution of the rate of profit for non-exporting enterprises.
- the distribution of the rate of profit for non-exporting enterprises first order stochastically dominates the distribution of the rate of profit for exporting enterprises.

Table 3: Rate of profit (percentage) for firms in different classes of the export-sales ratio (1999 – 2004)[1]

Year		Number of enterprises	Mean	Standard deviation	p1[2]	p25[2]	p50[2]	p75[2]	p99[2]
1999	0%	5049	12.42	13.90	-20.58	4.76	10.98	19.11	54.28
	> 0% and ≤ 5%	2340	12.22	13.70	-21.06	4.77	10.48	18.30	53.84
	> 5% and ≤ 10%	1329	11.97	14.61	-33.16	4.43	10.32	18.34	53.48
	> 10% and ≤ 20%	2093	12.96	13.58	-16.89	4.76	10.48	18.73	56.49
	> 20% and ≤ 50%	3921	13.19	13.46	-19.17	5.34	11.76	19.61	55.20
	> 50%	2043	13.31	14.66	-28.91	5.44	12.22	20.27	57.48
2000	0%	4890	11.75	13.60	-20.05	4.22	10.17	18.04	53.07
	> 0% and ≤ 5%	2175	11.66	13.95	-18.33	4.13	10.02	17.30	54.61
	> 5% and ≤ 10%	1312	11.92	13.34	-16.76	4.54	9.93	17.61	54.50
	> 10% and ≤ 20%	2048	12.61	13.40	-13.13	4.62	10.08	18.28	55.60
	> 20% and ≤ 50%	3917	13.36	13.23	-18.21	5.57	11.68	19.72	53.42
	> 50%	2292	14.13	14.26	-19.14	5.79	12.36	21.20	56.65
2001	0%	4412	11.24	13.04	-19.42	3.66	9.81	17.26	51.50
	> 0% and ≤ 5%	1985	10.74	13.40	-20.30	3.62	9.45	16.54	50.44
	> 5% and ≤ 10%	1209	12.29	14.51	-16.77	4.69	10.01	17.99	54.84
	> 10% and ≤ 20%	1887	12.06	13.22	-19.02	4.62	9.96	16.90	56.00
	> 20% and ≤ 50%	3824	12.54	13.29	-18.17	4.77	10.81	19.12	52.14
	> 50%	2336	13.37	14.42	-21.51	4.92	11.84	20.51	55.18
2002	0%	4098	10.56	12.94	-21.48	3.17	8.97	17.01	49.94
	> 0% and ≤ 5%	1817	10.40	13.44	-20.59	3.22	8.93	16.01	52.29
	> 5% and ≤ 10%	1099	11.23	13.12	-20.46	3.48	9.13	16.47	54.24
	> 10% and ≤ 20%	1756	11.74	13.09	-17.46	4.16	9.58	17.18	52.70
	> 20% and ≤ 50%	3779	12.09	13.22	-20.09	4.39	10.45	18.34	51.40
	> 50%	2434	12.90	14.40	-20.07	4.61	11.27	20.27	56.19

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Continued from Table 3

2003	0%	4005	11.14	12.86	-18.27	3.77	9.76	17.25	49.07
	> 0% and ≤ 5%	2039	11.16	14.38	-18.35	3.50	9.34	17.30	55.04
	> 5% and ≤ 10%	1170	11.17	15.59	-25.19	4.13	9.92	17.36	53.53
	> 10% and ≤ 20%	1989	11.46	13.78	-21.05	4.27	9.48	16.99	56.95
	> 20% and ≤ 50%	3960	12.23	13.21	-18.72	4.80	10.30	18.45	50.29
	> 50%	2753	12.27	14.78	-25.89	4.32	11.09	19.55	53.93
2004	0%	3954	11.53	12.60	-18.84	4.13	9.97	17.67	49.69
	> 0% and ≤ 5%	1906	10.89	14.90	-24.50	3.88	9.70	16.86	52.50
	> 5% and ≤ 10%	1123	11.38	13.43	-25.35	4.18	9.88	17.22	48.36
	> 10% and ≤ 20%	1935	11.95	13.66	-18.87	4.25	9.63	17.31	54.42
	> 20% and ≤ 50%	4021	12.82	13.76	-17.33	5.35	11.13	19.01	51.96
	> 50%	2791	13.42	14.18	-22.41	5.27	11.78	20.01	54.71

[1] For definition of the rate of profit see text.
[2] p1, p25, p50, p75 and p99 are the first, 25th, 50th, 75th and 99th percentile of the distribution of the rate of profit.

Table 4: Exports and profits: Evidence from regression models (1999 – 2004)
Endogenous variable: Rate of profit (percentage)

Exogenous variable	Model	Pooled data 1	2	3	4	Fixed enterprise effects 5	6	7	8
Exporter	ß	0.962				0.298			
(Dummy; 1 = yes)	p	0.000				0.210			
Share of exports in total	ß		0.031	0.065	0.049		0.030	-0.005	0.048
sales (percentage)	p		0.000	0.000	0.000		0.000	0.728	0.072
Share of exports in total	ß			-0.0005	0.0001			0.0005	-0.001
sales (squared)	p			0.000	0.815			0.021	0.109
Share of exports in total	ß				4.48e-6				0.0001
sales (cubic)	p				0.132				0.037
Number of employees	ß	0.001	0.001	0.001	0.001	-4.5e-5	-0.0001	-0.0001	-0.0001
	p	0.000	0.000	0.000	0.000	0.833	0.644	0.733	0.706
Number of employees	ß	-3.78e-9	-3.41e-9	-3.37e-9	-3.36e-9	-1.24e-9	-1.50e-9	-1.36e-9	-1.14e-9
(squared)	p	0.000	0.000	0.000	0.000	0.295	0.205	0.249	0.232
Share of employees in R&D	ß	-0.015	-0.032	-0.032	-0.032	-0.002	-0.004	-0.004	-0.005
	p	0.298	0.027	0.026	0.027	0.935	0.856	0.827	0.825
Constant	ß	11.284	11.366	11.148	11.192	-0.012	-0.011	-0.012	-0.012
	p	0.000	0.000	0.000	0.000	0.611	0.615	0.614	0.614
Interaction terms of year and 4-digit industry		included	included	included	included	included	included	included	included
Number of observations		95644	95644	95644	95644	95644	95644	95644	95644
R^2		0.083	0.084	0.084	0.084	0.0002	0.002	0.001	0.001

Table 5: Rate of profit in export starters and non-starters in the start year and three years before start

Cohort of starters		2002	2003	2004
Number of enterprises	Starters	159	307	138
	Non-starters	3497	3172	2854
Rate of profit in start year (percentage):	Starters	11.16 (0.92)	12.61 (14.15)	11.22 (11.29)
Mean (standard deviation)	Non-starters	12.94 (0.22)	12.23 (13.06)	11.72 (12.89)
t-test for difference in the mean[1]	p-value	0.062	0.650	0.618
Kolmogorow-Smirnov test[2]				
- Difference: yes	p-value	0.077	0.422	0.383
- Starters > Non-starters	p-value	0.922	0.229	0.215
- Non-starters > Starters	p-value	0.046	0.744	0.276
Profit premia of export starters (percentage points)[3]	ß	-1.554	0.392	1.378
	p-value	0.105	0.642	0.157

[1] The t-test does not assume equal variances for both groups. A p-value of 0.05 (or smaller) indicates that the null- hypothesis of equal mean values for export starters and non-starters in the start year can be rejected at an error level of five percent (or less).

[2] A p-value of 0.05 (or smaller) indicates that the hypothesis stated in the first column of the row cannot be rejected at an error level of five percent (or less), meaning that

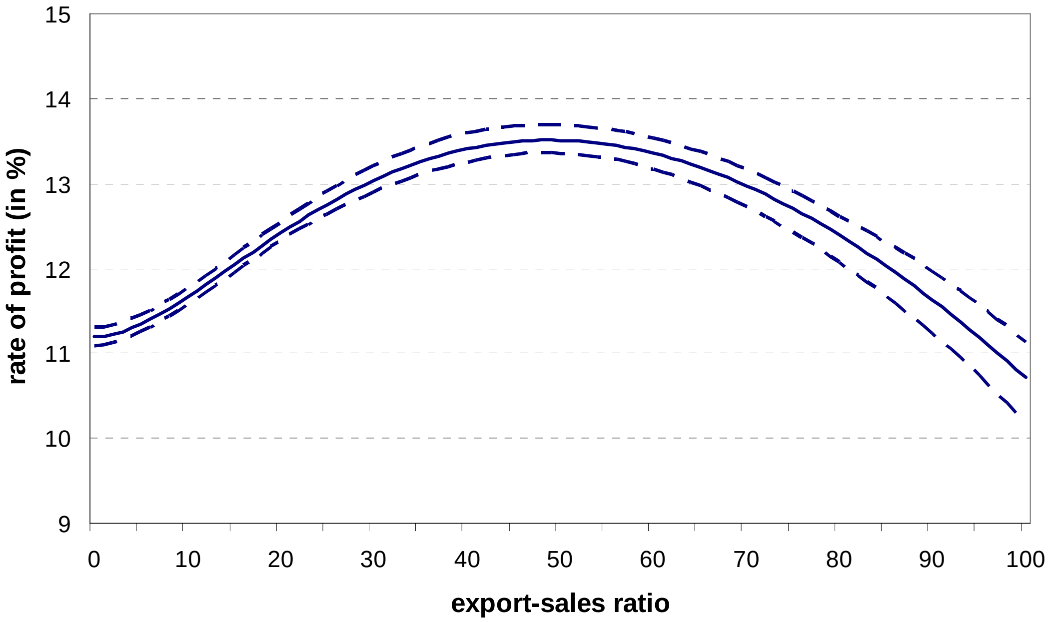
- the distributions of the rate of profit differ between export starters and non-starters in the start year.
- the distribution of the rate of profit for export starters first order stochastically dominates the distribution of the rate of profit for non-starters in the start year.
- the distribution of the rate of profit for non-starters first order stochastically dominates the distribution of the rate of profit for export starters in the start year.

[3] The profit premia is the estimated regression coefficient of a dummy variable (taking the value one for export starters, and zero for non-starters) from an OLS-regression of the rate of profit on this dummy, controlling for the number of employees and its squared value, the share of employees in R&D in all employees, and a complete set of 4-digit industry dummy variables, all measured three years before the export start.

Table 6: Determinants of the export-sales ratio (endogenous variable) – results of the fractional logit model

Exogenous variable	Pooled data	
Number of employees (log)	ß	0.785
	p	0.000
Number of employees (squared) (log)	ß	-0.049
	p	0.000
Share of employees in R&D	ß	2.307
	p	0.000
Wage per employee (log)	ß	0.619
	p	0.000
Labour productivity (sales per employee) in t-1 (log)	ß	0.307
	p	0.000
Constant	ß	-13.507
	p	0.000
Interaction terms of year and 4-digit industry	included	
Number of observations	89,417	
Log-likelihood	-30,006.91	
R^2	0.410	

Figure 1: Estimated dose-response function



Solid lines: estimated conditional expectation of firms' profits given the export-sales ratio in *t* and the estimated generalised propensity score (GPS).
Dotted lines: simulated 90% confidence interval, using the 5th and 95th percentiles of the bootstrap distribution (100 replications).

Appendix

A.1 The generalised propensity score (GPS) method

This paper applies the generalised propensity score (GPS) method developed by Imbens (2000) and Hirano and Imbens (2004). The GPS method allows for continuous treatment, that is, in our case, different levels of firms' export-sales ratios. It is a generalisation of the binary treatment propensity score methodology as derived by Rosenbaum and Rubin (1983).

The key assumption of the GPS method is a generalisation of the strong unconfoundedness assumption made by Rosenbaum and Rubin (1983) for binary treatments (cf. Imbens (2000)). Let the treatment D take on values in the interval $\mathfrak{D} = [d_0, d_1]$. Assignment to treatment D is *weakly unconfounded*, given a vector of pre-treatment variables X, if

(1) $$Y(d) \perp D \mid X \quad \text{for all} \quad d \in \mathfrak{D},$$

with $Y(d)$ as the outcome associated with treatment level d. It is important to note that this assumption does not require joint independence of all potential outcomes $\{Y(d)\}_{d \in \mathfrak{D}}$. Instead, weak unconfoundedness only requires pairwise independence of the treatment with each of the potential outcomes. In other words, the random variable D (the treatment) is assumed to be conditionally independent with the random variable Y (the outcome), measured at an arbitrarily chosen treatment level d.

Let further $r(d,x)$ be the conditional density of the treatment given the covariates:

(2) $$r(d,x) = f_{D|X}(d|x).$$

Then the generalised propensity score is defined as $R = r(D, X)$ (Hirano and Imbens (2004), p. 74). Assuming that assignment to treatment D is weakly unconfounded given pre-treatment variables X, it can be proved that for every treatment level d

(3) $$f_D\left(d \middle| r(d,X), Y(d)\right) = f_D\left(d \middle| r(d,X)\right),$$

i.e., assignment to treatment D is unconfounded given the GPS (Hirano and Imbens (2004), p. 75). Equation (3) shows that the conditional density of the treatment level at d is calculated using the GPS at the corresponding level of the treatment. Thus, the GPS methodology uses as many propensity scores as there are levels of the treatment.

In the case of binary treatment, Rosenbaum und Rubin (1983) demonstrate that conditioning on the one-dimensional propensity score (i.e. the conditional probability of receiving the treatment given pre-treatment variables) is sufficient to remove all the bias associated with differences in pre-treatment variables between treated and non-treated individuals or firms. With continuous treatment, Hirano and Imbens (2004) prove that adjusting for the GPS eliminates any biases associated with differences in the pre-treatment variables. Assuming that assignment to treatment D is weakly unconfounded given pre-treatment variables X und using the result from equation (3), it can be shown that

(4) $$\eta(d,r) = E\left[Y(d) \middle| r(d,X) = r\right] = E\left[Y \middle| D = d, R = r\right] \qquad \text{and}$$

(5) $$\mu(d) = E\left[\beta\left(d, r(d,X)\right)\right] = E\left[Y(d)\right].$$

Thus, the bias-removing property is obtained in two steps. In the first step, the conditional expectation of the outcome Y is estimated as a function of the treatment D and the GPS R, $\eta(d,r) = E\left[Y \middle| D = d, R = r\right]$. Hirano and Imbens (2004) stress, however, that the regression function $\eta(d,r)$ does not have a causal interpretation. In the second step, the conditional expectation $\eta(d,r)$ is averaged over the GPS evaluated at a particular level of the treatment $r(d,X)$. This leads to an estimation of the dose-response function $\mu(d)$ at any level or dose of the continuous treatment variable.

Hirano and Imbens (2004) suggest a three-stage approach to implement the GPS method. In the first stage, the conditional distribution of the treatment variable given the covariates is estimated. In our case, the distribution of the treatment variable *D*, i.e. the firms' export-sales ratios, is highly skewed. In particular, it has many limit observations at the value zero, representing firms without any international sales. Following Wagner (2001, 2003), we apply the fractional logit model developed by Papke and Wooldridge (1996) to estimate the export intensity of the firms in our sample. Papke and Wooldridge assume that, for all observations *i*, the expected value of D_i conditional on a vector of covariates X_i is given by

(6) $$E\left(D_i \middle| X_i\right) = F\left(X_i\beta\right),$$

with $0 < F\left(X_i\beta\right) < 1$ for all $X_i\beta \in \mathbb{R}$, ensuring that the predicted values of D_i lie in the interval (0, 1). Nevertheless, equation (6) is defined even if D_i takes the limit observations zero or one. The function *F*(·) is assumed to be the cumulative distribution function (cdf) of the logistic distribution:

(7) $$F\left(X_i\beta\right) \equiv \Lambda\left(X_i\beta\right) \equiv \frac{\exp\left(X_i\beta\right)}{1+\exp\left(X_i\beta\right)}.$$

Papke and Wooldridge propose a quasi-maximum likelihood estimator (QMLE) of β. The estimation procedure maximises the Bernoulli log-likelihood function given by

(8) $$l_i\left(\beta\right) \equiv D_i \cdot \log\left[\Lambda\left(X_i\beta\right)\right] + \left(1-D_i\right) \cdot \log\left[1-\Lambda\left(X_i\beta\right)\right]$$

using the generalised linear models (GLM) framework developed by McCullagh and Nelder (1989). The estimated GPS based on the Bernoulli log-likelihood function defined in equation (8) is then given by

(9) $$\hat{R}_i = \left[\Lambda\left(X_i\hat{\beta}\right)\right]^{D_i} \cdot \left[1-\Lambda\left(X_i\hat{\beta}\right)\right]^{\left(1-D_i\right)}.$$

In the second stage of Hirano and Imbens' GPS methodology the conditional expectation of outcome Y_i (the rate of profit in our case) is modelled as a function of the treatment D_i and the (estimated) generalised propensity score $\hat{R}_i$. Following Hirano and Imbens, we use a quadratic approximation for the conditional expectation of Y_i:

$$(10) \qquad E\left[Y_i \middle| D_i, \hat{R}_i\right] = \alpha_0 + \alpha_1 \cdot D_i + \alpha_2 \cdot D_i^2 + \alpha_3 \cdot \hat{R}_i + \alpha_4 \cdot \hat{R}_i^2 + \alpha_5 \cdot D_i \cdot \hat{R}_i .$$

Equation (10) corresponds to equation (4) and is estimated by OLS. As Hirano and Imbens point out, the estimated regression coefficients $\hat{\alpha}$ do not have any direct meaning and will therefore not be reported in section 5 for reasons of space.

In the last stage of the GPS method, the average expected outcome at treatment level *d* is estimated, using the regression coefficients $\hat{\alpha}$ from the second stage of the GPS method:

$$(11) \qquad \widehat{E\left[Y(d)\right]} = \frac{1}{N}\sum_{i=1}^{N}\left(\hat{\alpha}_0 + \hat{\alpha}_1 \cdot d + \hat{\alpha}_2 \cdot d^2 + \hat{\alpha}_3 \cdot \hat{r}(d, X_i) + \hat{\alpha}_4 \cdot \hat{r}(d, X_i)^2 + \hat{\alpha}_5 \cdot d \cdot \hat{r}(d, X_i)\right),$$

with *N* as the number of observations. Equation (11) corresponds to equation (5). In order to obtain an estimate of the entire dose-response function, equation (11) is calculated at each export intensity *d* in the interval from zero to one. Hirano and Imbens (2004) state that asymptotic normality for the estimator in equation (11) can be proved. However, following the same procedure as Hirano and Imbens, the confidence intervals of the dose-response functions in this paper are determined via bootstrapping.

Applying the GPS methodology, we do not calculate the effect of the treatment per se, that is, we do not compare the potential outcome for non-treated individuals or firms with that for all treated entities simply allowing for different levels or doses of the treatment variable. Instead, the dose-response function we estimate shows the average potential outcome at each dose of the treatment and how average responses vary along the interval

$\mathfrak{D} = [d_0, d_1]$. From this curve we can calculate pairwise treatment effects of the form (cf. Flores 2004):

(12) $E\left(\Delta^{d'd''}\right) = E\left[Y\left(d'\right) - Y\left(d''\right)\right]$ for $d', d'' \in \mathfrak{D}$.

In other words, we estimate the average response of outcome at one particular treatment level and compare this outcome with the average outcome at any other, deliberately chosen treatment level. Since the GPS model controls for differences in pre-treatment variables, potential differences between the average outcomes at two deliberately chosen levels of treatment can be interpreted as a causal effect of varying doses of the continuous treatment variable.

Table A.1: Rate of profit (percentage) in exporting and non-exporting enterprises (1999 – 2004) – without enterprises with extreme values for the rate of profit[1]

Year		Number of enterprises	Mean	Standard deviation	p1[2]	p25[2]	p50[2]	p75[2]	p99[2]
1999	Exporters	11486	12.80	11.83	-13.57	5.16	11.21	19.01	48.16
	Non-Exporters	4953	12.48	11.67	-13.01	4.88	10.99	18.97	47.13
2000	Exporters	11514	12.83	11.63	-11.14	5.13	11.01	18.96	47.95
	Non-Exporters	4793	11.85	11.47	-12.80	4.41	10.20	17.89	47.18
2001	Exporters	11012	12.22	11.65	-12.74	4.67	10.48	18.31	47.09
	Non-Exporters	4330	11.26	11.08	-11.90	3.78	9.82	17.10	45.06
2002	Exporters	10665	11.77	11.69	-12.77	4.18	10.06	17.70	46.47
	Non-Exporters	4021	10.59	11.14	-14.13	3.29	8.99	16.89	43.79
2003	Exporters	11674	11.88	11.65	-12.99	4.43	10.09	17.98	46.49
	Non-Exporters	3937	11.12	11.10	-13.45	3.84	9.76	17.00	43.96
2004	Exporters	11536	12.42	11.49	-11.80	4.88	10.64	18.28	46.63
	Non-Exporters	3888	11.50	10.96	-13.22	4.22	9.98	17.51	44.17

[1] For definition of the rate of profit see text. The enterprises with the one percent lowest and highest values for the rate of profit were excluded from the calculations.
[2] p1, p25, p50, p75 and p99 are the first, 25th, 50th, 75th and 99th percentile of the distribution of the rate of profit.

Table A.2: Tests for differences in the rate of profit between exporting and non-exporting enterprises (1999 – 2004) – without enterprises with extreme values for the rate of profit[1]

Year	t-test for difference in the mean (p-value)[2]	Kolmogorov-Smirnov test (p-value)[3] Difference: yes	Exporters > Non-Exporters	Non-Exporters > Exporters
1999	0.112	0.020	0.010	0.998
2000	0.000	0.005	0.003	1.000
2001	0.000	0.010	0.005	0.935
2002	0.000	0.002	0.001	0.998
2003	0.000	0.125	0.065	0.981
2004	0.000	0.006	0.003	0.992

[1] For definition of the rate of profit see text. The enterprises with the one percent lowest and highest values for the rate of profit were excluded from the calculations.

[2] The t-test does not assume equal variances for both groups. A p-value of 0.05 (or smaller) indicates that the null hypothesis of equal mean values for exporters and non-exporters can be rejected at an error level of five percent (or less).

[3] The rate of profit is measured as the deviation from the mean value in the 4-digit industry; see text. A p-value of 0.05 (or smaller) indicates that the hypothesis mentioned in the header of the column cannot be rejected at an error level of five percent (or less), meaning that

- the distributions of the rate of profit differ between exporting and non-exporting enterprises.
- the distribution of the rate of profit for exporting enterprises first order stochastically dominates the distribution of the rate of profit for non-exporting enterprises.
- the distribution of the rate of profit for non-exporting enterprises first order stochastically dominates the distribution of the rate of profit for exporting enterprises.

Table A.3: Rate of profit (percentage) for firms in different classes of the export-sales ratio (1999 – 2004)[1] – without enterprises with extreme values for the rate of profit

Year		Number of enterprises	Mean	Standard deviation	p1[2]	p25[2]	p50[2]	p75[2]	p99[2]
1999	0%	4953	12.48	11.67	-13.01	4.88	10.99	18.97	47.13
	> 0% and ≤ 5%	2294	12.23	11.58	-14.22	4.89	10.48	18.05	47.62
	> 5% and ≤ 10%	1301	12.34	11.77	-10.86	4.62	10.44	18.33	47.96
	> 10% and ≤ 20%	2056	12.64	12.05	-11.69	4.80	10.45	18.52	49.55
	> 20% and ≤ 50%	3850	13.10	11.66	-13.42	5.41	11.73	19.44	47.00
	> 50%	1985	13.36	12.20	-15.35	5.69	12.25	20.02	48.23
2000	0%	4793	11.85	11.32	-12.80	4.41	10.20	17.89	47.18
	> 0% and ≤ 5%	2132	11.67	11.47	-10.43	4.23	10.01	17.09	48.78
	> 5% and ≤ 10%	1288	11.81	11.29	-12.52	4.74	9.93	17.43	47.39
	> 10% and ≤ 20%	2013	12.30	11.71	-10.40	4.63	10.04	17.96	48.63
	> 20% and ≤ 50%	3847	13.38	11.66	-11.40	5.74	11.71	19.55	47.83
	> 50%	2234	14.05	11.83	-10.85	6.00	12.33	20.79	48.01
2001	0%	4330	11.26	11.08	-11.90	3.78	9.82	17.10	45.06
	> 0% and ≤ 5%	1949	10.82	11.10	-12.08	3.73	9.47	16.50	47.01
	> 5% and ≤ 10%	1183	12.09	11.52	-13.57	4.72	10.00	17.78	46.89
	> 10% and ≤ 20%	1849	11.74	11.50	-12.92	4.65	9.94	16.45	49.20
	> 20% and ≤ 50%	3755	12.52	11.59	-12.49	4.88	10.81	18.90	45.84
	> 50%	2276	13.40	12.27	-12.87	5.08	11.85	20.18	48.22
2002	0%	4021	10.59	11.14	-14.13	3.29	8.99	16.89	43.79
	> 0% and ≤ 5%	1781	10.46	11.25	-12.29	3.39	8.94	15.79	45.04
	> 5% and ≤ 10%	1075	11.01	11.56	-13.22	3.51	9.11	16.27	46.53
	> 10% and ≤ 20%	1726	11.59	11.68	-11.77	4.22	9.53	16.98	47.43
	> 20% and ≤ 50%	3708	12.07	11.69	-12.83	4.48	10.45	18.16	46.19
	> 50%	2375	12.74	11.99	-13.09	4.70	11.17	19.89	46.53

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Continued from Table A.3

2003	0%	3937	11.12	11.10	-13.45	3.84	9.76	17.00	43.96
	> 0% and ≤ 5%	2002	10.92	11.58	-13.35	3.54	9.27	17.06	47.40
	> 5% and ≤ 10%	1143	11.45	10.77	-10.28	4.41	9.94	17.19	43.91
	> 10% and ≤ 20%	1944	11.32	11.22	-12.03	4.40	9.47	16.72	45.27
	> 20% and ≤ 50%	3903	12.29	11.68	-12.96	4.90	10.31	18.37	47.18
	> 50%	2682	12.57	12.24	-13.91	4.57	11.17	19.42	46.57
2004	0%	3888	11.50	10.96	-13.22	4.22	9.98	17.51	44.17
	> 0% and ≤ 5%	1859	11.18	11.16	-14.39	4.07	9.70	16.72	44.24
	> 5% and ≤ 10%	1103	11.84	10.97	-9.26	4.33	9.97	17.22	46.63
	> 10% and ≤ 20%	1895	11.82	11.46	-11.26	4.33	9.58	17.15	47.60
	> 20% and ≤ 50%	3952	12.76	11.34	-11.87	5.41	11.08	18.79	45.66
	> 50%	2727	13.45	12.02	-12.12	5.42	11.78	19.77	47.91

[1] For definition of the rate of profit see text. The enterprises with the one percent lowest and highest values for the rate of profit were excluded from the calculations.
[2] p1, p25, p50, p75 and p99 are the first, 25th, 50th, 75th and 99th percentile of the distribution of the rate of profit.

Table A.4: Exports and profits: Evidence from regression models excluding enterprises with extreme values for the rate of profit (1999 – 2004)[1]
Endogenous variable: Rate of profit (percentage)

	Model	Pooled Data 1	2	3	4	Fixed enterprise effects 5	6	7	8
Exogenous variable									
Exporter	ß	0.874				0.186			
(Dummy; 1 = yes)	p	0.000				0.344			
Share of exports in total	ß		0.029	0.058	0.049		0.027	0.012	0.029
sales (percentage)	p		0.000	0.000	0.000		0.000	0.324	0.188
Share of exports in total	ß			-0.0004	-0.0001			0.0002	-0.0003
sales (squared)	p			0.000	0.792			0.216	0.579
Share of exports in total	ß				2.70e-6				4.15e-6
sales (cubic)	p				0.283				0.384
Number of employees	ß	0.0005	0.0004	0.0004	0.0004	-4.53e-5	-0.0001	-0.0001	-0.0001
	p	0.000	0.000	0.000	0.000	0.818	0.627	0.668	0.658
Number of employees	ß	-3.23e-9	-2.88e-9	-2.85e-9	-2.84e-9	1.26e-9	1.51e-9	1.44e-9	1.46e-9
(squared)	p	0.000	0.000	0.000	0.000	0.245	0.166	0.183	0.178
Share of employees in R&D	ß	0.030	0.014	0.014	0.014	0.021	0.019	0.019	0.019
	p	0.002	0.155	0.155	0.151	0.157	0.195	0.205	0.207
Constant	ß	11.282	11.351	11.158	11.184	-0.002	-0.001	-0.001	-0.001
	p	0.000	0.000	0.000	0.000	0.925	0.954	0.961	0.960
Interaction terms of year and 4-digit industry		included	included	included	included	included	included	included	included
Number of observations		93762	93762	93762	93762	93762	93762	93762	93762
R^2		0.092	0.094	0.094	0.094	0.0003	0.003	0.003	0.003

[1] The enterprises with the one percent lowest and highest values for the rate of profit were excluded from the calculations.

Table A.5: Descriptive statistics for the samples used in the regressions for Table 4 and A.4[1]

Variable	All enterprises	Without enterprises with extreme values for the rate of profit[2]
Rate of profit (percentage)	12.11 (13.67)	11.10 (12.10)
Exporter (Dummy; 1 = yes)	0.72 (0.45)	0.72 (0.45)
Share of exports in total sales (percentage)	21.14 (24.47)	21.09 (24.41)
Share of exports in total sales (squared)	1045.75 (1805.00)	1040.65 (1797.04)
Share of exports in total sales (cubic)	63635.91 (144739.8)	63182.28 (143908.2)
Number of employees	301.64 (2244.02)	301.67 (2253.54)
Number of employees (squared)	5126570 (2.27e+8)	5169404 (2.75e+8)
Share of employees in R&D	1.73 (4.80)	1.71 (4.73)
Number of observations	95644	93762

[1] Mean values; standard deviations in brackets
[2] The enterprises with the one percent lowest and highest values for the rate of profit were excluded from the calculations.