The Impact of a Firm's Share of Exports on Revenue, Wages, and Measure of Workers Hired

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Theory and Evidence

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Abstract

In the past years, a new generation of trade models with heterogeneous firms and workers has received strong empirical support. However, all of these models only allow for a firm's export status to be binary so that they cannot explain why some firms export to more countries than others and have hence, in general, a higher share of exports. This paper addresses the question if a firm's precise export share is of additional value when assessing the relationship between trade and certain firm characteristics. By linking an extension to the Melitz (2003) model that allows for a firm's export status to be continuous to the Helpman et al. (2010*a*) framework, we argue that a change in a firm's share of exports, triggered for example by a decrease in trading costs, can be accounted for changes in its revenue, its average wage as well as its measure of workers hired. The predictions of the model are ultimately borne out by the LIAB, a German linked employer-employee panel data set, via reduced-form evidence.

Keywords: International Trade, Firm Heterogeneity

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1. INTRODUCTION

For a long time now, empirical findings of exporting firms outperforming non-exporting firms in various categories, see e.g., Bernard et al. (1995) for the US or Bernard & Wagner (1997) for Germany, are well established in the literature. Thanks to the link between a firm's productivity and its export status, the Melitz (2003) model was for the first time able to theoretically explain these findings. Based on Melitz (2003), a new generation of trade models arose that received strong empirical support by recent research. By allowing for heterogeneous firms and workers, these models were able to explain observed wage differences between workers with similar characteristics, see e.g., Attanasio et al. (2004), either through search and matching frictions, see e.g., Helpman et al. (2010*a*) — henceforth HIR —, efficiency wages, see e.g., Davis & Harrigan (2011), or fair wages, see e.g., Egger & Kreickemeier (2009). Various extensions and adaptations have since then addressed different empirical questions. Thus, Amiti & Davis (2012), for example, adapted the framework of HIR to assess in theory and ultimately via reduced-form evidence in data the impact of tariff cuts on Indonesian wages. Empirical evidence in favor of exporter wage premia also comes from Egger et al. (2013) who structurally estimated a fair wage preference model with data from Bosnia-Herzegovina, Croatia, France, Serbia, and Slovenia. Using German establishment panel data, Capuano & Schmerer (2014) presented evidence that trade liberalization reduces unemployment in the long run via structural estimation. Further research extended the models to answer questions about the link between trade liberalization and wage inequality, see e.g., Akerman et al. (2013) and Helpman et al. (2014), or labor market dynamics, see e.g., Dix-Carneiro (2014).

However, common to all of these models is that they only allow for a firm's export status to be binary, i.e., non-exporting or exporting, so that a firm either confines itself to the domestic market or exports to a number of symmetric countries. Thus, these frameworks do not explain why some firms export to more countries than others and have therefore, in general, a higher share of exports. This raises the question of whether the established empirical findings of revenue premia, wage premia, and employment premia also extend to firms whose share of exports exceeds the one of their peers? We address this question and argue that a firm's precise share of exports is of large additional value when trying to assess the importance of trade on certain key firm characteristics.

Our argumentation is borne out by an extended Melitz (2003) model in which we loosen the symmetry assumption in order to allow for heterogeneous countries with different aggregate expenditures and different aggregate prices. Thanks to this asymmetry, some firms will — in a similar manner to Helpman et al. (2004) — be able to export to a few countries, while other, more productive firms, are even able to export to more countries and will hence have, on average, a higher share of exports. We further link our multi-country model to the Helpman et al. (2010*a*) framework so as to establish a connection between a firm's share of exports and its revenue, its average wage as well as its measure of workers hired.

Ultimately, we use the LIAB, a linked employer-employee panel dataset from Germany, in order to empirically test our model's key predictions. We like to think of German data to be particularly suited for this exercise, as Germany is not only one of the major exporting countries of the world, but was able due to the enlargement of the European Union in May 2004 and the entailed decrease in trading costs to increase its exports to the ten new member countries in the four ensuing years by about 70%. We run fixed effects regressions of the firm specific variables mentioned above on the share of exports with and without controls for certain firm specific characteristics. A dummy variable for the firm's binary export status — modeled as a productivity gain a firm might experience as it starts to export — is perceptive to the above-mentioned findings of exporting firms outperforming non-exporting firms. Our results show that already small changes in a firm's export share can be accounted for relatively large changes in the variables of interest.

The remainder of this paper is structured as follows. Section 2 presents the theoretical framework. Section 3 describes the dataset used. Section 4 contains our empirical results and Section 5 concludes. An Online Appendix provides the basic derivations of the model.

2. THEORETICAL FRAMEWORK

a. A Firm's Productivity

Our model consists of a world with a home country and n asymmetric countries, while the asymmetry stems from different distributions of firm and worker productivity across countries. As in the Melitz (2003) model, after entering the market, each firm k in a given sector s draws its initial productivity parameter φ'_k from a country specific Pareto distribution $g_c(\varphi')$ with support over $[\varphi'_{\min,c}, \infty)$.[1] The continuous cumulative distribution is given by

$$G_c(\varphi') = 1 - \left(\frac{\varphi'_{\min,c}}{\varphi'}\right)^{z_c} \quad \text{for } \varphi' > \varphi'_{\min,c} \text{ and } z_c > 1 \text{ for all } c = 1, ..., n+1\,,$$

where less productive countries have a higher z_c and/or a smaller $\varphi'_{\min,c}$.

By analogy to Melitz (2003), the draw of a productivity level that is not sufficient to serve the domestic market, i.e., φ' is smaller than the domestic cutoff productivity level $\varphi'^{*}_{d,c}$, will force a firm to immediately exit the market. Though in contrast to Melitz (2003), from the point of view of the home country, there are now n different export cutoff productivity levels $\varphi'^{*}_{x,c}$ for each foreign country $c = 1, ..., n$. Without loss of generality, we can arrange these cutoff levels in ascending order, where 1 corresponds to the country with the lowest export cutoff productivity level. Accordingly, a domestic firm with a productivity φ', so that $\varphi'^{*}_{x,c'} < \varphi' < \varphi'^{*}_{x,c'+1}$, can export to the c' least productive countries, with $1 \leq c' \leq n$. We further assume that a firm can only export to foreign markets if it serves its domestic market, i.e., $\varphi'^{*}_{d,c} \leq \varphi'^{*}_{x,1}$.

Since empirical evidence has shown that firms starting to export often experience productivity gains, see e.g., De Loecker (2007) or Lileeva & Trefler (2010), we allow for a term $e^{\iota(\varphi')}$, with $\iota(\varphi') \in \mathbb{R}$, that can boost a firm's productivity once it starts exporting. As described in Coe & Helpman (1995), one can think of this productivity gain as a sort of R&D benefit that could be caused by learning about new technologies and materials, leaner production processes, or better organizational methods. We can hence decompose a firm's productivity into

$$\varphi = \varphi' e^{\mathbb{I}\iota(\varphi')}\,, \tag{1}$$

[1] For reasons of simplicity, we henceforth suppress the country, sector, and firm subscript whenever possible.

where $\mathbb{I}$ is an indicator variable that equals 1 if the firm exports and 0 otherwise. As in the Melitz (2003) model no price discrimination and an equal elasticity of substitution $\sigma = 1/(1-\rho)$, with $0 < \rho < 1$, for each industry across countries is assumed.

b. Worker Ability

We assume worker ability to be independently distributed across countries and to be drawn from a Pareto distribution with the continuous cumulative distribution

$$G_{a,c}(a) = 1 - \left(\frac{a_{\min,c}}{a}\right)^{\zeta_c} \quad \text{for } a > a_{\min,c} \text{ and } \zeta_c > 1 \text{ for all } c = 1, ..., n+1 .$$

As in HIR, before hiring, firms will pay search costs of bm in order to be randomly matched with m workers. Since worker ability is unobservable beforehand, firms have to pay screening costs of $\varepsilon a_\varepsilon^\delta/\delta$, with $\varepsilon > 0$ and $\delta > 0$, to identify from those m workers the ones that have at least an ability of a_ε. Note that as more productive firms will set the screening threshold higher and will sample more workers, both a_ε and m are dependent of φ, i.e., $a_\varepsilon(\varphi)$ and $m(\varphi)$, respectively. In line with the findings of Lileeva & Trefler (2010), the boost in productivity due to exporting will hence increase the average ability of an exporting firm's workforce as it raises the screening threshold.

c. A Firm's Revenue and Export Decision

Following HIR, the production side is represented by a simple Cobb-Douglas function so that a firm's output $y(\varphi)$ is given by

$$y(\varphi) = \varphi h(\varphi)^\gamma \bar{a} , \tag{2}$$

where $h(\varphi) = m(\varphi)(a_{\min,c}/a_\varepsilon(\varphi))^{\zeta_c}$ is the measure of workers hired, with $0 < \gamma < 1$, and $\bar{a} = \zeta_c a_\varepsilon(\varphi)/(\zeta_c - 1)$ the average ability of the firm's workforce. The equilibrium domestic revenue of a firm that is exclusively serving the domestic market, which is indexed by d, can be written as

$$r_d(\varphi) = y_d(\varphi)p_d(\varphi) = y_d(\varphi)^\rho A_d , \tag{3}$$

where $p_d(\varphi)$ is the price of a firm's product in the domestic market and $A_d = P_d^\rho I_d^{1-\rho}$ is the domestic demand shifter, with P_d being an index of the domestic price level and I_d domestic income.

Assuming country specific iceberg trading costs of τ_c such that $\tau_c > 1$ units of a variety must be exported for one unit to arrive in country c, the overall revenue of a firm, $r(\varphi)$, can hence be written as

$$r(\varphi) \equiv r_d(\varphi) + \sum_{c=1}^{c'} r_{x,c}(\varphi) = y_d(\varphi)^\rho A_d + \sum_{c=1}^{c'} \left(\frac{y_{x,c}(\varphi)}{\tau_c}\right)^\rho A_{x,c} , \tag{4}$$

where $y_{x,c}(\varphi)$ denotes the output exported to country c and $A_{x,c}$ is the demand shifter for country c.

In an analogous way to HIR, a firm with a productivity high enough to export to c' countries will allocate its domestic output and its exports to country c to equate its marginal revenue for every market. Thus, we obtain c' different first-order conditions

$$\frac{\partial r_d(\varphi)}{\partial y_d(\varphi)} = \frac{\partial r_{x,c}(\varphi)}{\partial y_{x,c}(\varphi)} \quad \Leftrightarrow \quad \frac{y_{x,c}(\varphi)}{y_d(\varphi)} = \tau_c^{\frac{\rho}{\rho-1}} \left(\frac{A_{x,c}}{A_d}\right)^{\frac{1}{1-\rho}} \quad \text{for all } c = 1, \ldots, c' . \tag{5}$$

Using (4) and (5), we can write a firm's total revenue as

$$r(\varphi) = y(\varphi)^{\rho} A_d \left(1 + \sum_{c=1}^{c'} \mathbb{I}_c \tau_c^{\frac{\rho}{\rho-1}} \left(\frac{A_{x,c}}{A_d}\right)^{\frac{1}{1-\rho}}\right)^{1-\rho}, \tag{6}$$

where $\mathbb{I}_c$ equals 1 if the firm exports to country c and 0 otherwise. With $\Upsilon \equiv 1 + \sum_{c=1}^{c'} \mathbb{I}_c \tau_c^{\frac{\rho}{\rho-1}} \left(\frac{A_{x,c}}{A_d}\right)^{\frac{1}{1-\rho}}$, we obtain

$$r(\varphi) = y(\varphi)^{\rho} A_d \Upsilon^{1-\rho} \quad \text{or equivalently} \quad r(\varphi) = r'_d \left(\frac{\varphi}{\varphi_d}\right)^{\frac{\rho}{\Gamma}} \Upsilon^{\frac{1-\rho}{\Gamma}},$$

where r'_d is the revenue of a non-exporting firm that makes zero profit, φ_d its respective productivity, with $\varphi_d \equiv \varphi'_d$, and $\Gamma \equiv 1 - \rho\gamma - \rho(1 - \gamma\zeta_d)/\delta$. Using the productivity decomposition (2), we can write revenue as

$$r(\varphi') = r'_d \left(\frac{\varphi'}{\varphi_d}\right)^{\frac{\rho}{\Gamma}} \Upsilon^{\frac{1-\rho}{\Gamma}} e^{\frac{\rho \mathbb{I} u(\varphi')}{\Gamma}}. \tag{7}$$

Note that (7) is equal to the key revenue equation in HIR but for the different definition of Υ and the productivity boost component from exporting. As can be seen, more productive firms are able to export to more countries and will hence have in general a higher revenue.

A firm's profit function can then be written as a combination of its domestic and foreign profits, i.e.,

$$\pi(\varphi) \equiv \pi_d(\varphi) + \pi_{x,c}(\varphi) = r_d(\varphi) + \sum_{c=1}^{c'} r_{x,c}(\varphi) - bm(\varphi) - \frac{\varepsilon}{\delta} a_{\varepsilon}(\varphi)^{\delta} - f_d - \sum_{c=1}^{c'} \mathbb{I}_c f_{x,c},$$

where f_d and $f_{x,c}$ are fixed entry costs for the domestic and country c's market, respectively.

By analogy with the Melitz (2003) model, in the end, a firm will only export to a certain country c, with $1 \leq c \leq c'$, if the respective profits are non-negative, i.e., $\pi_{x,c}(\varphi) \geq 0$. Therefore, a firm's export decision depends not only on its own productivity surpassing the export cutoff productivity level, which is a necessary condition, but also on the demand shifters, trading costs as well as the fixed entry costs. By taking this into account, the number of countries a firm is actually exporting to, denoted by c^*, can be smaller than c', i.e., $c^* \leq c'$.

When focussing on trading costs, this framework can explain two kinds of changes in a firm's share of exports. Thus, for example, a small decrease in trading costs to countries with a relatively low export cutoff productivity level can make it profitable for some firms to start exporting to these countries. As highly productive firms with a relatively large share of exports might increase their exports to these countries only slightly, this change in trading costs will mainly affect the extensive margin of exports. On the other hand, an overall decrease in trading costs to high productivity countries will especially affect the intensive margin of exports, for firms already exporting to these countries will find it profitable to increase their output allocated to these countries. Therefore, a change in Υ can both cause changes in the intensive and extensive margin. Since we assume — like the Melitz (2003) model — no changes in a firm's initial productivity draw, changes in a firm's share of exports can accordingly only occur through shifts in the countries' demand, productivity gains from exporting, or changes in trading costs. As we will focus on the latter, we can hence state that a decrease in trading costs will weakly increase the firm's share of exports and its revenue.

d. A Firm's Average Wage

In the following, we again rely on HIR to establish a link between a firm's average wage and its share of exports. The solution to the bargaining game between a firm and its workers yields that the total wage bill is $\rho\gamma/(1+\rho\gamma)$ of the average revenue while the firm keeps a share of $1/(1+\rho\gamma)$.[2] The resulting profit maximization problem for a firm in the home country is then defined by

$$\pi(\varphi) \equiv \max_{\substack{m(\varphi)\geq 0,\\ a_\varepsilon(\varphi)\geq a_{\min,d}}} \left\{ \frac{1}{1+\rho\gamma} \left[1 + \sum_{c=1}^{c'} \mathbb{I}_c \tau_c^{\frac{\rho}{\rho-1}} \left(\frac{A_{x,c}}{A_d}\right)^{\frac{1}{1-\rho}} \right]^{1-\rho} \right.$$
$$\left. \times A_d \left(\varphi \frac{\zeta_d}{\zeta_d - 1} a_{\min,d}^{\gamma\zeta_d} m(\varphi)^\gamma a_\varepsilon(\varphi)^{1-\gamma\zeta_d} \right)^\rho e^{\frac{\mathbb{I}_t(\varphi)}{1-\rho}} - bm(\varphi) - \frac{\varepsilon}{\delta} a_\varepsilon(\varphi)^\delta - f_d - \sum_{c=1}^{c'} \mathbb{I}_c f_{x,c} \right\}.$$

For the measure of workers sampled $m(\varphi)$ and the ability threshold $a_\varepsilon(\varphi)$, we derive the first-order conditions of the profit maximization problem,

$$\frac{\rho\gamma}{1+\rho\gamma} r(\varphi) = bm(\varphi) \tag{8}$$

and

$$\frac{\rho(1-\gamma\zeta_d)}{1+\rho\gamma} r(\varphi) = \varepsilon a_\varepsilon(\varphi)^\delta\,, \tag{9}$$

respectively. As one can see, firms with a higher revenue will not only sample more workers, but will also set a higher ability threshold. Note that under the assumption $\delta > \zeta_c$, firms facing this trade-off will see their measure of workers hired positively driven by revenue. We use the first-order conditions along with $h(\varphi) = m(\varphi)(a_{\min,d}/a_\varepsilon(\varphi))^{\zeta_d}$ in order to write the firm's average wage as

$$w(\varphi) = \frac{\rho\gamma}{1+\rho\gamma} \frac{r(\varphi)}{h(\varphi)} = \frac{bm(\varphi)}{h(\varphi)} = b \left[\frac{a_\varepsilon(\varphi)}{a_{\min,d}} \right]^{\zeta_d}. \tag{10}$$

The relation we get from this last equation is in line with the general intuition that firms with a higher revenue will also employ workers with a higher ability level who will correspondingly be better paid. Using again (5) and (6) as well as the productivity decomposition (1), we can write a firm's average wage in a similar manner to equation (7), namely

$$w(\varphi') = w'_d \left(\frac{\varphi'}{\varphi_d}\right)^{\frac{\rho\zeta_d}{\delta\Gamma}} \Upsilon^{\frac{\zeta_d(1-\rho)}{\delta\Gamma}} e^{\frac{\rho\zeta_d \mathbb{I}_t(\varphi')}{\delta\Gamma}}\,, \tag{11}$$

where w'_d denotes the lowest average firm wage. Again, we can see that a decrease in trading costs will weakly increase the firm's share of exports and the average wage paid to its employees.

e. A Firm's Measure of Workers Hired

Making once again use of (8) and (9) along with $h(\varphi) = m(\varphi)(a_{\min,d}/a_\varepsilon(\varphi))^{\zeta_d}$, we can, in a similar manner as before, derive the firm's measure of workers hired. We obtain

$$h(\varphi') = h'_d \left(\frac{\varphi'}{\varphi_d}\right)^{\rho\left(1-\frac{\zeta_d}{\delta}\right)} \Upsilon^{\frac{(1-\rho)(1-\zeta_d/\delta)}{\Gamma}} e^{\rho\left(1-\frac{\zeta_d}{\delta}\right)\mathbb{I}_t(\varphi')}\,, \tag{12}$$

[2] A derivation of the solution to the bargaining game can be found in Acemoglu et al. (2007) and in the Technical Appendix to HIR, Helpman et al. (2010*b*).

with h'_d being the lowest measure of workers hired. By analogy to the firm's revenue (7) and its average wage (11), we can see that a decrease in trading costs will weakly increase the firm's share of exports and its measure of workers hired.

3. DATA

In order to empirically test the model's predictions that a firm's revenue, wage, and measure of workers hired is positively driven by its share of exports, we use the 'LIAB cross-sectional model 2' from the German Institute for Employment Research (IAB). The LIAB is a linked employer-employee panel dataset containing information on German establishments, henceforth referred to as firms, from the annual waves of the IAB establishment panel and information on individuals liable to social security from the process-generated data of the Federal Employment Agency. A detailed description of the dataset can be found in Jacobebbinghaus & Seth (2010). In the following, we closely rely on the adjustments to the dataset made in Hesse (2014). Thus, we only use the years from 2000 to 2008 as a shift in the IAB industry classification in 2000 does not allow for a consistent extension of our panel to the years before 2000. In addition, the dataset only contains information on East German firms and workers as of the year 1996, which would reduce a second panel to four years. Since we focus on industries with a general interest in exports, we only include the first 25 industries in the IAB industry classification which are all industries in the primary and secondary sector as well as industries in the IAB industry categories 'Trade and repair' and 'Transport and communication'. To ensure that our results are not distorted by idiosyncratic factors of very small businesses, we follow a suggestion of Helpman et al. (2014) and only include observations of firms with at least five full-time workers. To exclude workers in part-time employment or in dormant employment relationships such as interns, workers during vocational training, or women during maternity leave, we only consider workers whose wages exceed twice the minimum wage. The minimum wage, which did not exist at the time in Germany, is based on the wage in minor employment which ranges from 10.56 to 13.15 Euros per day.[3] As wages are right-censored at the highest level of earnings that is subject to social security contributions, ranging from 144.16 to 173.77 Euros per day, we estimate wages within a range of 2 Euros at the limit according to the imputation procedure proposed by Gartner (2005).[4] Wages are further deflated by the consumer price index obtained from the German Federal Statistical Office (Destatis) using the year 2000 as the base year. Table 1 reports the unweighted firm and employment shares as well as the relative log mean wage for each industry in the base year 2000.

We then compute for each firm, each year, and each of the three skill levels, un- or semi-skilled, skilled, and highly qualified, the average daily gross wage. By matching the individual-level variables with the annual waves of the IAB establishment panel, we obtain a dataset of 49 860 firm-years,

[3] By imposing this particular threshold, we follow a suggestion of Klein et al. (2013).

[4] The independent variables of the wage estimating equation are age, gender, education, nationality, region, industry, number of days in establishment, and a simplified skill level (un- or semi-skilled; skilled; highly qualified; manager). The skill level was built from the Blossfeld (1985) skill classification which categorizes the employer's stated occupational 3-digit code of each employee into 12 groups. The quality of the education variable has been improved by the routine proposed by Fitzenberger et al. (2006) which mainly relies on extrapolation of past and future information to cope with missing and presumable invalid observations.

TABLE 1
Employment Shares and Relative Mean Log Wages across Industries for the Base Year 2000

Industry	Employ-ment share	Exporter share firms	Exporter share employment	Relative mean log wage
Agriculture, hunting, forestry & fishing	0.55%	11.11%	12.52%	−0.35
Mining, electricity, gas & water supply	5.55%	12.12%	17.00%	0.25
Manuf. of food products	3.89%	33.77%	60.49%	−0.18
Manuf. of textiles & apparel	1.18%	70.00%	74.64%	−0.14
Manuf. of paper products, printing & publishing	2.40%	47.65%	68.78%	0.19
Manuf. of wood products (no furniture)	1.02%	32.59%	71.02%	−0.16
Manuf. of chemicals, coke & petroleum	10.11%	77.23%	82.45%	0.17
Manuf. of rubber & plastic products	3.34%	67.63%	88.74%	−0.03
Manuf. of other non-metallic mineral products	2.47%	41.94%	70.64%	−0.02
Manuf. of basic metals	6.30%	60.28%	82.52%	0.06
Manuf. of fabricated & structural metal products	5.31%	46.70%	77.23%	0.00
Manuf. of machinery & equipment	11.27%	73.68%	92.83%	0.18
Manuf. of motor vehicles & trailers	12.39%	61.48%	90.59%	0.06
Manuf. of other transport equipment	4.28%	60.66%	81.23%	0.13
Manuf. of electrical equipment	6.45%	67.41%	85.87%	0.09
Manuf. of precision & optical equipment	1.75%	39.02%	84.97%	−0.03
Manuf. of furniture, jewelry & other products	1.46%	59.48%	87.58%	−0.08
Recycling	0.20%	18.42%	10.22%	−0.19
Building of complete constructions or parts	3.73%	3.55%	5.48%	−0.02
Building installation & completion	1.64%	5.16%	16.13%	−0.08
Sales, maintenance & repair of motor vehicles	1.24%	15.83%	22.62%	−0.06
Wholesale & commission trade	3.11%	37.25%	38.83%	0.12
Retail trade & repair of household goods	2.63%	6.19%	10.33%	−0.12
Transport	7.14%	31.16%	15.82%	0.02
Communication	0.60%	16.67%	3.96%	0.24
All industries	100.00%	35.97%	63.88%	65.82

Notes. Unweighted mean of all industries in the year 2000. Relative mean log wage is the industry's mean log wage minus the employment weighted average log wage across all industries. Source: LIAB, Version 2, Year 2000.

corresponding to 8 364 979 worker-years. Summary statistics for all firms in the dataset used can be found in Table 2.

Note that in contrast to the IAB establishment panel, the IAB provides no appropriate sampling weights for the LIAB. Also the use of the IAB sampling weights would not result into a representative sample, for a significant number of firms in the IAB establishment panel cannot be matched correctly with the information on individuals. In line with the approach of Card et al. (2013), Capuano & Schmerer (2014), and Felbermayr et al. (2014), we hence use the unweighted sample data in the ensuing empirical analysis. However, we would like to point out that due to the sampling process of the IAB establishment panel large firms and small federal states are overrepresented.

TABLE 2
Summary Statistics

	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
Share of exports	11.158	11.170	11.698	11.893	12.570	13.545	13.413	13.550	13.256	12.420
	(21.308)	(21.031)	(21.546)	(22.049)	(22.942)	(23.801)	(23.648)	(23.933)	(23.200)	(22.592)
Binary export status	0.360	0.375	0.382	0.375	0.381	0.396	0.396	0.396	0.409	0.385
	(0.480)	(0.484)	(0.486)	(0.484)	(0.486)	(0.489)	(0.489)	(0.489)	(0.492)	(0.487)
Revenue (in million Euros)	43.774	46.166	47.166	49.193	55.087	71.177	61.341	65.478	69.773	55.858
	(216.792)	(263.919)	(220.745)	(315.467)	(349.118)	(545.863)	(451.008)	(562.822)	(708.472)	(423.897)
Wage (all)	76.853	76.880	78.949	79.610	80.469	82.117	82.553	82.631	82.290	80.137
	(23.458)	(23.604)	(24.736)	(25.449)	(26.012)	(27.387)	(28.055)	(28.772)	(28.660)	(26.290)
Wage (un- or semi-skilled)	70.543	70.569	72.316	72.757	73.497	75.211	75.371	75.505	75.307	73.347
	(21.606)	(21.985)	(22.773)	(23.325)	(23.869)	(25.021)	(25.530)	(25.827)	(26.510)	(24.090)
Wage (skilled)	78.170	78.091	80.237	80.727	81.728	83.365	84.056	84.204	84.380	81.515
	(23.160)	(22.970)	(23.781)	(24.418)	(25.029)	(26.145)	(26.787)	(27.612)	(27.721)	(25.352)
Wage (highly qualified)	115.658	116.108	120.385	122.379	123.288	126.151	127.358	128.647	128.374	122.812
	(34.759)	(35.248)	(36.746)	(39.071)	(38.875)	(40.403)	(41.424)	(43.280)	(43.204)	(39.403)
All workers	170.499	170.236	164.268	159.480	170.484	181.060	165.914	158.389	169.197	167.769
	(630.386)	(870.561)	(851.045)	(877.624)	(943.511)	(965.483)	(723.469)	(789.440)	(1029.016)	(860.398)
Un- or semi-skilled workers	78.161	76.586	72.283	69.815	74.885	78.026	69.985	65.564	70.438	73.004
	(287.198)	(369.050)	(344.774)	(351.925)	(379.892)	(381.802)	(267.384)	(267.327)	(363.765)	(338.730)
Skilled workers	62.257	62.888	60.080	58.963	62.420	67.006	63.458	59.762	63.508	62.235
	(222.505)	(312.542)	(303.034)	(315.352)	(325.988)	(347.377)	(334.474)	(335.914)	(404.289)	(323.874)
Highly qualified workers	30.081	30.763	31.906	30.702	33.179	36.029	32.471	33.063	35.251	32.531
	(167.724)	(223.517)	(252.777)	(259.493)	(277.790)	(285.352)	(217.446)	(284.713)	(350.145)	(260.629)
Collective agreement	0.826	0.824	0.815	0.808	0.781	0.801	0.775	0.764	0.753	0.794
	(0.133)	(0.134)	(0.158)	(0.145)	(0.186)	(0.136)	(0.141)	(0.143)	(0.145)	(0.147)
Age	40.744	40.855	41.185	41.549	41.821	42.045	42.276	42.486	42.604	41.730
	(1.022)	(1.068)	(1.416)	(1.285)	(1.245)	(1.192)	(1.097)	(1.077)	(1.174)	(1.330)
Number of firms	5 733	6 205	5 847	5 650	5 547	5 438	5 123	5 201	5 116	49 860
Number of workers	977 473	1 056 317	960 475	901 063	945 675	984 604	849 977	823 781	865 614	8 364 979

Notes. Unweighted mean over all firms by year. Standard deviation in brackets. One observation is one firm in one year. Source: LIAB, Version 2, Years 2000–2008.

4. EMPIRICAL RESULTS

We now assess the model's predictions of a positive relation between a firm's share of exports and its revenue, its average wage, and its measure of workers hired.

As in the Melitz (2003) model, we assume constant initial firm productivity φ' over the years, which means in return that changes in a firm's share of exports can only be caused by either shifts in the foreign and domestic demand, productivity gains from exporting or changes in trading costs. We claim that for the case of Germany in the years from 2000 to 2008 especially the latter occurred. Thus, the enlargement of the European Union in May 2004, along with previously established bilateral trade agreements, considerably facilitated German exports into Eastern European countries, allowing German exports to the ten new members to increase from 2004 to 2008 by about 70%. At the same time Germany's exports to the rest of the world only increased by about 31%.[5]

Since the model states that revenue, average wage, and measure of workers hired are positively driven by the firm's share of exports, $\sum_{c=1}^{c^*} y_{x,c}/y_d$, a variable not available in the dataset, we have to find a reliable proxy for the ensuing empirical analysis. For this purpose, we divide a firm's total turnover by its domestic share of total turnover. Using (4) this leads to

$$\frac{r}{r_d} = 1 + \frac{\sum_{c=1}^{c^*} r_{x,c}}{r_d} = 1 + \sum_{c=1}^{c^*} \tau_c^{-\rho} \frac{A_{x,c}}{A_d} \left(\frac{y_{x,c}}{y_d}\right)^{\rho} \equiv \Upsilon_{\mathrm{P}} \,.$$

Note the close relation of Υ_{P} to the share of exports and hence to

$$\Upsilon = 1 + \frac{\sum_{c=1}^{c^*} y_{x,c}}{y_d} = 1 + \sum_{c=1}^{c^*} \mathbb{I}_c \tau_c^{\frac{-\rho}{1-\rho}} \left(\frac{A_{x,c}}{A_d}\right)^{\frac{1}{1-\rho}} \,.$$

As can be seen, a decrease in trading costs as well as an increase in the foreign demand shifters will increase both Υ and Υ_{P}. Though the proportions of the changes might be different in both cases, depending on ρ, our proxy Υ_{P} nevertheless presents very similar features as the firm's share of exports. Note that Υ_{P} captures both changes in the intensive and extensive margin of exports.

Due to the presence of the productivity gain component from exporting and the firm's continuous share of exports in the model's key equations, (7), (11), and (12), we can in particular examine if our extension of the HIR framework to a multi-country model is of any additional predictive value when trying to estimate the impact of trade liberalization on a firm's revenue, its average wage, or its measure of workers hired.

Since Υ and Υ_{P} are not defined for firms that do not produce for the domestic market — which is in accordance with one of the model's basic assumptions — we include a dummy variable to represent those firms in the panel that export 100% of their total output and categorize them with firms that export 99%. Note that overall results would not change if these 174 firm-years were dropped from the panel.

a. Revenue

In the following, we assess the relation between the share of exports — or to be more precise, the share of revenue from exporting — and firm revenue. By taking the logarithm of (7), we obtain the

[5] Data obtained from the German Federal Statistical Office (Destatis).

following estimating equation

$$\ln r_{kst} = \beta_0 \ln r'_{d,st} + \beta_1 \ln\left(\frac{\varphi'_{kst}}{\varphi_{d,st}}\right) + \beta_2 \ln \Upsilon_{\mathrm{P},kst} + \beta_3 \mathbb{I}_{kst} + \psi_s + \xi_t + u_{kst} ,$$

where t indexes years, ψ_s is an industry fixed effect, i.e., the intercept of each industry, ξ_t are time fixed effects, and u_{kst} denotes the stochastic error. Note that β_1 corresponds to ρ/Γ, β_2 to $(1-\rho)/\Gamma$ and β_3 to $\rho\iota(\varphi')/\Gamma$. Since a firm's initial productivity φ' is assumed to be constant over time, any changes in the data of a firm's productivity are either captured by the error term or the binary export status, which is represented by the productivity boost component. Accordingly, β_1 cannot be captured by the regression. Table 3 reports the coefficients of interest, β_2 and β_3, see FE 1.

First of all it can be seen that the mere fact of becoming an exporting firm will, on average, increase the total revenue by 192%, a number consistent with other literature, see e.g., Verhoogen (2008). As predicted by the model, the share of exports — even in the presence of the binary export status — does have a clear positive impact on revenue. For an idea of our results, we consider a firm that receives 10% of its total revenue from abroad, i.e., $\sum_{c=1}^{c^*} r_{x,c}/r = 0.1$. Now an increase from 10% to 11% in this share — thereby reducing r_d/r from 90% to 89% — would lead to a 1.124% increase in Υ_P and therefore to a 0.916% increase in total revenue. An effect of

TABLE 3
Regression of Revenue on Share of Exports with and without Firm Specific Controls

	Dep. var.: Log revenue ($\ln r$)	
	(FE 1)	(FE 2)
Zero profit revenue ($\ln r'_d$)	0.0535**	0.0425**
	(0.0213)	(0.0196)
Share of exports ($\ln \Upsilon_\mathrm{P}$)	0.8155***	0.6869***
	(0.0822)	(0.0662)
Binary export status ($\mathbb{I}$)	1.0704***	1.0441***
	(0.1863)	(0.1589)
Controls:		
Collective agreement		1.0903***
		(0.1176)
Share of un- or semi-skilled workers		0.1501
		(0.2602)
Average age		0.0031
		(0.0147)
N.obs.	44 490	44 490
R^2	0.1512	0.2445

Notes. An observation in the regression is one firm in one year. All regressions include nine year and 25 industry dummies as well as a dummy variable for firms with an export share of 100% (not reported). We report clustered standard errors at the industry level in brackets. Since not all firms stated their annual revenue, the N.obs. are smaller than in the ensuing empirical analyses of wage and measure of workers hired. Nevertheless, the mean of the share of exports (12.5524) and its standard deviation (22.5751) of this subsample only differ slightly from the full sample. Source: LIAB, Version 2, Years 2000–2008. *** indicates significance at 1% level, ** at 5% level, * at 10% level.

considerable magnitude, keeping in mind the rather small increase in the export revenue ratio. As far as the coefficient of the industry's zero profit revenue β_0 is concerned, we can see that though being significant it is nonetheless of very small importance.

Next, we include some firm specific controls into our analysis. We extend our main estimating equation to a dummy variable that equals 1 if a firm is subject to collective bargaining and 0 otherwise.[6] We furthermore include controls for the average age of a firm's workforce and its share of unskilled workers. As one can see in FE 2, collective agreements tend to have a relatively large positive effect on revenue whereas the share of un- or semi-skilled workers as well as the average age of its workforce appear to be of no importance. Though this extension to firm specific controls slightly decreases the effect of the share of exports, the coefficient stays highly significant.

b. Wages

While several empirical studies have shown that differences between average firm wages can be explained by differences in workforce composition, see e.g., Verhoogen (2008) or Monte (2011), there is also empirical evidence emphasizing the role of unobserved skill differences, see e.g., Attanasio et al. (2004), Cosar et al. (2013), or Helpman et al. (2014). In order to take these findings into account, we perform two different estimations. While relying in both cases on our key wage equation (11), we first use the average firm wage for each of the three different skill categories (un- or semi-skilled, skilled, and highly qualified) as dependent variable. In our second estimation, we instead use the firm fixed wage component, which is purged from worker observables for each skill-year category, as dependent variable.

Average Firm Wage

By analogy to the previous subsection, we take the logarithm of (11) and obtain

$$\ln w_{ks\ell t} = \beta_0 \ln w'_{d,s\ell t} + \beta_1 \ln\left(\frac{\varphi'_{kst}}{\varphi_{d,st}}\right) + \beta_2 \ln \Upsilon_{\mathrm{P},kst} + \beta_3 \mathbb{I}_{kst} + \psi_s + \xi_t + u_{kst}\,,$$

where the different skill categories are denoted by ℓ. We then run fixed effects regressions using the average firm wage in each skill-year category as dependent variable. Since not all firms do employ workers with all three kinds of skill levels, the number of observations differs across regressions.

Table 4.A reports the coefficients of interest, β_2 and β_3, for all three different wage categories, see FE 1, FE 3, and FE 5. As predicted by the model, a firm's average wage appears to be positively driven by the share of exports. Furthermore, the binary export status again has a positive effect on average wage. To get an idea of the magnitude of the export share's coefficient, we again consider a firm whose share of revenue from exporting increases from 10% to 11%, i.e., a 1.124% increase in Υ_{P}. According to our estimates of FE 1, this firm would increase its average wage paid to its un- or semi-skilled employees by 0.106%. While this effect is of far smaller magnitude than the previously established rise in revenue, the outcome of the bargaining game — where workers will get $\rho\gamma/(1+\rho\gamma)$ of the revenue, while the firm keeps a share of $1/(1+\rho\gamma)$ — is in accordance with these figures.

[6]A detailed description of collective bargaining in Germany can be found in Felbermayr et al. (2014) and Hesse (2014)

TABLE 4
Regression of Wage on Share of Exports with and without Firm Specific Controls

	A. Dep. var.: Average firm log wage ($\ln w$)					
	un- or semi-skilled		skilled		highly qualified	
	(FE 1)	(FE 2)	(FE 3)	(FE 4)	(FE 5)	(FE 6)
Lowest wage ($\ln w'_d$)	0.0216	0.0042	-0.0176^{*}	-0.0130	0.0022	-0.0018
	(0.0188)	(0.0178)	(0.0099)	(0.0106)	(0.0216)	(0.0173)
Share of exports ($\ln \Upsilon_P$)	0.0940^{***}	0.0604^{***}	0.1167^{***}	0.0958^{***}	0.0990^{***}	0.0798^{***}
	(0.0130)	(0.0083)	(0.0114)	(0.0087)	(0.0113)	(0.0102)
Binary export status ($\mathbb{I}$)	0.0666^{**}	0.0543^{*}	0.1094^{***}	0.1040^{***}	0.0833^{**}	0.0871^{***}
	(0.0299)	(0.0273)	(0.0229)	(0.0174)	(0.0372)	(0.0311)
Controls:						
Collective agreement		0.2237^{***}		0.2088^{***}		0.2198^{***}
		(0.0146)		(0.0161)		(0.0173)
Share of un- or semi- skilled workers		-0.2902^{***}		0.0734^{*}		0.0212
		(0.0377)		(0.0422)		(0.0458)
Average age		0.0011		0.0029		0.0021
		(0.0022)		(0.0019)		(0.0043)
N.obs.	35 527	35 527	38 164	38 164	20 474	20 474
R^2	0.0486	0.2584	0.0975	0.2349	0.0836	0.2138

	B. Dep. var.: Firm fixed log wage component (η)					
	un- or semi-skilled		skilled		highly qualified	
	(FE 1)	(FE 2)	(FE 3)	(FE 4)	(FE 5)	(FE 6)
Lowest wage ($\hat{\eta}'_d$)	0.1152^{***}	0.1132^{***}	0.0375	0.0383	0.0701^{***}	0.0712^{***}
	(0.0303)	(0.0384)	(0.0345)	(0.0304)	(0.0205)	(0.0168)
Share of exports ($\ln \Upsilon_P$)	0.0939^{***}	0.0677^{***}	0.1110^{***}	0.0897^{***}	0.0913^{***}	0.0733^{***}
	(0.0120)	(0.0099)	(0.0119)	(0.0092)	(0.0102)	(0.0091)
Binary export status ($\mathbb{I}$)	0.0690^{***}	0.0675^{***}	0.1113^{***}	0.1134^{***}	0.0662^{**}	0.0708^{***}
	(0.0247)	(0.0228)	(0.0549)	(0.0180)	(0.0247)	(0.0212)
Controls:						
Collective agreement		0.2284^{***}		0.2034^{***}		0.2030^{***}
		(0.0151)		(0.0163)		(0.0150)
N.obs.	35 527	35 527	38 164	38 164	20 474	20 474
R^2	0.0492	0.2066	0.0919	0.2173	0.0702	0.1929

Notes. An observation in the regression is one firm in one year. All regressions include nine year and 25 industry dummies as well as a dummy variable for firms with an export share of 100% (not reported). We report clustered standard errors at the industry level in brackets. N.obs. differ for not every firm employs workers of all three kinds of skill levels. Source: LIAB, Version 2, Years 2000–2008. *** indicates significance at 1% level, ** at 5% level, * at 10% level.

We again control for firm specific variables, see FE 2, FE 4, and FE 6. As one might expect, in all cases, participation in a collective agreement appears to have a positive impact on wages. In addition, a higher share of un- or semi-skilled workers significantly drives down the average wage of the corresponding skill group. In line with the general intuition, the average age of the firm's workforce, yet not significant, positively drives wages in all three cases. Though the coefficients of interest are robust to our set of controls, they all decrease in magnitude.

Firm Fixed Wage Component

As these results could be driven by worker specific characteristics, we now decompose individual worker wages into their components and use the obtained firm fixed wage component as dependent variable. We thereby rely strongly on the methods presented in Helpman et al. (2014) and Akerman et al. (2013). Thus, we first estimate the following OLS Mincer regression separately for each industry-skill-year

$$\ln w_{is\ell t} = z'_{is\ell t}\lambda_{s\ell t} + \eta_{ks\ell t} + \nu_{is\ell t}\,,$$

where $w_{is\ell t}$ is a worker i's wage in industry s with a skill level of ℓ in a given year t. The vector $z'_{is\ell t}$ denotes individual observable worker characteristics, while $\lambda_{s\ell t}$ captures the returns to these characteristics. $\eta_{ks\ell t}$ is the fixed effect of firm k's respective skill group and $\nu_{is\ell t}$ the stochastic error. Our specification for observable worker characteristics is as follows: education (using categories for: no degree at all, vocational training or high school degree, vocational training and high school degree, technical college degree, university degree as well as missing values), age (using the categories: 19–24, 25–29, 30–39, 40–49, 50–65), and gender. As in the previous case, we only consider firms with at least five observations in a given firm-skill-year. Since the regression is estimated separately for each industry-skill-year, the coefficients on worker characteristics as well as the firm fixed effects can vary over time and across skill levels. The firm fixed effects are further normalized to sum to zero for each industry-skill-year, whereby the regressions' intercepts are absorbed by the observable worker characteristics components. By analogy to the average firm wage case, we then estimate the following fixed effects specification

$$\hat{\eta}_{ks\ell t} = \beta_0\hat{\eta}'_{d,s\ell t} + \beta_1 \ln\left(\frac{\varphi'_{kst}}{\varphi_{d,st}}\right) + \beta_2 \ln \Upsilon_{\mathrm{P},kst} + \beta_3\mathbb{I}_{kst} + \psi_s + \xi_t + u_{ks\ell t}\,,$$

where $\hat{\eta}'_{d,s\ell t}$ denotes the industry's lowest firm log wage component for the respective skill group at time t. Results are reported in Table 4.B. As can be seen, all coefficients of interest are significant and of the same magnitude as in the average firm wage case, see FE 1, FE 3, and FE 5, while being robust to controls for collective agreements, see FE 2, FE 4, and FE 6. As this shows that the share of exports drives the firm's average skill group wage primarily through the firm-level wage component, the model's predictions are borne out.

c. Measure of Workers Hired

As we have seen, both a firm's revenue and its average wage are positively driven by its share of exports. Ultimately, we want to assess if, as the model suggests, firms with a higher share of exports also employ more workers. Using the logarithm on (12), we obtain the following estimating equation

$$\ln h_{kst} = \beta_0 \ln h'_{d,st} + \beta_1 \ln\left(\frac{\varphi'_{kst}}{\varphi_{d,st}}\right) + \beta_2 \ln \Upsilon_{\mathrm{P},kst} + \beta_3 \mathbb{I}_{kst} + \psi_s + \xi_t + u_{kst}\,.$$

Since the data stems from voluntary surveys of a sample of firms that is matched with information on individuals, there are two different kinds of observations for the measure of workers hired. On the one hand, there is the number of workers reported by the firm, referred to as 'reported', and on the other hand, there is the actual number of correctly matched workers, referred to as 'matched'. These two variables slightly differ in some cases for various reasons. For example the reported number of workers contains both workers in part-time employment and dormant employment relationships. These are workers we initially tried to exclude from our sample by introducing a wage threshold. However, since we cannot be perfectly sure that our sample reflects an accurate image of a firm's actual full-time workforce, for we might have excluded too few or too many workers, the use of the reported number of workers is not only a way to ensure more reliable results, but also gives us an additional control for our previous estimations.

The results of the fixed effects regressions are reported in Table 5. As predicted by the model, the measure of workers hired is in both cases positively driven by the share of exports. Again, an increase

TABLE 5
Regression of Measure of Workers Hired on Share of Exports with and without Firm Specific Controls

	Dep. var.: Log measure of workers hired ($\ln h$)			
	reported		matched	
	(FE 1)	(FE 2)	(FE 3)	(FE 4)
Lowest measure of workers hired ($\ln h'_d$)	0.0054	−0.0003	0.6383*	0.6121*
	(0.0310)	(0.0312)	(0.3681)	(0.3518)
Share of exports ($\ln \Upsilon_{\mathrm{P}}$)	0.5329***	0.4367***	0.5530***	0.4625***
	(0.0819)	(0.0671)	(0.0807)	(0.0676)
Binary export status ($\mathbb{I}$)	0.7324***	0.6964***	0.7662***	0.7378***
	(0.1259)	(0.1042)	(0.1410)	(0.1146)
Controls:				
Collective agreement		0.8429***		0.8314***
		(0.0923)		(0.0989)
Share of un- or semi-skilled workers		0.5251***		0.4099**
		(0.0858)		(0.1564)
Average age		−0.0016		0.0031
		(0.0107)		(0.0112)
N.obs.	49 860	49 847	49 860	49 860
R^2	0.1112	0.2095	0.1182	0.2091

Notes. An observation in the regression is one firm in one year. All regressions include nine year and 25 industry dummies as well as a dummy variable for firms with an export share of 100% (not reported). N.obs. differ in FE 2 since not all firms reported their share of unskilled workers. We report clustered standard errors at the industry level in brackets. Source: LIAB, Version 2, Years 2000–2008. *** indicates significance at 1% level, ** at 5% level, * at 10% level.

from 10% to 11% in the firm's share of revenue from exporting would go along with a 0.599%, see FE 1, or a 0.621%, see FE 3, increase in the measure of workers hired. With an average reported measure of workers of 168, this effect is quite large considering the relatively small increase in the share of exports.

We ultimately extend the estimating equation to our set of firm specific control variables, see FE 2 and FE 4. While collective agreements appear to have a positive influence, the average age of a firm's workforce appears to have no effect at all. In accordance with the reported measure of workers hired, we use the reported share of unskilled workers as a control in FE 2. Though this variable is better suited as a control than the previously used matched share of un- or semi-skilled workers, for it also contains workers in part-time employment, we are suspicious that its accuracy has suffered due to the fact that firms had to decide by themselves if a worker's task requires him or her to be skilled or not.

When comparing results for both measures, we can see that the coefficients are in both cases, i.e., with and without controls, of a similar magnitude. A fact that reassures us of the adjustments we made to the dataset in order to create an accurate representation of the sample's full-time workforce.

5. CONCLUSION

By expanding the Melitz (2003) model to a multi-country model with asymmetric countries and therefore to a model with different aggregate demand shifters and trading costs, we can explain why firms export to a varying number of countries, all depending on their initial productivity draw, trading costs, and the countries' export thresholds. Thanks to productivity gains a firm might experience when starting to export, this setting incorporates both a firm's continuous export share and the commonly used binary export status. While assuming that the initial productivity drawn by a firm stays constant over time, its export status can still be subject to variation through productivity gains from exporting, shifts in the countries' demand, or changes in trading costs. A link to the HIR framework ultimately creates a model that predicts a higher revenue, a higher average wage as well as a higher measure of workers hired on account of an increasing share of exports.

We further use the LIAB, a German linked employer-employee panel dataset, in order to empirically corroborate the predictions of our model. Using fixed effects regressions, we are able to show that all three measures are positively driven by the share of exports while being robust to a set of firm specific controls. In addition, the long-established importance of a firm's binary export status, represented by productivity gains from exporting, remains unaffected. The coefficients of the effects are in all cases of a considerable magnitude and act in accordance with the model's parameter limitations.

As a concluding remark, we like to point out that our results do not only give further empirical support to a relatively new line of research of trade models with labor market frictions, but also show that allowing for a continuous export status is of additional values when predicting the impact of trade liberalization on domestic firms.

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