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ABSTRACT

International trade has been cited as a source of widening wage inequality in industrial nations. Consistent with this claim, we find a significant export wage premium for high-skilled workers in German manufacturing and an export wage discount for lower skilled workers, using matched employer-employee data. Estimates suggest that the export wage premium to high-skilled workers represents up to one third of their overall skill premium. But, while an increase in exports increases wage inequality along the dimension of skill, it diminishes the wage inequality associated with both gender and nationality. In this way, trade contributes to narrowing wage gaps and mitigating wage inequality in German manufacturing.

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1. Introduction

Manufacturing plants that export differ from those that do not along a variety of dimensions; they are larger, more productive, more capital intensive, and, of particular interest, pay higher wages. In an influential analysis of United States manufacturing plants, Bernard and Jensen (1995) found a wage premium of between 7 and 11 percent in exporting plants, controlling for a number of observable plant-level characteristics. Subsequent work by these authors (1999, 2004) and Bernard et al. (2007) have confirmed the exporter wage premium in the United States, while others have found evidence of an exporter wage premium in other industrial countries, including Denmark (Munch and Skaksen, 2008), Germany (Bernard and Wagner, 1997, who study the German Federal State of Lower Saxony, as well as Arnold and Hussinger, 2005, and Schank, Schnabel and Wagner, 2007), Korea (Hahn 2004), Portugal (Martins and Opromolla, 2009), Spain (Farinas and Martin-Marcos, 2007), Sweden (Hansson and Lundin, 2004), and the United Kingdom (Greenaway and Yu, 2004).[1]

A key source of the interest in the wage differential between exporters and other firms is that this could contribute to rising inequality in industrial countries (Krugman, 2008, Helpman, Itskhoki and Redding, 2009). Bernard and Jensen (1997) argue that much of the rise in wage inequality in United States manufacturing in the 1980s can be accounted for by an increase in relative labor demand by exporters, who, as compared to non-exporting firms, employ relatively more highly skilled, non-production-line workers as compared to lower skilled production-line workers.[2] This argument turns on the difference in the demand for skilled labor between exporting plants and those that do not export, rather than differences in the exporter wage premia across skill levels.[3]

These distributional effects are magnified if the export wage premium is more pronounced for higher-skilled workers than for lower-skilled workers. For example, the Bernard and Jensen (1997) inequality effect that occurs through an expansion of the

[1] Schank, Schnabel and Wagner (2007) survey these results. Interestingly, to the best of our knowledge there is no evidence for an export wage premium in France (see for instance Kramarz, 2008, p. 25).
[2] Blum (2008) argues that trade played a role in rising United States wage inequality in the 1970s, but not subsequently.
[3] Bernard and Jensen (1995) find that both production-line workers and non-production-line workers enjoy a wage premium in plants that export as compared to those that do not export.

export sector is bolstered if the export wage premium for high-skilled workers exceeds that of their lower skilled co-workers. There are theoretical reasons to believe that this might, in fact, be the case.[4] Thus, an investigation of the skill structure of the export wage premium has potentially important implications for the distributional effects of trade.

Most existing studies cannot speak to the skill structure of the exporter wage premium, however, because of data limitations. Studies using plant-level data can, at best, differentiate production-line workers from non-production-line workers. Some of these studies find positive and significant wage premia for both non-production-line workers and production-line workers (e.g. Bernard and Jensen 1995, 1999, 2004, Hahn 2004, Hansson and Lundin 2004 for 1990 observations), while others find a premium for non-production-line workers only (e.g. Bernard and Wagner 1997, and Hansson and Lundin 2004, for 1999 observations). Other, more recent, analyses use linked employer-employee data sets. Munch and Skaksen (2008) use a Danish matched worker-firm longitudinal data set and find that wages are higher in firms with high export intensity and highly educated workers, but there is a lower wage premium in high-export-intensity firms with workers who have lower levels of education. Schank, Schnabel and Wagner (2007) use the German LIAB data set which links employee statistics to the IAB Establishment Panel to estimate separate regressions for blue-collar and white-collar workers while controlling for a range of individual characteristics including age, gender, level of education, and nationality. In contrast with much of the other literature, they find a higher export wage premium for blue collar workers than for white collar workers.

In this paper, we investigate the skill structure of the wage premia (or discounts) over the period 1993 – 2007 for workers employed by western German manufacturing plants that export, using the linked employer-employee LIAB data set. This panel data set provides us with information that enables us to characterize both workers and plants at a level of detail that contributes importantly to the analysis. The data enables us to construct four skill categories for workers by using information on their educational attainment, their occupation, and the manner in which they are classified by the German

[4] See Yeaple (2005), Bustos (2007), Helpman, Itskhoki and Redding (2009, 2010), Felbermayr, Prat and Schmerer (2010), Amiti and Davis (2008), Egger and Kreickemeier (2009), and Davis and Harrigan (2007).

social security system. We find that there is a significant export wage premium for workers in the two highest skill categories, and evidence of an export wage discount for lower-skilled workers. These results are confirmed when estimating the export wage premium across the 340 occupations defined in the data set rather than the four skill categories we have constructed. The export wage premium for higher-skilled workers combined with the wage discount for lower-skilled workers implies an increase in manufacturing wage disparities with an expansion in the number of plants that export, or with an increase in the share of exports relative to total manufacturing output.

But while an expansion in exporting may widen inequality across skill levels, another set of results presented in this paper shows that an increase in exports diminishes manufacturing wage gaps due to gender or nationality. Higher-skilled women, who are paid less than men with comparable personal characteristics in comparable plants, enjoy a higher export wage premium than men, and there is no evidence of an export wage discount for medium-skilled and lower-skilled women. Likewise, higher-skilled manufacturing workers who are not German citizens enjoy an export wage premium and there is not a significant export wage discount for these workers either. One conjecture is that exporting firms exhibit less wage discrimination than non-exporting firms because they face stiffer competition, which would be consistent with Becker (1957). Thus, while an increase in the average export share of the German economy raises wage inequality along the dimension of skill, it lowers wage inequality along the dimensions of gender and citizenship, and hence reduces conditional wage inequality.

The next section of this paper introduces the matched employer-employee data set we use and provides some statistics on workers' skill levels and firms' export status. Section 3 presents estimates of the skill structure of the export wage premium. Differences in the skill structure of the export wage premium between men and women, and between German citizens and workers who are not citizens, are shown by the estimates in Section 4. Section 5 offers some concluding comments.

2. Skills and Exports

The matched employee-employer dataset on German establishments used in this analysis combines the IAB establishment panel from the German Labor Agency with its LIAB employee panel.[5] The matching of workers with the firms that employ them enables us to use detailed information on workers' skills and attributes as well as information about firms' international exposure. Our sample is representative for western German manufacturing plants for the period 1993 – 2007.[6] However, plants are drawn randomly from strata of different drawing probabilities. These strata are formed along the dimensions of region, industry and plant size class. Hence, all reported means and estimates in this paper will be inversely weighted by their drawing probabilities. Our dataset does not comprehensively follow individuals over time, since workers that leave sampled plants drop out of the dataset. Still, there are a large number of individuals who switch from one plant in the sample to another also included in the sample in our data set. A complete data description is given in the appendix.

In this section we describe these two dimensions of the data, and provide some statistics for both skill levels and export share. Other variables used in the analysis are described in Section 3.

2.1 Workers' Skill Levels

A worker's skill is positively associated with educational attainment, and is also reflected by his or her occupation. The LIAB data set includes employee information along both of these dimensions. The educational attainment variable for each employee differentiates among 6 categories: up to 10 years of schooling and no vocational training; up to 10 years of schooling and vocational training; high-school degree without vocational training; high-school degree with vocational training; college degree; and university degree. The LIAB also identifies 340 occupations. The division of this wide set of occupations into a much smaller set of higher-skilled and lower-skilled jobs is not straightforward in the absence of other information. Fortunately, there is an official German government classification system that places each occupation into one of two job

[5] Appendices A2 and A3 provide all variable definitions and includes detailed information on the data set.
[6] This is the area of the former Federal Republic of Germany.

categories based on the tasks required by that job; the lower-skilled category of *Arbeiter* which includes occupations that employ unskilled, blue-collar workers who might have some vocational training, and the higher-skilled category of *Angestellter* that includes occupations employing master craftsmen and white-collar workers.[7]

The Figure in Appendix A1 demonstrates the high correspondence between a worker's occupation and whether he or she is classified as an *Arbeiter* or an *Angestellter*. For example, more than 90 percent of the workers in more than 200 of the 340 occupations are classified as either *Arbeiter* or an *Angestellter*. In contrast, fewer than 20 occupations have no more than two-thirds of their workers in either the *Arbeiter* or an *Angestellter* category. Thus, the *Arbeiter* / *Angestellter* distinction is largely, though not exclusively, a categorization by occupational category.

We use the *Arbeiter* / *Angestellter* distinction, along with educational attainment, to construct four categories of workplace skill level; low-skilled workers, medium-skilled workers; high-skilled workers, and workers with college or university degrees (which we call "university-educated"). The use of four skill categories, rather than the 340 occupations, allows for tractable results concerning the skill interaction with export status.[8] These four categories provide a more accurate indicator of workplace skill level than one based solely on educational attainment. In particular, the medium-skill and high-skill categories have the same educational attainment, but different levels of job-related skills. These categories are also more refined than those based on the production / non-production distinction typically used in studies based on plant-level data.

We summarize our categorization in Table 1, and show the proportion of each group in the sample. Low-skilled workers make up 34 percent of the sample. They have, at most, 10 years of schooling and no vocational training, and their occupation does not require more education than this. Workers in the medium-skilled category (35 percent of the sample) and high-skilled category (24 percent of the sample) have a high school degree and may have vocational training.

[7] More information on the *Arbeiter* and *Angestellter* categories is included in the data appendix.
[8] The occupation information is used in the regression analysis, however, by including the 340 occupations as fixed effects. We also present some corroborating evidence for our skill-based findings by listing occupations with the lowest and highest estimated conditional export wage premia.

Table 1: Skill Levels by Education / Occupation

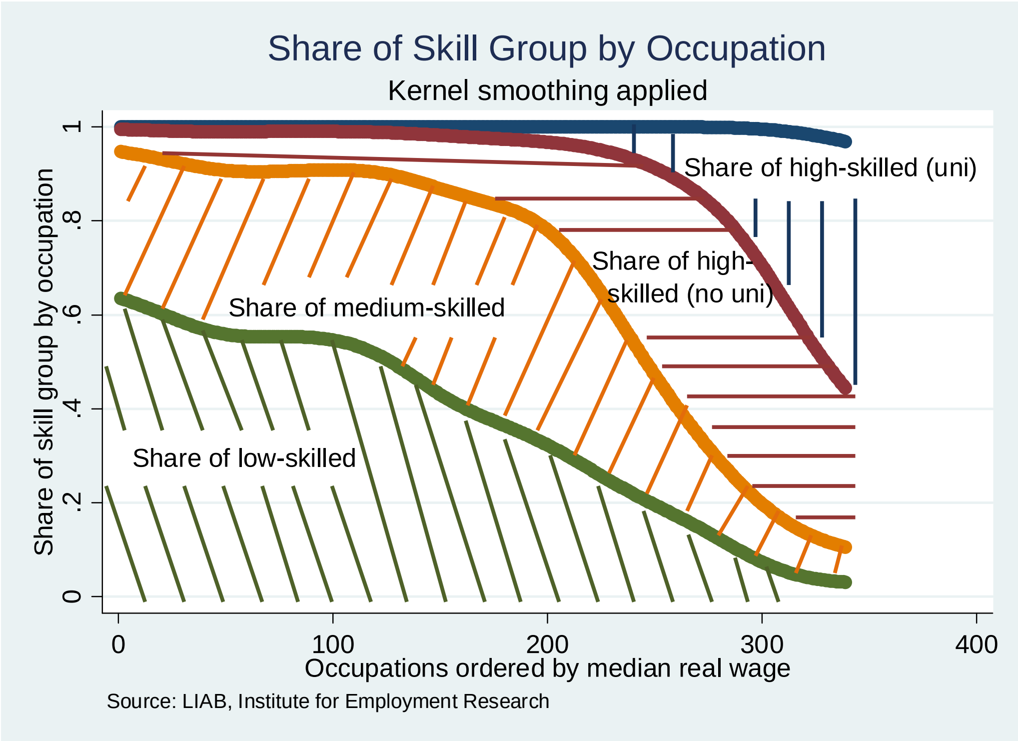
Education	Occupation Classification (*Prop. Of Sample*)	
	Arbeiter	*Angestellter*
≤ 10 years, no vocational training	Low-skilled (*0.34*)	*No observations*
≤ 10 years, vocational training High School degree, no voc. training High School degree, vocational training	Medium-skilled (*0.35*)	High-skilled (*0.24*)
College Degree University Degree	*No observations*	Univ. Educated (*0.07*)

Source: LIAB, Institute for Employment Research; Means are drawing probability weighted.

Although workers in the last two categories may have the same level of formal education, they are distinguished by whether their occupation is listed in the *Arbeiter* or *Angestellter* categories. A chef, for example, could be included in the high-skilled category if his occupation is in the *Angestellter* category, while a less-skilled cook would be included in the *Arbeiter* category. Also, an occupation in the *Angestellter* category may require more supervisory obligations than a somewhat similar occupation listed in the *Arbeiter* category. Our highest skill category includes workers with college or university degrees whose occupation is always in the *Angestellter* category. This category represents 7 percent of the sample.

To see that the distinctions among the 4 skill groups make sense, we calculate mean daily gross wages (in constant 2005 euros) for 340 occupation groups, order these occupation groups according to their mean wage from lowest to highest and plot the share of each skill group by occupation group. The results are shown in Figure 1. Unsurprisingly, the occupations with the highest average wages are those that have the largest share in the two categories with the highest skills, and occupations dominated by low-skilled workers have lower average wages. Nevertheless, there is substantial wage variation within the four skill categories, and this justifies the use of occupation-level controls in the regression estimates.

Figure 1: Proportion of Skills by Occupation Ordered By Mean Wage



2.2 Plant Export Share Characteristics of Exporting Firms

Our dataset is representative for manufacturing plants in western Germany and is from the IAB establishment panel. All fulltime workers at these plants are matched to their place of employment in the LIAB dataset. The employer data provides information about the international transactions for each plant, including the share of exports in its total sales. The proportion of plants by their export share class is presented in Figure 2. This figure shows that about 75 percent of plants do not export. However, the proportion of employees in plants that do not export is less than 30 percent, indicating that, on average, exporting plants have many more employees than non-exporting plants (see Figure 3). For those 25 percent of plants that export, the export shares for the 25th, 50th, and 75th percentiles over the sample period are presented in Figure 4. For example, the 75th percentile export share among all exporting plants was 20 percent in 1993 and rose to over 50 percent in 2007. The 50th and 25th percentile export shares grew as well, roughly doubling their values over this period.

Figure 2: Proportion of Plants by Openness Class

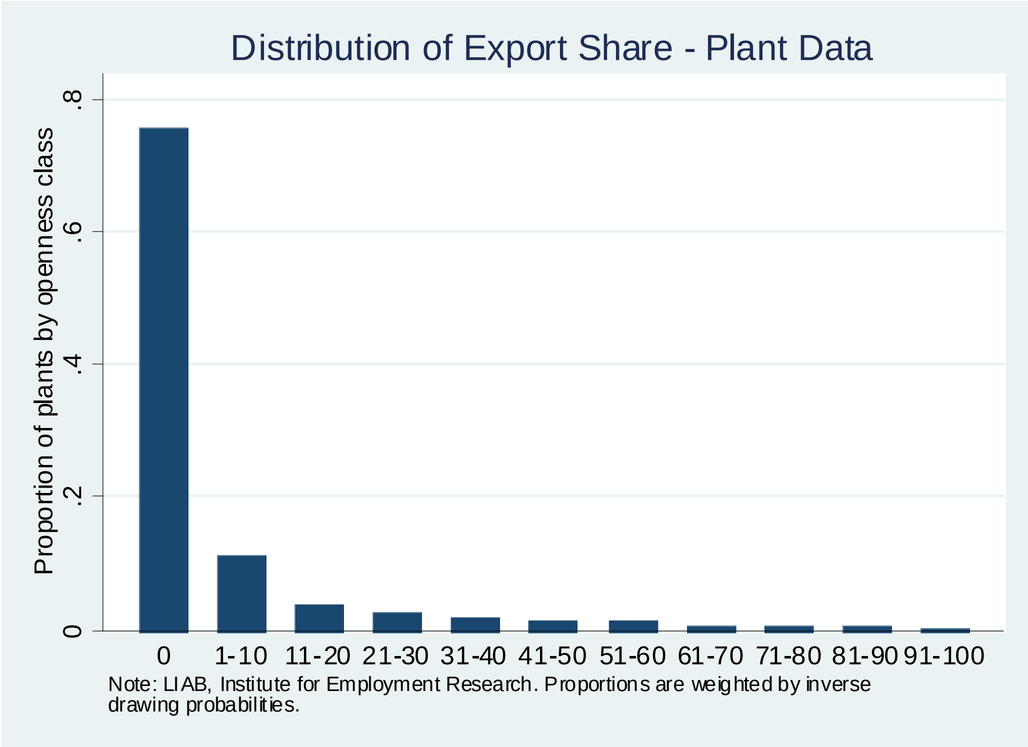


Figure 3: Proportion of Employees by Openness Class

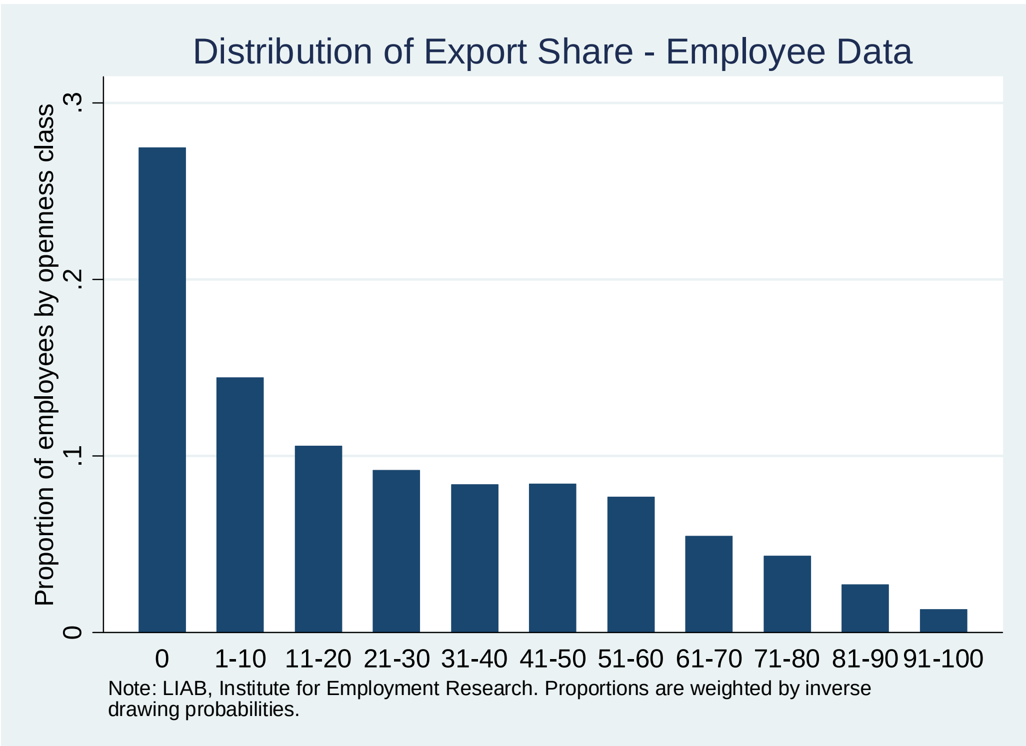
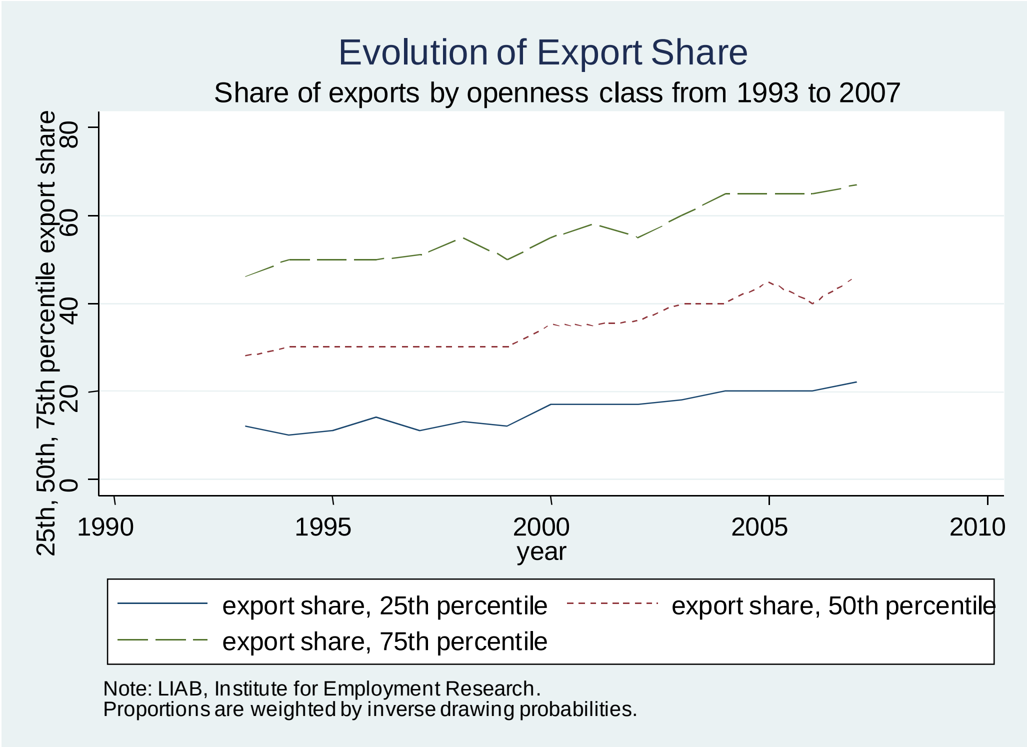


Figure 4: Time path of export share by exporting plant percentiles



Exporting plants differ from those that do not export along a number of dimensions; they have more employees, pay higher wages, and have different skill compositions. Somewhat surprisingly, not only is the share of employees with college or university degree larger in exporting plants, but so is the share of low-skilled employees.

Table 2: Composition of Employees

	All Plants	*Exporters*	*Non-Exporters*
No. Obs. (worker-year)	8,041,676	7,227,010	814,666
Skill Composition			
Low-skilled	0.337	0.367	0.255
Medium-skilled	0.354	0.310	0.472
High-skilled	0.239	0.239	0.239
Univ./College Educated	0.070	0.083	0.035
Proportion Women	0.202	0.239	0.217
Proportion Foreigner	0.102	0.107	0.082

Note: LIAB, Institute for Employment Research; worker-year observations unweighted; Proportions are weighted by inverse drawing probabilities.

Thus, the share of medium skilled employees is smaller in exporting plants than in non-exporting plants, as shown by the statistics in Table 2.[9] The focus of this paper is the determination of wage differentials by skill category, between plants that export and those that do not.

The regressions in Part 3 use the wages to determine the export premium, conditional on a number of factors. Table 3 provides some initial statistics on unconditional wage differences across categories. The wage variable represents the logarithm of average daily gross wage of individual fulltime workers in base year 2005 Euros.[10] All worker categories obtain larger wages on average in exporting plants, albeit the differences across groups are considerable, ranging from 8% for medium skilled woman to 37% for high-skilled woman.

Table 3: Wage by Worker Categories (logarithm, constant 2005 Euros)

	All	*Exporters*	*Non-Exporters*	*Exp – Non.Exp*
All Workers	4.565	4.618	4.425	***0.193***
ln Wages by Skill Level				
Low-skilled	4.370	4.392	4.268	***0.124***
Medium-skilled	4.521	4.578	4.423	***0.155***
High-skilled	4.713	4.802	4.479	***0.323***
Univ./College Educated	5.217	5.233	5.115	***0.118***
ln Wages of Women				
Low-skilled	4.173	4.201	4.056	***0.145***
Medium-skilled	4.138	4.183	4.099	***0.084***
High-skilled	4.379	4.515	4.143	***0.372***
Univ./College Educated	4.856	4.878	4.748	***0.130***
ln Wages of Non-Citizens				
Low-skilled	4.383	4.402	4.303	***0.099***
Medium-skilled	4.501	4.566	4.378	***0.188***
High-skilled	4.683	4.779	4.427	***0.352***
Univ./College Educated	5.140	5.158	4.983	***0.175***

Note: LIAB, Institute for Employment Research; means are weighted by inverse drawing probabilities.

[9] This could indicate that exporting might be related to job polarization, which refers a decrease in relative demand for medium-skilled jobs (e.g. Goos and Manning, 2007, and Autor et al., 2006). To anticipate one robustness check, our results on export wage premia are not sensitive to the inclusion of occupational time trends that can be expected to encompass relative demand-shifts between skill-categories over time.

[10] The wage data of the most highly compensated employees are censored above a certain value. We follow the methodology employed by others in imputing these wage values (e.g. Schank et al., 2007, Dustmann et al., 2009). See the appendix for details.

3. The Skill Structure of the Trade Wage Premium

The statistics in Table 3 indicate a substantial unconditional export wage premium for western German manufacturing plants, a result consistent with those presented in the published research discussed in the introduction. Of course, that research focuses on the conditional, rather than the unconditional, export wage premium. In this section we extend that research with our estimates of differences in the conditional wage premium across skill levels.

Before turning to the empirical methodology, it is worthwhile to consider the theoretical predictions concerning the export wage premium. In many models of international trade, exporters are distinguished from non-exporters because they have higher levels of exogenous productivity (e.g. Dornbusch, Fischer and Samuelson 1977, Melitz 2003). Models that seek to explain differences in wages between exporting and non-exporting firms must also offer reasons for a lack of full labor mobility between exporting and non-exporting firms, and reasons why exporting (i.e. higher productivity) firms pay higher wages. Helpman, Itskhoki and Redding (2009) present a model in which a firms' production function includes an exogenous productivity indicator, the number of employed workers, and the average skill level of its workforce. The inclusion of the average skill level of the workforce in the production function results in complementarities that are strongest for the most productive firms. Potential employees' skills can only be gleaned through costly screening. The incentive to screen workers, and incur the cost of doing so, is strongest among highest productivity firms because production complementarities rise with the productivity of the firm. Thus, more productive firms, the ones that find it profitable to pay a fixed price in order to export, have workforces with the highest average ability. These workers are also more costly to replace than lower-ability workers in less productive firm, so, through strategic bargaining, there is an export wage premium across firms in this model.

Extensions of this model allow for different export wage premium for workers in different occupations within a firm.[11] In one extension of the model that allows for

[11] The export wage premium can be justified by other models that combine Melitz (2003) with some labor market friction. We can distinguish between two strands: First, *search and matching models of*

different available technologies, more productive firms choose skill-intensive technologies that would contribute to increasing wage inequality as an economy moves from autarky to trade. In another extension, the presence of capital that is a complement to skilled workers, but a substitute for unskilled workers, could lead to an export wage premium for skilled workers and an export wage discount for unskilled workers. In these cases, an expansion of trade (in this model, the move from the autarky equilibrium to the trade equilibrium) affects overall inequality through both changes in within-occupation inequality and changes in between-occupation inequality. Within-occupation inequality rises with a move from autarky to trade, while between-occupation inequality may rise or fall. Thus, within this framework, the overall link between expanding trade and between-occupation inequality becomes an empirical question.

Our method for addressing this empirical question using the data set that includes linked employer-employee data augments a regression specification that estimates the effect of trade status on wages by distinguishing this effect by skill level. Before considering estimates based on that approach, it is useful to first consider the simpler specification that estimates the overall export wage premium,

$$\ln W_{i,j,t} = \beta X_{j,t} + \sum_{Z=2}^{4} \alpha_Z S_{i \in Z,t} + \Psi I_{i,t} + \Omega P_{j,t} + \tau_t + F_{i,j} + \varepsilon_{i,j,t} \qquad [1]$$

where the dependent variable is the logarithm of $W_{i,j,t}$, which is introduced in Table 3 and represents the average daily gross wage of worker i who is employed at plant j in year t. The export wage premium in this specification is β, which shows the effect on wages of the share of exports in total revenue of plant j in year t, $X_{j,t} \in [0,1]$ ($X_{j,t} = 0$ if plant j does not export in year t). An individual's skill level is captured by the dummy variables in the three element vector $S_{i \in Z,t}$, where $Z =$ 2 for medium-skilled, 3 for high-skilled, and 4

unemployment with individual or collective wage bargaining are proposed for instance by Felbermayr, Prat and Schmerer (2010) and - as discussed above - by Helpman, Itskhoki and Redding (2009). The second strand of the literature argues that firms are willing to pay higher than market-clearing wages, i.e. efficiency wages, for one of two reasons. On the one hand, any wage that falls short of being perceived as fair would reduce a worker's effort. In this spirit, Amiti and Davis (2008) and Egger and Kreickemeier (2009) explain the export wage premium with a *fair-wage model*, whereby the fair wage level depends on firm profitability and its export status. On the other hand, if a worker has distaste for effort and firms imperfectly monitor workers' efforts, higher wages make the threat of being fired when caught shirking more credible. Davis and Harrigan (2007) offer a *shirking model*, where the costs of monitoring the workers' efforts differ across firms. If a worker's effort is more valuable to or less perfectly monitored by an exporting firm, this model will also offer an underlying mechanism for an export wage premium.

for university educated (low-skilled is the omitted dummy). Other individual characteristics are represented by the vector $I_{j,t}$ and include the logarithm of experience, the logarithm of tenure, and dummy variables for gender and German citizenship.[12] Plant-level characteristics other than export share, represented by the vector $P_{j,t}$, include the logarithm of number of employees as well as further characteristics of the establishment.[13] Time fixed effects are represented by τ_t. A list of variable definitions of firm and employee control variables is given in Appendix A2.

The regression specification includes other fixed effects as well, as represented by $F_{i,j}$. Tables 4 and 5 offer estimates based on different types of fixed effects specifications. Plant fixed effects, denoted *P* in the tables below, control for unobserved, non-time-varying differences in exporting plants as compared to non-exporting plants (this is equivalent to including *J-1* plant-specific dummy variables if there are *J* plants).[14] These fixed effects do not control for time-varying differences in occupational composition between exporting plants and other plants. We can control for occupation fixed effects, and allow for the possibility that occupations affect wages differently across plants, through the inclusion of plant-occupation fixed effects (which, with 340 occupation categories, effectively introduces a possible maximum of $[(J\times 340) - 1]$ dummy variables, although the actual number used will be many fewer because each firm does not have the full set of all possible occupations). This specification is denoted as $P\times O$.[15] A third

[12] Experience is measured as the number of days since the worker's entry into employment, and tenure is measured as the number of days since the worker's entry into his or her current position.

[13] The vector $P_{j,t}$ includes a number of dummy variables. One indicates the presence of a work council at a plant; workers at plants with more than 20 employees have the right to establish a work council to represent their interests, although they are not obliged to do so. Two other dummy variables indicate whether a plant represents the entire company (Single Plant Company), and another indicating whether the plant belongs to a Holding Company – thus, the omitted category is a headquarter plant in a multi-plant company. In addition, some regressions also include a dummy variable that equals 1 if managers self-assess their plant as operating at the technological frontier for its industry.

[14] Identification of the export wage premium in a regression that includes some type of plant-level fixed effect is through changes in the export share for individuals across time, including changes in the export share for workers in a particular plant as well as movements of workers from a plant with one value of the export share to another plant with a different value. In contrast, in an OLS regression with no plant-level fixed effects, unobserved plant differences that are associated with both higher productivity and a propensity to export will appear as an export wage premium. Thus, we would expect a higher estimated export wage premium in estimates that do not control for unobserved plant-level effects since exporting is correlated with higher productivity. Likewise, we would expect a higher estimated export wage premium in regressions using establishment-level data. Results presented below suggest this is, in fact, the case.

[15] The use of 340 narrowly-defined occupations as controls is one way in which this analysis is distinguished from others who use much broader occupation classifications, such as Munch and Skaksen

option would be to control for individual fixed effects and plant fixed effects. Abowd, Kramarz and Margolis (1999) show that the failure to control for unobserved individual and firm heterogeneity can lead to a substantial estimation bias. It is well known that the underlying assumption – apart from the usual exogeneity of explanatory variables – is random sorting conditional on time-invariant person and firm effects.[16] An even more general specification is one that includes person-firm spell-effects, which controls additionally for unobservable match-specific productivity effect.[17] This is denoted $P \times I$, and is equivalent to including a full set of interaction terms between plant and individual dummy variables. With spell-fixed effects $P \times I$, the export wage premia are identified exclusively from workers changing their wages over time while staying in one and the same plant that changes its export share over time. Instead, when controlling for person- and firm-specific effects such as in Abowd, Kramarz and Margolis (1999), the wage premia of exporting may additionally be identified through workers switching from plants with low export share to plants with high export share or vice versa. For example, if there is self-sorting such that workers who learned a lot in their previous job moved to firms with larger export share, then the wage premia would be overestimated, picking up unobservable learning – something that does not affect the estimates if using worker-firm spell effects $P \times I$. For this reason, we will report results from worker-firm spell effects rather than firm- and worker-fixed effects.[18, 19]

(2008) who have 9 occupational dummy variables, and Schank et al. (2007) who include a single dummy variable to distinguish master craftsmen or foremen from other blue-collar workers.

[16] Solon (1988), Gibbons and Katz (1992), and Winter-Ebmer and Zweimüller (1999), among others, stress that random sorting conditional on observables and time-invariant fixed effects might be too strong an assumption and self-selection of workers leads to inconsistent estimates. Frias, Kaplan and Verhoogen (2009) attempt to control for time-variant individual effects and do not find evidence for sorting on individual ability playing a significant role in explaining the export wage premium of Mexico (when also relaxing the assumption that the explanatory variable of interest is exogenous allowing it to be predetermined).

[17] Woodcock (2008) derives match-specific wage components in a wage regression on employee-employer matched data from a rent-sharing model with match-specific productivity and discusses the identification conditions of the spell estimator. Andrews et al. (2008) discussed worker-firm spell-effects before, which were also applied in Schank, Schnabel, and Wagner (2007) and Munch and Skaksen (2008) in the context of estimating the average export wage premium.

[18] However, we have also estimated a specification with worker- and firm-fixed effects along the lines of Abowd, Creecy and Kramarz (2002), where standard errors were calculated by a plant-clustered bootstrap, and results turned out to be very similar to the estimates with firm- and worker-spell effects. The same is true for a specification using individual but not plant fixed effects.

[19] Estimates may still be asymptotically biased if there is self-sorting of workers such that worker-specific unobservable wage components grow faster in firms the export shares of which grow faster. This may be

Table 4 presents estimates of β, as well as the other coefficients in Equation 1, for four specifications that differ in their treatment of fixed effects. In each case, the export wage premium coefficient is significant at better than the 99 percent level of confidence. This coefficient is 0.064 when no fixed effects are included, which yields an export wage premium of 3.2 percent at the median value of export share of 0.5 (this median is based only on the set of firms that export). This is less than half the value that has been reported in work based on plant-level data. One explanation for this discrepancy is that these regressions, unlike those based on plant-level observations, control for individual characteristics. This explanation is supported by an estimate from a regression using the same set of observations but only including the logarithm of plant employment and year dummy variables as additional regressors (not shown in Table 4). In this regression, the coefficient on export share is 0.153 (with a standard error of 0.016), so the estimated export wage premium for a firm with the median level of exports is nearly 8 percent. This value is within the range reported in Bernard and Jensen (1996).

The fixed effects estimates of the export wage premium presented in columns 2 through 4 of Table 4 are striking for two reasons. First, they are all much smaller than the estimate obtained with OLS, with values about one-fourth as big. This is consistent with an important role played by unobserved plant-level fixed effects linked to both productivity and exporting. Second, once we control for unobserved plant-level effects, there is little marginal effect on estimated values of β obtained by controlling for either unobserved occupational effects or unobserved individual effects. Each of the coefficients in the second through fourth columns of the table is between 0.016 and 0.018. This suggests that it is unobserved plant level effects, rather than unobserved occupation effects or unobserved individual effects, which are correlated with characteristics that affect both the export share of a plant and the overall wage premium to workers in plants that export.

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the case, for example, if workers increase their productivity through learning or inventions, rendering the firm more competitive internationally, the rents from which are shared with the workers. While we are not aware of any methodology that allows circumvent this potential source of bias, it may be limited in practice. To see this, learning effects are monotonically increasing productivity of workers while the export share of single firms fluctuates considerably over time, such that the correlation between them is probably quite small.

Table 4: Effect of Export Share on Wages, Not Differentiating by Skill level

Variable	*OLS*	*P*	*P×O*	*P×I*
Export Share (j)	0.064**	0.018**	0.018**	0.016*
(s.e.)	(0.010)	(0.007)	(0.007)	(0.007)
Medium-skilled (i)	0.133**	0.118**	0.063**	0.019**
(s.e.)	(0.004)	(0.003)	(0.003)	(0.005)
High-skilled (i)	0.387**	0.367**	0.197**	0.104**
(s.e.)	(0.005)	(0.004)	(0.005)	(0.006)
Univ. Educated (i)	0.752**	0.706**	0.398**	0.256**
(s.e.)	(0.006)	(0.005)	(0.007)	(0.018)
Woman (i)	-0.328**	-0.287**	-0.215**	—
(s.e.)	(0.006)	(0.004)	(0.003)	—
Foreigner (i)	-0.005	-0.022**	-0.008**	0.003
(s.e.)	(0.004)	(0.002)	(0.001)	(0.004)
ln(Tenure) (i)	0.025**	0.037**	0.036**	0.016**
(s.e.)	(0.002)	(0.001)	(0.001)	(0.002)
ln(Experience) (i)	0.085**	0.072**	0.062**	0.042**
(s.e.)	(0.002)	(0.001)	(0.001)	(0.002)
ln(Employment) (j)	0.045**	0.009	0.016*	0.046**
(s.e.)	(0.002)	(0.007)	(0.007)	(0.007)
Single Plant Co. (j)	-0.008	-0.001	-0.001	-0.000
(s.e.)	(0.006)	(0.002)	(0.002)	(0.003)
In a Holding Co. (j)	0.033**	0.001	0.001	0.003
(s.e.)	(0.006)	(0.003)	(0.003)	(0.004)
Work Council (j)	0.075**	0.005	0.003	0.005
(s.e.)	(0.008)	(0.005)	(0.006)	(0.006)
R^2	0.57	0.67	0.77	0.93
No. of Observations	8,041,676	8,041,676	8,041,676	8,041,676

† = sig. at 90% to 95% level of confidence
* = sig. at 95% to 99% level of confidence.
** = significant at ≥ 99% level of confidence
Fixed Effects year in all specifications. Other fixed effects include plant (*P*), plant-occupation (*P×O*), and plant-individual (*P×I*). Estimates weight observations by inverse drawing probability weights.

The overall export wage premia reported in Table 4 could be masking differences in wage premia across skill levels – indeed, the existence of these differences is the focus of this paper. To investigate this possibility, we estimate a modified version of Equation [1] that includes interactions between each of the four skill levels and export share, rather than a single export share variable.[20] The specification we use is

$$\ln W_{i,j,t} = \sum_{Z=1}^{4} \beta_Z \left(S_{i\in z,t} \times X_{j,t} \right) + \sum_{Z=2}^{4} \alpha_Z S_{i\in z,t} + \Psi I_{i,t} + \Omega P_{j,t} + \tau_t + F_{i,j} + \varepsilon_{i,j,t}, \qquad [2]$$

where all variables are defined as above. The four estimated skill-specific export wage premium in this equation are β_L (low-skilled), β_M (medium-skilled), β_H (high-skilled) and β_U (university educated). The three skill coefficients, α_M, α_H and α_U, represent the skill premia relative to the low-skilled group that are not associated with exporting. As with the estimation of Equation [1], we allow for different types of fixed effects estimation of Equation [2].[21] The three panels of Table 5 correspond to estimates using the plant (*P*), plant-occupation ($P\times O$), and plant-individual ($P\times I$) fixed effects, respectively.

Estimates of Equation [2] coefficients β_L, β_M, β_H and β_U, as well as α_M, α_H and α_U, are reported in Table 5. In addition, the table includes tests of the pairwise differences among all four export wage premium coefficients. These are presented as the difference of the higher-skilled category minus the lower-skilled category, so a positive value indicates an increasing wage gap with an expansion of exports. These differences can be interpreted as export-induced skill premia.

Results presented in Table 5 show that, with each of the three fixed effects specifications, each of the three α coefficients are significant at better than the 99 percent level of confidence, with values rising with skill level. Three of the four β coefficients are significant with each fixed effects specification at better than the 99 percent level of confidence, with β_H and β_U significant in all three cases, β_M significant with plant fixed effects and plant-occupation fixed effects, and β_L significant with plant-individual fixed effects. Also, in all three sets of estimates, $\beta_U > \beta_H$ and both are greater than β_L and β_M, although $\beta_M > \beta_L$ with plant-individual fixed effects only. The right side of each panel shows that five of the six differences between pairs of the β coefficients are significant at better than the 95 percent level of confidence. The linear combination $\beta_U - \beta_H$ is not

[20] Schank, Schnabel and Wagner (2007) take a different approach and estimate separate regressions for each of their two categories of workers.

[21] While results presented in Table 4 may be viewed as indicating the use of occupation or individual fixed effects is unimportant, given their marginal role in altering estimates of β, there could be an important difference between the effect of occupation and individual fixed effects on estimates of the overall export premium, β in Equation [1], and their effects on the four skill-specific export wage premia in Equation [2].

significant with plant fixed effects, but significant at the 99 and 90 percent level of confidence for the plant-occupation and plant-individual fixed effects, respectively.

Table 5: Effect of Export Share on Wages, By Skill Level

A: *P*, Plant FE	R^2 = 0.67	n = 8,041,676			
Skill Level	α_Z *(Skill)*	β_Z *(Skill×Exp)*	$\beta_{Medium} - \beta_Z$	$\beta_{High} - \beta_Z$	$\beta_{Univ.} - \beta_Z$
Low-skilled	—	-0.015	-0.053**	0.138**	0.147**
(s.e.)	—	(0.009)	(0.009)	(0.013)	(0.017)
Medium-skilled	0.133**	-0.068**	—	0.191**	0.200**
(s.e.)	(0.004)	(0.009)	—	(0.014)	(0.018)
High-skilled	0.327**	0.123**	—	—	0.009
(s.e.)	(0.006)	(0.013)	—	—	(0.015)
Univ. Educated	0.651**	0.132**	—	—	—
(s.e.)	(0.009)	(0.018)	—	—	—
B: *P×O*, Plant-Occupation FE	R^2 = 0.77	n = 8,041,676			
Skill Level	α_Z *(Skill)*	β_Z *(Skill×Exp)*	$\beta_{Medium} - \beta_Z$	$\beta_{High} - \beta_Z$	$\beta_{Univ.} - \beta_Z$
Low-skilled	—	0.007	-0.033**	0.044**	0.094**
(s.e.)	—	(0.008)	(0.009)	(0.019)	(0.012)
Medium-skilled	0.073**	-0.026**	—	0.081**	0.127**
(s.e.)	(0.004)	(0.008)	—	(0.013)	(0.020)
High-skilled	0.185**	0.051**	—	—	0.050**
(s.e.)	(0.007)	(0.011)	—	—	(0.014)
Univ. Educated	0.366**	0.101**	—	—	—
(s.e.)	(0.010)	(0.020)	—	—	—
C: *P×I*, Plant-Individual FE	R^2 = 0.93	n = 8,041,676			
Skill Level	α_Z *(Skill)*	β_Z *(Skill×Exp)*	$\beta_{Medium} - \beta_Z$	$\beta_{High} - \beta_Z$	$\beta_{Univ.} - \beta_Z$
Low-skilled	—	-0.021**	0.016*	0.073**	0.129**
(s.e.)	—	(0.008)	(0.007)	(0.013)	(0.037)
Medium-skilled	0.015**	-0.005	—	0.057**	0.113**
(s.e.)	(0.006)	(0.007)	—	(0.011)	(0.037)
High-skilled	0.081**	0.052**	—	—	0.056†
(s.e.)	(0.007)	(0.012)	—	—	(0.029)
Univ. Educated	0.210**	0.108**	—	—	—
(s.e.)	(0.021)	(0.037)	—	—	—

† = sig. at 90% to 95% level of confidence
* = sig. at 95% to 99% level of confidence.
** = significant at ≥ 99% level of confidence
Fixed Effects year in all specifications. See Table 5 for list of other regressors. Estimates weight observations by inverse drawing probability weights.

The interpretation of the estimates presented in Table 5 is facilitated by Figure 5. This figure plots the export wage premium for each of the four groups of workers as a function of the export share. The intercept of each line represents the respective α coefficients (with $\alpha_L = 0$ since the low-skill dummy is omitted in this specification). Differences in the values of the intercept show the skill wage premium, relative to low-skilled workers, for firms that do not export. The slope of each line represents the respective semi-elasticity of wages with respect to the export share in total revenue, that is, $\left.\frac{\partial \ln W_{i,j,t}}{\partial X_{j,t}}\right|_Z$ where *Z=L, M, H,* or *U*. These semi-elasticities may be positive or negative.

As drawn, the figure presents an export wage discount, rather than an export wage premium, for medium-skilled workers and low-skilled workers which, as will be shown, is consistent with most of the estimates presented in this paper.

Figure 5: Interpretation of Equation [2] Estimates

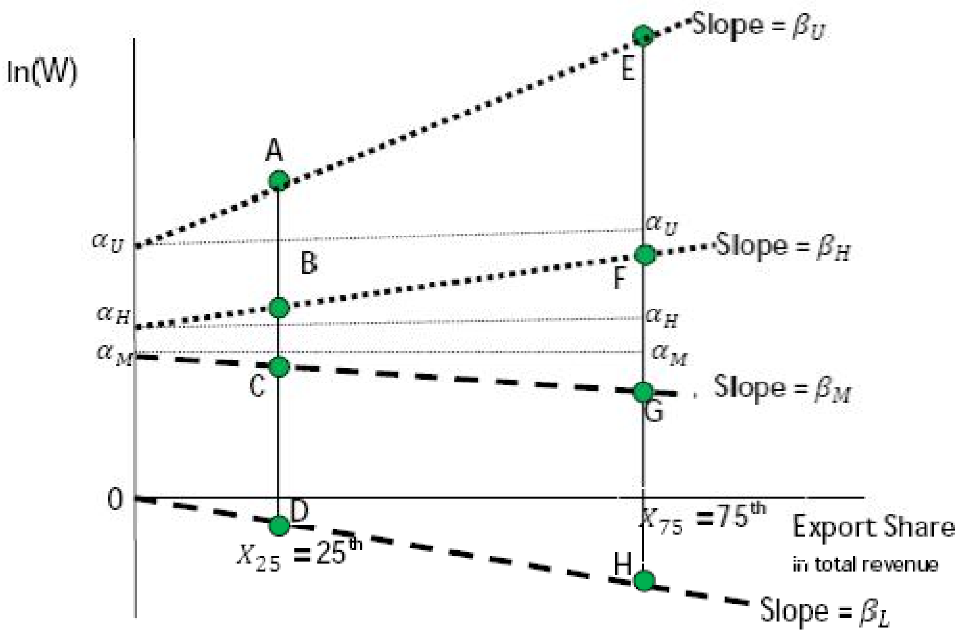


Table 6 includes five sets of relevant results that can be calculated from the estimates in Table 5.[22] Panel I presents the export wage premium at various values of the export share. This is represented in Figure 5 as, for example, the vertical distance between the point E and the line denoted α_U representing the wage premium for university educated workers in a plant that is in the 75th percentile of the export share distribution. The value associated with this based on the regression estimates is $\beta_U \times X_{75th}$.

[22] These estimates are based on the results from the specification with firm-worker spell effects in Table 5.

Table 6: Estimates of Export Wage Premia and Skill Premia

I. Export Wage Premia (percent)

$$\beta_Z \times X_i \times 100\%$$

Skill Category	Export Share 25th Percentile	Export Share 50th Percentile	Export Share 75th Percentile
Low-Skilled	-0.63**	-1.05**	-1.40**
Medium-Skilled	-0.15	-0.25	-0.33
High-Skilled	1.56**	2.60**	3.40**
Univ. Educated	3.24**	5.40**	7.02**

II. Percent of Wage Premium Due to Export Wage Premium

$$\left[\left(\beta_Z \times X_i\right) \big/ \left(\alpha_Z + \left(\beta_Z \times X_i\right)\right) \right] \times 100\%$$

Skill Category	Export Share 25th Percentile	Export Share 50th Percentile	Export Share 75th Percentile
Medium-Skilled	-10.9	-19.7	-27.2
High-Skilled	16.2**	24.4**	29.6**
Univ. Educated	13.3**	20.4**	25.0**

III. Differences in Export Wage Premia by Export Share - Export-induced Skill Premia

$$\left(\left[\beta_{Z'} - \beta_Z\right] \times X_i\right) \times 100\%$$

	$\beta_{Medium} - \beta_Z$			$\beta_{High} - \beta_Z$			$\beta_{Univ.} - \beta_Z$		
Percentile	25th	50th	75th	25th	50th	75th	25th	50th	75th
Low-Skilled	0.5*	0.8*	1.0*	2.2**	3.6**	4.8**	3.9**	6.4**	8.4**
Medium-Skilled				1.7**	2.9**	3.7**	3.4**	5.6**	7.3**
High-Skilled							1.7†	2.8†	3.6†

IV. Percent of Overall Skill Premia Due to Export-induced Skill Premia

$$\left[\left(\left[\beta_{Z'} - \beta_Z\right] \times X_i\right) \big/ \left(\left[\alpha_{Z'} - \alpha_Z\right] + \left(\left[\beta_{Z'} - \beta_Z\right] \times X_i\right)\right) \right] \times 100\%$$

				High − Z			Univ. − Z		
Percentile	25th	50th	75th	25th	50th	75th	25th	50th	75th
Medium-Skilled				21**	30**	36**	15**	22**	27**
High-Skilled							11†	18*	22*

V. Differences in Export-induced Skill Premia with Increasing Export Share

$$\left(\beta_{Z'} - \beta_Z\right)\left(X_{75th} - X_{25th}\right) \times 100\%$$

	$\beta_{Medium} - \beta_Z$	$\beta_{High} - \beta_Z$	$\beta_{Univ.} - \beta_Z$
	75th – 25th	75th – 25th	75th – 25th
Low-Skilled	0.56*	2.56**	4.50**
Medium-Skilled		2.00**	3.94**
High-Skilled			1.94†

Note: Calculations based on estimates for plant-individual fixed effects regressions in Table 5, standard errors are available from the authors upon request. Strata drawing probabilities are taken into account.

Panel I of Table 6 shows that the export wage premium is negative for low-skilled and medium-skilled workers (although it is not statistically significant for medium-skilled workers – the statistical significance of the results in Panel I depend upon the statistical significance of each of the four respective β coefficients). The estimated export wage premia are positive for high-skilled and university-educated workers. The export wage premia for university-educated workers, which range from 3.24 percent for workers in firms at the 25th percentile of export share to 7.02 percent for workers in firms at the 75th percentile of export share, are more than double that of high-skilled workers at respective percentiles of export share.

Panel II of Table 6 reports the proportion of the overall wage premium for a given skill group that is due to the export wage premium at the 25th, 50th, and 75th percentile values of export share.[23] As an example of this from Figure 5, consider the export wage premium relative to the overall wage premium for university-trained workers in the 75th percentile of export shares. This is represented by the vertical distance between the point E and the line denoted α_U relative to the vertical distance from the horizontal axis to point E. In terms of the regression coefficients, this is

$$\left(\beta_U \times X_{75th}\right) \Big/ \left(\alpha_U + \left(\beta_U \times X_{75th}\right)\right).$$

The statistics presented in Panel II show that the export wage premium is an important component of the overall wage premium. For example, it is a fifth of the wage premium for university-educated workers in firms at the 50th percentile of export share, and one-quarter for these workers who are employed in firms at the 75th percentile of export share. The comparable values for high-skilled workers are 24.4 percent and 29.6 percent. The export wage premium mitigates the overall premium for medium-skilled workers, reducing it by up to 27.2 percent for workers in firms at the 75th percentile of export share.

The calculations in the first two panels of Table 6 reflect wage premia relative to low-skilled workers at firms that do not export. Panels III, IV, and V offer pairwise differences across all four categories of workers at firms with comparable levels of

[23] These premia are relative to low-skilled workers at firms that do not export. Thus, the only premium for low-skilled workers is through the export wage premium and, for that reason, the export wage premium represents 100 percent of their wage premium – for this reason, calculations for low-skilled workers are not included in this panel.

exports. Panel III presents the pairwise differences in export wage premia at the 25th, 50th, and 75th percentile values of export share.[24] These can be illustrated by considering Figure 5 where, for example, the difference in the export wage premium for university-educated workers as compared to medium-skilled workers at the 75th percentile of export share is $((E - \alpha_U) - (G - \alpha_M))$. The corresponding value from the regression coefficients is $([\beta_U - \beta_M] \times X_{75th})$. The results in this panel exhibit substantial skill premia within plants due to exporting. For example, the export wage premium of university-educated workers relative to low-skilled workers, medium-skilled workers, and high-skilled workers at a plant at the 75th percentile of export share is 8.4 percent, 7.3 percent, and 3.6 percent, respectively, and high-skilled workers have a premium of 4.8 percent over low-skilled workers and 3.7 percent over medium-skilled workers.

Panel IV shows that the values in Panel III, which represent the wage premia associated with exporting, represent substantial proportions of the pairwise differences in the respective overall wage premia across skill levels. The results in this panel are comparable to those in Panel II, although there the comparison group is exclusively low-skilled workers in firms that do not export and, in Panel IV, comparisons are made across skill groups in plants with a common level of export share. For example, a representative statistics in Panel IV is that of high-skilled workers as compared to medium-skilled workers at the 75th percentile of export share. The difference in the export wage premium, relative to the difference in the overall wage premium, for this pair is

$$\left[([\beta_U - \beta_M] \times X_{75th}) \Big/ ([\alpha_U - \alpha_M] + ([\beta_U - \beta_M] \times X_{75th}))\right] \times 100\%$$

As shown in this panel, the differences in the export wage premia represent a substantial proportion of the pairwise differences in the overall wage premia. At the median value of export share, the export-induced skill premia represents about one-third of the overall skill premia of high-skilled workers and university-educated workers relative to medium-skilled workers, and almost one-quarter of the overall skill premium of university-educated workers to high-skilled workers.

[24] The statistics in this table are export wage premia of workers of one skill-level versus another where both skill levels are at a plant with a common export share. Thus, the export wage premium relative to low skilled workers exceeds that in Panel I since those statistics are for low-skilled workers in a plant that does not export and there is a negative export wage premium for low-skilled workers.

The final panel of Table 6 shows how a change in export share affects the wage gap between workers at two different skill levels. These statistics represent the percentage point change in export-induced skill premia due to a change in the export share from the 25th percentile level to the 75th percentile level. As shown in Panel V, a change of this magnitude increases the difference between university-educated workers and low-skilled workers by 4.5 percentage points, and between medium-skilled workers and low-skilled workers by 4.0 percentage points. The effects are smaller for the difference in wages between high-skilled workers and medium-skilled workers (2.0 percentage points) or low-skilled workers (2.6 percentage points). Each of the estimates in Panel V are statistically significant at better than the 95 percent level of confidence but for that between high-skilled and university-educated workers, which is significant at better than the 90 percent level of confidence.

We next provide a further disaggregation of the export wage premia by moving beyond an analysis based on 4 different skill groups to one in which we interact each of 340 occupation dummies with the export share, obtaining a different estimated export wage premium for each of these occupations, as shown in

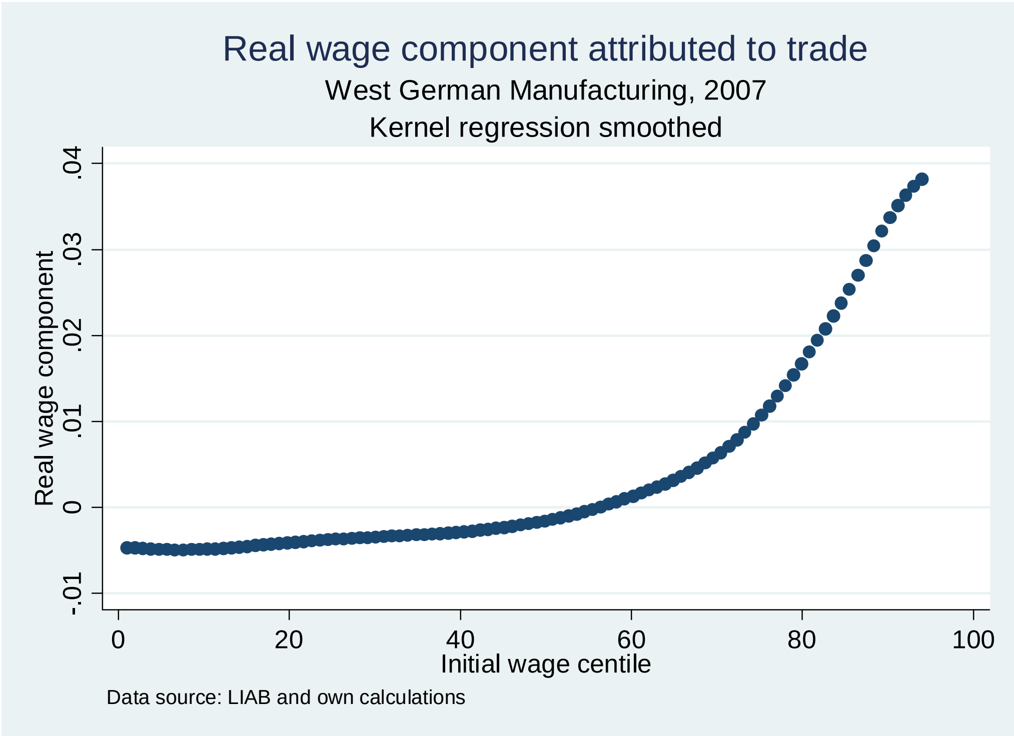
$$\ln W_{i,j,t} = \sum_{o=1}^{340} \beta_o'\left(O_{i\in o} \times X_{j,t}\right) + \sum_{Z=2}^{4} \alpha_Z S_{i\in z,t} + \Psi I_{i,t} + \Omega P_{j,t} + \tau_t + F_{i,j} + \varepsilon_{i,j,t}, \qquad [3]$$

where O_i is a dummy variable vector containing the 340 occupation dummies and β_o contains the occupation-specific export share wage premium. To display the results, we form wage centiles c_{kt}, k=1,…,100, separately for each year with k=1 the lowest wage centile. Then, we calculate the average wage premium of exporting by wage centile k in year t:

$$E\left[Exportpremium_{kt} \mid X_{j,t} > 0\right]$$
$$= \frac{1}{\sum_i p_{it} \cdot I\left[i \in c_{kt}; X_{j,t} > 0\right]} \sum_i \sum_{o=1}^{340} \beta_o'\left(O_{i\in o} \times X_{j,t}\right) \cdot p_{it} \cdot I\left[i \in c_{kt}; X_{j,t} > 0\right], \qquad [4]$$

where *I[.]* is the indicator function and p_{it} the inverse drawing probability of an observation. If the conditional mean independence assumption and the stable unit treatment value assumption hold, then this conditional expectation has the interpretation of an average treatment effect on the treated of exporting on wages.[25] The result of such an average export wage premium by wage centile for the year 2007 is depicted in Figure 6, where we apply Epanechnikov-Kernel smoothing at very small bandwidth covering 3 centiles.

Figure 6: Export Wage Premium by Income Percentile



We observe that workers in the lowest wage centiles have a wage discount. The wage discount decreases as we move to higher wage centiles, with a switch from a wage discount to a wage premium at about the 55th centile.

An impression of the type of occupations most affected by exporting is provided in Table 7. This table reports the ten occupations with the highest export wage premia and the ten occupations with the largest export wage discounts (among those occupations

[25] The estimates presented here of the conditional effect of exporting on wage inequality may be biased downwards. Our estimates of the effect of exporting on wage inequality are based on an assumption that these effects operate only on German manufacturing firms that are expanding their exports. However, it is reasonable to also assume that the occupational wage structure in firms that do not export, and in firms with constant levels of exports, are influenced by changes in firms which are expanding exports. If this is the case, these general equilibrium effects violate the stable unit treatment value assumption under which wage effects from export expansion are confined to those firms alone. The violation of this assumption means that our estimates are a lower bound of the actual effect of exporting on wage inequality. Dustmann et al. (2009) apply the same caveat to their results.

that have at least 20,000 observations in the population to ensure economic significance of these effects). We also report the predominant skill group for each of these occupations.

Table 7: Biggest Winners and Losers by Occupation

Largest Export Wage Discounts by Occupation		
Occupation	*Wage Discount (in percent)*	*Predominant Skill-group*
Wood preparers	-11.46%	Low-Skilled
Household cleaners	-8.43%	Low-Skilled
Office auxiliary workers	-5.88%	Low-/High-Skilled
Machine attendants	-5.39%	Low-Skilled
Packagers, good receivers	-4.24%	Low-Skilled
Toolmakers	-3.83%	Low-Skilled
Plastic processors	-3.82%	Medium-Skilled
Stores, transport workers	-3.61%	Low-Skilled
Transportation equipment drivers	-3.48%	Low-Skilled
Motor vehicle repairers	-2.97%	Medium-Skilled
Largest Export Wage Premia by Occupation		
Occupation	*Wage Premium (in percent)*	*Predominant Skill-group*
Entrepreneurs, managing directors	19.56%	Univ.educated
Management consultants	13.98%	Univ.educated
Foreman, master mechanics	13.78%	Medium-Skilled
Other engineers	13.38%	Univ.educated
Other manufacturing engineers	13.15%	Univ.educated
Economic and social scientists	11.46%	Univ.educated
Electrical engineering technicians	10.90%	High-Skilled
Data processing specialists	10.60%	High-Skilled
Electrical engineers	10.33%	Univ.educated
Commercial agents, travelers	9.43%	High-Skilled

Note: Based on results from Table 5, Panel C, plant-individual fixed effects, at least 20,000 employees per occupation; all reported coefficients on wage premia/discounts are significant at least at the 95 percent confidence level.

The range of export wage premia and discounts is quite considerable, ranging from a discount of more than 10% for wood preparers to wage premia of up to 20% for entrepreneurs and managing directors. The occupations with the highest estimated export wage premium include several engineering disciplines, business and management, and qualified technicians – all among the two highest skill categories. Those occupations with the highest estimated export wage discount include several types of manual workers and service personal – all among the two lowest skill categories.

To sum up, the results in Table 6 and 7 show that differences in the export wage premium represent an important proportion of the overall difference in wages across skill levels and can be quite significant for important occupation groups. The manner in which the export wage premium increases with the skill level suggests that this contributes to wage inequality across skill groups. But, as will be shown in Section 5, exporting firms serve to diminish wage inequality along the dimensions of gender and citizenship.

4. Robustness

In this section we investigate the robustness of our results with respect to an alternative hypothesis, that exporting merely serves as a proxy for firm productivity, and that workers share the rents generated in higher-productivity firms. We first test for the robustness of the results presented above to this explanation of the skill structure of the export wage premium by augmenting, in three separate specifications, the estimating equation used in Panel C of Table 5 with the interaction of each of the 4 skill groups with three different proxies for productivity; sales, value added, and average labor productivity.[26] Table 8 presents these results, with the three various productivity proxies in columns 2, 3, and 4 and, for sake of comparison, the benchmark specification from Panel C of Table 5 in column 1. As shown in this table, the skill-based export wage discount for low-skilled workers and the export wage premia for high-skilled and university-educated workers remain significant and largely unchanged with the inclusion of any of these three other sets of interaction terms.

[26]Helpman, Melitz and Yeaple (2004) argue that sales is a theoretically viable proxy for productivity.

Table 8: Alternative Hypotheses to the Export Wage Premia, by Skill Level

β_Z *(Skill×Exp)*	*Benchmark Tab. 5 C*	*Y=Sales*	*Y=Value added*	*Y=Labor product.*	*Y=High-tech*	*Y=New tech/prod.*	*Occupation time trend*
Low-skilled	-0.028**	-0.025**	-0.027**	-0.028**	-0.014	-0.023	-0.019**
(s.e.)	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)	(0.025)	(0.007)
Medium-skilled	-0.001	-0.007	-0.010	-0.010	-0.003	-0.016	-0.005
(s.e.)	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)	(0.023)	(0.007)
High-skilled	0.057**	0.048**	0.056**	0.057**	0.044**	0.076*	0.051**
(s.e.)	(0.012)	(0.011)	(0.012)	(0.012)	(0.012)	(0.035)	(0.011)
Univ. Educated	0.142**	0.130**	0.141**	0.141**	0.065†	0.195*	0.106**
(s.e.)	(0.039)	(0.034)	(0.039)	(0.039)	(0.038)	(0.099)	(0.036)
γ_Z *(Skill×Y)*							
Low-skilled	-	0.014**	-0.000	-0.001†	-0.006	0.000	-
(s.e.)		(0.004)	(0.000)	(0.000)	(0.008)	(0.020)	
Medium-skilled	-	0.016**	0.000	0.000	-0.005	0.015	-
(s.e.)		(0.004)	(0.000)	(0.000)	(0.008)	(0.016)	
High-skilled	-	0.029**	0.001**	0.001*	-0.005	0.008	-
(s.e.)		(0.005)	(0.000)	(0.000)	(0.010	(0.034)	
Univ. Educated	-	0.068**	0.002**	0.002*	0.014	0.053	-
(s.e.)		(0.013)	(0.001)	(0.001)	(0.036)	(0.058)	
No. of Observations	7,077,849	7,077,849	7,077,849	7,077,849	7,854,440	2,754,079	8,041,676

† sig. at 90% to 95% level of confidence; ** sig. at 95% to 99% level of confidence; *** significant at ≥ 99% level of confidence. Firm-employee spell- and year-fixed effects in all specifications. See Table 5 for list of other regressors. Estimates weight observations by inverse drawing probability. The specification *Y=new tech/prod.* covers only 5 years.

Our results are also robust to the inclusion of an interaction of the export share with a variable that represents the self-assessment by firms of whether they operate at the technology frontier. These results are presented in column 5 of Table 8, and show that the export premium for high-skilled workers, and, to a somewhat lesser extent, to university-educated workers, remains with the inclusion of the additional four interaction terms (notably, none of which are significant), although the wage discount for low-skilled workers is no longer significant. An alternative specification interacts the four skill levels with a dummy variable that equals 1 if a firm has implemented either a new technology or a new product in the previous two years (Z=tech/prod). These results show a larger wage premium for high-skilled and university-educated workers than the baseline case (and again, none of the new interactions are significant). Finally, in the last column of Table 8, we allow each occupation to have a different linear time trend on top of person- and firm spell effects. This specification is meant to capture long-run trends in shifts of relative labor demand by occupation through technological change. The export wage premium profile is not confined to high-tech firms or firms that introduce new products or technology and it is not reflecting long-run time trends of occupations.[27] The estimated export skill premia in this case are very close to those in the baseline scenario, both quantitatively and in terms of significance.

5. Gender, Nationality, and Export Wage Premia

Economic theory suggests that discrimination is a luxury that is more difficult to indulge in a competitive environment than in one where firms enjoy greater market power (Becker 1957).[28] Various types of evidence support this prediction. Black and Strahan (2001) find that female wages declined less than male ones in the aftermath of the U.S. banking regulation, starting in the mid 1970s and increased product market competition reduced wage discrimination in this sector. Similarly, Black and Brainard (2004)

[27] The low-skilled wage premium shows up insignificantly when controlling for the technology interactions. However, these specifications are misspecified by inclusion of irrelevant variables since none of the technology interactions is significant. It is well known that this leads to efficiency loss of estimates which may be responsible for the insignificant low-wage export premia in these two specifications.

[28] For a review on the gender wage gap and the theories of wage discrimination see for instance Altonji and Blank (1999), Blau and Kahn (2000) or Weichselbaumer and Winter-Ebmer (2007).

document that exogenous, comparably-sized increases in trade in United States manufacturing sectors led to a more rapid narrowing of the gender wage gap in concentrated industries than in more competitive industries. Oostendorp (2009) analyzes the impact of globalization on the gender wage gap for large cross-section of countries and reports that gender wage discrimination decreases with economic development and trade.[29]

Following this reasoning, and given this evidence, we may expect to find less wage discrimination in German manufacturing firms that export and face keener competition from abroad than among those firms that are insulated from world markets. In this section we show that exporting firms indeed pay more to women and workers who are not German citizens than non-exporting firms. These two groups of workers earn less than comparably-skilled males or German citizens, conditional on individual and firm characteristics. Thus, while exporting firms contribute to wage inequality across skill categories, the results in this section show that these exporting firms narrow wage gaps across gender, and even eliminate wage gaps across citizenship status.

These conclusions are based on analyses that modify the specification used in the previous section to allow for differences in the overall wage premium, as well as the export wage premium by skill levels, depending upon, in one case, whether an individual is a woman, or, in another case, if a person is not a German citizen (foreigner, for short). The specification takes the form

$$\ln W_{i,j,t} = \sum_{Z=1}^{4} \beta_Z \left(S_{i\in z,t} \times X_{j,t}\right) + \sum_{Z=2}^{4} \alpha_Z S_{i\in z,t} + D_i \times \left(\sum_{Z=1}^{4} \beta_z^D \left(S_{i\in z,t} \times X_{j,t}\right) + \sum_{Z=1}^{4} \alpha_z^D S_{i\in z,t} \right) + \\ + \Psi I_{i,t} + \Omega P_{j,t} + \tau_t + F_{i,j,t} + \varepsilon_{i,j,t} \quad [5]$$

where D_i equals 1 if the individual is a women (in one set of regressions considering gender differences), or 1 if the individual is not a German citizen (in another set of regressions analyzing differences in wages between foreigners and others), and all other variables are as described above.[30] The coefficients represented by α_Z^D, which are

[29] Although the evidence that discrimination is lower in more competitive markets, the evidence is more mixed for developing countries (see, e.g., Berik et. al., 2004, and Jolliffe and Campos, 2005).

[30] The estimates employ plant-occupation fixed effects, which can be directly compared to the results of Panel B in Table 5. Individual-level fixed effects cannot be used with the inclusion of the immutable person-level characteristic of gender or citizenship.

negative in all estimates, represents the wage shortfall for women or foreigners of skill level Z, conditional on personal characteristics and the characteristics of the non-exporting plants in which they work. The coefficient β_Z^D, which is positive in all but one case (and in that case, $\beta_{Low}^{Foreigner}$ is not statistically significant), represents the extent to which this shortfall is mitigated by working in a plant that exports. The coefficients α_Z and β_Z capture the wages for men (in the regression where D_i represents gender) or for German citizens (in the regression where D_i represents citizenship) in non-exporting and exporting firms, respectively.

Results presented in Tables 9 and 10 report the coefficients α_Z^D, β_Z^D, α_Z, and β_Z, as well as the export wage premia, $\left(\beta_Z + \beta_Z^D\right)X_i$ for X_i representing the 25th, 50th, or 75th percentile values of export share. Table 9 includes estimates where D_i represents gender. As shown in the α_Z^{Woman} column of the top panel, there is a large shortfall in conditional wages for women in plants that do not export, ranging from 17.5 percent for medium-skilled workers to 30.3 percent for high-skilled workers. This difference is smaller (though still present) in plants that export. As shown in the second panel, women working in a plant that exports are estimated to have higher wages than those who work in non-exporting plants across all four skill groups, and this difference is statistically significant for low-skilled, high-skilled, and university-educated women. This contrasts with the wage discounts for low and medium skilled men that is evident from the β_Z column of the top panel. High-skilled women have an export wage premium that is statistically distinct from that of high-skilled men, and more than twice as large (0.077 vs. 0.034). The conditional wage shortfall faced by women is notably smaller in plants with large export shares than in plants that do not export. The conditional wage shortfall for university-educated women is 27 percent smaller in plants that have an export share in the 75th percentile, and 21 percent smaller in plants with the median export share, as compared to plants that do not export. Comparable statistics for high-skilled women are 17 percent and 13 percent, and for Low-skilled women the statistics are 20 percent and 15 percent. Thus, exporting plants mitigate, but do not eliminate, gender-based wage discounts across skill levels.

Table 9: Export Wage Premium for Women

***P×O*, Plant-Occupation FE**	R^2=0.77	No. obs. = 8,041,676		
Skill Level	α_Z *(Skill)*	β_Z *(Skill×Exp)*	α_Z^D *(Women)*	β_Z^D *(Women)*
Low-skilled	—	-0.004	-0.178**	0.057**
(s.e.)	—	(0.009)	(0.005)	(0.011)
Medium-skilled	0.079**	-0.029**	-0.175**	0.037
(s.e.)	(0.004)	(0.008)	(0.012)	(0.028)
High-skilled	0.223**	0.034**	-0.303**	0.043**
(s.e.)	(0.007)	(0.012)	(0.008)	(0.014)
Univ. Educated	0.388**	0.099**	-0.266*	0.013
(s.e.)	(0.011)	(0.020)	(0.011)	(0.021)

Export Wage Premium for Women, by Export Share Percentile			
Skill Level	25th Percentile	50th Percentile	75th Percentile
Low-skilled	0.016**	0.026**	0.034**
(s.e.)	(0.004)	(0.006)	(0.008)
Medium-skilled	0.003	0.004	0.006
(s.e.)	(0.008)	(0.014)	(0.178)
High-skilled	0.023**	0.039**	0.051**
(s.e.)	(0.005)	(0.008)	(0.010)
Univ. Educated	0.033**	0.056**	0.073**
(s.e.)	(0.007)	(0.012)	(0.016)

Note: Other control variables as in Table 5. Estimates weight observations by inverse drawing probabilities.

Foreigners also face a conditional wage shortfall, although it is not as large as the one faced by women, and it is not statistically significant across all skill groups (see Table 10). At plants that do not export, there is a statistically significant wage discount of 2 percent for medium-skilled workers and high-skilled workers (significant at the 90 percent level for the latter), and of 3 percent for university-educated workers (also significant at the 90 percent level), but there is no evidence of a significant wage discount for low-skilled workers. Medium-skilled foreign workers, unlike their German counterparts, do not suffer an export wage discount, and university-educated foreigners have an export wage premium 75 percent higher than that of German citizens. High-skilled foreigners have an export wage premium 88 percent higher than that of German citizens, although in this case the difference is statistically significant at better than the 90 percent (but less than the 95 percent) level of confidence.

Table 10: Export Wage Premium for Foreigners

***P×O*, Plant-Occupation FE**	R^2=0.77	No. obs. = 8,041,676		
Skill Level	α_Z *(Skill)*	β_Z *(Skill×Exp)*	α_Z^D *(Foreigner)*	β_Z^D *(Foreigner)*
Low-skilled	—	0.009	-0.004	-0.008
(s.e.)	—	(0.008)	(0.003)	(0.006)
Medium-skilled	0.074**	-0.027**	-0.021**	0.024*
(s.e.)	(0.004)	(0.008)	(0.006)	(0.012)
High-skilled	0.186**	0.050**	-0.021†	0.044†
(s.e.)	(0.007)	(0.012)	(0.013)	(0.023)
Univ. Educated	0.368**	0.097**	-0.031†	0.073*
(s.e.)	(0.010)	(0.019)	(0.019)	(0.031)

Export Wage Premium for Foreigners, by Export Share Percentile

Skill Level	25th Percentile	50th Percentile	75th Percentile
Low-skilled	0.003	0.005	0.001
(s.e.)	(0.003)	(0.004)	(0.006)
Medium-skilled	-0.001	-0.002	-0.002
(s.e.)	(0.005)	(0.008)	(0.009)
High-skilled	0.028**	0.047**	0.061**
(s.e.)	(0.008)	(0.013)	(0.016)
Univ. Educated	0.051**	0.085**	0.111**
(s.e.)	(0.012)	(0.019)	(0.002)

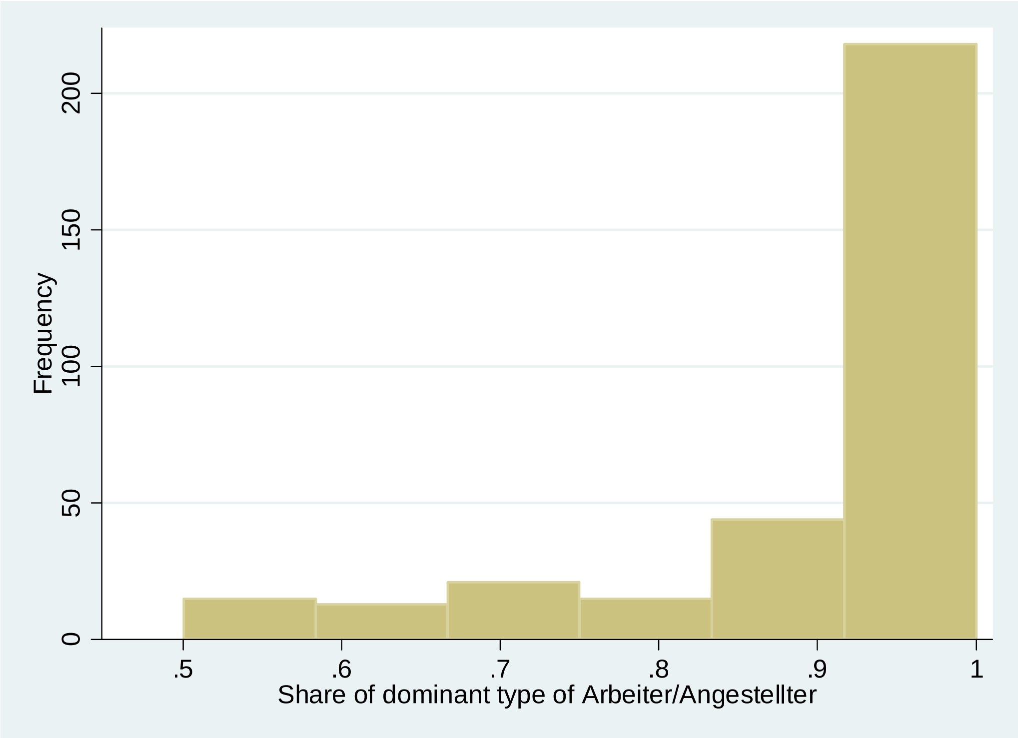
Note: Other control variables as in Table 5. Estimates weight observations by inverse drawing probabilities.

The statistically significant wage shortfall for foreign workers at plants that do not export is eliminated for high-Skilled workers and university-educated workers at plants that have an export share at the 25th percentile or greater, and medium-skilled workers at plants at the 75th percentile or greater. The wage shortfall is actually reversed, and university-educated foreign workers earn higher conditional wages than their German counterparts, at plants where the export share is at the 75th percentile or higher.

6. Conclusion

International competition has been long been cited in debates on the sources of rising wage inequality. In this paper, we argue that it is important to consider inequality along several dimensions. Our use of a linked employer-employee data base enables us to examine how wages in exporting plants differ from wages in plants that do not export for workers at different skill levels, as well as for workers who are members of groups that have traditionally been the subjects of discrimination. As with other research, we find evidence of an export wage premium. Our work is distinguished from previous research, however, by our identification of differences in the export wage premium across skill groups. Lower skilled workers in German manufacturing are shown to have an export wage discount while higher skilled workers have an export wage premium. This is a source of conditional wage inequality within exporting plants, and exacerbates inequality between exporters and non-exporters. But while the exporting / non-exporting distinction contributes to conditional wage inequality along the dimension of skill, it reduces gender-based and nationality-based conditional wage inequality in ways that are both statistically significant and economically meaningful. Thus, the overall effect of exporting on inequality is somewhat ambiguous; production complementarities contribute to skill-based inequality while stronger competition reduces gender or nationality-based inequality.

Appendix A1: Figure on Share of Dominant Type of Arbeiter-Angestellter in Each Occupation



Note: Total number of occupations is 340; source: IAB LIAB dataset.

Appendix A2: Table on Variable Definitions

Variable name	*Description*
Dependent variable	
ln(Wage) (i)	Daily gross wage (in logarithm) in Euros; incomes from different sources or of different kinds are aggregated.
Variables of interest	
Export share (j)	Share of sales abroad relative to total sales at establishment (j) in year t, which can vary between 0 and 1.
Low-skilled (i)	Dummy variable takes the value of 1 if the worker (i) in year t has less than 10 years of education and no vocational training and 0 otherwise.
Medium-skilled (i)	Dummy variable takes the value of 1 if the worker (i) in year t is classified by its employer as an *"Arbeiter"* and the worker has i) less than 10 years of education and no vocational training or ii) a high school degree and no vocational training or iii) a high school degree and vocational training and 0 otherwise.
High-skilled (i)	Dummy variable takes the value of 1 if the worker (i) in year t is classified by its employer as a *"Angestellter"* and the worker has i) less than 10 years of education and no vocational training or ii) a high school degree and no vocational training or iii) a high school degree and vocational training and 0 otherwise.
Univ. Educated (i)	Dummy variables that takes the value of 1 if the worker (i) in year t has a university or college degree and 0 otherwise.

Control variables	
ln(Experience) (i)	Days (in logarithm) since worker's (i) entry into work life.
ln(Tenure) (i)	Days (in logarithm) since worker's (i) entry into the current establishment.
Foreigner (i)	Dummy variable takes the value of 1 if worker (i) does not hold the German citizenship and 0 otherwise.
Gender (i)	Dummy variable takes the value of 1 if worker (i) is female and 0 otherwise.
Occupation	Occupation held by worker (i) at time t; 340 different occupations from the "Berufsordnung" classification enter the plant-occupation fixed effect.
Ln (Employment) (j)	Number of full-time employees (in logarithm) at establishment (j) in year t.
Single Plant Company (j)	Dummy variable takes the value of 1 if establishment (j) in year t constitutes the entire company.
In a Holding Company (j)	Dummy variable takes the value of 1 if establishment (j) in year t is an affiliate of a larger company (the omitted category for this dummy and the preceding one is the headquarter of a company with multiple establishments).
Work Council (j)	Dummy variable takes the value of 1 if establishment (j) in year t has a work council; workers in companies with more than 20 employees have the right to organize a work council.
High-tech (j)	Dummy variable takes the value of 1 if plant (j) in year t is at the technology frontier, based on self-assessment by employer. There were originally 5 categories. We define high-tech as the two highest categories.

Source: LIAB, Institute for Employment Research.

Appendix A3: The Matched IAB – LIAB data set.

The IAB establishment panel is a stratified sample of all establishments in the entire economy over the years 1993 until 2007.[31] Strata consist of category cells by region (Länder), industry and firm size, and each cell has its own drawing probability. Drawing probabilities vary between 90% for establishments with more than 1000 employees contributing to the social security system, and about 0.1% for establishments with less than 5 employees contributing to the social security system. Unless otherwise noted, we always adjust our statistics and regressions for these different drawing probabilities by applying inverse probability weighted estimators and means.

Matching of the IAB establishment data with the LIAB employee data occurs through the use of an establishment identifier. The LIAB data set is based on obligatory reporting by employers, and it includes essentially the entire population of the German workforce. At least once a year, employers report employment, biographical and wage information on each employee contributing to the social security system (the IAB data were originally constructed as spell data in the "Beschäftigten-Leistungsempfänger-Historik-Datei," on which the German social security system is based). The IAB selects from the "Beschäftigten-Leistungsempfänger-Historik-Datei" all those employees that were employed on June 30 of each year in one of the establishments contained in the IAB establishment panel. There are several observations for a person in one year, if this person holds several jobs (only one of which needs to be in an IAB establishment panel plant) or obtains some government support via the social security system besides her wage. Overall, the IAB identifies 77 different types of spells, including leaving a company, starting a new job, going on unpaid sabbatical, registering as unemployed and obtaining unemployment benefits, and taking a second job. An employee disappears from the data set if he or she becomes unemployed, shifts to an establishment outside of the IAB establishment panel, or if his or her establishment stops responding to the IAB establishment panel.

The dependent variable in our analysis is the logarithm of the employer-reported average daily gross wage, a value that includes extraordinary allowances. Its value in a particular year is for the annual reporting spell that includes June 30 of that year, or aggregated over all sub-annual spells including the one that includes June 30 of that year. Wages, as well as all other nominal variables, are deflated using the GDP deflator (from SVR). There is upper censoring of wage data because employees are not obliged to contribute any share of their income above the censoring level to the public pension system. Employers report the censoring level of the wage instead of its true value, however, this is a very high wage. For example, in 2003 the censoring level was €167.5 per day, and only 7.2% of all workers had a wage at this level or higher. We follow the imputation procedure of Gartner (2005) to correct for censoring by replacing the reported wage with the predicted value from a tobit estimation that regresses log daily wages on education level, gender, experience, experience squared, tenure, nationality and a dummy for West Germany separately for each year. Importantly, imputation does not use

[31] A description of the IAB establishment data is found in Bellmann (2002). The participation is voluntary. However, the data collection is conducted by professional interviewers and the answer rate is very high (up to 80%). Whenever the managers of a plant cease to answer the survey, that plant is replaced by a random draw from the same stratum. If an establishment has not answered and drops out, then it may be drawn again into a sample after a certain period of years. It obtains a new identifier number in this case.

establishment information such as export status of the establishment. The imputation is done on LIAB alone (not excluding non-manufacturing employees at this stage to ensure comparability of our results with those of previous studies).

Missing values of an employee's education data is imputed following Fitzenberger et al. (2005). Specifically, missing values of an employee's education level are imputed from the information on the education level in previous or following years of the same person from age 19 to 28 onwards, depending on the level of education. Information on vocational training is imputed from a separate question on occupational position ("Stellung im Beruf"). If there are several observations per worker and year, wages are added up and the observations are aggregated to one observation per employee and year.

When matching establishment and employee data, the IAB is unable to match about 6% of all establishments (Jacobebbinghaus, 2008). This may be the case if there is a change in the ownership of a plant. Then IAB establishment panel keeps the old plant identification number while a new one may be assigned to the LIAB data. Moreover, if there are several plants at the same address (e.g. holding company headquarter and production site), the plants are often aggregated to represent one unit in the IAB establishment panel if it appears economically as one unit to the interviewer and the separation is only for legal reasons. This would result in a mismatch in the size of the IAB establishment panel plant and the number of employees from LIAB assigned to it. For this reason, we exclude all establishments, where the number of reported full time employees from the IAB establishment panel deviate by more than 30 per cent from the corresponding number in LIAB for establishments with more than 50 full-time employees or by more than 10 employees for establishments with less than 50 employees, which is common practice for this dataset (Jacobebbinghaus, 2008). This eliminates another roughly 9% of all establishments.

Then, we exclude all part-time workers, home workers, observations with one-time income (e.g. contract for work and services "Werkvertrag"), interns, workers during vocational training or retraining, and all observations with a wage per day of less than € 21.36 (or € 2.67 per hour assuming an 8 hour day), which would be well below the social security aid if choosing not to work. This excludes roughly 20% of the remaining observations. We also perform consistency checks and exclude all observations when either the beginning of the work spell or the beginning of an employee's employment occurs after the year of the survey. We also correct information on education when the education variable and the variable of occupational position (Stellung im Beruf) give contradictory information on whether a worker is uneducated. In this case, we give preference to the occupational position information, since it refers to the skill needed for the current occupation.

Finally, we select all observations of West-German manufacturing firms. We exclude East German plants, because they were not surveyed in the first years of the sample period.

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