# Higher productivity in importing German manufacturing firms: self-selection, learning from importing, or both?

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# Higher productivity in importing German manufacturing firms: self-selection, learning from importing, or both?

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**Abstract** This paper uses a newly available comprehensive panel data set for manufacturing enterprises from 2001 to 2005 to document the first empirical results on the relationship between imports and productivity for Germany, a leading actor on the world market for goods. Furthermore, for the first time the direction of causality in this relationship is investigated systematically by testing for self-selection of more productive firms into importing, and for productivity-enhancing effects of imports ('learning-by-importing'). We find a positive link between importing and productivity. From an empirical model with fixed enterprise effects that controls for firm size, industry, and unobservable firm heterogeneity we see that the premia for trading internationally are about the same in West and East Germany. Compared to firms that do not trade at all two-way traders do have the highest premia, followed by firms that only export, while firms that only import have the smallest estimated premia. We find evidence for a positive impact of productivity on importing, pointing to self-selection of more productive enterprises into imports, but no clear evidence for the effect of importing on productivity due to learning-by-importing.

**Keywords** Imports · Exports · Productivity · Enterprise panel data · Germany

**JEL Classification** F14 · D21

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## 1 Motivation

Since the mid-1990s economists used micro data at the firm level from many countries to uncover the role that firms play in international trade. These micro-econometric studies revealed a number of stylized facts regarding differences between exporting and non-exporting firms (summarized in Bernard et al. 2007) that in turn inspired theoretical models with heterogeneous firms in open economies (see the influential contributions by Melitz 2003 and Bernard et al. 2003) instead of the representative firm models from the older literature on international economics with a focus on industries or countries. Productivity differences between exporting and non-exporting firms from the same industry play a central role in both the empirical investigations and the new theoretical models. Numerous empirical studies show that exporting firms are more productive than non-exporting firms even if observed and unobserved firm characteristics are controlled for, and that there is self-selection of the more productive firms into exporting, while empirical evidence for positive effects of exporting on productivity is scarce (for a survey of the empirical literature see Wagner 2007a).

While the causes and consequences of export and its mutual relationships with productivity (and with other firm characteristics, including firm size and growth, and wages paid) are prominent topics in the recent literature on internationally active firms, imports are seldom dealt with. A case in point is the recently published Bruegel study on the internationalisation of European firms (Mayer and Ottaviano 2008) where imports are not dealt with at all. As Bernard et al. (2007: 123) recently put it, "(t)he empirical literature on firms in international trade has been concerned almost exclusively with exporting, largely due to limitations in data sets …. As a result, the new theories of heterogeneous firms and trade were developed to explain facts about firm export behaviour and yield few predictions (if any) for firm import behaviour."

This situation, however, is changing rapidly. With new data sets that include information on imports at the firm level becoming available for more and more countries a new literature (reviewed in Sect. 2 below) is emerging since 2005 that has a focus on the links between productivity and imports. This paper contributes to the literature by presenting the first empirical results on the relationships between imports and productivity for Germany, a leading actor on the world market for goods.[1] Furthermore, we look for the first time systematically at the direction of causality in this relationship by testing for self-selection of more productive firms into importing, and for productivity-enhancing effects of imports ('learning-by-importing').

The rest of the paper is organized as follows: Sect. 2 reviews the recent literature on imports and productivity. Section 3 introduces the newly available firm level panel data for Germany used in our empirical investigation. Section 4 reports productivity premia for firms active in international trade. Section 5 investigates

[1] The relationship between exports and productivity in Germany is investigated in Bernard and Wagner (1997) and in Wagner (2002, 2007b).

whether more productive firms self-select into import activities. Section 6 reports findings on productivity-enhancing effects of imports. Section 7 concludes.

## 2 Literature review

In their comprehensive empirical study of firms in the US that trade goods Bernard et al. (2005: 5) noted "that there is virtually no research documenting and analyzing importing firms". This is no longer the case. A number of recently published empirical studies based on data from a wide range of countries document the shares of firms that are exporters, importers, and two-way traders (that both export and import), or that sell or buy on the national market only, and they look at differences between these four types of firms. Differences in productivity and their relationship with different degrees of involvement in international trade are at the centre of these studies. As of today[2] we have evidence on this issue for Belgium (Muuls and Pisu 2007), Chile (Kasahara and Rodrigue 2005; Kasahara and Lapham 2008), Hungary (Halpern et al. 2005; Altomonte and Békés 2008), India (Tucci 2005), Indonesia (Sjöholm 1999), Italy (Castellani et al. 2008), Poland (Hagemejer and Kolasa 2008), Sweden (Andersson et al. 2008), and the US (Bernard et al. 2007).[3]

Details aside, the big picture that emerges from this literature can be sketched as follows: There is a positive link between importing and productivity at the firm level, documented by a significant productivity differential between firms that import and firms that do not trade internationally; the same holds for exporting. Two-way traders are more productive than firms that either only import, or only export, or do not trade at all. Often, two-way traders are the most productive group of firms, followed by importers and then exporters, while firms selling or buying on the national market come last.

How can this empirical regularity of a positive relationship between importing and productivity at the firm level be explained theoretically? In the literature arguments for both a positive impact of productivity on importing (henceforth, hypothesis H1) and for a positive impact of importing on productivity (henceforth, hypothesis H2) are discussed. While H1 is in accordance with self-selection of more productive firms into import markets, H2 points to productivity-enhancing effects of imports ('learning-by-importing'). Let us consider the arguments in turn.

To start with H1, Kasahara and Lapham (2008) extent the Melitz (2003) model to incorporate imported intermediate goods. In their model, the use of foreign intermediates increases a firm's productivity but, due to fixed costs of importing, only inherently highly productive firms import intermediates. Andersson et al. (2008)

[2] The literature on the micro-econometrics of imports is growing rapidly. We are grateful for any hints to empirical studies not listed here.

[3] Related papers include Tomiura (2007) who looks at productivity differentials between Japanese firms that export, invest abroad, and contract out manufacturing or processing tasks to other firms overseas; Amiti and Konings (2007) who investigate the productivity effects of tariff reductions on final goods and on imported intermediate inputs in Indonesia; and MacGarvie (2006) who, in a study on patent citations, reports differences in labour productivity between exporters and non-exporters, and non-importers and importers, for a sample of French firms.

point out that importing is associated with fixed costs that are sunk costs, because the import agreement is preceded by a search process for potential foreign suppliers, inspection of goods, negotiation, contract formulation etc.. Castellani et al. (2008) argue in a similar way, adding that there are sunk costs of importing due to the learning and acquisition of customs procedures.

As regards H2, Andersson et al. (2008) argue that there are strong arguments in favour of a causal effect of imports on productivity, because by importing a firm can exploit global specialization and use inputs from the forefront of knowledge and technology. They point to the literature on international technology diffusion that advances imports as an important vehicle for knowledge and technology transfer. Furthermore, importing intermediate products allows a firm to focus resources and to specialize on activities where it has particular strengths. Similarly, Castellani et al. (2008) argue that importers may improve productivity by using higher quality foreign inputs or by extracting technology embodied in imported intermediates and capital goods. Altomonte and Békés (2008) point to this 'learning' effect, in which importing firms acquire part of the technology incorporated in the imported goods; furthermore they mention a variety effect (in which the broader range of available intermediates contributes to production efficiency) and a quality effect caused by imported intermediates that might be of better quality than local ones (see also Halpern et al. 2005; Muuls and Pisu 2007). If importing increases productivity, this might lead firms to self-select into export markets and help to improve their success in these markets, which might contribute to an explanation of the empirical regularity that two-way traders are the most productive firms on average (see Andersson et al. 2008).

From a theoretical point of view, therefore, the direction of causality between productivity and importing can run from either sides, or from both sides simultaneously. Only some of the studies mentioned above tackle this issue (or at least a part of it) empirically. In the earliest contribution to this literature Sjöholm (1999) reports some indications of a positive growth effect from imports for his sample of Indonesian firms, but he adds as a caveat that this result is sensitive to changes in the specification of the variables and the test equation. Altomonte and Békés (2008) find that adding a new trade activity—for example, starting to import—has a positive impact on the performance of Hungarian firms. Similarly, Kasahara and Rodrigue (2005) document that switching from being a non-importer to being an importer of foreign intermediates improves productivity in Chilean manufacturing plants, while the inherently more productive plants tend to use imported intermediates. They argue that their findings indicate that the direction of causality between productivity and import status goes both ways.

The bottom line, then, is that we have convincing empirical evidence on a positive relationship between importing and productivity at the level of the firm for a large and growing number of developed and developing countries, while research on the direction of causality between productivity and import status is still in its infancy. Furthermore, none of the very few papers tackling the issue of direction of causality does so by applying the now standard approach used to uncover the direction of causality between productivity and exporting (detailed e. g. in the survey by Wagner 2007a).

## 3 Data

In our empirical investigation we use data from the German Turnover Tax Statistics Panel (described in detail in Vogel and Dittrich 2008). This data set is based on the yearly turnover tax statistics and includes information on more than 4.3 million enterprises from all economic sectors over the time period from 2001 to 2005. All enterprises with a turnover that exceeds a rather low threshold (17,500€ since 2003) are covered in the data.

For our study we focus on enterprises from manufacturing because import and export activities can only be identified for firms from this part of the economy.[4] However, neither exports nor imports are directly recorded in the data set. Regarding exports, the information about 'tax free turnover with input tax deduction' can be used as a proxy. This item contains mainly the exports of goods and some activities of minor importance like gold deliveries to central banks. In addition, exports of goods within the EU (intra-Community deliveries and other performances) are directly included in the data set. Concerning import activities, imports from EU member states are reported under the item of 'intra-Community acquisitions'. The amount of imports from states beyond the EU is not included in the turnover tax statistics. In this case an import turnover tax is charged by the customs authorities. Nonetheless, this import turnover tax is deductible as input tax and therefore reported in the data set. With this information a dummy variable which shows whether the enterprise imports from non-EU states or not can be generated (taking the value 1 if the import turnover tax is greater than 0, and 0 if no import turnover tax is deducted as input tax). Therefore, it is possible to distinguish between four types of enterprises, namely enterprises that both import and export, that only export, that only import, and that neither export nor import.

Productivity is defined as labour productivity, computed as turnover per employee covered by social insurance, because information on the number of employees was matched to the data from the turnover statistics from the German business register, and these figures refer to employees covered by social insurance only. Therefore, we had to drop all enterprises without employees that were liable to pay social insurance. Note that we can not use more appropriate measures of productivity like value added per employee, or total factor productivity, because the information needed to compute these measures are lacking in the data. In our empirical investigation we will control for the industry an enterprise is active in by using information at the detailed 3-digit-industry level to take care of inter-industry variation in capital intensity and the degree of vertical integration. Furthermore, some enterprises reported either tiny or very huge amounts of turnover in some years, leading to tiny or very huge values of labour productivity. Due to data protection rules it is impossible for us to investigate the reasons for these implausible figures, and to discriminate between reporting errors, idiosyncratic events, or other causes. Given that outliers of this kind might influence findings from both descriptive statistics and econometric investigations, enterprises from the

[4] For further details, see Vogel and Dittrich (2008).

**Table 1** Import and export participation of manufacturing enterprises in West and East Germany

| | Share of enterprises (in %) that … | | | | Number of total observations |
|---|---|---|---|---|---|
| | Neither export nor import | Only export | Only import | Both export and import (two-way traders) | |
| West Germany | | | | | |
| 2001 | 54.35 | 10.08 | 11.26 | 24.31 | 135,827 |
| 2002 | 54.07 | 10.10 | 11.19 | 24.64 | 131,941 |
| 2003 | 52.73 | 10.18 | 11.48 | 25.62 | 134,288 |
| 2004 | 51.08 | 10.17 | 11.91 | 26.84 | 132,305 |
| 2005 | 49.97 | 10.07 | 12.47 | 27.49 | 131,170 |
| East Germany | | | | | |
| 2001 | 68.37 | 5.75 | 13.03 | 12.85 | 30,630 |
| 2002 | 67.43 | 6.02 | 13.05 | 13.51 | 29,490 |
| 2003 | 66.14 | 6.00 | 13.43 | 14.43 | 28,718 |
| 2004 | 63.25 | 6.64 | 14.12 | 15.99 | 27,894 |
| 2005 | 61.89 | 7.03 | 14.17 | 16.91 | 27,451 |

*Note*: Only enterprises with one or more employees liable for paying social insurance and a turnover higher than €17,081 in 2001 prices are considered. Tax groups and enterprises with a foreign legal form are excluded from all computations. Data source: German turnover tax statistics panel 2001–2005

bottom and top 1% of the labour productivity distribution were excluded from all computations.

Our empirical study, therefore, is based on information for all German enterprises from the manufacturing sector in the period 2001–2005 that had a turnover that exceeded the (small) tax threshold and that had at least one employee covered by social insurance, excluding very small enterprises that are mostly sole proprietorships. Table 1 reports the share of enterprises that both import and export, that only export, that only import, and that neither export nor import in each year. Given that there are large differences in the participation in international trade between manufacturing firms from West and East Germany[5] results are reported for both parts of Germany separately.

In West Germany about half of all enterprises participated in international trade. Among the trading enterprises, about 50% are two-way traders that both export and import, while the share of firms that only import is somewhat larger than the share of firms that only export. The share of firms that are active on the German market only declined between 2001 and 2005, while both the share of two-way traders and firms that only import increased, and the share of firms that only export remained the same. The picture for East Germany is different. The share of firms that do not participate in international trade is more than 10% points higher than in West Germany, and the share of both two-way traders and firms that only export is much lower in East Germany, while the share of firms that only import is even larger. Over time the share of all kinds of trading firms increased in East Germany.

[5] For a discussion of the difference in export participation see Wagner (2008).

Table 2a, b report how many enterprises changed their status (neither export nor import; only export; only import; both export and import) between the first and the last year covered by our empirical investigation in West and East Germany, respectively. Among the firms that were active in both years the largest group in both parts of Germany is made of firms that did not change their status. This type of stability is most often found among two-way traders. Enterprises that were active in 2001 but not in 2005 are found among all four types. Status changes in and out of one of the four categories can be found in both parts of Germany, but note that switching from no trade to two-way trade (and vice versa) is a rare event. Interestingly, about half of all firms that were not active in 2001 in West Germany, and some 40% of these firms in East Germany, were trading in 2005, with 25.8 and 17.4% of these new firms being two-way traders that might be considered to be 'born globals'.

## 4 Productivity premia for firms in international trade

As a first step in our empirical investigation we compare the four types of enterprises with respect to labour productivity. Results are fully in line with the big picture that emerges from the literature reviewed in Sect. 2 above. For 2005, figures reported in Table 3 for the mean value of labour productivity show a positive link between importing and productivity at the firm level, documented by an unconditional productivity differential between firms that import and firms that do not trade internationally; and the same holds for exporting. Two-way traders are more productive than firms that either only import, or only export, or do not trade at all. In both parts of Germany two-way traders are the most productive group of firms, followed by importers and then exporters, while firms selling on the national market only come last. All these results hold for 2001, too, and *t*-tests show that all these differences in means are statistically different from zero at an error level of 0.01 or better.[6] Note that these statistically significant differences in mean labour productivity are of an economically relevant size if two-way traders or one-way traders are compared to firms that do not trade, and if two-way traders are compared to firms that either only import or only export.[7]

If one looks at differences in the mean value for both groups only, one focuses on just one moment of the productivity distribution. A stricter test that considers all moments is a test for stochastic dominance of the productivity distribution for one group over the productivity distribution for another group. More formally, let $F$ and $G$ denote the cumulative distribution functions of productivity e.g. for importers and non-traders. If $F(x) - G(x) = 0$ means that the two distributions do not differ, and first order stochastic dominance of $F$ relative to $G$ means that $F(z) - G(z)$ must be less than or equal to zero for all values of $z$, with strict inequality for some $z$. Whether this holds or not is tested non-parametrically by

[6] To economize on space results for statistical tests of differences in means (or distributions—see below) are not reported in detailed tables but summarized in the text. Detailed results are available on request.

[7] Note that the levels of labour productivity differ considerably if firms from West and East Germany are compared. This is one reason why all empirical investigations are carried out for the two parts of Germany separately.

**Table 2** Transition matrix of manufacturing enterprises in (A) West Germany 2001/2005, (B) East Germany 2001/2005

| | | Enterprise status in 2005 | | | | | |
|---|---|---|---|---|---|---|---|
| | | Not active in 2005 | Neither export nor import | Only export | Only import | Both export and import (two-way traders) | Total |
| A | | | | | | | |
| Enterprise status in 2001 | Not active in 2001 | – | 19,826 | 3,749 | 4,958 | 9,941 | 38,474 |
| | | | (30.2) | (28.4) | (30.3) | (27.6) | (22.1) |
| | | | [51.5] | [9.7] | [12.9] | [25.8] | [100.0] |
| | Neither export nor import | 25,289 | 39,918 | 2,909 | 4,375 | 1,333 | 73,824 |
| | | (58.6) | (60.9) | (22.0) | (26.8) | (3.7) | (42.4) |
| | | [34.3] | [54.1] | [3.9] | [5.9] | [1.8] | [100.0] |
| | Only export | 4,284 | 2,128 | 4,411 | 493 | 2,377 | 13,693 |
| | | (9.9) | (3.2) | (33.4) | (3.0) | (6.6) | (7.9) |
| | | [31.3] | [15.5] | [32.2] | [3.6] | [17.4] | [100.0] |
| | Only import | 4,650 | 3,048 | 492 | 5,134 | 1,965 | 15,289 |
| | | (10.8) | (4.7) | (3.7) | (31.4) | (5.4) | (8.8) |
| | | [30.4] | [19.9] | [3.2] | [33.6] | [12.9] | [100.0] |
| | Both export and import (two-way trader) | 8,908 | 626 | 1,651 | 1,394 | 20,442 | 33,021 |
| | | (20.7) | (1.0) | (12.5) | (8.5) | (56.7) | (18.9) |
| | | [27.0] | [1.9] | [5.0] | [4.2] | [61.9] | [100.0] |
| | Total | 43,131 | 65,546 | 13,212 | 16,354 | 36,058 | 174,301 |
| | | (100.0) | (100.0) | (100.0) | (100.0) | (100.0) | (100.0) |
| | | [24.7] | [37.6] | [7.6] | [9.4] | [20.7] | [100.0] |
| B | | | | | | | |
| Enterprise status in 2001 | Not active in 2001 | – | 4,859 | 557 | 1,127 | 1,377 | 7,920 |
| | | | (28.6) | (28.9) | (29.0) | (29.7) | (20.5) |
| | | | [61.4] | [7.0] | [14.2] | [17.4] | [100.0] |
| | Neither export nor import | 7,991 | 10,880 | 586 | 1,185 | 300 | 20,942 |
| | | (72.0) | (64.0) | (30.4) | (30.5) | (6.5) | (54.3) |
| | | [38.2] | [52.0] | [2.8] | [5.7] | [1.4] | [100.0] |
| | Only export | 572 | 335 | 480 | 88 | 286 | 1,761 |
| | | (5.2) | (2.0) | (24.9) | (2.3) | (6.2) | (4.6) |
| | | [32.5] | [19.0] | [27.3] | [5.0] | [16.2] | [100.0] |
| | Only import | 1,328 | 811 | 97 | 1,261 | 493 | 3,990 |
| | | (12.0) | (4.8) | (5.0) | (32.4) | (10.6) | (10.4) |
| | | [33.3] | [20.3] | [2.4] | [31.6] | [12.4] | [100.0] |
| | Both export and import (two-way trader) | 1,208 | 104 | 209 | 229 | 2,187 | 3,937 |
| | | (10.9) | (0.6) | (10.8) | (5.9) | (47.1) | (10.2) |
| | | [30.7] | [2.6] | [5.3] | [5.8] | [55.5] | [100.0] |
| | Total | 11,099 | 16,989 | 1,929 | 3,890 | 4,643 | 38,550 |
| | | (100.0) | (100.0) | (100.0) | (100.0) | (100.0) | (100.0) |
| | | [28.8] | [44.1] | [5.0] | [10.1] | [12.0] | [100.0] |

*Note*: Reported are the number of cases, the column percentages in parenthesis (), and the row percentages in brackets [ ]. Only enterprises with one or more employees liable for paying social insurance and a turnover higher than €17,081 in 2001 prices are considered. Tax groups and enterprises with a foreign legal form are excluded from all computations. Data source: German turnover tax statistics panel 2001–2005

**Table 3** Comparison of internationally active and non-active manufacturing enterprises in West and East Germany in 2005

| | Labour productivity | | Number of employees liable to pay social insurance | |
|---|---|---|---|---|
| | Mean (in € 1,000) | Index (in %) | Mean | Index (in %) |
| West Germany | | | | |
| All enterprises | 143.1 | 100.0 | 25.5 | 100.0 |
| Enterprises that … | | | | |
| Neither export nor import | 110.7 | 85.8 | 6.2 | 41.7 |
| Only export | 141.0 | 98.4 | 11.1 | 59.6 |
| Only import | 145.5 | 101.5 | 12.7 | 77.6 |
| Both export and import | 199.8 | 125.9 | 72.0 | 232.2 |
| East Germany | | | | |
| All enterprises | 91.4 | 100.0 | 16.3 | 100.0 |
| Enterprises that … | | | | |
| Neither export nor import | 76.6 | 90.5 | 6.9 | 53.5 |
| Only export | 99.7 | 99.2 | 14.4 | 96.0 |
| Only import | 105.1 | 109.3 | 15.2 | 107.5 |
| Both export and import | 131.1 | 127.9 | 52.9 | 268.8 |

*Note*: The index is computed as the percentage difference of the respective variable in an enterprise compared to the average value of all enterprises from the same 3-digit industry. Only enterprises with one or more employees liable for paying social insurance and a turnover higher than €17,081 in 2001 prices are considered. Tax groups, enterprises with a foreign legal form and the 1st and the 99th percentiles of the labour productivity distribution are excluded from all computations. Data source: German turnover tax statistics panel 2001–2005

adopting the Kolmogorov–Smirnov test.[8] Here six Kolmogorov–Smirnov tests were performed, comparing the productivity distribution of neither exporting nor importing enterprises versus only exporters, neither exporting nor importing enterprises versus only importers, neither exporting nor importing enterprises versus two-way traders, only exporters versus two-way traders, only exporters versus only importers, and only importers versus two-way traders.

Given that enterprises from the four groups compared are from different industries with different values of average labour productivity (due to, e.g., differences in capital intensity), and that trading and non-trading, exporting and importing enterprises are not evenly distributed among the different industries, we control for these inter-industry differences by not using the unconditional labour productivity. Instead, we use an index that is computed as the percentage difference of labour productivity in an enterprise compared to the average value of all enterprises from the same 3-digit industry. For both West Germany and East Germany, and for both years, the Kolmogorov–Smirnov test indicates (at an error level of 0.01 or smaller) that the distributions do differ, and that the distribution for firms that participate in international trade first-order stochastically dominates the

[8] This method has been used to discuss the issue of exports and productivity for the first time by Delgado et al. (2002).

distribution for non-traders. The hierarchy of distributions is the same as the one found for the mean values of the unconditional labour productivity.

Table 3 shows that the firms from the four groups differ in size (measured by the number of employees covered by social insurance), too. In both West and East Germany enterprises that do not participate in international trade at all are on average smaller than firms that trade. Among the trading firms those that only export are smaller than those that only import, while the two-way traders are much larger on average than enterprises from both other groups of trading firms. *T*-tests and Kolmogorov–Smirnov test again show that all these differences are statistically different from zero at an error level of 0.01 or smaller for the unconditional mean values of firm size and the whole distributions of the number of employees conditional on the 3-digit industries.

These descriptive findings for Germany fit into the big picture that emerges from the literature reviewed in Sect. 2. The next step in our empirical investigation is a test for the existence or not of so-called trader premia, defined as the ceteris paribus percentage difference of labour productivity between enterprises from the four groups. This is motivated by the fact that firms with different forms of participation in international trade tend to differ in size (as demonstrated above) and might be concentrated in different industries. Therefore, e.g., a positive unconditional productivity differential in favour of two-way traders compared to firms that do not trade at all comes at no (or only a small) surprise. The question is whether or not this differential exists if other factors related to productivity are controlled for. To test for these trader productivity premia log labour productivity is regressed on three dummy variables indicating whether or not an enterprise exports only, imports only, or is a two-way trader (using the enterprises that do not trade at all as the reference group). The empirical model is estimated using pooled data from the years 2001 to 2005. As control variables the number of employees and its squared value and a full set of interaction terms of dummies for each year and each 3-digit-industry are included in the model. The year-industry interaction terms control for time and industry specific effects like variations in output prices and labour costs (see Lichtenberg 1988, p. 425). The empirical model is specified as follows:

$$\ln \mathrm{LP}_{it} = a + ß_1\,\text{Ex-only}_{it} + ß_2\,\text{Im-only}_{it} + ß_3\text{Im-and-Ex}_{it} + c\,\text{Control}_{it} + e_{it} \quad (1)$$

where $i$ is the index of the enterprise, $t$ it the index of the year, LP is labour productivity, Ex-only and Im-only are dummy variables for enterprises that only export and only import in year $t$, and Im-and-Ex is a dummy variable for two-way traders in $t$. Control is the vector of control variables, and $e$ is an error term. The trader premium, computed from the estimated coefficient ß as $100(\exp(ß) - 1)$, shows the average percentage difference in labour productivity between an enterprise from the respective group of trading firms and the non-trading enterprises, controlling for the characteristics included in the vector Control.[9]

[9] Note that the regression equation specified in (1) is not meant to be an empirical model to explain labour productivity at the firm level; the data set at hand here is not rich enough for such an exercise. Equation (1) is just a vehicle to test for, and estimate the size of, trader premia controlling for other firm characteristics that are in the data set. 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).

To demonstrate the importance of distinguishing four different groups of firms according to their involvement in international trade instead of only looking at exporting versus non-exporting firms when productivity differences between internationally active and non-active firms are investigated a variant of the model (1) is estimated that includes a dummy variable that takes the value 1 if a firm is an exporter (and 0 otherwise), completely ignoring any import activities. This is a model that is a workhorse in the empirical literature on exports and productivity (surveyed in Wagner 2007a).

To control for unobserved plant heterogeneity due to time-invariant firm characteristics which might be correlated with the variables included in the empirical model and which might lead to a biased estimate of the trader premia, (1) is estimated using pooled data for the years 2001–2005 and including fixed enterprise effects, too.

Results are reported in Table 4. All estimated productivity premia for firms that engage in international trade are highly statistically significant and often large from an economic point of view. Controlling for fixed enterprise effects[10] reduces the estimated premia considerably, pointing to the role of unobserved heterogeneity and the importance of enterprise specific factors that are both important for productivity and correlated with international activities of firms, and that lead to biased estimates of trade premia in the pooled regressions. From the results for model 1 with fixed enterprise effects we see that the premia are about the same in West and East Germany. Two-way traders do have the highest premia, followed by firms that only export, while firms that only import have the smallest estimated premia. This hierarchy differs from the picture painted by the descriptive evidence reported in Sect. 3 where it was found that firms that only import are more productive than firms that only export. A comparison of the exporter premia estimated in model 2 with the premia for firms that export only and firms that both export and import estimated in model 1 demonstrates that it is important to consider import activities, too, even if one is interested in the relationship between exports and productivity only. In part the exporter premium estimated in model 2 here is an importer premium.

## 5 Do more productive firms self-select into importing?

Descriptive evidence reported in Sect. 3 and evidence from a panel-econometric study presented in Sect. 4 show a positive relationship between importing and productivity at the firm level for West and East German manufacturing enterprises. This finding is in accordance with results for other countries reviewed above. As discussed in the literature survey in Sect. 2 one hypothesis to explain this stylized fact is that causality runs from productivity to imports, and that more productive firms self-select into import activities. To shed light on the empirical validity of the

[10] Due to limitations concerning the size of main memory available on the computers in the research data centre, it was not possible to estimate the fixed effects model with all West German enterprises. Therefore, the mean number of observations, the mean coefficients, and the mean *p*-values of five 30% random samples are reported. A documentation of the results for the five random samples can be found in Table 11 in the Appendix.

**Table 4** Export and import productivity premia in manufacturing enterprises in West and East Germany (2001–2005)

| | Estimation of the log labour productivity in $t$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | West Germany | | | | East Germany | | | |
| | Pooled regression | | Fixed effects* | | Pooled regression | | Fixed effects | |
| | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Exporter dummy$_t$ | – | 36.7 | – | 5.25 | – | 26.8 | – | 5.7 |
| | | (0.00) | | (0.00) | | (0.00) | | (0.00) |
| Only export dummy$_t$ (ß1) | 18.9 | – | 4.17 | – | 12.3 | – | 4.6 | – |
| | (0.00) | | (0.00) | | (0.00) | | (0.00) | |
| Only import dummy$_t$ (ß2) | 22.3 | – | 2.31 | – | 25.6 | – | 3.8 | – |
| | (0.00) | | (0.00) | | (0.00) | | (0.00) | |
| Two-way trader dummy$_t$ (ß3) | 55.8 | – | 8.79 | – | 47.8 | – | 10.4 | – |
| | (0.00) | | (0.00) | | (0.00) | | (0.00) | |
| Number of observations | 652,219 | | 195,623 | | 141,299 | | 141,299 | |

*Note:* Reported are the estimated regression coefficients and the $p$-values (in parentheses) from two estimations of the log labour productivity at $t$. Model 1 contains an only export, an only import and a two-way trader dummy. ß1 is the average percentage productivity difference between exporters and non-exporters among enterprises that do not import. ß2 is the average percentage difference between importers and non-importers among non-exporters. ß3 is the average percentage difference between importer-exporters and enterprises that do neither export nor import. Model 2 contains an exporter dummy that shows the average percentage productivity difference between exporters and non-exporters. To facilitate the interpretation, the estimated coefficients of the dummy variables are transformed by $100(\exp(ß) - 1)$. Both models include the number of employees and its squared value, and a full set of interaction terms of year dummy variables and dummy variables for 3-digit level industries. Only enterprises with one or more employees liable for paying social insurance and a turnover higher than €17,081 in 2001 prices are considered. Tax groups, enterprises with a foreign legal form and from the 1st and the 99th percentiles of the labour productivity distribution are excluded from all computations. Data source: German turnover tax statistics panel 2001–2005

* Due to limitations concerning the size of main memory available on the computers in the research data centre, it was not possible to estimate the fixed effects model with all West German enterprises. Therefore, the mean number of observations, the mean coefficients, and the mean $p$-values of five 30% random samples are reported. A documentation of the results for the five samples can be found in Table 11 in the Appendix

hypothesis that the more productive firms go abroad and import the pre-entry differences in productivity between import starters and non-importers are investigated next.

If more productive firms become importers then we should expect to find significant differences in productivity between future import starters and future non-starters several years before some of them begin to import. A way to test whether today's import starters were more productive than today's non-importers several years back when all of them did not import is to select all firms that did not import between year $t - 3$ and $t - 1$, and compute the average difference in labour productivity in year $t - 3$ between those firms who did import in year $t$ and those who did not. Note that some of the firms labelled "import starters" might have

imported several years earlier, stopped to import then, and started again at time $t$. Unfortunately, the panel used here is not long enough to identify these "re-starters". The data set we use in this empirical investigation covers the years 2001–2005. Therefore we can look at two cohorts of import starters—firms that start to import in 2005 (where $t - 3$ corresponds to 2002, and $t$ to 2005) and firms that start to import in 2004 (where $t - 3$ is equal to 2001 and $t$ to 2004). Furthermore, we can on the one hand compare firms that did not trade internationally at all between $t - 3$ and $t - 1$ and that start to import in $t$ with firms that did not trade at all between $t - 3$ and $t$, and on the other hand firms that exported but not imported between $t - 3$ and $t - 1$ and start to import in $t$ with firms that exported but not imported between $t - 3$ and $t$.

If one looks at differences in the mean value for both groups only, one focuses on just one moment of the productivity distribution. A stricter way that considers all moments is to test for a difference in the distribution, and for stochastic dominance of the productivity distribution for future importers over the productivity distribution for future non-importers, and to apply the Kolmogorov–Smirnov test (discussed in more detail in Sect. 4 above) to the data for year $t - 3$ (using, like in Sect. 4, an index that is computed as the percentage difference of labour productivity in an enterprise compared to the average value of all enterprises from the same 3-digit industry).

Results reported in Table 5a (for import starters in 2005) and Table 5b (for import starters in 2004) indicate self-selection of more productive (and larger) enterprises into import activities. Regardless of the start year $t$, the part of Germany, and the definition of starters and the reference group, on average the future importers were more productive and had a larger number of employees than the future non-importers 3 years before starting to import. If firms that did not trade internationally at all between $t - 3$ and $t - 1$ and that start to import in $t$ are compared with firms that did not trade at all between $t - 3$ and $t$, at an error level of 0.01 or less these average differences are statistically significantly different from zero according to $t$-tests, and the distribution of import starters stochastically dominates the distribution of non-starters. If firms that exported but not imported between $t - 3$ and $t - 1$ and start to import in $t$ are compared with firms that exported but not imported between $t - 3$ and $t$, the picture is different—the differences in productivity are never statistically significant at a usual error level, and the same holds for differences in the number of employees in East Germany.

Furthermore, labour productivity premia of future importers compared to future non-importers were estimated controlling for plant size and industry affiliation by estimating the empirical model

$$\ln \mathrm{LP}_{it-3} = a + ß\,\mathrm{Import}_{it} + c\,\mathrm{Control}_{it-3} + e_{it} \qquad (2)$$

where $i$ is the index of the firm, $t$ is the index of the year, LP is labour productivity in year $t - 3$, Import is a dummy variable for current import status (1 if the firm imports in year $t$, 0 else), Control is a vector of control variables (the number of employees—also included in squares—and 3-digit industry dummies), and $e$ is an error term. The pre-entry premium, computed from the estimated coefficient ß as

**Table 5** Import starters versus non-starters in West and East Germany in 2005 and 2004

| | Labour productivity in 2002 | | Number of employees liable to pay social insurance in 2002 | | Number of cases |
|---|---|---|---|---|---|
| | Mean (in €1,000) | Index (in %) | Mean | Index (in %) | |
| In 2005 | | | | | |
| West Germany | | | | | |
| Non-trading enterprises that start to import in 2005 | 112.0 | 103.8 | 9.6 | 149.3 | 2,122 |
| Enterprises that neither export nor import between 2002 and 2005 | 102.6 | 99.8 | 6.2 | 97.7 | 44,566 |
| Exporters that start to import in 2005 | 151.9 | 103.1 | 15.2 | 118.2 | 666 |
| Enterprises that only export between 2002 and 2005 | 150.2 | 99.4 | 13.2 | 96.7 | 3,702 |
| East Germany | | | | | |
| Non-trading enterprises that start to import in 2005 | 88.5 | 111.4 | 10.0 | 155.0 | 606 |
| Enterprises that neither export nor import between 2002 and 2005 | 71.2 | 99.5 | 6.7 | 97.4 | 12,614 |
| Exporters that start to import in 2005 | 112.9 | 105.8 | 21.2 | 112.2 | 87 |
| Enterprises that only export between 2002 and 2005 | 94.5 | 98.7 | 15.0 | 97.2 | 380 |
| | Labour productivity in 2001 | | Number of employees liable to pay social insurance in 2001 | | Number of cases |
| | Mean (in €1,000) | Index (in %) | Mean | Index (in %) | |
| In 2004 | | | | | |
| West Germany | | | | | |
| Non-trading enterprises that start to import in 2004 | 118.9 | 106.5 | 8.5 | 140.9 | 2,033 |
| Enterprises that neither export nor import between 2001 and 2004 | 106.7 | 99.7 | 6.4 | 98.2 | 46,932 |
| Exporters that start to import in 2004 | 154.1 | 101.6 | 17.0 | 125.4 | 673 |
| Enterprises that only export between 2001 and 2004 | 152.3 | 99.7 | 13.6 | 95.7 | 3,945 |
| East Germany | | | | | |
| Non-trading enterprises that start to import in 2004 | 85.6 | 108.8 | 11.9 | 165.7 | 629 |
| Enterprises that neither export nor import between 2001 and 2004 | 73.6 | 99.6 | 6.9 | 96.9 | 13,483 |
| Exporters that start to import in 2004 | 116.5 | 106.0 | 17.1 | 113.0 | 65 |
| Enterprises that only export between 2001 and 2004 | 97.4 | 99.0 | 15.6 | 97.8 | 393 |

*Note:* The index is computed as the percentage difference of the respective variable in an enterprise compared to the average value of all enterprises from the same 3-digit industry. Only enterprises with one or more employees liable for paying social insurance and a turnover higher than €17,081 in 2001 prices are considered. Tax groups, enterprises with a foreign legal form and the 1st and the 99th percentiles of the labour productivity distribution are excluded from all computations. Data source: German turnover tax statistics panel 2001–2005

**Table 6** Self-selection into import markets of manufacturing enterprises in West and East Germany

| | OLS estimation of the log labour productivity in $t-3$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | West Germany | | | | East Germany | | | |
| | $t=2004$ | | $t=2005$ | | $t=2004$ | | $t=2005$ | |
| | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Non-trader that starts to import in $t$ (dummy) | 10.4 (0.00) | – | 7.3 (0.00) | – | 14.4 (0.00) | – | 14.1 (0.00) | – |
| Exporter that starts to import in $t$ (dummy) | – | 4.7 (0.06) | – | 8.4 (0.00) | – | 9.3 (0.30) | – | 11.0 (0.20) |
| Number of observations | 48,965 | 4,618 | 46,688 | 4,368 | 14,112 | 458 | 13,220 | 467 |

*Note:* Reported are the estimated regression coefficients and the *p*-values (in parentheses) from the OLS estimation of the log labour productivity at $t-3$. To facilitate the interpretation, the estimated coefficient for the export dummy has been transformed by 100(exp(ß) − 1). In model 1 the transformed coefficient shows the average percentage productivity difference at $t-3$ between import starters at $t$ and enterprises with no international activities over the whole period (year $t-3$ to $t$). In model 2 the transformed coefficient shows the average percentage productivity difference at $t-3$ between exporters that start to import at $t$ and exporters that do not start to import. Both models include the number of employees and its squared value, and a full set of dummy variables for 3-digit level industries. Only enterprises with one or more employees liable for paying social insurance and a turnover higher than €17,081 in 2001 prices are considered. Tax groups, enterprises with a foreign legal form and the 1st and the 99th percentiles of the labour productivity distribution are excluded from all computations. Data source: German turnover tax statistics panel 2001–2005

100(exp(ß) − 1), shows the average percentage difference between today's importers and today's non-importers 3 years before starting to import, controlling for the characteristics included in the vector Control.

Results are reported in Table 6. In model 1 the coefficient shows the average percentage productivity difference at $t-3$ between import starters at $t$ and enterprises with no international activities over the whole period (year $t-3$ to $t$). In model 2 the coefficient shows the average percentage productivity difference at $t-3$ between exporters that start to import at $t$ and exporters that do not start to import. All point estimates are positive, and larger for East than for West Germany. In both parts of Germany the pre-entry productivity premia of import starters are statistically different from zero at a usual error level, and large from an economic point of view, when non-traders that start to import in $t$ are compared to firms that do not trade at all over the whole period. For exporters that start to import in $t$ compared to exporters that do not import over the whole period this is only the case in West Germany. Note, however, that the number of import starters from this group is small in East Germany (65 and 87 firms in the starter cohort 2004 and 2005, respectively; see Table 5a, b), and this may cause an imprecisely estimated regression coefficient.

The bottom line, then, is that for German manufacturing firms we find evidence in favour of H1—a positive impact of productivity on importing.

## 6 Do import starters become more productive?

The second hypothesis why importers can be expected to be more productive than their counterparts that buy intermediate inputs on the domestic market only points to the role of learning-by-importing. As is argued in Sect. 2, an importing firm can exploit global specialization and use inputs from the forefront of knowledge and technology. Imports, therefore, can act as an important vehicle for knowledge and technology transfer. Furthermore, importing intermediate products allows a firm to focus resources and to specialize on activities where it has particular strengths.

The possible causal effect of imports on productivity can be divided in two effects: First, a continuous learning effect that improves the post-entry performance of import starters. This "dynamic" effect could be caused by, for example, knowledge flows from international sellers and competitors as well as continuous knowledge and technology transfer. Second, one could expect that starting to import raise immediately the productivity level of the firm. Such a static level effect could be explained, for example, by inputs of better quality or cheaper inputs from abroad that are used immediately in the production process. Below both effects are investigated empirically. Section 6.1 analyses the dynamic and Sect. 6.2 the static effect of imports on productivity.

### 6.1 Dynamic effect of imports on the pre-entry productivity growth

If importing improves the post-entry productivity growth then we should expect to find significant differences in the rate of growth of labour productivity between import starters and firms that continue to buy intermediate inputs on the national market only during the years after the start. This hypothesis is tested by looking at the growth rate of labour productivity over the period 2004–2005 for a cohort of import starters in 2003 compared to the growth performance of non-importers over the same period. Furthermore, for the period 2004–2005 the performance of exporters that start to import in 2003 is compared to the performance of firms that only export between 2001 and 2005.

Results are reported in Table 7. On average, the productivity growth performance of import starters from both groups was better compared to non-importers in West Germany, and the same holds for the growth of the number of employees. The big picture is the same for East Germany except for productivity growth in import starters compared to non-trading firms. All these post-entry performance differences, however, are never statistically different from zero at an error level of 5% using *t*-tests or Kolmogorov–Smirnov tests.

Furthermore, differences in productivity growth between import starters and non-importers are investigated based on the empirical model

$$\ln \mathrm{LP}_{it+2} - \ln \mathrm{LP}_{it+1} = a + ß\,\mathrm{Start}_{it} + c\,\mathrm{Control}_{it} + e_{it} \qquad (3)$$

where $i$ is the index of the firm, $t$ is the index of the year, LP is labour productivity, Start is a dummy variable for import starters (1 if the firm starts to import in year $t$, 0 else), Control is a vector of control variables (the number of employees—also included in squares—and 3-digit industry dummies), and $e$ is an error term. Results

**Table 7** Growth rates of import starters and non-starters in West and East Germany

| | Growth rates of labour productivity between 2004 and 2005 | | Growth rates of employees liable to pay social insurance between 2004 and 2005 | | Number of cases |
|---|---|---|---|---|---|
| | Mean (in %) | Index (in %) | Mean (in %) | Index (in %) | |
| West Germany | | | | | |
| Non-trading enterprises that start to import in 2003 | 4.4 | 100.7 | 2.0 | 101.2 | 607 |
| Enterprises that neither export nor import between 2001 and 2005 | 3.9 | 99.9 | 0.4 | 100.0 | 36,255 |
| Exporters that start to import in 2003 | 4.7 | 101.2 | 1.7 | 101.2 | 385 |
| Enterprises that only export between 2001 and 2005 | 3.1 | 99.8 | −0.2 | 99.8 | 2,757 |
| East Germany | | | | | |
| Non-trading enterprises that start to import in 2003 | 7.3 | 98.5 | 1.9 | 102.2 | 116 |
| Enterprises that neither export nor import between 2001 and 2005 | 7.4 | 100.0 | −0.5 | 100.0 | 9,690 |
| Exporters that start to import in 2003 | 8.7 | 101.4 | 7.3 | 105.5 | 49 |
| Enterprises that only export between 2001 and 2005 | 2.4 | 99.7 | 1.5 | 99.0 | 266 |

*Note:* The index is computed as the percentage difference of the respective growth rate in an enterprise compared to the average growth rate of all enterprises from the same 3-digit industry. Only enterprises with one or more employees liable for paying social insurance and a turnover higher than €17,081 in 2001 prices are considered. Tax groups, enterprises with a foreign legal form and the 1st and the 99th percentiles of the labour productivity distribution are excluded from all computations. Data source: German turnover tax statistics panel 2001–2005

are reported in Table 8. To facilitate interpretation, the estimated coefficient for the starter-dummy has been transformed by $100(\exp(ß) - 1)$. In model 1 the transformed coefficient shows the average productivity growth premium of import starters in 2003 compared to enterprises with no international activities 2 years after starting to import. In model 2 the transformed coefficient shows the average productivity growth premium of exporters that start to import in 2003 compared to enterprises that only export over the whole period 2 years after starting to import. While the point estimates of three out of four regression coefficients are positive, none is statistically different from zero at a conventional level of significance. Therefore, again we have no evidence for learning-by-importing. Note, however, that the number of import starters is small in East Germany (see Table 7), and this may cause imprecisely estimated regression coefficients.

In line with a recent development in the literature on the impact of exporting on productivity an alternative approach to test for productivity enhancing effects of starting to import is applied next. To motivate this approach, consider the following situation: Assume that a study reports that plants entering the import market have substantially faster productivity growth in the following years than firms that keep

**Table 8** Learning-by-importing in manufacturing enterprises in West and East Germany

| | OLS estimation of growth of labour productivity (log labour productivity$_{t+2}$ − log labour productivity$_{t+1}$) | | | |
|---|---|---|---|---|
| | West Germany | | East Germany | |
| | 1 | 2 | 1 | 2 |
| $t = 2003$ | | | | |
| Non-trading enterprise that starts to import in $t$ (dummy) | 1.2 | | −2.8 | |
| | (0.33) | | (0.40) | |
| Exporter that starts to import in $t$ (dummy) | | 1.9 | | 3.0 |
| | | (0.18) | | (0.51) |
| Number of observations | 36,862 | 3,142 | 9,806 | 315 |

*Note:* Reported are the estimated regression coefficients and the $p$-values (in parentheses) from the OLS estimation of log labour productivity in 2005 minus log labour productivity in 2004. To facilitate interpretation the estimated coefficient for the starter-dummy has been transformed by 100(exp(ß)−1). In model 1 the transformed coefficient shows the average productivity growth premium of import starters in 2003 compared to enterprises with no international activities 2 years after starting to import. In model 2 the transformed coefficient shows the average productivity growth premium of exporters that start to import in 2003 compared to enterprises that only export over the whole period 2 years after starting to import. Both models include the number of employees and its squared value plus a full set of 3-digit industry dummy variables. Only enterprises with one or more employees liable for paying social insurance and a turnover higher than €17,081 in 2001 prices are considered. Tax groups, enterprises with a foreign legal form and the 1st and the 99th percentiles of the labour productivity growth rate distribution are excluded from all computations. Data source: German turnover tax statistics panel 2001–2005

buying intermediate inputs on the domestic market only. Does this point to a causal effect of starting to import on productivity? The answer is, obviously, no: If better firms self-select into import-starting, and if, therefore, today's import starters are 'better' than today's non-importers (and have been so in the recent past), we would expect that they should, on average, perform better in the future even if they do not start to import today. However, we cannot observe whether they would really do so because they do start to import today; we simply have no data for the counterfactual situation. So how can we be sure that the better performance of starters compared to non-importers is caused by importing (or not)? This closely resembles a situation familiar from the evaluation of active labour market programs (or any other form of treatment of units): If participants, or treated units, are not selected randomly from a population but are selected or self-select according to certain criteria, the effect of a treatment cannot be evaluated by comparing the average performance of the treated and the non-treated. However, given that each unit (plant, or person, etc.) either participated or not, we have no information about its performance in the counterfactual situation. A way out is to construct a control group in such a way that every treated unit is matched to an untreated unit that has been as similar as possible (ideally, identical) at the time before the treatment. Differences between the two groups (the treated, and the matched non-treated) after the treatment can then be attributed to the treatment (for a comprehensive discussion, see Heckman et al. 1999).

The use of a matching approach to search for effects of starting to export on productivity (and other dimensions of firm performance) has been pioneered by

Wagner (2002), and it has been used in a growing number of empirical studies (surveyed in Wagner 2007a) ever since. Here, import starters in 2003 were matched with "twins" from the large group on non-importers based on characteristics of the enterprises in 2002 (the year before the starters start),[11] and the difference in the average rate of growth of labour productivity over the period 2004–2005 between import starters and matched non-importers is computed. This difference is the so-called average treatment effect on the treated, or ATT, the estimated effect of import start on the growth of labour productivity (see Wagner (2002) for a discussion of this method).

Results are reported in Table 9. The big picture arising from comparing import starters with matched non-importers is the same as the one sketched above based on the comparison of import starters and all non-importers. The estimated ATT is positive for three out of four cases, but it is statistically significantly different from zero (and negative) for East Germany only when non-trading enterprises that start to import in 2003 are compared to matched enterprises that do not trade at all. Therefore, from the matching approach we have no evidence in favour of the learning-by-importing hypothesis for German manufacturing enterprises.

### 6.2 Static effect of imports on the productivity level

To capture the static effect of imports on the productivity level we compare the productivity levels before and after the import start of two cohorts of import starters (start year $t$: 2003 and 2004). However, again we would need information about the counterfactual situation to be sure that the level differences are due to the start of importing. Therefore, in line with Sect. 6.1 import starters in 2003 and 2004 were matched with "twins" from the group of non-importers based on characteristics of the firms in the year before the starters start to import.[12] Then the level difference that is caused by the import start (average treatment effect on the treated) is computed by comparing the average rate of growth of labour productivity over the period $t-1$ to $t$ as well as $t-1$ to $t+1$ between import starters and matched non-importers. Following the previous sections we compare in addition the growth rates

[11] Matching was done by nearest neighbours propensity score matching. The propensity score was estimated from a probit regression of a dummy variable indicating whether or not a firm is an import starter in 2003 on the log of labour productivity, number of employees, and 3-digit industry dummy variables (all measured in year 2002) plus the rate of growth of labour productivity in the years 2001–2002. The balancing property (that requires an absence of statistically significant differences between the treatment group and the control group in the covariates after matching) is satisfied. The difference in means of the variables used to compute the propensity score were never statistically significant between the starters and the matched non-starters. The common support condition (that requires that the propensity score of a treated observation is neither higher than the maximum nor less than the minimum propensity score of the controls) was imposed by dropping import starters (treated observations) whose propensity score is higher than the maximum or lower than the minimum propensity score of the non-importers (the controls). Matching was done using Stata 10 and the psmatch2 command (version 3.0.0), see Leuven and Sianesi (2003). The results of the probit estimates used in the matching are available on request.

[12] The propensity score was estimated from a probit regression of a dummy variable indicating whether or not a firm is an import starter in t (2003 or 2004 respectively) on the log of labour productivity, number of employees, and 3-digit industry dummy variables (all measured in year $t-1$) plus the rate of growth of labour productivity in the years $t-2$ to $t-1$.

**Table 9** Growth rates of matched import starters and non-starters in West and East Germany—dynamic effect of imports on productivity

| | Growth of labour productivity between 2004 and 2005 | | | |
|---|---|---|---|---|
| | Mean (in %) | ATT | Bootstrapped *p*-value | Observations (treated) |
| West Germany | | | | |
| Non-trading enterprises that start to import in 2003 | 4.6 | 1.8 | 0.449 | 517 |
| Matched enterprises that neither export nor import between 2001 and 2005 | 2.7 | | | |
| Exporters that start to import in 2003 | 4.7 | 3.1 | 0.224 | 343 |
| Matched enterprises that only export between 2001 and 2005 | 1.6 | | | |
| East Germany | | | | |
| Non-trading enterprises that start to import in 2003 | 5.3 | −15.8 | 0.047 | 102 |
| Matched enterprises that neither export nor import between 2001 and 2005 | 21.1 | | | |
| Exporters that start to import in 2003 | 13.0 | 12.2 | 0.096 | 35 |
| Matched enterprises that only export between 2001 and 2005 | 0.7 | | | |

*Note:* Reported are the mean labour productivity growth rates of the treated and the matched control groups, the average treatment effects (ATT) as well as the bootstrapped (1,000 replications) *p*-values that indicates the statistical significance of the ATT. Matching was done by nearest neighbours propensity score matching. The propensity score was estimated from a probit regression of the import starter dummies on the log of labour productivity, number of employees, and a set of 3-digit industry dummy variables (all measured in 2002) plus the rate of growth of labour productivity between 2001 and 2002. The common support condition was imposed by dropping import starters (treated observations) whose propensity score was higher than the maximum or lower than the minimum propensity score of the control group. Only enterprises with one or more employees liable for paying social insurance and a turnover higher than €17,081 in 2001 prices are considered. Tax groups, enterprises with a foreign legal form and the 1st and the 99th percentiles of the labour productivity growth rate distribution are excluded from all computations. Data source: German turnover tax statistics panel 2001–2005. The matching was done using Stata 10 and the psmatch2 command (version 3.0.0), see Leuven and Sianesi (2003)

over the period $t-1$ to $t$ as well as $t-1$ to $t+1$ between exporters that start to import in $t$ with the growth rates of firms that only export in all periods.

Results for the cohort of import starters 2003 are reported in Table 10a and for the cohort of import starters 2004 in Table 10b. Overall, the results are somewhat mixed: In five of the 16 cases the estimated ATT is negative but not significant, in seven cases the ATT is positive but not significant, and in four cases a significant positive (at least at a weak significance level) estimated ATT is found. Therefore, the evidence concerning a static effect of imports on productivity is not clear.[13]

[13] Descriptive mean comparisons as well as OLS estimations of the growth of labour productivity in the above mentioned time periods on import starter dummies confirm the big picture of unclear evidence. The results are available on request.

**Table 10** Growth rates of matched import starters and non-starters in West and East Germany 2003 (A) and 2004 (B)—static effect of imports on productivity

| | Growth of labour productivity between 2002 and 2003 | | | Growth of labour productivity between 2002 and 2004 | | | Number of cases (treated) |
|---|---|---|---|---|---|---|---|
| | Mean (in %) | ATT | *p*-value | Mean (in %) | ATT | *p*-value | |
| A | | | | | | | |
| West Germany | | | | | | | |
| Non-trading enterprises that start to import in 2003 | 5.3 | 1.9 | 0.279 | 3.4 | −0.3 | 0.905 | 798 |
| Matched enterprises that neither export nor import between 2001 and 2004 | 3.4 | | | 3.7 | | | |
| Exporters that start to import in 2003 | 5.6 | 3.2 | 0.126 | 11.6 | 5.4 | 0.068 | 497 |
| Matched enterprises that only export between 2001 and 2004 | 2.3 | | | 6.2 | | | |
| East Germany | | | | | | | |
| Non-trading enterprises that start to import in 2003 | 10.2 | 3.0 | 0.449 | 9.6 | 7.5 | 0.127 | 194 |
| Matched enterprises that neither export nor import between 2001 and 2004 | 7.2 | | | 2.1 | | | |
| Exporters that start to import in 2003 | 6.5 | 6.3 | 0.248 | 3.2 | −6.1 | 0.388 | 61 |
| Matched enterprises that only export between 2001 and 2004 | 0.2 | | | 9.4 | | | |
| | Growth of labour productivity between 2003 and 2004 | | | Growth of labour productivity between 2003 and 2005 | | | Number of cases (treated) |
| | Mean (in %) | ATT | *p*-value | Mean (in %) | ATT | *p*-value | |
| B | | | | | | | |
| West Germany | | | | | | | |
| Non-trading enterprises that start to import in 2004 | 3.4 | 2.1 | 0.223 | 4.9 | 5.3 | 0.011 | 925 |
| Matched enterprises that neither export nor import between 2002 and 2005 | 1.3 | | | −0.4 | | | |
| Exporters that start to import in 2004 | 4.5 | −1.6 | 0.471 | 6.6 | 1.5 | 0.548 | 548 |
| Matched enterprises that only export between 2002 and 2005 | 6.1 | | | 5.1 | | | |
| East Germany | | | | | | | |
| Non-trading enterprises that start to import in 2004 | 3.4 | 6.1 | 0.047 | 8.1 | 8.7 | 0.011 | 314 |
| Matched enterprises that neither export nor import between 2002 and 2005 | −2.8 | | | −0.6 | | | |
| Exporters that start to import in 2004 | 4.0 | −2.1 | 0.748 | 10.7 | −3.9 | 0.668 | 68 |

**Table 10** continued

| | Growth of labour productivity between 2003 and 2004 | | | Growth of labour productivity between 2003 and 2005 | | | Number of cases (treated) |
|---|---|---|---|---|---|---|---|
| | Mean (in %) | ATT | *p*-value | Mean (in %) | ATT | *p*-value | |
| Matched enterprises that only export between 2002 and 2005 | 6.1 | | | 14.6 | | | |

*Note* (footnote for A)*:* Reported are the mean labour productivity growth rates of the treated and the matched control groups, the average treatment effects (ATT) as well as the bootstrapped (1,000 replications) *p*-values that indicate the statistical significance of the ATT. Matching was done by nearest neighbours propensity score matching. The propensity score was estimated from a probit regression of the import starter dummies on the log of labour productivity, number of employees, and a set of 3-digit industry dummy variables (all measured in 2002) plus the rate of growth of labour productivity between 2002 and 2004. The common support condition was imposed by dropping import starters (treated observations) whose propensity score was higher than the maximum or lower than the minimum propensity score of the control group. Only enterprises with one or more employees liable for paying social insurance and a turnover higher than €17,081 in 2001 prices are considered. Tax groups, enterprises with a foreign legal form and the 1st and the 99th percentiles of the labour productivity growth rate distribution are excluded from all computations. Data source: German turnover tax statistics panel 2001–2005. The matching was done using Stata 10 and the psmatch2 command (version 3.0.0), see Leuven and Sianesi (2003)

*Note* (footnote for B)*:* Reported are the mean labour productivity growth rates of the treated and the matched control groups, the average treatment effects (ATT) as well as the bootstrapped (1,000 replications) *p*-values that indicate the statistical significance of the ATT. Matching was done by nearest neighbours propensity score matching. The propensity score was estimated from a probit regression of the import starter dummies on the log of labour productivity, number of employees, and a set of 3-digit industry dummy variables (all measured in 2003) plus the rate of growth of labour productivity between 2003 and 2005. The common support condition was imposed by dropping import starters (treated observations) whose propensity score was higher than the maximum or lower than the minimum propensity score of the control group. Only enterprises with one or more employees liable for paying social insurance and a turnover higher than €17,081 in 2001 prices are considered. Tax groups, enterprises with a foreign legal form and the 1st and the 99th percentiles of the labour productivity growth rate distribution are excluded from all computations. Data source: German turnover tax statistics panel 2001–2005. The matching was done using Stata 10 and the psmatch2 command (version 3.0.0), see Leuven and Sianesi (2003)

## 7 Concluding remarks

This paper uses a newly available comprehensive panel data set for manufacturing enterprises from 2001 to 2005 to present the first empirical results on the relationship between imports and productivity for Germany, a leading actor on the world market for goods. Furthermore, for the first time the direction of causality in this relationship is investigated systematically by testing for self-selection of more productive firms into importing, and for productivity-enhancing effects of imports ('learning-by-importing').

Descriptive statistics show a positive link between importing and productivity at the firm level, documented by an unconditional productivity differential between firms that import and firms that do not trade internationally; and the same holds for exporting. From an empirical model with fixed enterprise effects that controls for firm size, industry, and unobservable firm heterogeneity we see that the premia for trading internationally are about the same in West and East Germany. Two-way traders do have the highest premia, followed by firms that only export, while firms that only import have the smallest estimated premia. We find evidence for a positive impact of productivity on importing, pointing to self-selection of more productive

enterprises into imports, but no evidence for positive effects of importing on productivity due to learning-by-importing.

The empirical evidence on a positive relationship between importing and productivity at the level of the firm is in accordance with findings for a large and growing number of developed and developing countries. Research on the direction of causality between productivity and import status, however, is still in its infancy. No other of the very few papers tackling the issue of direction of causality known to us does so by applying the approach used here. Future research will hopefully show whether the lack of evidence for learning-by-importing (that is matched by a similar lack of evidence regarding learning-by-exporting, see Wagner 2007b) found for Germany is special, or whether it can be found in other developed and developing countries, too. Stylized facts based on comparable studies using data from many countries can then be used as an input for both appropriate theoretical models of heterogeneous firms that trade, and the discussion of policy conclusions based thereon.

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## Appendix

See Appendix Table 11.

**Table 11** Export and import productivity premia in manufacturing enterprises in West Germany (2001–2005)—results for the five 30% random samples

| | Estimation of the log labour productivity in *t* Model with fixed effects, West Germany | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Random sample 1 | | Random sample 2 | | Random sample 3 | | Random sample 4 | | Random sample 5 | |
| | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Exporter dummy$_t$ | – | 4.98 (0.00) | – | 5.00 (0.00) | – | 5.23 (0.00) | | 5.79 (0.00) | – | 5.25 (0.00) |
| Only export dummy$_t$ (ß1) | 4.12 (0.00) | – | 3.81 (0.00) | – | 4.14 (0.00) | – | 4.28 (0.00) | – | 4.51 (0.00) | – |
| Only import dummy$_t$ (ß2) | 2.71 (0.00) | – | 2.81 (0.00) | – | 2.20 (0.00) | – | 2.02 (0.00) | – | 1.83 (0.00) | – |
| Two-way trader dummy$_t$ (ß3) | 8.60 (0.00) | – | 9.12 (0.00) | – | 8.73 (0.00) | – | 9.57 (0.00) | – | 7.90 (0.00) | – |

**Table 11** continued

| | Estimation of the log labour productivity in *t*<br>Model with fixed effects, West Germany | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Random sample 1 | | Random sample 2 | | Random sample 3 | | Random sample 4 | | Random sample 5 | |
| | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Number of observations | 195,591 | | 195,633 | | 195,777 | | 194,562 | | 196,553 | |

*Note:* Due to limitations concerning the size of the main memory available on the computers in the research data centre, it was not possible to estimate the fixed effects model with all West German enterprises. Therefore, the mean values of the estimated regression coefficients and the *p*-values of five 30% random samples taken from all firms are reported in Table 4. This table reports the results for each of these samples. Model 1 contains an only export, an only import and a two-way trader dummy. ß1 is the average percentage productivity difference between exporters and non-exporters among enterprises that do not import. ß2 is the average percentage difference between importers and non-importers among non-exporters. ß3 is the average percentage difference between importer-exporters and enterprises that do neither export nor import. Model 2 contains an exporter dummy that shows the average percentage productivity difference between exporters and non-exporters. To facilitate the interpretation, the estimated coefficients of the dummy variables are transformed by $100(\exp(ß) - 1)$. Both models include the number of employees and its squared value, and a full set of interaction terms of year dummy variables and dummy variables for 3-digit level industries. Only enterprises with one or more employees liable for paying social insurance and a turnover higher than €17,081 in 2001 prices are considered. Tax groups, enterprises with a foreign legal form and the 1st and the 99th percentiles of the labour productivity distribution are excluded from all computations. Data source: German turnover tax statistics panel 2001–2005

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