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International Trade and Inter-Industry Wage Structure in Swedish Manufacturing
- Evidence from matched employer-employee data*

by

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Abstract

This study examines the inter-industry wage structure in Swedish manufacturing by using matched employer-employee data for the period 1996 to 2000. First, we use detailed individual and job characteristics to estimate industry-specific and time-varying wage premiums. Second, we investigate the impact of international trade on wage premiums, after controlling for effects of domestic competition and technical progress.

Our results indicate that industries that face intensive import competition from low-income countries have lower wage premiums. Surprisingly, the wage premiums are not related to export intensities. Furthermore, technical progress, measured by investment in R&D activity, appears to enhance inter-industry wage premiums.

Keywords: Inter-industry wage structure; International trade; Matched employer-employee data
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1. Introduction

The existence of inter-industry wage differentials is a well-documented phenomenon in the literature. [1] As shown by Edin and Zetterberg (1992) and Arai (1994), in Sweden, there appears to be significant differences in wage levels between industries when characteristics of individuals and firms are controlled for. A less investigated question is how industrial wage differentials are related to trade performance? From a Swedish perspective this is an issue of particular interest, since Swedish manufacturing is exposed to intensive import competition and at the same time depends highly on exports to international markets.

The aim of this study is mainly to analyze the effects of international trade on the inter-industry wage structure in Swedish manufacturing in the late 1990s. More specifically, controlling for individual, firm and industry characteristics, we investigate how international trade affects on inter-industry wage structure through both export competitiveness and import penetration. We focus on the impact of international trade, and we also add controls for the distinguishing features of Swedish product and labor markets.

In our analyses we make use of a unique matched employer-employee dataset for the period 1996 to 2000. It contains detailed information about worker characteristics, the firms that employ them, and the industries to which the firms belong. With such a detailed dataset we expect the measures of inter-industry wage premiums to be more accurate than in earlier studies that have been carried out at more aggregate levels.

To preview of our results, we find that industries that face intensive import competition from low-income countries have lower wage premiums. Surprisingly, the wage premiums are not related to how export-oriented the industries are. Finally, technical progress, measured by investment in R&D activity, appears to enhance inter-industry wage premiums.

The outline of this paper is as follows. Section 2 discusses theoretical issues, while section 3 briefly reviews the relevant literature. Section 4 introduces the dataset and the empirical strategy. Section 5 contains discussions of the estimation of inter-industry wage premiums and the impact of international trade. Section 6 concludes.

[1] See Dickens and Katz (1986), and Krueger and Summers (1986, 1988) for the US, Gera and Grenier (1994) for Canada, Haisken-DeNew and Schmidt (1999) for a comparison between the US and Germany, and Abowd and Kramarz (2000) for a comparison between the US and France.

2. Theoretical background

Firms and industries pay different wages to workers with different levels of human capital and competence as reflected in, for instance, education and experience. But one may ask why some firms and industries choose to pay more than others for the same type of workers? A necessary condition for that is the existence of some rents to share. For instance, in the presence of excess market power among producers in the product market, higher wages may be paid to workers as a form of rent sharing.[2]

Given that firms have the opportunity to pay non-competitive wages, the efficiency wage literature offers some economic reasons why such behavior might be profitable and increase productivity: (1) minimization of the turnover costs, (2) motivation on workers' efforts, (3) enhancement of workers' loyalty, and (4) selection on workers with high quality.

In general, international trade models support the view that trade liberalization and/or increased economic integration generate income redistributions among different types of labor with different qualifications. However, when production factors are mobile across industries, as predicted in a standard Heckscher-Ohlin-Samuelson model, factor prices will be equalized across industries. The industrial wage differences for the same type of workers will disappear.

On the other hand, in the specific-factor model, where workers, e.g. due to various frictions, are assumed to be immobile across industries, changes in real wages depend on whether the workers are in industries in which prices rise or fall.[3] An increased degree of internationalization through declining trade barriers and trade costs in all sectors should result in falling prices in import competing industries and increasing prices in exporting industries. These price changes thus lead to higher wages in the exporting industries and lower wages in the importing industries. In other words, winners and losers are distinguishable by the industry affiliation of workers instead of by the type of workers. Empirical evidences from the labor economic literature provide some support for labor immobility. Helwege (1992) shows that skills that have been accumulated over time might be firm- and industry specific and make workers less mobile. This is particularly true for senior and more experienced workers.

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[2] The monopoly-wage hypothesis implies that workers share excess profits of firms in concentrated industries (Weiss 1966).

[3] According to OECD's country survey in 2004, Swedish workers are more inclined to stay in the same job than what their counterparts in other OECD countries seem to be.

Technical progress has, in the specific-factor model, similar effects as price changes, i.e. wages are growing faster for workers in industries with high rates of technical progress. Technical progress may be induced through innovation efforts, e.g. by expenditure on R&D. To the extent that R&D activities pass-through to industrial wages, we would expect higher wages in R&D intensive industries.

Finally, we should notice that the specific-factor model assumes perfect competition on both product and factor markets. Imperfect competition, therefore, opens up additional channels through which international competition may affect inter-industry wage premiums.

3. Some previous empirical studies

The first study to examine the inter-industry wage structure in Sweden is Edin and Zetterberg (1992). They compare their results for Sweden with Krueger and Summers' study (1987, 1988) for the US. Their analysis indicates that the magnitude of inter-industry differentials at the one-digit level is much smaller in Sweden than that for the US. They also show that most of the observed industry wage differentials in Sweden are due to differences in labor quality and other non-pecuniary conditions. In contrast to Edin and Zetterberg (1992), the findings by Arai (1994) exhibit substantial inter-industry wage differentials in Sweden at the two-digit level, even when unmeasured worker-characteristics and working condition are controlled for.

Most of the empirical studies investigating inter-industry wage structure are found in the labor economics literature, while the empirical evidence of the impact of international trade obtained by combining information on individuals with firm- and industry- level data is still rather scarce.

Katz et. al. (1989) address industry wage differentials in the light of active industrial policy in the US. They use detailed data of individual characteristics and trade data at the industry level. Their results suggest that the workers in export-intensive sectors enjoy higher wage premiums, while the workers in import-intensive sectors have lower premiums. This is particularly true for the industries within the manufacturing sector. Grey (1993) examines wage premiums and trade performance for Canadian manufacturing industries at the three-digit level for 1985. He finds that Canada experienced similar influences of trade on inter-industry wage premiums as in the US.

Abowd and Kramarz (1999) examine the impact of international trade and mobility of French workers on wage premiums using individual information and international trade data for the period 1986-1990. They find that imports at the firm level have negative effects on wages. Salvanes et al. (1998) use matched employer-employee data for Norway in the period 1991-1995. After controlling for conventional individual human capital variables and job characteristics, they find that a higher degree of openness gives higher wage premiums.

A new strand of literature examines how trade reforms have affected industry wage premiums in developing countries. Goldberg and Pavcnik (2001) investigate the impact of trade reforms on the industry wage structure in Colombia in the 1980s, while Pavcnik et al. (2003) do the same for Brazil in the 1990s. According to the study on Colombia, the relationship between trade protection and wage is negative without industry fixed effects, while the reverse relationship is true when industry fixed effects are included. However, no significant statistical link between changes in industry wage premiums and changes in trade policy is found in the study on Brazil.

In short, most of the earlier studies conducted by using matched employer-employee data have found evidence supporting the positive effect of exports and the negative effect of imports on inter-industry wage premiums. In the case of Sweden, however, the previous studies have dealt with pure labor economic issues and have used data from the 1970 and 1980s. In this study, we employ more detailed data from the late 1990s and focus mainly on the impact of international trade on wage premiums in the Swedish manufacturing.

4. Data and empirical strategy

The data used for this study are from Statistics Sweden and have been compiled into a microeconomic database at the Trade Union Institute for Economic Research (FIEF). The information on individuals is based on a representative sample for the Swedish economy. Since we only have trade data for manufacturing, we constrain the dataset to contain individuals working in the manufacturing sector. It is a matched employer-employee dataset to which structural characteristics at the industry level are added.

In the administrative wage register, every employee has a personal code and an employer code. In the first step of matching, the employer code is used to match to the employee in the financial accounts of his/her main employer. The employers comprise all Swedish manufacturing firms with more than 20 employees.[4] The data employed in our study contain full and part-time manufacturing employees aged 16 and older. Multiple job-holdings are excluded from our analyses. In the second step of matching, the employee and firm-level information has been linked to industry-level data by matching the classification codes of industry in both the administrative wage register and the financial accounts of enterprise. We obtain then a panel of the Swedish manufacturing for the period 1996-2000 in which there are, for each year, between 373,881 to 432,625 employees and in between 945 and 1,327 firms.[5]

We measure the wages by taking logarithms of real monthly wages. The consumer price index with 1990 as the base year is used as a deflator. The wages for the part-time employees are recalculated up to the full-time employment by taking account of hours worked. This adjustment is made by Statistics Sweden.

In the empirical analyses, we follow the two-stage industry wage premium estimation developed by Krueger and Summers (1988) and further refined by Haisken-DeNew and Schmidt (1997). We first regress individual wages on a set of characteristics of individuals and firms and a set of industry dummy variables.[6] A baseline industry is dropped as a reference group and we assume that the omitted industry has zero wage premium and estimate a standard ordinary least square (OLS) regression. Having obtained the estimated coefficients on the industry dummies, i.e. the wage premiums, we make a linear transformation and re-normalize the estimated industry premiums and adjust the standard errors accordingly. We use employment share of each industry as weights. The normalized wage premium thus can be interpreted as the proportional difference in wage for an average worker in a given industry relative to an average worker in all manufacturing industries with the similar observable characteristics.[7] As discussed in Haisken-DeNew and Schmidt (1997), this improved procedure provides a more meaningful economic interpretation of the coefficient that measures deviation from an overall average rather than from a base category. Following the Haisken-DeNew and Schmidt

[4] We use 20 employees as a cut-off point because information of both production and export are incomplete for the firms that have less than 20 employees in our dataset.

[5] During the period of 1996-1999, the individual workers are matched with their main employers within the private sector only. For 2000, the employer codes are available for both the private and the public sectors, and hence the numbers of individuals and firms for this year are larger in comparison to the figures for the previous period. Appendix 1.1 gives more detailed information on the panel.

[6] Appendix 1.2 provides detailed definitions of these variables.

[7] We use the approximation log point as percent throughout this paper.

(1997) procedure, we employ the exact formula to compute both adjusted and weighted standard deviations of transformed inter-industry wage premiums and a summary measure of the overall variability of industry wage premiums.[8]

5. Empirical specification and results

The empirical analyses are divided into two parts. In Section 5.1, we estimate inter-industry wage premiums on an annual basis for the period 1996 to 2000. Having obtained the adjusted measures of inter-industry wage premiums, in Section 5.2, we estimate the impact of international trade on the wage premiums. [9]

5.1 Estimation of industry wage premiums

We obtain the industry-specific wage premiums by estimating the wage equation:

$$\ln w_{ijk} = \beta_i Individual_{ijk} + \beta_f Firm_{jk} + wp_k \times DI_k + \varepsilon_{ijk} \qquad (1)$$

where i is the index for the individual, j is the index for the firm and k is the index for the industry and the variables are defined as the following:

$\ln w_{ijk}$: The log of average monthly wage deflated by the consumer price index.

$Individual_{ijk}$: A vector of characteristics of individuals, such as age, gender, educational level and profession.

$Firm_{jk}$: A vector of characteristics of firms, such as firm size, capital intensity, technology, and profitability.

[8] The coefficients of the industry dummies are restricted so that their sum, weighted by the industry employment shares in the sample, equals zero. Thus, each coefficient indicates approximately the percentage of wage difference between an employee in a given industry and the average employee in all industries. The weighted and adjusted standard deviation of the coefficient is calculated as: $\hat{s}(\beta) = \sqrt{w'\upsilon'((b^*)b^* + w'v'(V(b^*)}).$

[9] Goldberg and Pavcnik (2001) and Pavcnik et al. (2003) apply a similar method to evaluate the effects of trade reforms in Brazil and Colombia using micro data.

DI_k: A set of three-digit manufacturing industry-dummy variables, which indicates individual *i*'s industry affiliation.

We estimate Equation (1) with OLS. Standard errors are adjusted for both heteroskedasticity and potential dependency among individuals in the same industry at the three-digit level. The industry wage premiums thus capture the part of variation in wages that cannot be explained by measurable individual and job characteristics, but can be affected by an individual's specific industry affiliation.

Table 1 reports the results of the cross-sectional estimations of regression Equation (1). The standard demographic and human capital variables yield similar results as in previous labor studies. Male workers receive, on average, 10 percent higher wages than female workers indicated by the positive and significant coefficients on gender. Using age as a proxy for experience reveals that experience involves higher wage, but at a decreasing rate. The education variables at different levels have positive and significant effects on wages. The size of the coefficients is increasing with the education level, indicating that each successive increase in education gives a positive return. Moreover, we control for professional categories by using a standard classification of occupations at the one-digit level. Owing to the multicollinearity between education and profession, only some of the estimates on profession are individually significant.

In our wage equation, we take also employer characteristics into account, such as firm size, capital intensity, relative total factor productivity (TFP) and profitability. Both firm size and capital intensity estimates provide clear-cut evidence that larger firms and firms with higher capital intensity pay higher wages. The coefficients on these two variables are highly significant and positive for the whole period. The coefficients on firm size are at the range of 1.1%-2.4%, while the coefficients on capital intensity are at the range of 2.2%-3.4%. Unlike earlier labor studies, we introduce an explicit measure of technology, namely the relative TFP. The relative TFP intends to capture technology advantages and superior management skills of the firms. The estimates on relative TFP, as we expected are positive and significant, and at the range of 5%-17%. Furthermore, we include profitability of the firms as a control variable.[10]

[10] In order to avoid the instability in the profit measures, we use an average profit over a three-year interval. For year 1996, the profit measure is computed as the average profit for year 1994, 1995 and 1996. Similarly for year 1997, we use the average for year 1995, 1996 and 1997, etc. The endogeniety between wage and profit is often addressed in rent-sharing literature. Since we do not explicitly model the rent-sharing mechanism, but use profitability as a control variable, this potential endogeniety problem is not explicitly addressed here.

Table 1. Cross-section estimations of wage premiums, 1996-2000

Dependent variable: Monthly real wage in logarithm					
	1996	1997	1998	1999	2000
Individual control variables					
Gender	0.104 [9.36]	0.107 [15.25]	0.106 [15.12]	0.096 [12.14]	0.090 [12.82]
Age	0.021 [11.93]	0.019 [15.29]	0.019 [12.11]	0.018 [9.41]	0.018 [10.93]
Age x Age	-0.0002 [-11.20]	-0.0002 [-14.03]	-0.0002 [-11.29]	-0.0002 [-9.21]	-0.0002 [-11.00]
Education2	0.052 [6.44]	0.053 [12.71]	0.056 [14.16]	0.045 [7.94]	0.038 [7.38]
Education3	0.073 [7.05]	0.076 [12.59]	0.079 [12.97]	0.067 [8.16]	0.060 [7.57]
Education4	0.100 [8.42]	0.104 [11.07]	0.122 [15.20]	0.113 [10.22]	0.121 [11.10]
Education5	0.232 [16.32]	0.243 [19.41]	0.256 [23.45]	0.242 [16.44]	0.223 [14.36]
Education6	0.427 [20.80]	0.439 [25.26]	0.438 [30.26]	0.428 [28.22]	0.423 [20.92]
Professions	Yes	Yes	Yes	Yes	Yes
Firm-level control variables					
Firm size	0.011 [1.93]	0.012 [2.58]	0.018 [2.84]	0.024 [6.19]	0.019 [5.99]
Capital intensity	0.030 [5.50]	0.027 [3.95]	0.022 [3.55]	0.034 [6.86]	0.025 [5.18]
Relative TFP	0.080 [1.87]	0.051 [2.16]	0.061 [3.95]	0.090 [4.70]	0.172 [5.21]
Profitability	-0.0020 [-0.46]	0.0003 [5.63]	0.0007 [4.60]	-0.0013 [-0.31]	-0.0009 [-0.94]
Industry dummies (3-digit)	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.53	0.48	0.50	0.54	0.58
F-statistics for industry dummies Degree of freedom	212 75	166 80	134 79	169 77	148 84
Observations	317962	316421	299761	329178	347353

Notes: Standard errors are adjusted both for heteroskedasticity and potential dependency among individuals in the same industry at 3-digit. White's heteroskedasticity-consistent t-statistics are in brackets.

The coefficients on profitability are unstable, which suggests that the positive effect on wage of profitability is not as clear-cut as in other labor economic studies.[11]

In the labor economics literature, particularly in studies using firm-level data, the choices of control variables are often open empirical issues. To check the robustness of our preferred specification in Table 1, we experiment with including the firm's market share and with employing an alternative profitability measure. The results of these exercises are reported in Appendix 2.

In some previous studies (e.g. Salvanes et al. 1998), market share is included to control for firms' market power or efficiency. As shown in Table A2.1 in Appendix 2, the positive effect of market share on wage is not clear-cut. Another consequence of including market share is that the coefficients on the relative TFP become smaller and less significant in comparison to the original specification of the wage equation. When we add firm size, the coefficients on market share become insignificant.[12] These results indicate that there seems to be mulitícollinearity among firm size, market share and relative TFP. Therefore, we choose the most parsimonious specification that excludes firms' market shares.

The other experiment we carry out is to use an alternative profitability measure, the logarithm of profit per employee, which is the most conventional measure of profitability in the labor economics literature, and exclude the TFP variable from the model. As shown in Appendix 2 Table A2.2, the coefficient on profitability is still not significant in every year.

Another possible determinant of wage premiums is the ownership structure. As a robustness check, we include foreign versus domestic and private versus public ownership dummy variables in the model. The results show that coefficients on ownership are not statistically significant and the estimates on other control variables remain unaffected when ownership is controlled for. Hence, we exclude the ownership controls from our specifications.[13]

To summarize, we have taken both relevant individual and job characteristics into account in the estimations of industry-specific wage

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[11] Arai (2003) and Heyman (2001) are two examples of such studies using data on Swedish firm and individuals.

[12] For brevity, the result that includes firm size is not presented, but is available upon request from the authors.

[13] The results with ownership controls are available at request from authors.

premiums. We find that the estimates are robust to these modifications of the specifications. Nevertheless, two empirical issues need to be discussed before we look at the estimates of the industry-wage premiums in more detail, namely unmeasured labor quality and compensation differentials.

It is often argued that labor quality cannot be adequately controlled for since non-measurable labor quality differences (such as motivation and innate ability) may vary systematically with industry and might then be picked up by industry-level variables instead of by human capital controls. This methodological issue is addressed in several previous studies by using fixed-effect estimates in the context of panel data instead of cross-sectional estimation. However, this solution is not without potential problems. At first, methodologically, it can only be applied to the individuals who switch industries. The most obvious drawback is that individuals do not switch across industries randomly. It causes therefore endogeneity bias in the estimation (Gibbons and Katz 1992). Furthermore, selection bias and measurement errors emerge immediately with such approaches. Theoretically, the expected number of industry-switchers may not be large, since in the short run labor is assumed to be immobile. Moreover, a number of recent studies show that the mobility of labor is more common across firms within the same industry than across industries.

The compensating wage differential argument means that since working conditions vary systematically across industries, different wages are paid to compensate employees for that. If such differences in working condition across industries are not taken into account, they may generate bias in the estimated wage premiums. The evidences from previous studies, e.g. Murphy and Topel (1987) and Krueger and Summers (1987), show that industry wage differentials in the US are robust after controlling for various working conditions. The dataset in this study does not offer any possibility to take various working conditions into account. However, the findings in Arai (1994) of substantial industry premiums in Sweden are not affected by the inclusions of variables controlling for working conditions and individual fixed effects.

The number of industries in Table 1, where we use the three-digit level industrial classification codes, is between 76 and 85 depending on the year of calculation. To give a more direct impression and a better overview of the magnitude of estimated wage premiums, we estimate the same model as in Table 1 employing two-digit level industry dummies. Table 2 presents the results.

Table 2 shows that the overall variability of the industry wage premiums at both the two-digit and the three-digit levels has a decreasing pattern. The convergence of wage premiums, indicated by declining standard deviations between 1996 and 2000, is clearer at the three-digit level.

Table 2. Industry wage premiums (two-digit level), 1996-2000

Sector	1996	1997	1998	1999	2000
15: Food & Beverage	-0.074 (0.008)	-0.052 (0.006)	-0.040 (0.005)	-0.059 (0.007)	-0.047 (0.004)
17: Textiles	0.002 (0.025)	-0.048 (0.008)	-0.044 (0.009)	-0.029 (0.007)	-0.047 (0.005)
18: Wearing apparels	-0.135 (0.010)	-0.104 (0.011)	-0.097 (0.012)	-0.030 (0.013)	-0.066 (0.011)
19: Leather, footwear	-	0.036 (0.015)	-0.018 (0.012)	-0.010 (0.011)	-0.034 (0.009)
20: Wood products	-0.029 (0.016)	-0.019 (0.013)	-0.012 (0.013)	-0.027 (0.009)	-0.016 (0.007)
21: Pulp and paper	0.026 (0.012)	0.059 (0.010)	0.036 0.011)	0.013 (0.010)	0.003 (0.008)
22: Publishing, print	0.008 (0.010)	0.046 (0.007)	-0.001 (0.009)	0.040 (0.007)	0.046 0.006)
23: Refined petroleum products	0.007 (0.011)	0.041 (0.009)	0.029 (0.006)	-0.005 (0.009)	0.032 0.006)
24: Chemicals & chemical products	-0.035 (0.009)	-0.004 (0.008)	-0.003 (0.006)	-0.020 (0.012)	-0.008 (0.007)
25: Rubber & plastic products	-0.057 (0.010)	-0.016 (0.006)	-0.029 (0.008)	-0.009 (0.008)	-0.027 (0.005)
26: Other non-metallic mineral products	-0.030 (0.006)	-0.004 (0.004)	-0.001 (0.005)	-0.018 (0.005)	-0.017 (0.004)
27: Basic metals	-0.012 (0.007)	0.048 (0.011)	0.042 0.010)	0.011 (0.011)	-0.005 (0.009)
28: Fabricated metal products	-0.093 (0.029)	0.007 (0.005)	-0.036 (0.004)	-0.022 (0.009)	-0.025 (0.005)
29: Machinery	-0.012 (0.007)	0.007 (0.003)	-0.014 (0.003)	-0.022 (0.003)	-0.019 (0.002)
30: Office machinery & computers	0.131 (0.014)	-	-	0.062 (0.013)	0.009 (0.005)
31: Electrical machinery & apparatus	-0.033 (0.007)	-0.005 (0.007)	0.005 (0.006)	0.011 (0.006)	-0.023 (0.005)
32: Radio, television, communication equipment	-0.009 (0.016)	0.031 (0.011)	0.031 (0.012)	0.051 (0.011)	0.055 (0.008)
33: Medical, precision instrument	0.002 (0.008)	0.029 (0.008)	-0.000 (0.007)	0.033 (0.004)	0.058 (0.005)
34: Motor vehicles, trailers	0.024 (0.015)	0.011 (0.009)	0.019 (0.011)	-0.015 (0.013)	0.003 (0.008)

Table 2. (continued)

35: Other transport equipment	-0.043 (0.008)	-0.022 (0.004)	-0.030 (0.005)	-0.027 (0.008)	-0.015 (0.004)
36: Furniture, manufacturing n. e. c.	-0.047 (0.008)	-	-0.022 (0.007)	-0.025 (0.009)	-0.047 (0.004)
Overall average	8.889 (0.082)	9.183 (0.250)	9.284 (0.180)	8.954 (0.104)	8.991 (0.056)
Overall variability of industry wage coefficients (two-digit)	0.013	0.007	0.007	0.009	0.005
Overall variability of industry wage coefficients (three-digit)	0.010	0.009	0.009	0.007	0.006
Number of observations	317962	316421	299761	329178	347353
Adjusted R^2	0.52	0.48	0.49	0.53	0.57
F statistics for no industry effect (two-digit industry) Degree of Freedom	552.27 19	425.78 19	234.85 20	303.55 20	306.27 20

Notes: The control variables at the individual- and the firm levels are the same as in the 3-digit industry specification.

Furthermore, the wage premiums are in general higher in some industries, e.g. pulp and paper (SNI21), office and computers (SNI30), radio, television and communication equipment (SNI32), medical and precision instrument (SNI33) and motor vehicles (SNI34). For instance, an average worker in the pulp and paper industry has 2.6 percent higher wage than an average worker in the whole manufacturing in 1996. In other industries, such as wearing apparels (SNI18), chemicals and chemical products (SNI 24), rubber and plastic products (SNI25) and other non-metallic mineral product (SNI26), the wage premiums are generally lower. An average worker in rubber and plastic products industry has, for example, 3.5 percent lower wage than an average worker in the whole manufacturing in 1996.

Table 3 uses year-to-year correlations between wage premiums over the whole period to check the stability of the wage structure. As shown in Table 3, the year-to-year correlations range from 0.86 to 0.73.[14] In Arai (1994), the correlations between wage premiums are 0.91 for 1968 and 1974, 0.63 for 1968 and 1981 and 0.62 for 1974 and 1981 for a sample of non-agricultural workers. Krueger and Summers (1988) report that industry wage premiums have a correlation up to 0.91 in the period 1974 to 1984 in

[14] Similar results are obtained for unadjusted wage premiums as well.

Table 3. Correlations of inter-industry wage premiums over time

	wp1996	wp1997	wp1998	wp1999	wp2000
wp1996	1.0000	-	-	-	-
wp1997	0.7902	1.0000	-	-	-
wp1998	0.7278	0.8590	1.0000	-	-
wp1999	0.6338	0.7298	0.7314	1.0000	-
wp2000	0.5510	0.6265	0.7210	0.8021	1.0000

Notes: The table presents the adjusted wage premiums. The correlations are statistically significant at 1% level.

the US. Roberson (1999) reports a correlation of 0.92 for the period 1987 to 1997. It is difficult to compare the correlations in various studies since different measures of wages for different samples are used. The correlation may also be sensitive to the time period and the sectors that are investigated. In our study, the yearly correlations of the inter-industry wages premiums appear to be relatively low.The relatively low correlations of the inter-industry wage premiums over time may suggest that industry wage structure reflects some transitory effects of the short-run demand shocks in a combination with limited mobility of labor. Hence, in the next step we relate the inter-industry wage premiums further to international trade as a potential source of such demand shocks.

5.2 Wage premiums and international trade

In this section, we assess the impact of international trade on industry wage premiums, controlling for domestic competition and technology progress. The transformed inter-industry wage premiums, wp_k from Section 5.1 over time are pooled as the dependent variable. Since the dependent variable in this stage is the estimate from Equation (1), the inverses of the adjusted and weighted variances of the wage premium coefficients are used as weights to deal with potential measurement errors. This procedure thus puts more weights on industries with smaller variances in industry premiums. In other words, the model is estimated by applying the weighted least square estimator (WLS).[15]

[15] See e.g. Goldberg and Pavcnik (2001).

The model is specified as the following:

$$wp_{kt} = \beta_{im} \mathrm{Im}\, port_{k,t-1} + \beta_{ex} Export_{k,t-1} + \beta_{rd} R\,\&\,D_{k,t-1} + \beta_h H_{k,t-1} + \beta_{h^2} H^2_{k,t-1} + \delta_t DY_t + \delta_k DI_k + \nu_{kt} \qquad (2)$$

where $\mathrm{Im}\, port_{kt}$ and $Export_{kt}$ are lagged import penetrations and lagged export ratios at the three-digit industry level. $R\,\&\,D_{k,t-1}$ and $H_{k,t-1}$ are lagged average R&D intensity and the Herfindahl index at the three-digit industry level. $R\,\&\,D_{k,t-1}$ is a proxy for technical progress and $H_{k,t-1}$ is a proxy for domestic competition.[16] DY_t is a vector of year dummies and DI_k is a set of industry dummies at the three-digit industry level. Alternatively, we divide imports into high- and low-income country groups to assess the differential effects of imports from different origins on wage premiums.[17]

The export- and import flows depend on factor prices and are potentially endogenous. Furthermore, there might be simultaneity problem between wages and technical progress. In the absence of valid external instruments, we use one-year lagged trade variables and lagged industrial R&D intensity in the estimation to avoid the potential endogeneity problems. One may alternatively employ a two-stage least squares (2SLS) method and use the lagged values of variables as instruments.[18] However, current and lagged values of these variables often reveal to be serially correlated and relatively persistent over time. Hence, the potential endogeniety problems may still lead to biased results, particularly in the specifications with relatively small number of observations (Shea 1997).

Table 4 reports the results from estimations of Equation (2). We estimate the model both with and without industry fixed effects. We regard the specifications without industry fixed effects as the preferred ones. We are interested in the inter-industry differences in wage premiums, but not within-industry variations of wage premiums over time.[19] Methodologically, there are a relatively large number of industry dummy variables

[16] Table A1.2 in Appendix 1 contains more detailed variable definitions.

[17] The country classification into high- and low-income countries is shown in the Appendix in Lundin (2003).

[18] We experiment with the 2SLS estimations, which yield similar results as in Table 4. The results are available on request.

[19] When industry-dummies are included in regressions, which are equivalent to fixed effects, the effects of the explanatory variables on inter-industry wage premiums disappear. The alternative estimation results are available on request.

included in the model (more than 70 industries) and the time period of the study is relative short (4 years after lagging the trade variables). Both of these factors prevent us from obtaining efficient and consistent estimates of the effects of trade and technology when a large number of industry dummies are included. Furthermore, we experiment with estimating the model by using between and first-difference estimators as robustness checks. Between estimators that use the cross-sectional information yields similar results as the WLS estimator.[20] The first-difference estimator is an alternative way to control for unobserved time-invariant industry-specific effects. For similar reasons, this estimator turns out to be inefficient as in the industry fixed effects estimation.[21] The discussion in the subsequent part focuses on the results obtained by WLS instead of the industry fixed effects estimation.

As shown in Table 4, column 1, the coefficient on lagged total import penetration is insignificant, whereas the estimate on lagged total export ratio is positive and significant at l0% level. When lagged total import penetration, in column 2, is divided into import from low- and high-income countries, the lagged import penetration from low-income countries shows a negative and significant effect on the inter-industry wage premiums. However, the coefficient on total export ratio then becomes insignificant.

Furthermore, as pointed out in the theoretical background in Section 2, both imperfect competition and technical progress may also affect the inter-industry wage structure. Thus, the models in columns 3 and 4 are further extended to include the industrial technical progress (R&D intensity) and market concentration (Herfindahl index). Like in column 2, the negative effect of lagged import penetration from low-income countries on the inter-industry wage premiums remains significant. Also, there is a positive effect of industrial R&D intensity, while market concentration seems to have no significant effect.

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[20] Since we use the inverses of the adjusted and weighted variances of the wage premium coefficients as weights to deal with potential measurement errors in the weighted least square (WLS) estimation, we regard the WLS as a preferred estimator. The between estimator yields similar results, but the measurement errors cannot be handled properly as in the WLS.

[21] The results of between-effect and first-difference estimators are available on request from the authors.

Table 4. International trade and inter-industry wage premiums, 1996-2000

Dependent variable: Adjusted industry wage premiums, *wp*						
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged import penetration	-0.035 [-1.62]	-	-0.033 [-1.65]	-	-0.032 [-1.72]	-
Lagged export ratio	0.034 [1.88]	0.010 [0.55]	0.021 [1.21]	0.004 [0.22]	0.023 [1.48]	0.007 [0.42]
Lagged high-income import penetration	-	0.005 [0.29]	-	0.004 [0.26]	-	0.003 [0.19]
Lagged low-income import penetration	-	-0.273 [-5.43]	-	-0.257 [-5.28]	-	-0.240 [-5.76]
Lagged R&D intensity	-	-	0.227 [2.84]	0.131 [1.78]	0.350 [4.05]	0.251 [3.14]
Herfindahl index	-	-	-0.026 [-1.28]	-0.023 [-1.21]	-0.256 [-3.34]	-0.236 [-3.18]
Herfindahl x Herfindahl index	-	-	-	-	0.269 [3.40]	0.249 [3.23]
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies (3-digit)	No	No	No	No	No	No
VIF[22]	1.79	1.74	1.66	1.65	3.46	3.28
Adjusted R^2	0.04	0.14	0.05	0.13	0.13	0.20
Number of observations	370	370	370	370	370	370

The specific factor model can be used to explain these results. At first, we examine the effect of import penetration from the low-income countries. When import competition from the low-income countries intensifies in the domestic market, it imposes a downward pressure on the prices that the domestic industries face. The lower prices (and also the lower relative prices) of import goods lower the revenues of domestic firms in the import competing industries. Thus the profits may be pressed downwards and even become negative. In this situation, the firms have to either contract by laying off workers or lowering the wages in order to eliminate their losses. Given that workers are assumed to be immobile – at least in the short-run – across industries and skills are industry specific, it is not easy to find a new job in another industry and lower wages become the final outcome.

[22] VIF stands for variance inflation factor. As a rule of thumb, VIF values greater than 10 need further investigation of collinearity problem in the model.

Alternatively, the workers may try to shift to another firm in the same industry. This is mainly due to the fact that it is difficult to shift across industries. In this case, the worker still has to accept a lower wage as he/she is still in the same industry that faces intensified import competition. This negative effect of imports from low-income countries is consistent with the results of the studies by Katz et al. (1989) for the US and Grey (1993) for Canada.

In our study we do not observe such negative effects on wages imposed by imports from high-income countries. A reason might be that imports from low-income countries often are homogenous goods and the competition is mainly based on prices, while the imports from high-income countries to a large extent, consist of highly differentiated products and the competition is based on quality rather than on price.

We now look at the export side. When the relative prices of export goods rise or the domestic industries achieve a competitive position in exporting markets, the firms in exporting industries receive increased revenues from sales in international markets. Thus, initially profits among these firms rise. The increase in profits stimulates the expansion of production. Since the firms in exporting industries, at least in the short-run, cannot expand their productions by attracting workers from other industries, they have to compete, initially, for workers who are already present in the industry. Accordingly, the competition among firms within exporting industries pushes up wages in these industries. However, we do not, in contrast to other similar studies, observe such positive effects of exports on the industry-wage premiums in our analyses.

The impact of trade explained by the specific factor model is under the assumption of perfect competition. In order to control for the effect of domestic competition, we specify a non-linear relationship between industry wage premiums and domestic concentration by including Herfindahl index in columns 5 and 6. Opposite to most of the earlier empirical studies, we find a negative relationship between concentration and industry wage premiums.[23] This can be interpreted as that large employers may exercise monopsonistic power. Furthermore, if the concentrated sectors are affected under import competition, the loss of excess profit may also lead to decreases in wages.[24] However, the negative effects of market concentration appear to be at a decreasing rate, indicated by the significantly positive coefficients on the squared Herfindahl index.

[23] Belman (1988) gives a detailed survey on agreement and disagreement on the effect of market concentration on wages.

[24] This hypothesis has been tested in Lundin (2003) on Swedish manufacturing for the period 1990-1999.

This reveals a U-shaped curve relationship between concentration and wages premiums. Within a certain interval of concentration level, the relationship is negative. However, when the concentration ratio reaches a higher level and passes a certain threshold, a positive relationship emerges.

As shown in columns 3-6, the positive effects of the average R&D intensity (as a proxy for technical progress) reflect the fact that technical progress has the same effects as price changes, i.e. increasing the price (wage) of the specific factor (labor) in industries with high rate of technical progress.[25]

The wage structure may be influenced by the institutional factors as well. For the Swedish labor market, the high rates of union participation and collective bargaining are important institutional features. First, the union participation ratios in Sweden are uniformly high across industries and persistent over time. The variation in the union participation variable is very limited. Second, the Swedish labor market is indeed characterized by a high degree of centralization in the wage setting but permits the industries and firms to have a substantial degree of local influence on wage determinations (Arai 1994 and 2003). This implies that the influence of the wage bargaining system takes place also through local wage negotiations within industries. These factors may explain why the union effect cannot be identified at an aggregate level in our study.[26] Furthermore, the unions in Sweden are organized not only at the firm- and industry levels but also on the basis of education levels and professions. It requires therefore, more detailed information on union participation at both the firm- and the industry levels and distributions of union participation at various education levels to identify potential union effects. Unfortunately, the information of these two aspects is not available for this study.

Finally, some additional robustness checks of the model specifications have been done.[27] We include, for instance, the growth rate of employment in order to control for the effect of the demand for labor. However the coefficient on employment growth is not statistically significant. Macroeconomic demand effects are probably picked up by the year dummy variables in Equation (2). Also, we include the average skill-intensity as an additional control for the aggregate effect of skills, which is often

[25] We use also average labour productivity as robustness measure for technology and the results using this measure are very similar to the R&D intensity. We use therefore R&D intensity as a more direct measure for technology progress.

[26] Although we experiment with inclusion of union participation rates at the two-digit industry level, we do not find any significant union premiums. See Heyman (2002) for a discussion on this point.

[27] Results from these alternative specifications are available on request from authors.

emphasized in the labor economic literature. However, this effect is not significant. It may imply that the aggregate skill effect has been captured by the R&D intensities, which can be regarded as a more direct measure of skill and technical requirement.

6. Conclusions

This paper aims to investigate trade-wage links in the Swedish manufacturing. At first, we estimate the inter-industry wage dispersion and then we analyze how international trade affects the inter-industry wage structure.

The first part of the analyses reveals substantial dispersion in inter-industry wage premiums after controlling for important human capital variables and characteristics of employers. These results provide evidence supporting both imperfect labor mobility and transitory demand shocks have affected on the wage structure in Swedish manufacturing. Nevertheless, the overall variability of wage premiums has decreased during the period 1996 to 2000.

In the second part of the analyses, we relate the inter-industry wage premiums to competition from abroad, as well as to domestic competition and technical progress. Consistent with most of the wage-technology literature, we find clear-cut evidence indicating that industries with higher technological level, measured by R&D intensities, enjoy higher wage premiums. Regarding international competition, we observe lower wages in import competing industries. Nevertheless, the producer concentration shows a non-monotonic effect on wage premiums.

To summarize, based on our results we conclude that the inter-industry wage premiums appear to be related to international competition, technology and market imperfection. In the context of increased international competition, labor mobility plays an important role both in reduction of short-run adjustment costs and in enhancement of productivity. Hence, the results of our study may have some labor market policy implications. The legislation on the labor market faces a challenge that on the one hand, it needs to provide job security, and on the other hand, it should also facilitate the labor mobility and ensure that workers may move to jobs where they can be more productive and earn a higher return for their skills. The results of this study suggest further that trade with low-income and high-income countries may have different effects on the inter-industry wage structure. This is probably due to the different technical standards and skill endowments in the trade with these two subgroups. It implies that there might be some skill bias related to the effect of trade on wages. For instance, high-skilled and low-skilled labor may be affected in different ways, although they are both in an import competition industry. This interaction between trade and skill calls for more detailed investigation in the future research.

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Appendix 1 Data description

Table A1.1 Panel information

Year	Number of individuals	Number of firms	Number of industries (3 digit)
1996	373,681	945	76
1997	400,271	960	81
1998	381,262	958	80
1999	390,187	989	78
2000	432,625	1327	85
Total number of observation: individual – year: 1,978,026.			

Table A1.2 Variable description

Variables	Descriptions
	Individual Characteristics
Gender	Gender=1, man; Gender=0, woman.
Age	Age = Current year minus year of birth.
Education1 – Education 6	Edu1: Education before-secondary school, less than 9 year. Edu2: Education before-secondary school, 9 years. Edu3: Secondary education. Edu4: Post-secondary education, less than 2 years. Edu5: Post-secondary education, 2 years and more. Edu6: Post-graduate education.
Profession 1-9	Profession 0: Armed forces. Profession 1: Legislators, senior officials and managers. Profession 2: Professionals. Profession 3: Technicians and associate professionals. Profession 4: Clerks. Profession 5: Service workers and shop sales workers. Profession 6: Skilled agricultural and fishery workers. Profession 7: Craft and related trades workers. Profession 8: Plant and machine operators and assemblers. Profession 9: Elementary occupations.
Monthly real wage	Log (nominal monthly wage*100/ consumer price index), 1990 as base year.
	Firm Characteristics
Firm size	Log (average employment).

Table A1.2 (continued)

Capital intensity	Ratio of book-value capital stock to employment (based on 1990's price).
Market share	Ratio of firm's sales to industry's sales at 3-digit level.
Profitability	Profitability1 = (Return to capital $_{t-2}$ + Return to capital$_{t-1}$ + Return to capital$_{t}$)/3. Profitability2 = [log (real accounting profit / employment)$_{t-2}$+ log (real accounting profit / employment)$_{t-1}$+ log (real accounting profit / employment)$_{t}$]/3
Relative TFP	Relative TFP$_t$ = TFP for firm *i* /average TFP in industry *k*. See Hansson and Lundin (2003) for details on the calculations of TFP.
	Industry Characteristics
Import penetration	Ratio of import to consumption.
Export ratio	Ratio of export to total turnover.
Herfindahl index (H)	Sum of squared of market share at 3-digit level.
R&D intensity	Ratio of R&D investment to total turnover.

Appendix 2 Additional results

Table A2.1 Robustness specification 1: Market share

Dependent variable: Monthly real wage in logarithm					
	1996	1997	1998	1999	2000
Individual control variables					
Gender	0.104 [9.31]	0.107 [15.18]	0.106 [15.20]	0.096 [12.00]	0.090 [12.92]
Age	0.021 [11.95]	0.019 [15.17]	0.019 [12.01]	0.018 [9.53]	0.018 [11.01]
Age x Age	-0.0002 [-11.21]	-0.0002 [-13.94]	-0.0002 [-11.15]	-0.0002 [-9.28]	-0.0002 [-11.02]
Edu2	0.052 [6.42]	0.053 [12.71]	0.056 [14.29]	0.045 [7.89]	0.038 [7.47]
Edu3	0.073 [7.07]	0.076 [12.63]	0.079 [13.08]	0.067 [8.08]	0.060 [7.65]
Edu4	0.100 [8.36]	0.104 [11.04]	0.122 [15.34]	0.114 [10.05]	0.121 [11.14]
Edu5	0.233 [16.34]	0.244 [19.65]	0.257 [23.82]	0.244 [16.45]	0.224 [14.59]
Edu6	0.427 [20.62]	0.440 [25.35]	0.440 [30.58]	0.430 [28.58]	0.424 [21.36]
Professions	Yes	Yes	Yes	Yes	Yes
Firm-level control variables					
Market Share	0.048 [1.67]	0.036 [1.70]	0.039 [0.90]	0.090 [3.25]	0.101 [4.41]
Capital intensity	0.028 [5.20]	0.027 [3.84]	0.023 [3.66]	0.029 [4.73]	0.020 [4.51]
Relative TFP	0.053 [1.40]	0.040 [1.61]	0.051 [2.44]	0.069 [3.01]	0.144 [4.77]
Profitability	-0.002 [-0.35]	0.0003 [5.19]	0.0007 [3.85]	-0.0020 [-0.46]	-0.0008 [-0.80]
Industry dummies	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.53	0.48	0.50	0.54	0.57
Observations	317962	316421	299761	329178	347353

Notes: Standard errors are adjusted both for heteroskedasticity and potential dependency among individuals working in the same industry at 3-digit. White's heteroskedasticity-consistent t-statistics are in brackets.

Table A2.2 Robustness specification 2: ln(profit/employee)

Dependent variable: Monthly real wage in logarithm					
	1996	1997	1998	1999	2000
Individual control variables					
Gender	0.107 [9.05]	0.110 [20.16]	0.106 [14.15]	0.102 [14.23]	0.095 [13.62]
Age	0.021 [10.21]	0.020 [13.81]	0.019 [11.75]	0.019 [9.16]	0.019 [10.43]
Age x Age	-0.0002 [-9.42]	-0.0002 [-12.96]	-0.0002 [-11.02]	-0.0002 [-8.93]	-0.0002 [-10.83]
Edu2	0.052 [5.41]	0.054 [11.18]	0.056 [12.04]	0.050 [8.57]	0.039 [7.23]
Edu3	0.074 [6.03]	0.077 [11.63]	0.080 [11.96]	0.076 [9.03]	0.061 [7.81]
Edu4	0.102 [7.78]	0.106 [11.75]	0.121 [13.57]	0.120 [9.78]	0.121 [10.36]
Edu5	0.237 [15.15]	0.247 [23.36]	0.255 [22.13]	0.254 [16.89]	0.229 [15.03]
Edu6	0.430 [20.44]	0.447 [27.95]	0.436 [26.52]	0.437 [27.90]	0.426 [22.45]
Professions	Yes	Yes	Yes	Yes	Yes
Firm-level control variables					
Firm size	0.005 [0.80]	0.013 [2.23]	0.019 [2.43]	0.024 [4.88]	0.017 [4.70]
Capital intensity	0.024 [3.23]	0.021 [3.35]	0.018 [2.39]	0.029 [4.34]	0.010 [1.71]
Profitability	0.003 [0.71]	0.001 [0.39]	0.001 [0.21]	0.009 [2.53]	0.019 [2.88]
Industry dummies	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.54	0.48	0.50	0.53	0.58
Observations	264172	253668	242492	256433	281968

Notes: Standard errors are adjusted both for heteroskedasticity and potential dependency among individuals working in the same industry at 3-digit. White's heteroskedasticity-consistent t-statistics are in brackets.

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