Winners and Losers: Fragmentation, Trade and Wages Revisited

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December 2003

Abstract

Our paper investigates the link between outsourcing and wages utilising a large household panel and combining it with industry level information on industries' outsourcing activities from input-output tables. By doing so we can arguably overcome the potential endogeneity bias as well as other shortcomings that affect industry level studies. We find that fragmentation has had a marked impact on wages. Distinguishing three skill categories we find evidence that outsourcing reduced the real wage for workers in the lowest skill categories; this result is robust to a number of different specifications and definitions of outsourcing. Furthermore we find some evidence that high-skilled workers experienced increased wages due to fragmentation.

Keywords: Outsourcing, Fragmentation, Skills, Wages, Trade

JEL: F16, L24, J31

*Earlier versions of the paper were presented at a workshop at Claremont McKenna College and a seminar at the University of Zurich. The authors are grateful to Mitsuyo Ando,Alan Deardorff, Peter Egger, Josef Falkinger, Edward Leamer, Matt Slaughter, Eric Strobl, Rainer Winkelmann and Peter Zweifel for helpful comments on an earlier draft. Furthermore we thank John Haisken-DeNew for providing us with a test version of his data retrieval tool "SOEP Menu". Holger Görg gratefully acknowledges financial support from the Leverhulme Trust (Grant No. F114/BF).

I Introduction

Outsourcing is a growing phenomenon in world trade and has sparked a lot of interest in the recent academic literature and business press. As for the car industry, the Economist (23 February 2002, p. 99) writes that: "The whole industry is disintegrating (or becoming less vertical) as vehicle assemblers try to outsource more and more of what they once did for themselves." There is plenty of anecdotal evidence that this is not limited to the car industry but is also observed in other manufacturing and services sectors.[1]

Hummels, Ishii and Yi (2001) provide evidence for the worldwide importance of outsourcing from data collected for 10 OECD and four emerging market countries. They find that trade in outsourced components in the vertical production chain accounts for around 21 percent of these countries' exports. Moreover, international outsourcing grew very strongly by approximately 30 percent between 1970 and 1990.[2]

Given that the increase in international outsourcing coincided with deteriorating relative wages and employment chances for low skilled workers in many developed countries much research has been devoted to assess the impact of this disintegration of production on domestic labour markets (see Feenstra and Hanson, 1996, 1999 and Morrison-Paul and Siegel (2001) for the US, Hijzen, Görg and Hine (2002) and Hijzen (2003) for the UK and Geishecker (2002) for Germany).[3] Most studies that investigate the impact of international outsourcing do so by estimating the relative demand for skilled labour derived from a cost function, or mandated wage regressions using aggregate industry or country level data. In a sense this is quite unsatisfactory, as outsourcing has implications for micro units (firms or workers) which should arguably be studied using micro level data. Also, as we discuss in more detail below, there are potential endogeneity problems when regressing industry relative wages on industry level outsourcing activity. A notable exception in this literature is the recent work on Japanese micro level data by Head and Ries (2002) which examines the impact of outsourcing on relative labour demand. They find that expansion of employment in affiliates in low income countries (which can be taken as a proxy of international outsourcing of low

[1] For example, Jones and Kierzkowski (2001) provide examples from IT, car manufacturing, sport shoe manufacturing etc.

[2] See also Feenstra (1998) for a discussion of the growth of outsourcing or fragmentation of production. We will use these two terms synonymously in this paper.

[3] There have also been studies for other countries. See Feenstra and Hanson (2001) for a concise review of this literature. The papers on labour market effects of outsourcing are of course related to the wider debate on the effects of trade and technology on wages, see Leamer (1998), Freeman (1995), Krugman (1995), Berman, Bound and Machin (1998)

skill production) raises the skill intensity of domestic production.

Our paper investigates the link between outsourcing and wages from a different perspective utilising a large household panel and combining it with industry level information on industries' outsourcing activities from input-output tables. Hence, we directly assess the effects of international outsourcing on wages at the level of the individual. By doing so we can arguably overcome the potential endogeneity bias as well as other shortcomings that may affect industry level studies.

Our empirical analysis uses data from the large German Socio-Economic Household Panel, which is described in some detail below, combined with industry level data for the period 1991 to 2000.[4] Germany is an interesting case to analyse, as there is a general consensus that relative wages of high vs. low skilled workers have remained virtually unchanged since the 1980s, even though fragmentation of activities has increased substantially during the 1990s, probably aided by the opening up of low wage Eastern and Central European markets which provided potential for fragmentation.[5] Against this background of nearly constant relative wages on aggregate, we find from our individual level data that fragmentation has, nevertheless, had a marked impact on wages. Distinguishing three skill categories we find evidence that outsourcing reduced the real wage for workers in the lowest skill categories; this result is robust to a number of different specifications and definitions of fragmentation. Furthermore we find some evidence that high-skilled workers experienced increased wages due to fragmentation and trade.

The remainder of the paper is structured as follows. Section II reviews briefly the theoretical and empirical literature on fragmentation and labour markets. Section III highlights recent labour market trends and motivates our empirical study. Section IV introduces the empirical model and discusses the data set. Section VI presents the empirical findings and section VII concludes.

II Fragmentation and wages

The causes and consequences of fragmentation of production have attracted considerable interest in the theoretical literature. While papers like Feenstra and Hanson (1996) and Kohler (2003) stress the importance of international differences in relative prices as driving

[4]See Hunt (2001), Burda and Mertens (2001) and Krueger and Pischke (1995) for analyses using this data set in different contexts.

[5]See the recent series of articles in the German business paper Handelsblatt under the heading "Globalisierung, neuester Stand" in the issue of 2 September 2003.

force of fragmentation, Jones and Kierzkowski (2001) and Harris (2001), for example, focus on the role of exogenous reductions in general services and telecommunications costs for allowing outsourcing to occur. The consequences of fragmentation for local labour markets are not clear cut in theory, depending on the models and assumptions chosen, outsourcing of the low skill intensive part of production can lead to decreases or increases in the wage of (unskilled) labour in the fragmenting economy (see, for example: Feenstra and Hanson (1996), Arndt (1997), Arndt (1999), Venables (1999); Jones and Kierzkowski (2001), Kohler (2004)). Whether workers in practice gain or lose from fragmentation is, therefore, largely an empirical question.

One of the first systematic empirical studies on the labour market impact of international fragmentation is Feenstra and Hanson (1996). In their study for the United States they estimate a factor share equation for an industry panel of more than 400 industries. In the model international outsourcing, approximated by the industries' import penetration ratios, is implemented as a shift parameter similar to technological progress. Following this procedure, the authors report that approximately 15% to 33% of the increase of the cost share of non-production labour over the period 1979-1987 can be explained by international outsourcing. In a follow-up study Feenstra and Hanson (1999) apply a narrower definition of international outsourcing by focusing on imported intermediate inputs of an industry from the same industry abroad. According to this study international outsourcing can explain between 11% and 15% of the observed decline in the cost share of production labour in U.S. manufacturing between 1979 and 1990. Morrison-Paul and Siegel (2001) extend the above studies by simultaneously incorporating several trade and technology related measures that can shift relative labour demand in a system of factor demand equations. Their results suggest that international outsourcing as well as trade and technological change significantly lowered relative demand for low-skilled labour.

The above studies have in common that international outsourcing is assumed to be exogenous to the industry, hence international outsourcing is no "choice factor" (Morrison-Paul and Siegel (2001) p. 245). This assumption could in principle be criticised since, at least to some degree, international fragmentation is an industry's choice variable, and relative labour demand and the extent of fragmentation are then determined simultaneously.

Falk and Koebel (2002) propose an approach that in principle overcomes endogeneity bias in industry level studies. Using a Box-Cox cost function, which nests the normalised quadratic as well as the translog functional form, they estimate elasticities of substitution from a system of input-output equations. Fragmentation is implemented in the model as a flexible choice variable captured by relative prices for imported intermediate goods and

purchased services. Their findings suggest that between 1978 and 1990 neither imported material inputs nor purchased services substitute for unskilled labour in German manufacturing industries.[6]

This approach can be criticised from a theoretical point since the impact of international fragmentation is only captured by relative price changes for imported intermediate inputs. However, intensified international fragmentation is consistent with unchanging or even increasing relative prices for imported intermediate inputs. The driving forces behind fragmentation are not necessarily the dynamics of relative price changes but exogenous factors such as trade liberalisation, the opening up of former communist states or new advances in communication technologies that enable firms or industries to economise on absolute cost differentials between domestic and foreign production at a fixed point in time (see Wood (2002), Jones and Kierzkowski (2001), Harris (2001)). Following the theory, international fragmentation should be understood as a fundamental exogenous shift in the production technology which affects relative demand for heterogenous labour over and above relative price changes between domestic and foreign input factors.

Our approach significantly differs from the previous empirical studies and may be considered suitable to overcome the shortcomings discussed above. Utilising a large household panel, we will incorporate the industry's international fragmentation activity as a shift parameter in a Mincerian (Mincer (1974)) wage model. Since the industry's fragmentation activities can be considered exogenous to the individual, endogeneity bias due to simultaneous determination of labour demand and international fragmentation undertaken at the industry or plant can be overcome without solely focusing on relative input prices.

Furthermore this approach has substantial advantages over the industry level analysis, as it allows controlling for individual observed and unobserved heterogeneity. In addition, changes in relative earnings can now be decomposed into wage gains and losses for different skill groups.

Given the nature of our econometric estimation our results should be interpreted as the short run effects of international fragmentation on wages of individuals within industries. Hence, we can think of our approach as essentially partial equilibrium, in line with the theoretical one sector setting of, e.g., Feenstra and Hanson (1996). This is consistent with a short run view of the economy such that labour is immobile between industries. Many previous empirical studies implicitly or explicitly make the same assumption (Feenstra and

[6] Another solution to this problem could be to instrument for international fragmentation, given that one can find valid instruments for international fragmentation (see Morrison-Paul and Siegel (2001) and Hsieh and Woo (2003) for applications).

Hanson (1996), Morrison-Paul and Siegel (2001), Hsieh and Woo (2003)).

The literature analysing the labour market impact of international trade in a household panel framework is sparse and studies more specifically assessing the impact of international fragmentation on the earnings distribution in the context of individual wage models are, to the best of our knowledge, not existing. [7]

In line with Feenstra and Hanson (1996) and Feenstra and Hanson (1999) we construct two measures of international fragmentation ($FRAG$) applying a narrow and a wide definition such that:

$$FRAG_{jt}^{narrow} = \frac{IMP_{jt}}{Y_{jt}} \quad (1)$$

$$FRAG_{jt}^{wide} = \frac{\sum_{j=1}^{J} IMP_{jt}}{Y_{jt}} \quad (2)$$

with j denoting the respective two-digit manufacturing industry ($j \epsilon J$), IMP the value of imported intermediate inputs from a foreign industry and Y the industry's output value. Hence, narrowly defined fragmentation only captures an industry's imported intermediate inputs from the same industry abroad while widely defined fragmentation incorporates all imported intermediate manufacturing goods of an industry.

III Recent labour market trends and fragmentation

It is well established that relative earnings of low skilled workers have decreased in most OECD countries during the last two decades. However, wage trends are far from uniform across countries with the US and Great Britain experiencing very strong increases in the wage dispersion, and countries such as Australia, Canada, Japan and Spain only experiencing modest decreases in the relative earnings of low skilled workers (see Freeman and Katz (1995), OECD (1994) for a detailed discussion).

In this study we focus on the German labour market which is an interesting case since it is not only the largest economy in Europe, but it is also far more open to international trade than for instance the U.S. and has a fairly rigid labour market. Furthermore political and economic transition in the former communist Central and Eastern European countries

[7] Haisken-DeNew and Zimmermann (1999) estimate the impact of trade on real wages for different skill groups and various measures of labour market mobility combining data from the German Socio-Economic Household Panel and industry level data for the period 1985-1991. Their results of a random effects model indicate that an increase in the trade deficit ratio lowers real wages for low-skilled as well as for high-skilled workers by a comparable amount. Hence, there is no indication of a skill bias in the wage impact of international trade.

(CEEC's) during the 1990's now allows for intensive production sharing with these economies at Germany's doorstep with potentially large implications for the German labour market. Nonetheless, considering the wage distribution in Germany, abundant empirical evidence suggests that relative wages of the low skilled have virtually not changed or have even increased since the 1980's (see Abraham and Houseman (1995), Fitzenberger (1999), Prasad (2000), Beaudry and Green (2000)).[8] Nonetheless, real net wages have fallen substantially in absolute terms over the 1990's.

Against this background international fragmentation in German manufacturing has grown substantially. Figure 1 shows the development of international fragmentation during the 1990's for the manufacturing industry as a whole. As can be seen, narrowly defined international fragmentation (as in equation 1) increased by around 60 percent between 1991 and 2000 while widely defined fragmentation grew somewhat slower by 45 percent over the same period. Figure 2 shows the evolvement of international fragmentation by two digit NACE industries. Even though international fragmentation is of very different importance for the separate industries and the dynamic patterns vary considerably almost every industry shows significant growth in the fragmentation activity.

Thus, constant relative earnings for low-skilled workers coincide with pronounced increases in international fragmentation which at first sight casts doubt on a connection between relative earnings and fragmentation. However, relative earnings can be determined by a whole range of demand and supply factors that might cancel each other out. A thorough analysis of the impact of international fragmentation on the wage distribution therefore requires simultaneous controlling for other important determinants of the wage structure.

IV The Empirical Model

In order to analyse more rigorously the impact of international outsourcing on wages we estimate variants of the following log wage equation:

$$\begin{aligned} ln\ WAGE_{ijt} &= \alpha + \beta\ DEMOG_{it} + \gamma\ WORK_{it} + \delta\ EDUC_{it} \\ &+ \theta\ IND_{jt} + \lambda\ FRAG_{jt} + \tau_j + \mu_t + \nu_{jt} + \iota_i + \epsilon_{it} \end{aligned} \tag{3}$$

where $WAGE_{ijt}$ denotes individual i's monthly wages in industry j. We apply control variables that are standard in such wage regressions, see for example Mincer (1974), Brown

[8] Our own analysis on the basis of the German Socio-Economic Panel for the years 1991-2000 also fails to identify significant changes in the earnings distribution between different skill groups, which is in line with the literature.

and Medoff (1989), Schmidt and Zimmermann (1991). $DEMOG$ denotes the demographic control variables age, age square, marital status, geographic region. The second set of control variables ($WORK$) contains characteristics related to the workplace such as size and ownership of the firm, tenure, tenure square, occupational category and the log of actual hours worked per week.[9] A third set of control variables ($EDUC$) contains educational dummies for high education ($edhigh$) and medium ($edmed$) education, low education ($edlow$) is the omitted category. We also control for time changing industry characteristics by including industry output (IND). We subsequently incorporate a narrow and a wide definition of international fragmentation ($FRAG$) as in equation 1 and 2. The error term is decomposed into general industry specific effects (τ_j), general time specific effects (μ_t) and industry specific time effects (ν_{jt}) which we estimate with a full set of industry dummies, time dummies and industry specific time dummies respectively. This also enables us to extensively control for time invariant and time varying industry level wage determinants other than captured by our fragmentation ($FRAG$) and output variable (IND). Furthermore the general time dummies and industry specific time dummies also capture supply side effects. We also allow for individual fixed effects (ι_i) that take account of unchanging observable and unobservable individual characteristics.[10] The remaining error term (ϵ_{it}) is assumed to be normally distributed.

Combining individual and industry level data could give rise to contemporaneous correlation that results in distorted standard errors as discussed in Moulton (1990). We are however confident that controlling for industry fixed (τ_j) and time specific effects (ν_{jt}) takes away this distortion.

One further potential problem casting doubt on the validity of our results could arise from sample selection as low-skilled workers are more likely to lose their jobs.[11] However sample selection bias only occurs if selection is correlated with the idiosyncratic error term. This is unlikely in our case, since we control for a wide range of observable as well as unobservable characteristics. Nevertheless we test for that hypothesis implementing the simple procedure suggested by Wooldridge (2002) in Chapter 17.7.1. This test allows us to reject correlation between selection and the idiosyncratic error term.

Equation (3) constrains all coefficients to the be same across skill groups. In order to relax

[9] We therefore allow for a stochastic relationship between working hours and pay to account for possible measurement error.

[10] Random effects were rejected in a Hausman specification test.

[11] A fact that is fairly well established in the literature (see Reinberg and Hummel (2002)) and that we can also confirm with our data.

these restrictions we also estimate the equation for each and every skill group separately.

V Data

The analysis is based on data from Sample A and E [12] from the German Socio Economic Panel (GSOEP) for the years 1991 to 2000 (see Haisken-DeNew and Frick (2003) for a detailed description of the panel).

Our sample is restricted to prime age (18 to 65 years) males working full time (more than 30 hours a week) in the manufacturing industry (NACE 15-36). Observations with missing wage information were excluded from the sample. In order to maximize the number of observations, we choose an unbalanced design of the sample. The sample therefore covers 2329 individuals yielding a total number of 7306 observations. In order to avoid selection bias with respect to item non-response that might be not completely random each explanatory variable was supplemented with a dummy for missing values. Subsequently missing values where recoded to zero and the generated dummies for missing values also act as regressors in the model.[13] Wages are monthly labour earnings preceding the respective interview month supplemented by the monthly share of additional payments such as 13th and 14th month pay, Christmas and holiday bonus and profit sharing payments.

We apply three different skill definitions that only partly overlap. A description of the alternative skill groupings can be found in Table 1. Firstly, we differentiate between three different skill groups based on information on educational attainment and vocational training. Secondly, we utilise internationally comparable information following the International Standard Classification of Education (ISCED)[14] to derive a somewhat different skill differentiation. Thirdly, we apply an alternative skill grouping based on the respondents information on the qualification that their current job actually requires. Applying this alternative skill grouping is an interesting extension since it takes account of the actually demanded qualification by employers as opposed to the supplied qualification by employees.

Table 2 shows the skill structure, based on educational attainment, within each manufacturing industry and the employment share of the respective industry.

Industry level data on international fragmentation were obtained from input-output tables by the German Federal Statistical Office. Intermediate inputs corresponding to narrowly defined international fragmentation are represented by the main diagonal of the input-output

[12] Respondents from the foreigner, the immigrant and the East-German sample are therefore excluded.
[13] In general these coefficients are only reported if statistically significant
[14] see UNESCO (1997)

matrix for imports. Intermediate inputs corresponding to the wide definition are represented by the column sum of imported intermediate inputs from manufacturing industries. Measures of trade competition are based on the OECD commodity trade database. SITC 5 digit trade data was aggregated to NACE 2 digit industries according to the concordance provided by EUROSTAT (http://europa.eu.int/comm/eurostat/ramon/). Data on industry output were obtained from the German Federal Statistical Office.

VI Results

The results of estimating equations (3) and (4) using a fixed effects estimator to allow for time invariant individual specific effects and applying the first skill definition[15] are reported in Table 3. The regressions also include a full set of regional dummies[16] and time dummies as well as a full set of time fixed and time varying industry dummies. Note that the coefficients on the individual and firm level variables are largely as expected: Age and tenure are positively related with wages (in a non-linear fashion for the former variable) and wages also increase for married workers and with the educational attainment. We also find that workers in small firms on average receive lower wages than in large (size $>$ 2000 employees is default category) firms, reflecting the common finding of a firm size-wage effect (Brown and Medoff (1989)).

The variable of most interest to us is, of course, the measure of international fragmentation. Column (a) reports results for the narrow measure of outsourcing as defined in equation (1), while column (b) is for the wide measure as in equation (2). As can be seen, in these regressions we find statistically significant negative effects of international outsourcing on wages. A one percentage point increase in the narrow fragmentation intensity leads to an overall reduction in wages by 4 percent and a one percentage point increase in the wide fragmentation intensity reduces overall wages by 3 percent.

We now estimate the model for each and every skill group[17] separately thereby allowing for differences in the wage determination for different skill groups. Again we incorporate a full set of regional dummies, year dummies, industry dummies and industry dummies interacted with time. Table 4 depicts the estimation results with narrowly and widely defined fragmentation for each skill group. Most notably, the coefficients on the individual and

[15] see Table 1

[16] The regional dummies are defined for each of the old West German federal states (Länder) plus one dummy capturing all new East German states.

[17] applying the first skill definition as in Table 1

firm level variables differ significantly between the estimations for the different skill groups. Constraining the coefficients to be uniform across skill groups therefore indeed seems not appropriate.[18]

With regard to the impact of fragmentation the coefficients also differ substantially from the previous specification (compare Table 3 and Table 4). For high-skilled workers the coefficient of narrowly defined outsourcing is now found to be statistically significant and positive with a one percentage point increase in the outsourcing intensity ceteris paribus yielding a positive wage premium of 3 percent. However, widely defined outsourcing is found to have no significant impact on the wage for high-skilled workers (see Table 4 columns a and d). For medium-skilled workers the estimated coefficient of narrowly measured fragmentation is now statistically insignificant. Contrasting this result the estimation with the wide measure of international outsourcing yields a negative significant coefficient with a one percentage point increase in the wide outsourcing intensity resulting in a 3 percent wage fall for medium-skilled workers (see Table 4 column e). Only for low-skilled workers both the narrow as well as the wide measure of fragmentation are found to have a significant negative impact on wages. A one percentage point increase in the narrow outsourcing intensity ceteris paribus decreases low-skilled workers' wages by 7 percent while a one percentage point increase in the wide fragmentation intensity ceteris paribus decreases wages by 13 percent.

As mentioned above, an earlier study by Haisken-DeNew and Zimmermann (1999) analysed the effect of trade on individuals' wages using data from the GSOEP for the 1985 - 1991 period. As a further test of the robustness of our results to the fragmentation measure used, we calculate a sectors' degree of import penetration as imports over gross production in industry j (similar to Haisken-DeNew and Zimmermann (1999)). In particular the latter measure can arguably be considered as measuring the outsourcing of low-skill intensive production to low-wage locations (Anderton and Brenton (1999)). The results of the regressions with Non-OECD import penetration ratios are reported in columns g-i in Table 4. As can be seen, low skilled workers lose from increased import penetration, while there is no statistically significant evidence that high skilled workers benefit in terms of receiving higher wages.

In additional model specifications we apply the two alternative skill measures based on ISCED classifications and required qualifications for the respondents current job (see section V and Table 1) and estimate the impact of narrow and wide fragmentation as well as import penetration for each skill groups of the alternative skill measures.

Applying the skill grouping in line with the International Standard Classification of Edu-

[18]This is also confirmed more formally by an F-test that rejects the parameter constraints.

cation (ISCED)[19] we find no statistically significant impact of narrow and wide outsourcing as well as import penetration on wages for high skilled workers. For medium- and low-skilled workers, however, a one percentage point increase in narrow fragmentation intensity ceteris paribus lowers wages by 4 respectively 5 percent while neither wide fragmentation nor import penetration are found to be statistically significant (see Table 5).

The results for the skill definition based on required education[20] indicate that narrow fragmentation has a significant positive impact on workers who report that their job requires a college or technical school training with a one percentage point increase in the narrow outsourcing intensity ceteris paribus raising wages by 2 percent. For workers with lower required qualifications we find a statistically significant negative effect of narrow outsourcing with a one percentage point increase ceteris paribus yielding a wage loss of 3 percent. With respect to wide fragmentation and import penetration our estimates suggest no significant wage effects (see Table 6).

In order to get a better idea of the economic significance of the coefficients we perform simulations based on the statistically significant results in Table 3 to 6. For the simulations we firstly use the estimation results in the tables to predict the expected wage for our sample. We then use the same regression results and data to obtain a prediction in which we constrain the outsourcing variable to the value of 1991. Hence, this prediction can be interpreted as showing the hypothetical average wage for the sample with constant outsourcing.

The comparisons of the standard prediction and the prediction without outsourcing are plotted in Figures 3 to 11 for the three measures of fragmentation and the various skill definitions.[21] In Figure 3, for example, the plots illustrate that in our sample of prime age, full time working men monthly wages for the average low-skilled manufacturing worker would have been approximately 300 DM higher in 1999 if there had been no increase in fragmentation since 1991. For high skilled workers, the wage gain following fragmentation was about 400 DM in the same year (see Figure 5). The predicted effects are in the same direction in all diagrams, it is notable, however, that the magnitude of the wage change related to fragmentation depends on the actual variable used to calculate the level of fragmentation.

[19] see Table 1

[20] see Table 1

[21] We only show predictions of the point estimates if statistically significant. Of course, we could also construct confidence intervals for the predictions but for the sake of clarity of the diagrams we refrain from plotting these.

VII Conclusion

This paper adds to the literature on the implications of outsourcing for labour markets by investigating the effect of the fragmentation of production on wages for different skill groups. To the best of our knowledge, this is the first paper to use individual level data to look at this issue. Our results show that fragmentation has a marked impact on wages. We find strong evidence of a negative effect of fragmentation on the real wage for low-skilled workers. This result is robust to a number of different specifications and definitions of outsourcing. We also find some evidence that high-skilled workers gain from fragmentation in terms of receiving higher wages.

This suggests that low-skilled workers are the losers from this form of globalisation of production, while high-skilled workers are, on average, the group who may be able to gain. This has implications for policy makers, who need to debate whether losers should be compensated or in any other way be the focus of policies aimed at easing the adjustment cost of globalisation

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A Graphs

Figure 1: Fragmentation in German Manufacturing Industry

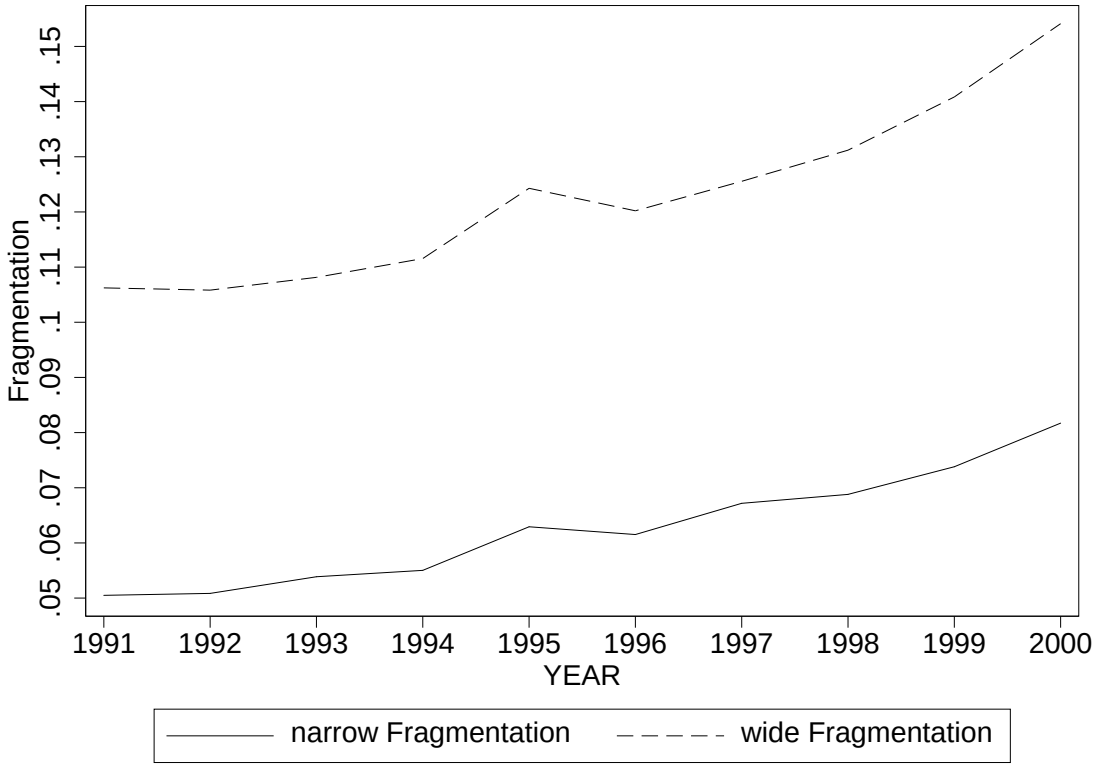


Figure 2: Fragmentation by Industry

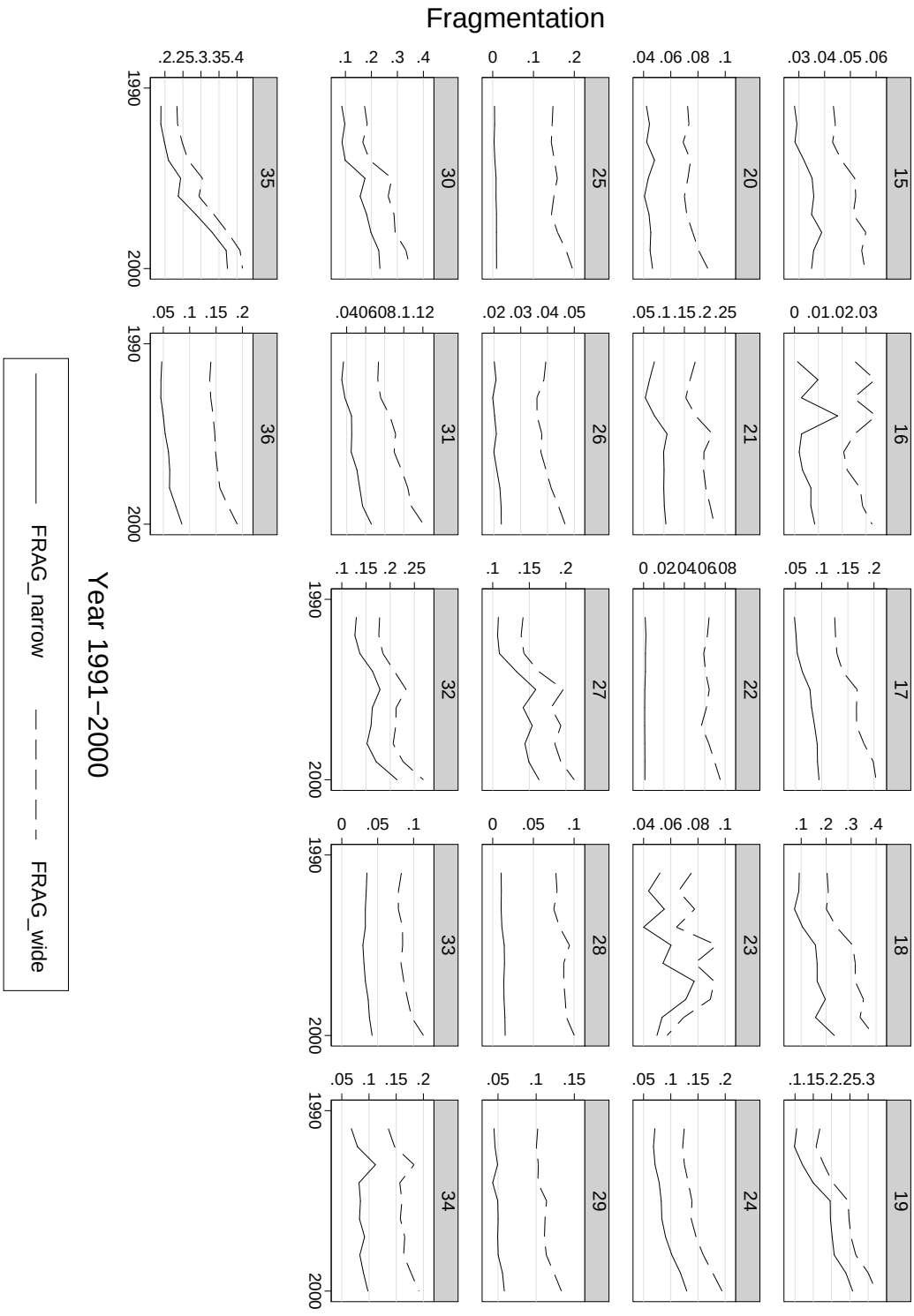


Figure 3: Wage Simulation for low-skilled worker with narrow Fragmentation

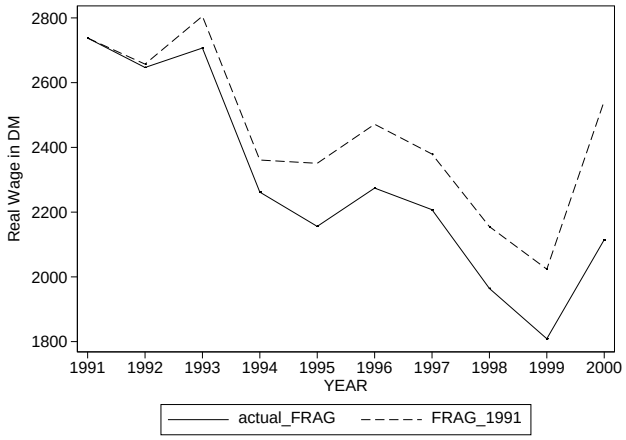


Figure 4: Wage Simulation for high-skilled worker with narrow Fragmentation

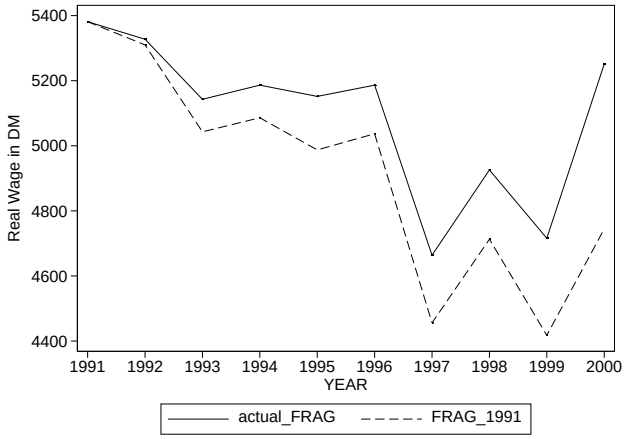


Figure 5: Wage Simulation for low-skilled worker with wide Fragmentation

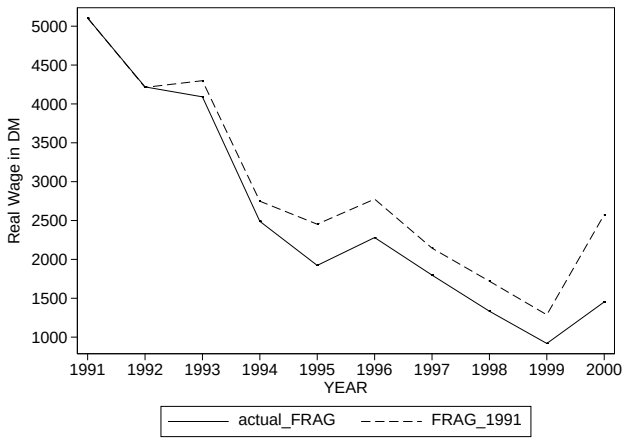


Figure 6: Wage Simulation for medium-skilled worker with wide Fragmentation

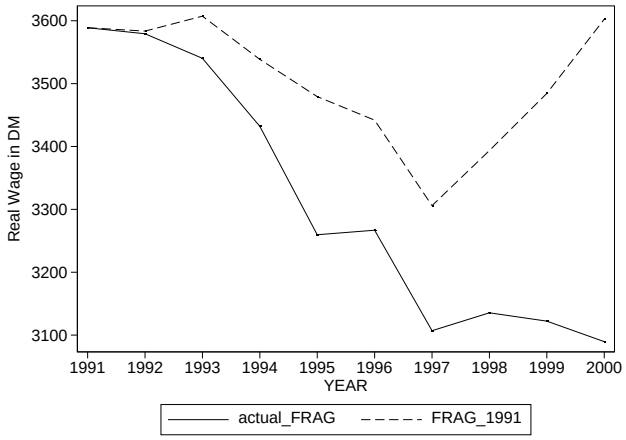


Figure 7: Wage Simulation for low-skilled worker with Import Penetration from Non-OECD

Figure 8: Wage Simulation for ISCED low-skilled worker with narrow Fragmentation

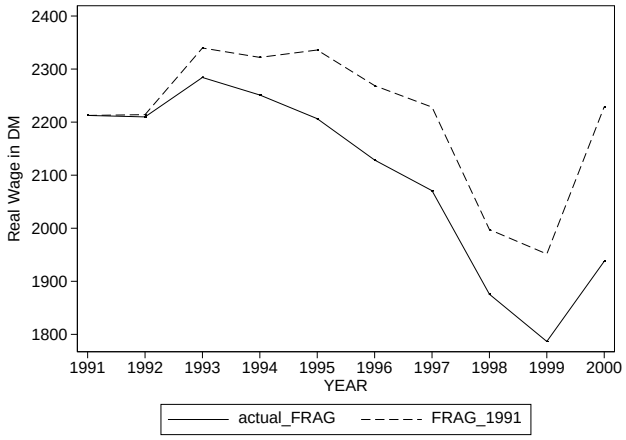


Figure 9: Wage Simulation for ISCED medium-skilled worker with narrow Fragmentation

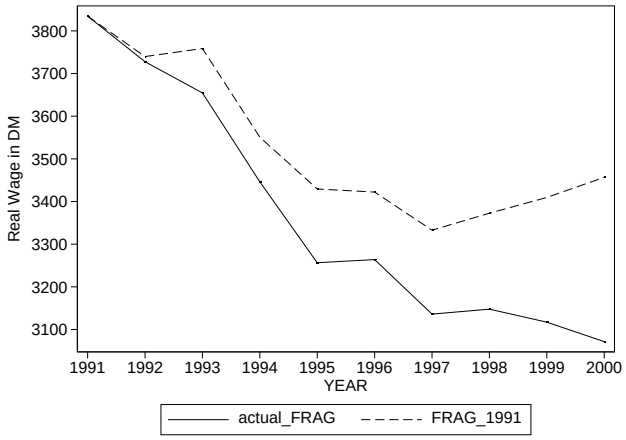


Figure 10: Wage Simulation for worker with low skill requirements with narrow Fragmentation

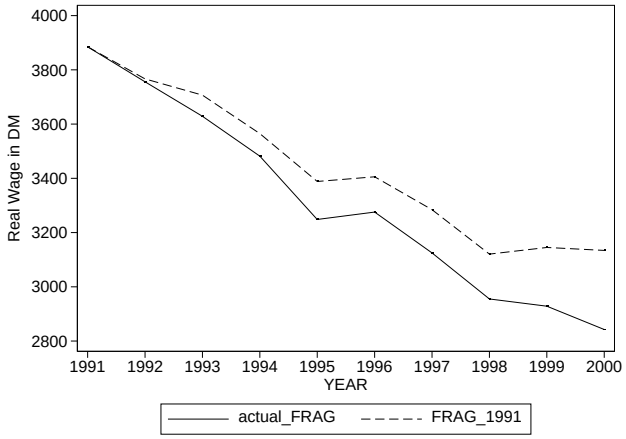
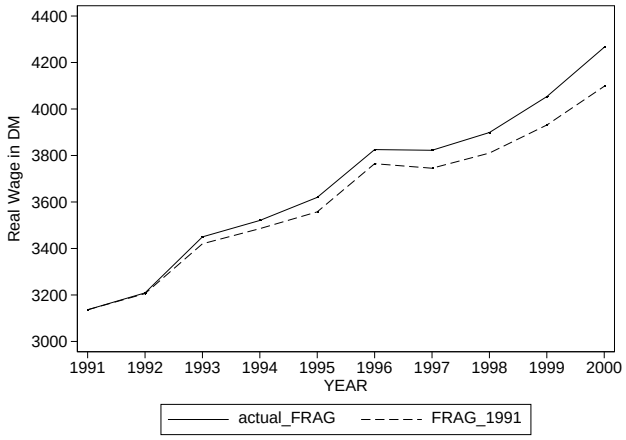


Figure 11: Wage Simulation for worker with high skill requirements with narrow Fragmentation



B Tables

Table 1: Alternative skill classifications

1) Educational Attainment	
low skill	no degree
	no degree + vocational training
	lower school degree
medium skill	lower school degree + additional vocational training
	intermediary school
	intermediary school + additional vocational training
	degree for professional college
	degree of professional college + additional vocational training
	high school degree
high skill	high school + additional vocational training
	higher technical college
	University degree
2) International Standard Classification of Education (ISCED)	
low skill	Lower secondary education, Second stage of basic education
medium skill	Upper secondary education, Post-secondary non tertiary education, first stage of tertiary education
high skill	Second stage of tertiary education
3) Required Qualification	
low skill	work requires less than technical college or university degree
high skill	work requires technical college or university degree

Table 2: Employment shares and skill* structure of industries in %

	Employment Share of industry	High-skilled	Medium-skilled within industry	Low-skilled
Food products and beverages	6.12	13.64	75.67	10.68
Tobacco	0.13	0.00	100.00	0.00
Textiles	1.74	1.76	94.48	3.77
Wearing apparel	0.34	5.00	95.00	0.00
Tanning,dressing of leather	0.56	0.00	85.33	14.67
Wood products, except furniture	1.93	6.60	73.93	19.47
Pulp, paper and paper products	1.51	5.77	74.81	19.42
Publishing, printing and reproduction	3.16	27.06	68.89	4.04
Coke, refined petroleum	0.58	17.78	82.22	0.00
Chemicals and chemical products	12.87	20.83	68.03	11.14
Rubber and plastic products	2.56	10.38	71.15	18.47
Other non-metallic mineral products	3.00	1.95	89.91	8.14
Basic metals	3.46	8.81	76.51	14.67
Fabricated metal products	20.44	9.59	77.61	12.80
Machinery and equipment	11.81	20.32	71.32	8.36
Office machinery and computer	0.30	22.50	77.50	0.00
Electrical machinery and apparatus	8.71	26.36	68.24	5.40
Radio, television and communication	1.89	31.78	65.49	2.73
Medical, precision and optical instruments	3.08	21.97	75.85	2.18
Motor vehicles, trailers	12.53	18.53	73.53	7.93
Other transport equipment	1.54	16.50	80.49	3.00
Furniture; manufacturing n.e.c.	1.97	16.43	70.95	12.62

*applying the first skill definition from Table 1

Table 3: Fixed Effects Log Wage Regression for Fragmentation

	Narrow Fragmentation	Wide Fragmentation
	(a)	(b)
Age	0.1302	0.1240
	[5.59]***	[5.74]***
Age^2	-0.0011	-0.0011
	[20.39]***	[20.39]***
Married	0.0666	0.0666
	[5.21]***	[5.21]***
Number of Children	0.0095	0.0095
	[1.62]	[1.62]
Firm size: < 20	-0.1060	-0.1060
	[5.89]***	[5.89]***
Firm size: < 200	-0.0428	-0.0428
	[2.93]***	[2.93]***
Firm size: < 2000	-0.0064	-0.0064
	[0.58]	[0.58]
Firm:Public Owner	-0.0356	-0.0356
	[0.92]	[0.92]
ln(Actual work hours)	0.3491	0.3491
	[11.55]***	[11.55]***
Tenure	0.0036	0.0036
	[4.24]***	[4.24]***
Tenure not known	-0.1326	-0.1326
	[1.58]	[1.58]
Occ:Managers/Legisl.	0.1064	0.1064
	[3.87]***	[3.87]***
Occ:Scientists	0.0570	0.0570
	[2.03]**	[2.03]**
Occ:Technicians	0.0171	0.0171
	[0.68]	[0.68]
Occ:Clerks	0.0007	0.0007
	[0.02]	[0.02]
Occ:Craft	0.0325	0.0325
	[1.41]	[1.41]
Occ:Operators/Assembl.	0.0700	0.0700
	[3.07]***	[3.07]***
High educated	0.4123	0.4123
	[10.95]***	[10.95]***
Medium educated	0.1248	0.1248
	[4.96]***	[4.96]***
$IndustryOutput$	-6.7400	-8.9200
	[2.29]**	[2.36]**
$FRAG$	-0.0480	-0.0336
	[2.13]**	[2.13]**
Constant	4.4189	4.9071
	[5.70]***	[6.45]***
Observations	7306	7306
Number of individuals	2329	2329
R^2	0.27	0.27

t-statistics in parentheses * significant at 10%, ** at 5%, *** at1%
not reported: full set of federal state dummies, year dummies, industry dummies and interaction terms of industry and year; default categories: Firm size:> 2000; Occ:Elementary; High Education; $IndustryOutput * 10^{12}$

Table 4: Fixed Effects Log Wage Regression for Fragmentation by Educational Attainment

	Narrow Fragmentation			Wide Fragmentation			Import Penetration Non-OECD		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Age	0.1401	0.1289	0.1200	0.1531	0.1172	0.2775	0.1630	0.1289	0.0515
	[4.05]***	[5.67]***	[3.69]***	[4.32]***	[5.71]***	[5.79]***	[4.86]***	[5.52]***	[1.31]
Age^2	-0.0010	-0.0009	-0.0007	-0.0010	-0.0009	-0.0007	-0.0010	-0.0009	-0.0007
	[5.67]***	[16.28]***	[2.58]**	[5.67]***	[16.28]***	[2.58]**	[5.67]***	[16.28]***	[2.58]**
Married	0.1006	0.0535	-0.0718	0.1006	0.0535	-0.0718	0.1006	0.0535	-0.0718
	[3.27]***	[3.74]***	[1.30]	[3.27]***	[3.74]***	[1.30]	[3.27]***	[3.74]***	[1.30]
Number of Children	0.0430	0.0123	-0.0316	0.0430	0.0123	-0.0316	0.0430	0.0123	-0.0316
	[3.39]***	[1.85]*	[1.29]	[3.39]***	[1.85]*	[1.29]	[3.39]***	[1.85]*	[1.29]
Firm size: < 20	-0.2194	-0.0530	-0.1231	-0.2194	-0.0530	-0.1231	-0.2194	-0.0530	-0.1231
	[4.16]***	[2.64]***	[1.65]	[4.16]***	[2.64]***	[1.65]	[4.16]***	[2.64]***	[1.65]
Firm size: < 200	-0.0193	-0.0128	-0.0579	-0.0193	-0.0128	-0.0579	-0.0193	-0.0128	-0.0579
	[0.59]	[0.78]	[0.88]	[0.59]	[0.78]	[0.88]	[0.59]	[0.78]	[0.88]
Firm size: < 2000	-0.0304	0.0077	0.0188	-0.0304	0.0077	0.0188	-0.0304	0.0077	0.0188
	[1.16]	[0.63]	[0.37]	[1.16]	[0.63]	[0.37]	[1.16]	[0.63]	[0.37]
Firm:Public Owner	-0.1606	-0.0095	-0.1391	-0.1606	-0.0095	-0.1391	-0.1606	-0.0095	-0.1391
	[2.02]**	[0.21]	[0.92]	[2.02]**	[0.21]	[0.92]	[2.02]**	[0.21]	[0.92]
ln(Actual work hours)	0.2086	0.3251	0.3296	0.2086	0.3251	0.3296	0.2086	0.3251	0.3296
	[3.01]***	[9.72]***	[2.56]**	[3.01]***	[9.72]***	[2.56]**	[3.01]***	[9.72]***	[2.56]**
Tenure	-0.0035	0.0025	-0.0030	-0.0035	0.0025	-0.0030	-0.0035	0.0025	-0.0030
	[1.27]	[2.66]***	[0.70]	[1.27]	[2.66]***	[0.70]	[1.27]	[2.66]***	[0.70]
Tenure not known	-0.5080	-0.2561	-0.1021	-0.5080	-0.2561	-0.1021	-0.5080	-0.2561	-0.1021
	[3.39]***	[1.97]**	[0.58]	[3.39]***	[1.97]**	[0.58]	[3.39]***	[1.97]**	[0.58]
Occ:Managers/Legisl.	0.2705	0.0893	0.3602	0.2705	0.0893	0.3602	0.2705	0.0893	0.3602
	[2.09]**	[2.92]***	[1.58]	[2.09]**	[2.92]***	[1.58]	[2.09]**	[2.92]***	[1.58]
Occ:Scientists	0.2552	-0.0096	0.3760	0.2552	-0.0096	0.3760	0.2552	-0.0096	0.3760
	[1.99]**	[0.28]	[1.82]*	[1.99]**	[0.28]	[1.82]*	[1.99]**	[0.28]	[1.82]*
Occ:Technicians	0.2272	-0.0086	0.0290	0.2272	-0.0086	0.0290	0.2272	-0.0086	0.0290
	[1.75]*	[0.31]	[0.15]	[1.75]*	[0.31]	[0.15]	[1.75]*	[0.31]	[0.15]
Occ:Clerks	0.2229	-0.0269	0.1967	0.2229	-0.0269	0.1967	0.2229	-0.0269	0.1967
	[1.65]*	[0.90]	[1.56]	[1.65]*	[0.90]	[1.56]	[1.65]*	[0.90]	[1.56]
Occ:Craft	0.2436	0.0088	0.0789	0.2436	0.0088	0.0789	0.2436	0.0088	0.0789
	[1.92]*	[0.34]	[1.22]	[1.92]*	[0.34]	[1.22]	[1.92]*	[0.34]	[1.22]
Occ:Operators/Assembl.	0.2142	0.0438	0.0482	0.2142	0.0438	0.0482	0.2142	0.0438	0.0482
	[1.99]**	[1.74]*	[0.81]	[1.99]**	[1.74]*	[0.81]	[1.99]**	[1.74]*	[0.81]
IndustryOutput	2.9400	3.5000	-1.4300	-2.9400	-9.3000	-1.7100	3.3700	-0.0659	-14.200
	[1.02]	[2.55]**	[4.29]***	[0.08]	[2.61]***	[4.92]***	[1.45]	[0.05]	[4.31]***
FRAG	0.0297	0.0052	-0.0725	0.0078	-0.0353	-0.1332	-0.0014	-0.0008	-0.0065
	[1.71]*	[0.56]	[3.13]***	[0.47]	[2.38]**	[4.94]***	[0.82]	[1.58]	[4.49]***
Constant	3.2035	3.2872	5.0544	3.1952	5.4093	0.9158	2.5011	3.7605	7.3130
	[2.88]***	[3.91]***	[4.91]***	[2.87]***	[7.19]***	[0.61]	[2.24]**	[4.14]***	[5.59]***
Observations	1185	5392	729	1185	5392	729	1185	5392	729
Number of individuals	378	1742	312	378	1742	312	378	1742	312
R^2	0.53	0.24	0.59	0.53	0.24	0.59	0.53	0.24	0.59

t-statistics in parentheses * significant at 10%, ** at 5%, *** at1%

not reported: full set of federal state dummies, year dummies, industry dummies and interaction terms of industry and year; default categories: Firm size:> 2000; Occ:Elementary; $IndustryOutput * 10^{12}$

Table 5: Fixed Effects Log Wage Regression for Fragmentation by ISCED Skill Groups

	Narrow Fragmentation			Wide Fragmentation			Import Penetration Non-OECD		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Age	0.1040	0.1063	0.0504	0.1041	0.1063	0.0326	0.1000	0.1098	0.0520
	[3.98]***	[4.91]***	[1.87]*	[3.96]***	[4.93]***	[0.66]	[2.93]***	[4.79]***	[1.39]
Age^2	-0.0009	-0.0007	-0.0002	-0.0009	-0.0007	-0.0002	-0.0009	-0.0007	-0.0002
	[5.40]***	[12.66]***	[0.92]	[5.40]***	[12.66]***	[0.92]	[5.40]***	[12.66]***	[0.92]
Married	0.1119	0.0783	-0.0207	0.1119	0.0783	-0.0207	0.1119	0.0783	-0.0207
	[3.63]***	[5.61]***	[0.36]	[3.63]***	[5.61]***	[0.36]	[3.63]***	[5.61]***	[0.36]
Number of Children	0.0413	0.0275	-0.0294	0.0413	0.0275	-0.0294	0.0413	0.0275	-0.0294
	[3.40]***	[4.17]***	[1.20]	[3.40]***	[4.17]***	[1.20]	[3.40]***	[4.17]***	[1.20]
Firm size: < 20	-0.1877	-0.0661	-0.1292	-0.1877	-0.0661	-0.1292	-0.1877	-0.0661	-0.1292
	[3.47]***	[3.33]***	[1.68]*	[3.47]***	[3.33]***	[1.68]*	[3.47]***	[3.33]***	[1.68]*
Firm size: < 200	-0.0154	-0.0221	-0.0435	-0.0154	-0.0221	-0.0435	-0.0154	-0.0221	-0.0435
	[0.45]	[1.39]	[0.60]	[0.45]	[1.39]	[0.60]	[0.45]	[1.39]	[0.60]
Firm size: < 2000	-0.0264	-0.0004	0.0368	-0.0264	-0.0004	0.0368	-0.0264	-0.0004	0.0368
	[1.02]	[0.03]	[0.66]	[1.02]	[0.03]	[0.66]	[1.02]	[0.03]	[0.66]
Firm:Public Owner	-0.1887	0.0629	-0.0904	-0.1887	0.0629	-0.0904	-0.1887	0.0629	-0.0904
	[2.40]**	[1.46]	[0.66]	[2.40]**	[1.46]	[0.66]	[2.40]**	[1.46]	[0.66]
ln(Actual work hours)	0.2232	0.3401	0.2775	0.2232	0.3401	0.2775	0.2232	0.3401	0.2775
	[3.04]***	[10.41]***	[2.47]**	[3.04]***	[10.41]***	[2.47]**	[3.04]***	[10.41]***	[2.47]**
Tenure	0.0017	0.0026	-0.0078	0.0017	0.0026	-0.0078	0.0017	0.0026	-0.0078
	[0.65]	[2.89]***	[1.64]	[0.65]	[2.89]***	[1.64]	[0.65]	[2.89]***	[1.64]
Tenure not known	-0.7559	-0.2005	-0.2388	-0.7559	-0.2005	-0.2388	-0.7559	-0.2005	-0.2388
	[3.63]***	[1.82]*	[1.33]	[3.63]***	[1.82]*	[1.33]	[3.63]***	[1.82]*	[1.33]
Occ:Managers/Legisl.	0.3205	0.0747	-0.1059	0.3205	0.0747	-0.1059	0.3205	0.0747	-0.1059
	[2.36]**	[2.53]**	[0.43]	[2.36]**	[2.53]**	[0.43]	[2.36]**	[2.53]**	[0.43]
Occ:Scientists	0.2897	0.0156	0.4205	0.2897	0.0156	0.4205	0.2897	0.0156	0.4205
	[2.17]**	[0.47]	[2.19]**	[2.17]**	[0.47]	[2.19]**	[2.17]**	[0.47]	[2.19]**
Occ:Technicians	0.2656	0.0025	0.1818	0.2656	0.0025	0.1818	0.2656	0.0025	0.1818
	[1.98]**	[0.10]	[0.71]	[1.98]**	[0.10]	[0.71]	[1.98]**	[0.10]	[0.71]
Occ:Clerks	0.2495	-0.0309	0.3008	0.2495	-0.0309	0.3008	0.2495	-0.0309	0.3008
	[1.78]*	[1.08]	[1.96]*	[1.78]*	[1.08]	[1.96]*	[1.78]*	[1.08]	[1.96]*
Occ:Craft	0.2589	0.0040	0.0202	0.2589	0.0040	0.0202	0.2589	0.0040	0.0202
	[1.71]*	[0.17]	[0.24]	[1.71]*	[0.17]	[0.24]	[1.71]*	[0.17]	[0.24]
Occ:Operators/Assembl.	0.2185	0.0430	0.0568	0.2185	0.0430	0.0568	0.2185	0.0430	0.0568
	[2.00]**	[1.80]*	[0.83]	[2.00]**	[1.80]*	[0.83]	[2.00]**	[1.80]*	[0.83]
IndustryOutput	-1.2800	-3.8100	-1.4500	-1.2900	-3.8500	-1.4800	2.0100	0.0613	-4.4300
	[0.53]	[1.87]*	[4.85]***	[0.51]	[0.27]	[4.76]***	[0.46]	[0.05]	[1.16]
FRAG	-0.0004	-0.0454	-0.0520	-0.0004	-0.0116	-0.0371	-0.0022	-0.0006	-0.0006
	[0.06]	[2.19]**	[2.46]**	[0.06]	[1.11]	[1.63]	[0.77]	[1.11]	[0.43]
Constant	4.7953	4.6791	6.8902	4.7947	4.2450	7.4356	4.6294	3.9812	5.4580
	[5.48]***	[6.73]***	[7.88]***	[5.48]***	[5.12]***	[5.21]***	[4.09]***	[4.48]***	[4.38]***
Observations	1151	5325	755	1151	5325	755	1151	5325	755
Number of individuals	356	1692	358	356	1692	358	356	1692	358
R^2	0.52	0.22	0.50	0.52	0.22	0.50	0.52	0.22	0.50

t-statistics in parentheses * significant at 10%, ** at 5%, *** at1%

not reported: full set of federal state dummies, year dummies, industry dummies and interaction terms of industry and year; default categories: Firm size:> 2000; Occ:Elementary; $IndustryOutput * 10^{12}$

Table 6: Fixed Effects Log Wage Regression by Required Skill

	Narrow Fragmentation		Wide Fragmentation		Import Penetr. Non-OECD	
	High	Low	High	Low	High	Low
	(a)	(b)	(c)	(d)	(e)	(f)
Age	0.1472	0.0814	0.1024	0.0810	0.1707	0.0847
	[7.47]***	[4.17]***	[3.85]***	[4.18]***	[7.15]***	[4.12]***
Age^2	-0.0010	-0.0005	-0.0010	-0.0005	-0.0010	-0.0005
	[6.55]***	[9.57]***	[6.55]***	[9.57]***	[6.55]***	[9.57]***
Married	0.0942	0.0503	0.0942	0.0503	0.0942	0.0503
	[3.16]***	[4.18]***	[3.16]***	[4.18]***	[3.16]***	[4.18]***
Number of Children	0.0323	0.0284	0.0323	0.0284	0.0323	0.0284
	[2.81]***	[4.98]***	[2.81]***	[4.98]***	[2.81]***	[4.98]***
Firm size: < 20	-0.0995	-0.0973	-0.0995	-0.0973	-0.0995	-0.0973
	[1.77]*	[5.71]***	[1.77]*	[5.71]***	[1.77]*	[5.71]***
Firm size: < 200	0.0146	-0.0417	0.0146	-0.0417	0.0146	-0.0417
	[0.44]	[3.01]***	[0.44]	[3.01]***	[0.44]	[3.01]***
Firm size: < 2000	-0.0196	-0.0072	-0.0196	-0.0072	-0.0196	-0.0072
	[0.72]	[0.69]	[0.72]	[0.69]	[0.72]	[0.69]
Firm:Public Owner	-0.1493	-0.0142	-0.1493	-0.0142	-0.1493	-0.0142
	[1.98]**	[0.37]	[1.98]**	[0.37]	[1.98]**	[0.37]
ln(Actual work hours)	0.1684	0.3273	0.1684	0.3273	0.1684	0.3273
	[2.35]**	[11.64]***	[2.35]**	[11.64]***	[2.35]**	[11.64]***
Tenure	0.0011	0.0047	0.0011	0.0047	0.0011	0.0047
	[0.52]	[5.98]***	[0.52]	[5.98]***	[0.52]	[5.98]***
Tenure not known	-0.4958	-0.0015	-0.4958	-0.0015	-0.4958	-0.0015
	[3.48]***	[0.02]	[3.48]***	[0.02]	[3.48]***	[0.02]
Occ:Managers/Legisl.	0.7295	0.1080	0.7295	0.1080	0.7295	0.1080
	[4.10]***	[4.41]***	[4.10]***	[4.41]***	[4.10]***	[4.41]***
Occ:Scientists	0.7082	0.0882	0.7082	0.0882	0.7082	0.0882
	[4.05]***	[2.71]***	[4.05]***	[2.71]***	[4.05]***	[2.71]***
Occ:Technicians	0.7180	0.0380	0.7180	0.0380	0.7180	0.0380
	[4.04]***	[1.76]*	[4.04]***	[1.76]*	[4.04]***	[1.76]*
Occ:Clerks	0.6274	0.0253	0.6274	0.0253	0.6274	0.0253
	[3.35]***	[1.05]	[3.35]***	[1.05]	[3.35]***	[1.05]
Occ:Craft	0.8394	0.0341	0.8394	0.0341	0.8394	0.0341
	[4.45]***	[1.76]*	[4.45]***	[1.76]*	[4.45]***	[1.76]*
Occ:Operators/Assembl.	1.1206	0.0693	1.1206	0.0693	1.1206	0.0693
	[4.05]***	[3.62]***	[4.05]***	[3.62]***	[4.05]***	[3.62]***
$IndustryOutput$	1.2300	-3.2300	10.5000	0.0390	4.7500	0.5230
	[0.49]	[1.05]	[1.43]	[0.03]	[1.63]	[0.46]
$FRAG$	0.0190	-0.0372	0.0088	-0.0126	0.0002	-0.0006
	[1.78]*	[2.00]**	[0.32]	[1.31]	[0.44]	[1.31]
Constant	2.7655	4.7902	3.8738	4.3561	1.5710	4.1341
	[3.73]***	[6.68]***	[4.81]***	[5.92]***	[1.65]*	[5.27]***
Observations	1146	5966	1146	5966	1146	5966
Number of individuals	373	2012	373	2012	373	2012
R^2	0.54	0.2	0.54	0.2	0.54	0.2

t-statistics in parentheses * significant at 10%, ** at 5%, *** at1%

not reported: full set of federal state dummies, year dummies, industry dummies and interaction terms of industry and year; default categories: Firm size:$>$ 2000; Occ:Elementary; $IndustryOutput * 10^{12}$