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# WORKING PAPER

# Wage and Employment Effects in the EU of International Trade with the Emerging Economies.

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April 2002

2002/142

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D/2002/7012/17

## Abstract.

We investigate whether significant HOS effects are present from trade liberalisation in the European Union vis-à-vis emerging economies on wages and employment of high- and lower-skilled workers. We allow for heterogeneity of the newly industrialised countries, using a more detailed geographical breakdown of international trade. Next, using a panel data approach, we allow for intra-EU heterogeneity of the (direct or indirect) wage effects of trade liberalisation.
We find that increased trade, especially with Asian NICs, had a significant, though limited influence on inequality between high- and lower-skilled workers. Evidence of trade induced technological change seems present for increased trade with Asian NICs and the Eastern European countries, but would be biased towards the lower-skilled labour intensive sectors, as one would expect from productivity increases because of import competition. Hence, the wage effect of technological change due to increased trade with the NICs *reduced* factor reward inequality, leaving a net increase that is almost negligible.

Increased international trade with the emerging economies under 'European assumptions' could however affect relative factor demand rather than factor reward. Using a flexible cost function approach, assuming sector output is produced using skilled labour, unskilled labour and physical capital, we estimated sectoral factor demand for a panel of ten countries and twelve sectors for the period 1985-1996. Import competition from the emerging economies, apparently did influence relative labour demand in favour of the high-skilled workers. Aggregate labour demand of the lower-skilled workers fell in a majority of member states, as well as at the level of the Union as a whole. These findings seem in line with the 'sticky wage' model, though our results concerning sectoral factor demand would indicate an intra-sectoral rather than an inter-sectoral specialisation in skill-intensive activities.

# Wage and Employment Effects in the EU of International Trade with the Emerging Economies.

by

L.Cuyvers , M. Dumont, G. Rayp and K. Stevens

## I. Introduction.

In the past decade, concern has risen in the EU member states about the impact of globalisation on wages and employment in Europe. Following the Heckscher-Ohlin-Samuelson (HOS) model, international trade will induce a decline of the reward of the production factor(s) a country is relatively badly endowed with. This prediction constitutes a potential explanation of the observed deterioration of the income position of the lower-skilled workers in the US or their high and increased unemployment rate in Europe, where labour market rigidities are supposed to prevent wage adjustments like in the US. The main alternative hypothesis to explain the differing odds by skill is skill-biased technological change, going back to the observation of Lawrence and Slaughter (1993) that despite the increase in the skill premium in the US since the 1970s, the skilled workers' share in employment increased as well.

Most existing studies do not find much evidence in favour of the HOS trade hypothesis (see e.g. Brenton 1998 for a review; Haskel and Slaughter 1999; Haskel and Slaughter 2000). Quite contrary to the *communis opinio*, an academic consensus has established on the at most limited effect of international trade and globalisation on wage inequality between the high- and lower skilled. The bulk of the existing evidence is however based on US data and only confirmed for Europe by a limited number of country studies, the UK, Germany and Sweden in particular (Lücke 1998; Oscarsson 2000). Can these findings be extrapolated to the whole of the European Union ? This is the *first question* we want to answer.

In addition, two specific questions may be relevant in quantifying the impact of globalisation in the EU context. First, in the EU the national dimension of globalisation may matter as well as the factor dimension. Since labor mobility between the EU member states is very low, the extent to which trade liberalisation causes an asymmetrical economic shock may constitute a first order policy issue. Even if the overall effect of globalisation on the EU economy remains limited, its distribution by member country may not be indifferent. Whether the economies of the EU member states are asymmetrically affected by increased trade with low wage countries or not, is the *second question* we deal with.

Finally, the HOS explanation of increased inequality and the deterioration of the position of the lower-skilled focuses on factor rewards. This is not necessarily adequate for the EU, where the generally acknowledged rigid labour markets may prevent relative wage adjustments. Hence, evidence for the EU based on evolution of the relative wage of the high- and lower skilled is not sufficient to assess the impact of globalization. Increased import competition may cause employment adjustments, rather than of wage adjustments. This raises the *third question* that we address, namely to what extent international trade with lower wage countries significantly affects relative labour demand.

In dealing with these three questions, we propose a final extension with respect to the existing literature related to the way globalisation is proxied empirically. Following the 'lifting all boats' argument of Bhagwati and Deheija (1994), we allow for heterogeneity of the low wage and newly industrialised countries, using a more detailed geographical breakdown of international trade. It might indeed be too heroic to assume that Latin American, (South-) East Asian and Eastern European countries are sufficiently similar with respect to factor endowments and technology (which determine the plausibility of the assumption of a common diversification cone with the EU), transportation costs and even trade liberalization.

We briefly present the theoretical framework in the first section and discuss the conceptual issues concerning international trade and wages, as well as international trade and employment in a sticky wage model. In the following section, we discuss our estimation results and conclude in the third section. The data that we used in our estimations are described in detail in the data appendix at the end of the paper.

## II. Trade, Wages and Employment in the Heckscher-Ohlin-Samuelson Framework.

### 1. Trade and wages.

How lower skilled workers may be hurt from globalization in the Heckscher-Ohlin framework is straightfowardly described by the Stolper-Samuelson theorem. The rewards (in real terms) of the relatively abundant production factors will rise, provided the relative price of the goods in which a country has a comparative advantage increases when trade is liberalized. Changes in factor rewards thus depend on the sector bias in relative price changes. In a (small) open economy, this is also what one expects from technological change. Rewards will rise for the factors that are intensively employed in the sectors that experience the highest technological improvement. Haskel and Slaughter (1999), following Leamer (1995), suggest a framework where both can be considered simultaneously and which allows to disentangle their respective weight, using the zero

profit condition (or a constant mark-up in case of imperfect competition) to model the relationship between changes in relative price and factor rewards. The zero profit condition for sector i is given as:

$$p_i^g = \sum_j a_{ji} w_j + \sum_k b_{ki} p_k^g \qquad i,k = 1,...,I \qquad (\mathbf{1})$$

Where $p_i^g$ represents domestic gross output price; $w_j$ the unit cost of the *j*th –sectoral perfectly mobile-production factor; $a_{ji}$ the quantity of factor j used per unit i; $p_k$ the domestic gross output price of intermediate good k and $b_{ki}$ the quantity of intermediate good k used per unit of i. Given labor supply, changes in prices or technology will 'mandate' changes in factor rewards that will restore zero profits in all sectors. This adjustment process can be formalised by differentiating (1)[1]:

$$\sum_j V_{ji} \Delta \log w_j = \Delta \log p_i + \Delta \log tfp_i \qquad (\mathbf{2})$$

$V_{ji}$ stands for the value -added share of factor j in sector i, $\Delta \log p_i$ for the change in value added prices (i.e. $\Delta \log p_i = \Delta \log p_i^g - \sum_k V_{ki} \log p_k^g$ ) and $tfp_i$ for the total factor productivity is sector i. From (2), one notices that the equilibrium restoring factor reward changes depend on the correlation between price and technology changes and the sectoral value added shares of the production factors, i.e. on the sector bias of price and technology changes. If the relative price of the high-skilled labor intensive good increases because of globalization or if technological change favors its production, the zero profit condition will imply an economy-wide increase of the wage of the high-skilled workers.

In the situation of a small country facing given international prices, the law of one price applies and all price changes will be of international origin, i.e. exogenous. Hence, factor reward change can be linked to total price change. However, in the situation of a large country, product prices may change for other reasons than international price adjustments. Haskel and Slaughter (1999) propose a two-stage approach, in which prices and technological change are considered as endogenous. In the first stage, price changes and tfp changes are regressed on the underlying determinants of international price competition and technological change, respectively $Z_{pr,i}$ and $Z_{tc,i}$ :

$$\Delta \log p_i = \sum_{pr} Z_{pr,i} \delta_{pr} + \varepsilon_{pr,i} \qquad (\mathbf{3})$$

$$\Delta \log tfp_i = \sum_{tc} Z_{tc,i} \delta_{tc} + \varepsilon_{tc,i} \qquad (\mathbf{4})$$

[1] Time subscripts are omitted to simplify the notation.

If we now regress the first stage estimates of vectors $\delta_{pr}$ and $\delta_{tc}$ on the factor shares, the estimated coefficients $\gamma_{j,pr}$ and $\gamma_{j,tc}$ give the wage change mandated by trade induced price changes and technological change:

$$\delta_{pr} Z_{pr,i} = \sum_j V_{ji} \gamma_{j,pr} + \varepsilon'_{pr,i} \qquad (5)$$

$$\delta_{tc} Z_{tc,i} = \sum_j V_{ji} \gamma_{j,tc} + \varepsilon'_{tc,i} \qquad (6)$$

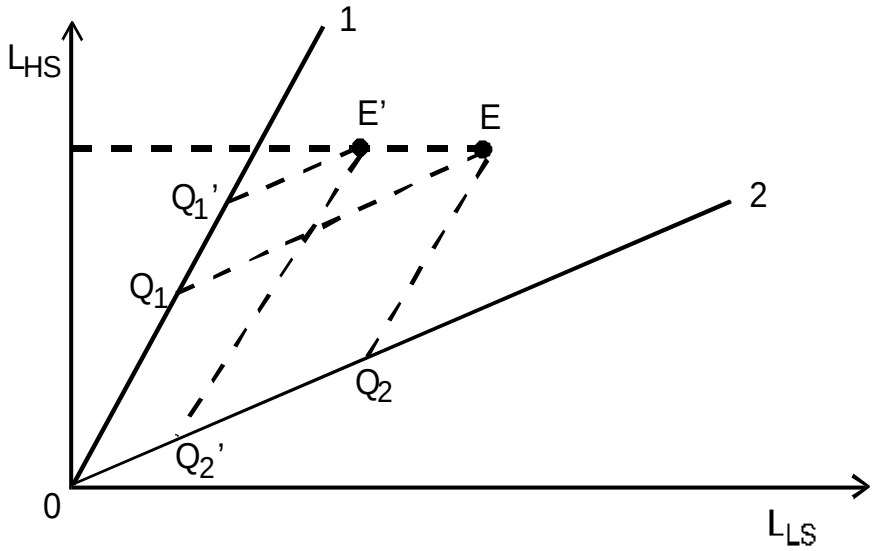
By including a measure of import competition in the vector $Z_{tc,i}$ we obtain an estimation of the influence of international trade on technological change and total factor productivity increase. Hence, we obtain an estimate of the direct effect of international competition on the factor rewards, as well as of the indirect effect, i.e. the effect on factor rewards of trade induced technological change.

## 2. Trade and Employment.

The Stolper-Samuelson theorem explains the factor reward implications of international trade, assuming that factor markets clear. This implies that the consequences of international trade for the owners of the production factors are entirely reflected by income adjustments at constant employment, here in particular by declining wages of lower skilled labor. However, the assumption of perfectly competitive labor markets is seemingly not in line with the EU reality, where labor market regulations limit the scope for wage adjustments and employment adjustments are more likely. In order to identify the consequences of (increased) international trade for the EU, we describe what might happen when relative wages are sticky instead of flexible (see Brecher 1974, Krugman 1995 and Bhagwati et al. 1999).

If international trade reduces the demand for a particular production factor of which the reward is fixed, then evidently a downward adjustment of its employment level occurs. Suppose we start from an autarkic economy with fixed factor rewards that fully employs all its resources of, e.g., high- and lower skilled labor. In Figure 1, this is represented by the endowment point E, where higher-skilled labor $L_{HS}$ and low-skilled labor $L_{LS}$ are allocated to the relatively higher skilled intensive industry 1 and the relatively low skilled intensive industry 2 according to the sectoral employment vectors $Q_1$ and $Q_2$. When this economy gets the possibility to trade with countries well-endowed in low-skilled labor, resources will shift to the higher-skilled intensive industry. Yet, because of fixed relative wages, the sectoral technology will not adjust and, as long as the economy does not fully specialize, this will be met by a net reduction in the demand of low-skilled labor. The economic equilibrium shifts to E', following the typical comparative advantage pattern of specialisation, but with positive unemployment of low-skilled labor, given by the horizontal distance between E and E'.

Figure 1 - *Employment Shift in the Sticky Wage Model*




*Source*: Krugman (1995)

If the rigid wage economy would be a small (price taking) country, then it would be completely driven out of the production of the lower-skilled labor intensive good. It would completely specialise in the production of the skilled labor intensive good, which might eventually restore full employment. Yet, if the rigid wage economy is large, and supply and demand conditions are not substantially influenced by international trade, then it will continue to produce both goods. With constant relative factor rewards, this implies that neither the relative price of the goods will change. Hence, we would only expect a shift in supply from domestic to foreign production, determined by the amount the foreign country is willing to offer at the domestic autarkic price ratio.

## III. Estimation Issues and Results.

### 1. Trade and Wages

The data allow us to create a panel of 9 EU countries and 12 industrial sectors[2] for which first differences were computed over the period 1985-1995. More details concerning the data are given in the data annex.

We performed a panel data estimation on the panel of 107 available observations. Because of the size of the EU economy, we considered price and technological change as not fully exogenous. Hence, before performing the

[2] Countries: Belgium, Denmark, Finland, France, Germany, Italy, Spain, Sweden and the UK.
Sectors: Food, drink & tobacco (ISIC 31); Textile, footwear & leather (ISIC 32); Wood, cork & furniture (ISIC 33); Paper, printing & publishing (ISIC 34); Chemicals (ISIC 35); Non-metallic mineral products (ISIC 36); Basic Metal Industries (ISIC

mandated wage regression, we first have to isolate the share of total change caused by the forces of international trade liberalization and technological progress in a two-stage estimation procedure.

As regards the effect of *import price competition* on domestic price changes, we regressed in the first stage the domestic price changes on country specific fixed effects, import price changes and the change in total factor productivity (in order to control for the output price effect of technological change) :

$$\Delta \log p_{i,dom} = \alpha_{0,i} + \alpha_{oecd}\Delta \log p_{i,oecd} + \alpha_{asia}\Delta \log p_{i,asia} + \alpha_{cee}\Delta \log p_{i,cee} + \alpha_{latin}\Delta \log p_{i,latin} + \alpha_{tfp}\Delta \log tfp_i + \varepsilon_{i,pr} \quad (6)$$

Import price changes were broken down by four country groups (the OECD countries, the (South-) East Asian NICs and NECs, the most advanced Central and Eastern European countries and the Latin American NICs[3]) in order to take account of cross-country heterogeneity in import competition and trade liberalization. Table 1 shows the first stage estimation results[4].

Table 1 - *Stage-one price regression*

| Dependent variable : $\Delta \log p_{i,dom}$ | (6) |
|---|---|
| $\Delta \log p_{i,oecd}$ | -0.15 (-2.56) |
| $\Delta \log p_{i,asia}$ | 0.06 ( 0.98) |
| $\Delta \log p_{i,cee}$ | 0.02 ( 0.98) |
| $\Delta \log p_{i,latin}$ | 0.05 ( 0.67) |
| $\Delta \log tfp_i$ | -4.31 (-2.48) |
| $R^2$ | 0.28 |
| *Note*: the results are fixed effects estimations - heteroskedastic-consistent t-statistics in brackets. | |

The parameters of Asian, Central and Eastern European as well as the Latin American import price changes ($\alpha_{asia}$, $\alpha_{cee}$, $\alpha_{latin}$) are positively correlated with EU domestic price changes, though not significantly different from 0. The effect of technological change on domestic price change is negatively signed as could be expected, clearly significantly different from zero and has a substantially more important effect on domestic price changes than import competition.

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37); Fabricated metal products (ISIC 381); Non-electrical machinery (ISIC 382); Electrical equipment (ISIC 383); Transport equipment (ISIC 384) and Precision instruments (ISIC 385).

[3] A detailed country list of each group is given in the data appendix.

[4] To control additionally for imperfect competition, we also tested a specification of the right hand side of the equation where the price changes were interacted with pass-through variables reflecting market structure. We used a sectoral concentration measure (C4) and a sectoral measure of returns to scale (the average capital-labor ratio) as proxies for the pass through variables. In each specification, an F test on parameter restriction did not reject the null hypothesis of zero pass-through parameters.

In the second stage, each foreign competition determinant of $\Delta \log p_{dom}$ is regressed on the factor shares, in order to estimate its contribution to the change in inequality between high and lower skilled workers.

$$\alpha_j \Delta \log p_{i,j} = V_{HS,i} \Delta \log w_{HS} + V_{LS,i} \Delta \log w_{LS} + V_{K,i} \Delta \log w_K + \varepsilon_{i,j} \quad (j = oecd, asia, cee, latin) \qquad \textbf{(7)}$$

where $V_{f,i}$ represents the value added shares of factor f (high skilled labor, lower skilled labor and capital) in sector i. Transforming as in Lücke (1998) :

$$V_{K,i} = 1 - V_{HS,i} - V_{LS,i}$$

we obtain :

$$\alpha_j \Delta \log p_{i,j} = \Delta \log w_K + V_{HS,i}(\Delta \log w_{HS} - \Delta \log w_K) + V_{LS,i}(\Delta \log w_{LS} - \Delta \log w_K) + \varepsilon_{i,j} \quad (j = oecd, asia, cee, latin) \qquad \textbf{(8)}$$

Hence, the coefficient estimate of $V_{f,i}$ indicates to what extent the remuneration of factor f diverged from that of capital (if it is significant or not and, if so, in what direction). A comparison of the estimated parameters of $V_{HS,i}$ and $V_{LS,i}$ gives an indication of the change in wage inequality between high- and lower skilled workers in the period considered.

In this second stage, we explicitly add an F-test on the specification of the model. The presence of country specific intercepts or slopes determines the degree of (intra-EU) country heterogeneity with respect to trade liberalization and this allows us to answer our second question. From (8), country specific intercepts would be an indication of country specificity of factor price evolutions and hence of income divergence within the EU, caused by globalization. Country specific slopes would in addition point to country differences in evolution of income inequality, which would exacerbate the income divergence trend. This may be especially problematic in an economic area with an overall low labour mobility. However (7) and (8), as well as (2) are only strictly valid in continuous time, but not for the approximate discrete time change used in an empirical test. For the latter, we have to take into account the interaction effect between the changes in factor input requirements and the changes in factor rewards (see e.g. Leamer 1995)[5]. By regressing the residuals of (8) on these interaction terms and performing an F-test on their significance, we tested whether our results might be affected by an omitted variable bias. This was rejected in all cases considered of the direct as well as of the indirect effects of import price competition on factor rewards[6].

The results of the second stage of the mandated wage regression are shown in Table 2.

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[5] The discrete time equivalent of (2) is : $\sum_j V_{ji} \Delta \log w_j (1 + \Delta \log a_{ji}) = \Delta \log p_i + \Delta \log tfp_i$

Table 2 - *Stage-two price regression*

| Dependent variable: | $\alpha_{oecd}\Delta p_{oecd}$ | $\alpha_{asia}\Delta p_{asia}$ | $\alpha_{cee}\Delta p_{cee}$ | $\alpha_{latin}\Delta p_{latin}$ |
|---|---|---|---|---|
| $\Delta \log w_{HS} - \Delta \log w_K$ | n.r. | 0.04 (2.15) | 0.02 (2.13) | 0.01 (0.70) |
| $\Delta \log w_{LS} - \Delta \log w_K$ | n.r. | 0.02 (1.07) | 0.01 (1.93) | 0.01 (0.78) |
| $\Delta \log w_K$ | n.r. | -0.00 (-0.13) | 0.00 (0.07) | 0.01 (0.81) |
| $R^2$ | | 0.04 | 0.03 | 0.01 |
| F-test: $\alpha(0)$ , $\alpha(j) = \alpha(0,i), \alpha(j,i)$ (j = oecd,asia, cee, latin) | 2.70 (0.00) | 1.35 (0.16) | 0.97 (0.52) | 1.54 (0.08) |
| F-test: $\alpha(0,i)$ , $\alpha(j) = \alpha(0,i)$ , $\alpha(j,i)$ (j = oecd,asia, cee, latin) | 3.29 (0.00) | 1.45 (0.14) | 0.80 (0.69) | 1.86 (0.04) |
| F-test: $\alpha(0)$ , $\alpha(j) = \alpha(0,i)$ , $\alpha(j)$ (j = oecd,asia, cee, latin) | 1.08 (0.38) | 1.07 (0.39) | 1.35 (0.23) | 0..79 (0.61) |

*Note*: heteroskedastic-consistent t-statistics between brackets- n.r.: not reported.
The values of three F-tests on function specification are reported, respectively : common intercept and slope versus country specific intercepts and slopes, common slopes versus country specific intercepts and slopes, and common intercept and slope versus country specific intercepts but common slopes (p-values in brackets)

Concerning the model specification, we do not reject the plain OLS specification with common intercept and slope in three out of four cases[7]. In particular, trade liberalization with newly industrialized countries would affect factor rewards in a fairly homogenous manner across the EU and apparently does not alter the relative intra-EU position of the member states. Intra-OECD trade liberalization on the contrary, would have country specific effects on income evolution and income distribution and might be at the origin of asymmetric shocks within the EU.

Concerning the factor reward effects of trade liberalization with the NICs, only trade liberalization with East and (South-) East Asian NICs had a significant influence on inequality between high- and low-skilled workers. It 'mandated' a profit clearing increase of the remuneration of higher-skilled workers of about 4%, whereas the wages of the lower-skilled increased some 2% less. However, taking into account that we consider total changes over a period of ten years, the effect is apparently very small. Increased trade with Central and Eastern Europe did significantly influence the remuneration of (high- and lower-skilled) labor and capital, but in a fairly skill-neutral manner[8] . Increased trade with Latin America did not seem to have influenced the factor reward growth. Hence, we do find some evidence of Stolper-Samuelson trade effects in the EU, which affected factor rewards and their distribution rather homogeneously but which differed according to regional import origin. Especially

[6] Results upon request available from the authors.
[7] Though only marginally in the case of factor reward changes due to trade with Latin America.
[8] The apparent difference of 1% is due to rounding errors (at the three digit precision level it would amount to 0.4%)

trade with East and South-East Asia would seem to have mattered for factor remuneration inequality, whereas trade with the Central and Eastern European countries affected factor reward more in a 'lifting-all-boats' manner.

In the first stage of the *total factor productivity growth* regression, we regressed tfp change on a proxy for its technological determinant and on international competition, allowing for country specific effects. For the first, we use the beginning of period sectoral domestic R&D stock (SRD), the non-sectoral domestic R&D stock (NSRD) and the foreign R&D stock (FRD). A proxy for non-sectoral and foreign knowledge is included to capture national and international knowledge spillover effects on technological progress (Grossman and Helpman 1992) of which Coe and Helpman (1995) found evidence at country level. To test the effect of international competition on technological change we also included the import prices changes relative to the base period domestic price (in order to avoid a potential simultaneity bias):

$$\Delta \log tfp_i = \beta_{i,0} + \beta_{srd} \log SRD_{i,85} + \beta_{ns} \log NSRD_{i,85} + \beta_{for} \log FRD_{i,85} + \frac{1}{p_{dom,i,85}} \left( \beta_{oecd} \Delta \log p_{oecd,i} + \beta_{asia} \Delta \log p_{asia,i} + \beta_{cee} \Delta \log p_{cee,i} + \beta_{latin} \Delta \log p_{latin,i} \right) + \varepsilon_{i,tc} \quad \textbf{(9)}$$

Table 3 - Stage-one TFP regression

| Dependent variable: $\Delta \log tfp_i$ | | |
|---|---|---|
| Log $SRD_i$ | $-0.44\ 10^{-13}$ | (-0.25) |
| Log $NSRD_i$ | $-0.09\ 10^{-12}$ | (-2.06) |
| Log $FRD_i$ | $0.29\ 10^{-11}$ | ( 1.77) |
| $(\Delta \log p_{oecd,i}) / p_{dom,i,85}$ | 0.01 | (1.83) |
| $(\Delta \log p_{asia,i}) / p_{dom,i,85}$ | -0.01 | (-2.24) |
| $(\Delta \log p_{cee,i}) / p_{dom,i,85}$ | -0.00 | (-0.59) |
| $(\Delta \log p_{latin,i}) / p_{dom,i,85}$ | -0.00 | (-0.62) |
| $R^2$ | 0.30 | |
| *Note*: see Table 1 | | |

In accordance with earlier estimations (e.g. Coe and Helpman, 1995; Lichtenberg and van Pottelsberghe, 1996), international R&D spillovers are found to be significantly positive. Surprisingly the coefficients of the domestic R&D stocks (intra and inter sectoral) are both negative. Moreover, the coefficient of the domestic intersectoral R&D stock is significant at the 5 % level. Again, effects of increased trade with (South-) East Asian NICs are significant, which would represent evidence of trade induced technological change, as pointed out in Wood

(1994). Though of the expected sign, increased trade with NICs of other continents seems to have no significant influence on technological innovation. How these determinants of technological change influence factor rewards is reported in Table 4.

Table 4 - *Stage-two TFP regression.*

| Determinant | Tech | | $M_{oecd}$ | | $M_{asia}$ | | $M_{cee}$ | | $M_{latin}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| $\Delta \log w_{HS} - \Delta \log w_K$ | n.r. | | n.r. | | -0.01 | (-2.38) | -0.002 | (-2.02) | -0.00 | (-0.95) |
| $\Delta \log w_{LS} - \Delta \log w_K$ | n.r. | | n.r. | | -0.005 | (-1.49) | -0.002 | (-2.16) | -0.00 | (-1.18) |
| $\Delta \log w_K$ | n.r. | | n.r. | | 0.00 | (0.58) | -0.00 | (-0.00) | -0.00 | (-0.52) |
| $R^2$ | | | | | 0.05 | | 0.04 | | 0.02 | |
| F-test: $\alpha(0)$ , $\alpha(j) = \alpha(0,i), \alpha(j,i)$ (j = oecd,asia, cee, latin) | 8.38 | (0.00) | 2.71 | (0.00) | 1.55 | (0.07) | 1.26 | (0.22) | 1.17 | (0.30) |
| F-test: $\alpha(0,i)$ , $\alpha(j) = \alpha(0,i)$ , $\alpha(j,i)$ (j = oecd,asia, cee, latin) | 2.28 | (0.01) | 2.93 | (0.00) | 1.74 | (0.05) | 0.92 | (0.55) | 1.43 | (0.15) |
| F-test: $\alpha(0)$ , $\alpha(j) = \alpha(0,i)$ , $\alpha(j)$ (j = oecd,asia, cee, latin) | 16.96 | (0.00) | 1.72 | (0.10) | 1.03 | (0.41) | 1.97 | (0.06) | 0.60 | (0.78) |

*Note*: see Table 2. The estimation results for the common intercept ($\Delta \log w_K$ ) or the common slopes are not reported when the plain OLS or fixed effects specification was rejected respectively.
The *Tech* variable captures the combined effect of the three R&D stocks that are considered. $M_{oecd}$ stands for $\beta_{oecd}(\Delta \log p_{oecd,i})/p_{dom,i,85}$; $M_{asia}$ for $\beta_{asia}(\Delta \log p_{asia,i})/p_{dom,i,85}$; $M_{cee}$ for $\beta_{cee}(\Delta \log p_{cee,i})/p_{dom,i,85}$; $M_{latin}$ for $\beta_{latin}(\Delta \log p_{latin,i})/p_{dom,i,85}$

The factor reward effect of the 'pure' technical determinant (tech) and the indirect effect of intra-OECD internationalization are apparently rather country specific as even the fixed effects specification (common slopes) is rejected in these cases. This would point to country specific *growth differentials* between factor rewards, i.e. national differences in the evolution of factor reward inequality, caused by the 'pure' technical effect and intra-OECD internationalization. The factor reward effect of total factor productivity growth, due to increased competition of the emerging economies seems again much more homogeneous. Independent from their regional origin, we did not reject a plain OLS specification, i.e. a common effect on the factor rewards and hence on inequality between lower- and high-skilled workers in the EU. The effects however are rather small in absolute value and seem fairly factor neutral. The evidence we find of sector biased technological change, would point to a bias of technological progress towards the *lower-skilled* labor intensive industries. In particular, especially trade with (South)-East Asia would 'mandate' a decline of inequality between high- and lower skilled workers of 0.5%. This would indeed be in line with a higher relative rate of total factor productivity growth in the *lower-skilled* labor intensive industries. In order to cope with increased import competition, technological

improvements accelerate in the lower-skilled intensive industries, which *ceteris paribus* increase the demand of high and lower-skilled workers in these industries and hence relative demand of lower-skilled labor.

The total effect on wage inequality between high and lower-skilled labor of trade liberalization with the emerging economies seems composed of a direct (or Stolper Samuelson) effect, which is partially *counterbalanced* by a factor demand effect of sector biased technological change. Though the effects are significant for two out of three considered import regions, the (South-) East Asian NICs and the Central and Eastern European countries, the gross effects are overall fairly small (especially taking account of the length of the period considered). The net effect on factor reward inequality between the high and lower skilled workers would have been limited to 1.5%. Hence, our estimation for the EU is somewhat lower than estimations in similar studies for the US, which perhaps is not surprising considering the differences in labor market characteristics. In addition, as regards its factor reward effects, globalization apparently affects the EU in a fairly homogenous manner and, in particular, would not cause asymmetrical shocks within the union. 'Pure' technological change, as well as intra-OECD competition would be much more responsible for changes in the relative intra-EU income position of the member states and for country specific changes in factor reward inequality.

## 2. Trade and Employment

Our estimation results concerning the relationship between trade and wages would confirm the findings of other studies for the US or individual EU member states, provided that the effect of trade on employment appears to be equally limited. The sticky wage model of international trade implies three basic predictions regarding the influence of trade on employment that can be empirically verified :

- constant full employment of the relatively abundant factor and a decline of the demand of the relatively scarce production factor at the aggregate level, i.e. an increase of relative demand of the relatively abundant production factor ;
- an increase of the demand of the relatively abundant as well as the relatively scarce production factor in the sectors in which the country has a comparative advantage ;
- a decline of the demand of the relatively abundant as well as the relatively scarce production factor in the sectors in which the country has a comparative disadvantage.

In our estimation of the employment effect of increased international trade with the NICs, we opted for a cost function approach, using a flexible functional specification. It characterizes the behavior and technology of firms, without making any a priori assumption concerning the substitution elasticities between the production factors, nor concerning returns to scale. From the cost function, we derive an expression for input demand (using Shephard's Lemma) and determine the elasticity of high and lower skilled labor demand with respect to trade within the OECD or with the emerging economies. The two most popular flexible functional specifications are the translog cost function (e.g. Berndt and Hesse, 1986) and the Generalized Leontief (GL) cost function (Morrison, 1988). We preferred the latter that may be considered as somewhat more general, since it allows a closed form solution of the long run equilibrium in a partial equilibrium framework, i.e. where account is taken of the quasi-fixity of certain production factors due to adjustment costs[9].

We assumed that sectoral output is produced using three inputs : high-skilled labor, lower-skilled labor and capital. Besides of the input factors (and their rewards), we assumed that the cost function is also a function of output, import competition and technological change. Though not necessary for estimation or identification purposes, we imposed constant returns to scale because the cost function is specified at the sectoral level. We obtained the following equation for each sector, country and year[10] :

$$C = Y\left(\sum_i \sum_j \alpha_{ij} w_i^{0.5} w_j^{0.5} + \sum_i \sum_m \delta_{im} w_i s_m^{0.5} + \sum_i w_i \sum_m \sum_n \gamma_{mn} s_m^{0.5} s_n^{0.5}\right) \qquad \textbf{(10)}$$

where Y stands for real output, $w_i$ ($w_j$) for the vector of the factor rewards of the production factors (the wage $w_{HS}$ of the skilled workers, $w_{LS}$ of the lower skilled workers and the unit capital cost $w_K$) and $s_m$ ($s_n$) for the other determinants of the cost function, i.e. imports from the rest of the OECD and the emerging economies ($m_{OECD}$ and $m_{NICS}$), and technological change (tech). The assumption of constant returns to scale in the long run implies that real output Y is omitted from $s_m$ ($s_n$ ).

The firm's cost-minimizing demand for an input i can be derived by differentiating the cost function with respect to the price of the input i, $w_i$ (using Shephard's lemma): $X_i = \frac{\partial VC}{\partial w_i}$. However, a more convenient expression is

[9] Adjustment costs are not our central concern though, because of degree of freedom limitations at a sufficient level of detail. We use a specification where allowance is made for adjustment costs and quasi-fixed input factors primarily as a robustness check on our results. Capital is often treated as a quasi-fixed input

[10] We omitted the different indices s, c and t for the sake of the legibility of the notation.

obtained by dividing through Y, yielding an input-output equation for high-skilled labor, lower-skilled labor and capital :

$$\frac{X_{HS}}{Y} = \frac{\partial C}{\partial w_{HS}} \frac{1}{Y} = \sum_{j=HS,LS,K} \alpha_{HS,j} \left( \frac{w_j}{w_{HS}} \right)^{0.5} + \sum_m \delta_{HS,m} s_m^{0.5} + \sum_m \sum_n \gamma_{mn} s_m^{0.5} s_n^{0.5} \qquad \textbf{(11)}$$

$$\frac{X_{LS}}{Y} = \frac{\partial C}{\partial w_{LS}} \frac{1}{Y} = \sum_{j=HS,LS,K} \alpha_{LS,j} \left( \frac{w_j}{w_{LS}} \right)^{0.5} + \sum_m \delta_{LS,m} s_m^{0.5} + \sum_m \sum_n \gamma_{mn} s_m^{0.5} s_n^{0.5} \qquad \textbf{(12)}$$

$$\frac{X_K}{Y} = \frac{\partial C}{\partial w_K} \frac{1}{Y} = \sum_{j=HS,LS,K} \alpha_{K,j} \left( \frac{w_j}{w_K} \right)^{0.5} + \sum_m \delta_{K,m} s_m^{0.5} + \sum_m \sum_n \gamma_{mn} s_m^{0.5} s_n^{0.5} \qquad \textbf{(13)}$$

From these three equations, the elasticities of the input demands respect to the input prices can then be derived in the following way:

$$\varepsilon_{ij} = \frac{\partial \ln X_i}{\partial \ln w_j} = \frac{\partial X_i}{\partial w_j} \frac{w_j}{X_i}, \text{ with i and j : HS,LS,K} \qquad \textbf{(14)}$$

The sensitivity of high and lower skilled labour demand with respect to the exogenous parameters can be expressed as:

$$\varepsilon_{im} = \frac{\partial \ln X_i}{\partial \ln s_m} = \frac{\partial X_i}{\partial s_m} \frac{s_m}{X_i} \text{ ; i = HS, LS ; } s_m = (m_{OECD}, m_{NICS}, \text{tech}) \qquad \textbf{(15)}^{11}$$

We were able to construct a panel database for this model, consisting of 10 countries[12], 12 sectors (at the ISIC two-digit level and three-digit level for the machinery sector) and 12 years (1985-1996). Since in the sticky wage model, sectoral factor demand is linked to trade *volume* at the *aggregate* level, we proxied import intensity by the national average of the sectoral import to GDP ratio. We allowed for a differential impact of trade with the other OECD countries and the emerging economies in our basic model, and for additional regional heterogeneity between the (South-) East Asian, the Latin American and the Central and Eastern European Countries in an extension of the model. In this way, we again tried to correct for geographical differences in factor endowments and product specialization, and in natural or legal trade barriers. Technological change was

[11] If at least one input factor were quasi-fixed in the short run, these expressions would apply to the short-run. Long-run elasticities would follow from the equilibrium value of the quasi-fixed inputs, which is obtained by equating the price of the quasi-fixed input and its shadow value. They can be calculated by determining the short-run elasticity and adding the associated long-run adjustment. The latter comprises the effect of a change in the exogenous variable on the equilibrium stock of the fixed input and the effect of the latter on factor input demand. See also Morrison (1988).

measured by knowledge capital (or stock), i.e. cumulative (discounted and depreciated) R&D expenditures[13]. We used iterative three stage least squares to estimate the system of equations (11), (12) and (13) for the 12 individual ISIC two digit and, for machinery, ISIC three digit, sectors[14] at the EU level, i.e. for all countries included. Lagged values of the variables were used as instruments.

To test the predictions of the sticky wage model we computed from the parameter estimates[15] the demand elasticities of high and lower skilled labor for the trade and technology variables at the sectoral average values of the variables. Table 5 and Table 6 give the results for our basic model, which distinguishes between trade with the OECD countries and the aggregate of the emerging economies.

Table 5 - *Estimated Elasticities of the Demand of Higher Skilled Labor at Sectoral Level, 1985-1996*

| | $\varepsilon_{HS,wHS}$ | $\varepsilon_{HS,wLS}$ | $\varepsilon_{HS,wK}$ | $\varepsilon_{HS,mOECD}$ | $\varepsilon_{HS,mNICS}$ | $\varepsilon_{HS,RDS}$ |
|---|---|---|---|---|---|---|
| ISIC 31 | -0.43*** | 0.09* | 0.34*** | 0.03 | 0.41*** | 0.30*** |
| ISIC 32 | -1.31*** | 0.80*** | 0.52*** | -1.09*** | 1.48*** | 0.004 |
| ISIC 33 | -0.20 | -0.01 | 0.20* | -0.28 | 0.85*** | 0.19* |
| ISIC 34 | -0.23* | 0.09*** | 0.14 | -0.40*** | 0.30*** | 0.02 |
| ISIC 35 | -0.15 | 0.07* | 0.08 | -0.16*** | 0.21** | -0.10 |
| ISIC 36 | -0.13 | -0.12 | 0.25 | -0.43*** | 0.56*** | -0.09 |
| ISIC 37 | -0.22* | -0.03 | 0.25** | -0.56*** | 0.57*** | -0.04 |
| ISIC 381 | -0.07 | -0.28*** | 0.35*** | -0.20** | 0.01 | 0.36*** |
| ISIC 382 | 0.01 | -0.39** | 0.38** | -0.08 | -0.01 | -0.12 |
| ISIC 383 | -0.49** | 0.03 | 0.46** | -0.36*** | 0.74*** | 0.15 |
| ISIC 384 | -0.37*** | 0.19* | 0.19* | -0.08 | 0.65*** | -0.22*** |
| ISIC 385 | -0.04 | 0.04 | 0.00 | -0.51*** | 0.54*** | 0.21*** |

*Note* : *, **, *** refer to significance at the 10%, the 5% and the 1% level.

[12] The nine countries included in the mandated wage regression (enumerated in footnote 2) and Portugal.

[13] Non sectoral and foreign knowledge capital were not included in order to limit the loss of degrees of freedom in this framework were each variable, its square and all its cross-products enter in the specification.

[14] See footnote 2 for their description.

[15] Not reported here for the sake of brevity but available from the authors upon request.

Table 6 - *Estimated Elasticities of the Demand of Lower Skilled Labor at Sectoral Level, 1985-1996*

| | $\varepsilon_{LS,wHS}$ | $\varepsilon_{LS,wLS}$ | $\varepsilon_{LS,wK}$ | $\varepsilon_{LS,mOECD}$ | $\varepsilon_{LS,mNICS}$ | $\varepsilon_{LS,RDS}$ |
|---|---|---|---|---|---|---|
| ISIC 31 | 0.09* | -0.28*** | 0.19*** | 0.66*** | -0.31*** | 0.26*** |
| ISIC 32 | 0.40*** | -0.62*** | 0.23*** | 0.38*** | -0.46*** | -0.08*** |
| ISIC 33 | -0.01 | -0.23*** | 0.24*** | 0.45 | 0.05 | -0.15** |
| ISIC 34 | 0.11*** | -0.21*** | 0.10 | 0.22*** | -0.33*** | -0.06** |
| ISIC 35 | 0.13 | -0.67*** | 0.54*** | 0.99*** | -0.69*** | 0.07 |
| ISIC 36 | -0.09 | -0.31*** | 0.40*** | 0.51*** | -0.30*** | 0.01 |
| ISIC 37 | -0.04 | -0.38*** | 0.42*** | 0.36*** | 0.18 | -0.08 |
| ISIC 381 | -0.22*** | -0.38*** | 0.60*** | 0.53*** | -0.33*** | -0.22*** |
| ISIC 382 | -0.44** | -0.16 | 0.60*** | 0.14 | -0.03 | -0.33*** |
| ISIC 383 | -0.04 | -0.37*** | 0.33*** | 0.46*** | -0.32** | 0.23** |
| ISIC 384 | 0.18*** | -0.22*** | 0.04 | 1.03*** | -0.03 | 0.15** |
| ISIC 385 | 0.09 | -0.87 | 0.78*** | 0.23 | -0.06 | 0.41*** |

Note *: *, **, *** refer to significance at the 10%, the 5% and the 1% level.*

As a consistency check, we added the estimated own and cross price elasticities of factor demand. In all estimates but one (yet not significantly different from 0) the price elasticities have the right sign. In addition, the cross price elasticities are at least once positive, which implies that input factors are never all complements. In line with a priori expectations, the demand for lower-skilled labor seems more factor price sensitive than high-skilled labor.

Regarding the effect of international trade on high- and lower-skilled labor demand, we notice first, that international trade significantly affects the demand of both types of labor and, second, that trade with the OECD countries and the emerging economies have an opposite effect on high- and lower-skilled labor demand. Whereas the first would lower relative demand for high-skilled labor, the latter would on the contrary increase the demand for high-skilled labor but lower the demand for lower-skilled labor, i.e. influence relative labor demand in the opposite direction. This pattern is apparently pervasive throughout the manufacturing sector and hence would again point to a homogeneous effect of globalization. The increase of relative demand of high-skilled labor from trade with the emerging economies might be seen as an indication that supports the sticky wage model. However, we do not find the clear sectorally differentiated but factor-symmetrical pattern of change in high- and lower-skilled labor demand one would also expect following the model. Hence, our findings are indications in favor of the sticky wage model, provided that we may accept that factor demand adjustments are *intra-sectoral* rather than *inter-sectoral*, i.e. that globalization causes a shift in the skilled-labor intensive production segment, within each sector of manufacturing. On the other hand, the effect of technological

innovation on high- and lower-skilled labor demand shows substantial sectoral heterogeneity and does not easily allow a general conclusion.

How robust are our results ? We re-estimated the model, taking account of adjustment costs in capital, which would only return to its optimal value after an adjustment lag and without imposing an instantaneous shift to a new economic equilibrium. We observed more or less the same pattern of an increase in the relative demand of high-skilled labor as a consequence of increased trade with the emerging economies [16]. In one sector (ISIC 35) the sign of the (long-run) demand elasticities shifted from significantly positive to significantly negative, but in all other cases where (long-run) estimations differed from the estimations of the fully flexible specification, they went to the most from significant to insignificant different from 0. Increased international trade with emerging economies would seem to have a smaller effect on high-and lower skilled labor demand when we allow for short run fixed production factors, which is not what one would readily expect. This might point to accuracy problems in estimating the long run equilibrium value of the capital stock in a model with adjustment costs.

Second, in order to further test for heterogeneity between the emerging economies, we estimated an extended version of the model, in which we included the national average import to GDP ratio, broken down by region (i.e., South–East Asia, Latin-America and the Central and Eastern European Countries), instead of the (average) aggregate import to GDP ratio for the NICs as such. Here, we noticed a pattern of the high- and lower-skilled labor demand elasticities for trade with (South-) East Asia that closely mirrors the global pattern, but a rather diverging pattern for trade with Latin-America and the Central and Eastern European Countries. The estimated elasticities remained generally opposite in sign between high- and lower skilled labor. Yet, whereas increased trade with (South-) East Asia would have a positive effect on the relative demand of high-skilled labor in (almost) all sectors of manufacturing, increased trade with the two other regions of NICs would have the opposite effect. In a framework with three production factors, this might be explained by a different elasticity of demand of capital for trade with emerging economies of the three regions and differences in factor substitution between capital and high- and lower-skilled labor.

From the symmetrical pattern of the estimates at sectoral level, we expect to find at the EU member state level, a corresponding increase in the relative demand of high-skilled labor due to increased trade with the emerging economies. In order to verify this, we used the estimations of the extended sectoral model to compute the

average factor demand elasticities for the period 1985-1995[17]. Multiplying this with the cumulative percentage change of the import to GDP ratio by region and the basic period employment level of high- and lower-skilled labor, we obtain an estimation of the sectoral effect on the demand of high- and lower-skilled labor of increased international trade by region. Aggregating the latter over all sectors and regions of emerging economies results in an estimation of the impact of increased international trade with the emerging economies on the demand of high- and lower skilled workers for the EU member states included in the sample. These are shown in Table 7.

Table 7 - *The Impact of Increased Trade with the Emerging Economies on the Demand of High- and Lower-Skilled Workers, EU Member States 1985-1995 (Annual Percentage Change)*

| Country | ΔHS/HS | ΔLS/LS |
|---|---|---|
| Germany | 1.5% | 0.4% |
| France (a) | 0.3% | -0.6% |
| Italy | 0.2% | 0.0% |
| Belgium | 2.2% | -1.1% |
| United Kingdom | 0.8% | -1.1% |
| Denmark | 2.0% | 0.4% |
| Sweden | 1.1% | 0.1% |
| Finland | 1.7% | -1.4% |
| Spain (a) | -0.5% | -1.9% |
| Portugal | 2.4% | -0.4% |

(a) : *Annual percentage change for 1990-1995.*

We notice that in all EU member countries included, relative demand for high- and lower-skilled labor indeed shifted in favor of the first because of increased trade with the NICs, in line with the predictions of the sticky wage model. Aggregating the estimated change in demand of lower-skilled labor at the national level, we obtain for the ten EU countries, a cumulative fall of 3.6% of the demand for lower-skilled workers due to increased trade with the emerging economies between 1985 and 1995. This is somewhat higher though of comparable impact than the value reported by Krugman (1995) for the OECD as a whole[18].

Since in all countries we observe the same relative labor demand shift, employment, like high- and lower-skilled labor rewards, is apparently rather symmetrically affected by increased import competition with the NICs. However, the employment effect might be more heterogeneous at the country level, compared to the wage effect.

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[16] Not reported here for the sake of brevity but available from the authors upon request.

[17] In the case of France and Spain : 1990-1995.

In a majority of countries included in the sample, we observe an effective fall of the demand for lower-skilled workers, whereas it stabilized or even increased slightly in the others. Hence, international trade with the emerging economies may have more controversial and conflicting consequences for employment in some countries than in others. From this point of view, it is less equally distributed in the EU than the wage effect.

## IV. Conclusion

We studied to what extent trade liberalization with the newly industrialized countries might be the cause of the recent increase of wage or employment inequality between high and lower skilled workers in the EU and whether it may cause asymmetrical shocks within the EU. Regarding wage and income inequality, we extended the 'mandated wage' framework at the EU scale. We find evidence of a significant impact of increased import competition on income inequality between the high and lower-skilled, though the net effect seems almost negligible, especially when we take the length of the considered period (10 years) into account. International trade with Asia in particular seems to have influenced income inequality among workers, causing a sector bias of product price changes that increased inequality but a compensating unskilled labor-intensive sector bias in technological change. Geographical origin of imports apparently matters : trade with Eastern European countries and Latin America fit better in a 'lifting all boats' framework. Next, both the direct effect as well as the indirect effect of trade liberalization with the emerging economies on income inequality is fairly symmetrical and leaves relative intra-EU income positions unaffected. Country heterogeneous effects are much more related to intra-OECD competition and the 'pure' technical determinants of innovation, which affect between as well as within country factor reward inequality.

We may conclude from these observations that the EU economy is fairly unaffected by trade with the emerging economies, provided that its impact on employment in a rigid wage area like the EU remains equally limited. From a Generalised Leontief cost function approach, we find stronger indications of a significant influence of international trade on employment demand, in line with the sticky wage model that probably fits the European reality better than the standard Heckscher-Ohlin framework. At the sectoral level, we observe in all cases but one a shift of relative demand in favor of high-skilled labor, due to increased trade with the emerging economies. Hence the sectoral shift in labor demand, predicted by the sticky wage model towards the sectors in which the

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[18] The negative effect on labor demand from import competition we obtain for the UK, is in line with the findings of Greenaway et. al. (1999). Oscarsson (2000) also reports this for Sweden, which however we cannot confirm..

economy has a comparative advantage for all input factors alike, is not corroborated. We rather find an intra-sectoral shift to the high-skill labor intensive segments within each sector. From our sectoral estimations, we also notice an increase in relative demand for high-skilled labor at the EU country level. This effect is however less symmetrically distributed between countries than the wage and income effect, as it implies a fall in absolute terms of the demand for lower-skilled labor in a majority of countries, whereas it remains stable in the others. The net effect on the demand for the lower-skilled at the EU level would also be negative and somewhat higher than estimations for the OECD as a whole.

Our findings suggest that, in the past decades, the EU economy has to some extent indeed been affected by Heckscher-Ohlin specialization effects, (relative) labor demand in particular. If wage as well as employment effects are considered, the influence of trade liberalization with the emerging economies is apparently limited but not fully negligible.

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## Data Appendix.

- Labour shares

For the computation of the value added shares of high-skilled labor, low-skilled labor and capital it proved impossible to stick to a single data source to compute the shares for a sufficient number of EU countries for the whole period. In most studies the distinction of high-skilled/ low-skilled workers is proxied by the classification manual/ non-manual – production/ non-production – operatives/ non-operatives or blue-collar/ white-collar.

For the period 1985-1991 data on the wage sum of operatives were taken from the UNIDO General Industrial Statistics (Vol I) database. This information was available for Germany, Italy, the UK, Denmark, Spain, Portugal and Finland, although not always for the entire period. The breakdown by operatives/ non-operatives is no longer provided by UNIDO after 1991. From 1992 onwards we used data from the Labour Force Surveys (LFS), provided by Eurostat. For some countries the LFS data start in 1992 but for most countries only in 1993.

The data source only contains information on the number of workers, not on wages. For data on wages we used Eurostat NewCronos (Theme 3- Harmonized earnings), which contains gross hourly earnings of manual workers and gross monthly earnings of non-manual workers.

The LFS data do not match the OECD data on total employment, which was also established by the OECD. The OECD secretariat adjusted the data to STAN data or data in the OECD National Accounts (OECD 1998, p.5). As the LFS data are the results of surveys, we held to the OECD STAN data on total employment and rescaled the ISCO numbers following the white-collar/ blue-collar ratio of LFS.

The value added share of non-manuals was computed using the monthly wages of non-manuals and the rescaled numbers of white-collar workers. From this the value added shares of manuals were computed. In general this led to intuitively acceptable results, except for Italy. For *Italy*, data on the number of hours worked by operatives were taken from the OECD Industrial Survey results, which for Italy is given only for 1992-94. The number of hours worked by operatives (i.e. blue-collar workers in the ISCO classification) and the gross hourly wages of manuals from NewCronos and the total wage sum from OECD STAN allowed us to compute the value added share of manuals. The results appeared to be more reliable. For *Belgium* we used social security data, on the number of manual and non-manual workers, provided by the National Office for Social Security (RSZ) for the entire period 1985-96. For *Sweden* Eva Oscarsson (Department of Economics-University of Stockholm) kindly provided us with data on employment and wages for the period 1970-1993, as used in Oscarsson (1997).

- Wages

Data on monthly wages of non-manual workers were taken from NewCronos. For manual workers this data source gives gross hourly wages. The data on the hours worked per month by manual workers are too scarce to compute monthly wages. For the period 1985-91 the UNIDO data gives the wage sum of operatives and the number of operatives which allows for a straightforward way of computing monthly wages of operatives. From 1992 onwards we computed monthly wages of manuals with the wage sum of manual workers (total wage sum-wage sum non-manual workers (LFS + NewCronos)) and the rescaled number of manual workers (LFS).

- Price of capital

In Berndt and Hesse (1986) the price of capital is calculated as: $P_{Ki,t} = q_{i,t}*(r_t + \delta_i)$,

with $q_{i,t}$: investment deflator of *i*th type capital (e.g. capital in sector i) in year t ;$r_t$: long-term government bond yield and $\delta_i$: depreciation rate of *i*th type capital.

Data on long-term government bond yields were taken from the IMF International Financial Statistics. The same source contains data on fixed capital consumption from which depreciation rates can be computed. Unfortunately this information is given for few countries, sectors and years. Rather than using the sectoral depreciation rate for just a couple of observations, and disregarding it for most observations, we only used $r_t$.

For $q_{i,t}$ we computed sector-specific deflators from the value added data given in STAN.

- Capital stock

Data on capital stocks were taken directly from the OECD International Sectoral Database (ISDB) or were estimated from ISDB annual investment data using the perpetual inventory method.

- Domestic prices

Domestic prices were computed from the OECD STAN data on sectoral value added.

- Unit value import prices

Unit value import prices were computed at the sector level (ISIC). This involved aggregation and conversion. We aggregated data on imports by EU countries from the OECD International Trade by Commodities (ITCS) into four geographical groups of exporting countries: OECD (minus countries included in other groups), South-East-and East Asian NICs (Hong Kong, Indonesia, Republic of Korea, Malaysia, Philippines, Singapore and Thailand), Latin-America (Argentina, Brazil, Chile and Mexico) and Central and East European emerging economies (Hungary, Czech Republic and Poland).

As ITCS data are given for SITC commodity classes and the estimation is done for ISIC sectors we had to convert the data from SITC to ISIC, with a table provided by OECD. Prices were computed for the period 1985-96.

As pointed out by Freeman and Revenga (1999) unit value prices are a 'mishmash' of aggregate prices of commodities. They find however, that sectors that experienced increased import penetration showed relative price declines which suggests that imports price changes are good proxies for import pressure. A caveat of unit value price changes that is often put forward is, that as it concerns aggregates, the changes might reflect a change of the commodity mix rather than a change of commodity prices. To preclude this possibility we computed, following the shift-share approach[19], unit value prices, keeping the commodity structure fixed.

- Total Factor Productivity

Tfp was taken from the OECD International Sectoral Database (ISDB) if available. For those countries for which ISDB does not provide data on TFP we computed it, from data on gross fixed capital formation and employment (STAN/ ISDB), using the formula given in OECD (1994).

- R&D stock

Haskel and Slaughter (1999) use innovation counts as a determinant variable of total factor productivity. This information is not available for enough EU countries to be used in our estimation. Instead we used R&D stocks. We computed national sectoral R&D stocks with data from ANBERD, completed with BERD data (both from OECD). The 1973 stock was taken as the initial stock and computed with the formula given by Coe and Helpman (1995). For each sector three R&D stocks were computed: the national R&D stock of the given sector, the total national R&D stock (minus the sector R&D stock) to estimate national intersectoral spillovers[20], and a foreign R&D stock which was weighted according to the procedure proposed by Lichtenberg and van Pottelsberghe de la Potterie (1996). As it concerns sectoral R&D stocks the foreign R&D stocks were weighted by total imports over the GDP of the exporting country times the share of the sector in the national output.

- Concentration

To control for the effects of imperfect competition on price setting, the share of the four largest firms in the output of a given sector (C4) was computed from firm data contained in the Amadeus database and data on sector output from STAN. To correct for errors due to the use of consolidated data we also computed an alternative measure of concentration using STAN data.

- Capital/labour ratio

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[19] The shift-share approach decomposes changes in unit value prices into three components: a component that measures which part is due to changes in the commodity mix, keeping commodity prices fixed at their begin of period values; a component measuring the part of unit value price changes that can be explained by changes in commodity prices, keeping the commodity mix fixed at its begin structure; and a last interaction component of changes of the commodity mix *and* commodity prices. We took the second component as a measure for unit value price changes.

[20] In principle national intersectoral spillovers could be computed with weights reflecting input-output linkages. Unfortunately input-output tables are only available for a limited number of countries.

As an alternative control variable for imperfect competition sectoral capital/labour ratio's were computed from OECD STAN data.

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