11. Determinants of sectoral average wage and employment growth rates in a specific factors model with production externalities and international capital movements

Ivo De Loo and Thomas Ziesemer[1]

1. INTRODUCTION

Sectoral wages are the average of the wages for skilled and unskilled labour. Explaining their development has recently led to some controversies (see Freeman, 1995). The major problems discussed are why wages for skilled and unskilled labour diverge in the USA and why unemployment has been heavily concentrated on low-skilled workers in Europe. These shifts can also be observed in newly industrialized countries (NICs) (see Richardson, 1995). The wage determination question, however, is of broader interest.

Many economists using closed or open economy growth models would explain wage growth mainly as a consequence of technical progress. Labour market economists would tend to emphasize (sectoral) supply and demand with little weight on international aspects (see Richardson, 1995). Trade economists would tend to ignore the supply of labour when using the Stolper–Samuelson theorem. However, in a multisectoral world of international trade and capital movements it is tempting to take a broader perspective. Consequently, one may ask the question, what is the relative importance of the major determinants of (average) wage growth and employment – international trade or factor movements, technological change or labour market developments – once one integrates all of them into one framework? In this chapter we try to answer this question with regard to the USA and six European countries (where wage inequality seemingly has changed much less than in the USA). The inequality issue will not be addressed in this chapter. We analyse average wages.

Lawrence and Slaughter (1993) and Krugman (1994) have argued that international trade would have an impact on wages, if any, via changes in the terms of trade. However, they indicate that the terms of trade of the USA are almost unchanged and therefore changes in wages must be due to technical change. This argument leaves us with several open issues.

1. Results may be different for countries other than just the USA.
2. Results may change if we do not argue in terms of a two-sector model but at a more disaggregated level, because some of us will remember that in continental Europe the shipbuilding sector did shrink in the 1970s, the motor industry was faced by increased competition from Japan in the early 1980s, and the European consumer electronics sector lost ground in the 1980s and 1990s. Ultimately, protectionists lobby at the sectoral or even the firm level, and not at the macro level.
3. Once international capital movements are taken into account, not only the terms of trade but also interest rates become an exogenous variable for a (model of a) country and their changes should have an impact on wage growth according to economic theory.

How did the literature treat these three issues? The only contribution on average wages so far is Lawrence and Slaughter (1993). Some other insights are gained from the wage inequality debate by Lücke (1997), who has looked at data for Germany and the UK, and Oscarsson (1997) for Sweden. Seemingly, for many other countries this has not been done (within an international trade framework). Oliveira Martins (1994), using an industrial economics rather than an international trade approach, also looks at several countries.

Leamer (1996) sees the point of relevance for single sectors too, mentioning apparel and textiles in the USA. Krugman and Lawrence (1993) acknowledge that Japan did threaten US textiles in the 1960s and semiconductors in the 1990s. Leamer (1993) takes international capital movements into account when making theoretical scenarios but not when running estimations. Wood (1995), as well as Sachs and Shatz (1994), also look at several sectors and international capital movements. However, they do not have an integrating framework but rather look at all aspects, separately running regressions that give some intuition on their idea that international trade, technology and international capital movements are all important. Thus it seems to be worthwhile to investigate all of these points more closely.

Most of the wage inequality debate in international economics has been conducted in terms of Heckscher–Ohlin (HO) models (see Sachs and Shatz, 1994; Baldwin and Cain, 1997; Lücke, 1997; Oscarsson, 1997). Krugman and Obstfeld (1997) give a justification for this choice: although labour may not be mobile between sectors because its skills are specific to one sector only, reschooling could achieve the desired mobility after some time, which would justify the mobility assumption of the Heckscher–Ohlin model. Against this we wish to propose that, before reschooling, labour is specific to one (or several) sector(s) and after reschooling it is specific to different sectors or just one. We prefer to capture this with a specific factors model that has an exogenously changing labour supply for each sector and allows for sectoral differences in wages, whereas the HO model does not (see Leamer, 1994). Also most of the literature uses the Stolper–Samuelson theorem for the analysis (see Leamer, 1994; Richardson, 1995; Baldwin and Cain, 1997; Lücke, 1997, Oscarsson 1997), which makes the latter heavily dependent on the empirical validity of the zero profit conditions in every sector or period.[2] Using the cost-minimization part of a specific factors model with production externalities for perfect and imperfect competition and international capital movements can avoid this drawback. It provides a simple way to include the supply of labour, technical change, international trade and factor movements in one framework. Yet it does so at the cost of slightly exaggerating the immobility aspect of labour (which is now restricted to merely one sector). Other alternatives to the Stolper–Samuelson approach are presented in Francois (1996).

To allow for the treatment of more sectors motivated under point (2) we will construct a multisectoral, specific factors model in section 2. The inclusion of international capital movements brings in interest rate changes in accordance with the motivation of point (3). In section 3, some remarks on the data and analysis techniques are made. Section 4 contains our main findings, after which section 5 will discuss the policy conclusions which may be drawn from them. Finally, section 6 addresses the limitations of our approach and gives some guidelines for further research.

2. MODEL DESCRIPTION

The details of our model are as follows. For each product i we assume the following production function for n identical firms to be responsible for the generation of variable costs, where Y indicates output, K capital, L labour, A technology and $Q = nY^i$ is sectoral output:

$$Y^i = (K^i)^{\alpha^i}(A^i)^{\theta^i}(L^i)^{\beta^i}Q^{\eta^i}e^{bt}$$

α, β and η are elasticities of the production of capital, labour and technology. η indicates production externalities which can have any sign. If the sum of α and β is smaller, larger than or equal to one, we have decreasing, increasing or constant returns to scale at the firm level and therefore upward- or downward-sloping or constant cost functions (for given technology A). We do not exclude any of these cases a priori.

From *cost minimization* we get (with w as the wage rate and r as the interest rate):

$$w^i = \lambda^i F^i{}_{L^i}$$

$$r = \lambda^i F^i{}_{K^i}.$$

λ is the Lagrange multiplier of the technology constraint, whose economic interpretation is marginal costs. Subscript indices K or L indicate a partial derivative with respect to K or L. The three equations given above allow us, together with the definition for sectoral output, Q, to find a solution for the value of the Lagrange multiplier. Dropping the index i, we get:

$$\lambda = \left(\frac{r}{\alpha}\right)^a Y^b A^c \left(\frac{w}{\beta}\right)^d Q^{-\eta b}$$

with

$$a = \frac{\alpha}{\alpha+\beta},\ b = \frac{1-\alpha-\beta}{\alpha+\beta},\ c = \frac{-\theta}{\alpha+\beta},\ d = \frac{\beta}{\alpha+\beta}.$$

In the case of perfect competition, marginal costs equal prices given by the world market (under the small country assumption) and marginal productivity conditions can therefore be rewritten as:

$$w^i = p^i F^i{}_{L^i}$$

$$r = p^i F^i{}_{K^i}.$$

Rewriting the marginal productivity conditions in growth rates, using the Cobb–Douglas form of production functions, and eliminating the term for capital yields an equation for several sectors in different countries (we do not write down a country index):

$$\hat{w}^i = \gamma_1 \hat{p}^i + \gamma_2 \hat{r} + \gamma_3 \hat{A}^i + \gamma_4 \hat{L}^i$$

$\ln w = \gamma_1 \ln p + \gamma_2 \ln r + \gamma_3 \ln A + \gamma_4 \ln L + \gamma_5 bt$

with

$$\gamma_1 = \frac{1}{1-\frac{\alpha^i}{1-\eta}} > 0,\ \gamma_2 = -\frac{\frac{\alpha^i}{1-\eta}}{1-\frac{\alpha^i}{1-\eta}} \le 0,$$

$$\gamma_3 = \frac{\dfrac{\theta^i}{1-\eta}}{1-\dfrac{\alpha^i}{1-\eta}} \geq 0, \; \gamma_4 = \frac{\dfrac{\beta^i+\alpha^i}{1-\eta}-1}{1-\dfrac{\alpha^i}{1-\eta}}$$

In this model, the terms of trade are exogenous in the case of perfect competition and the small country assumption. These assumptions are made in most of the related literature. With perfect capital movements, the real interest rate, r, is given by the world market at each moment in time. Technology is exogenous by assumption and so is labour input because of the assumption that it is specific to each sector. Alternatively, we could have had employment as an endogenous variable and wages as an exogenous one. Then the equation would seek to explain employment of a sector in a country.[3]

The right-hand side of the above equation captures all variables that play a role in the debate on real wages. International trade is captured by changes in the terms of trade, technology is contained and international capital movements are represented by changes in the interest rate. Finally, factor supply is included, which could not be done in a Stolper–Samuelson approach using the zero profit assumption.

An estimate of this equation at the firm level would give us a result for $\alpha/(1-\eta)$, the elasticity of production of capital of a sector in a country corrected for the production externality, from either γ_1 or γ_2. Therefore we have to impose or test the constraint, $\gamma_1 + \gamma_2 = 1$, when doing the estimation. Having found a value for $\alpha/(1-\eta)$ we can deduct the value of $\beta/(1-\eta)$ from γ_4 and that of $\theta/(1-\eta)$ from γ_3. The question whether or not we have increasing returns to scale can be answered by looking at γ_4. If it is less than, more than or equal to zero, we have decreasing, increasing or constant returns to scale in labour and capital at the sectoral level, including the production externalities. However, only if the previous coefficient restriction is accepted may we draw such a conclusion, for then we may suspect that the definitions of the other coefficients hold too. Moreover, the assumption of perfect competition is only justified if we have non-increasing returns to scale at the firm level, which means that $(\alpha + \beta - 1) \leq 0$. It will turn out below that the estimations yield a positive sign for the labour variable, although it can have any sign. With non-increasing returns at the firm level this requires a positive externality that is large enough to make the numerator positive but also leaves the denominator positive. With the positive denominator the signs given for all terms in the previous formula follow.

In the case of increasing returns to scale at the firm level, we have to resort to imperfect competition and endogenous prices. Therefore we must give up the small country assumption, because price determination by domestic firms and prices given by the world market are mutually exclusive concepts (see Helpman and Krugman, 1989). If a sector is faced by a constant-elasticity demand function, $p^i = B^i Y^{i\phi} M_{eu}^{i\delta} M_{neu}^{i\varepsilon}$, with ϕ as an inverse of the price elasticity, M_{eu} as import quantities of competing products from the EU, M_{neu} as their non-European equivalent, B as a shift parameter which captures all other demand effects (such as effects of other imports coming into the country) and each product being produced by only one firm (as it would under monopolistic competition), profit maximization will yield $p^i = \lambda^i/(\phi^i + 1)$. Prices are now an endogenous variable because marginal costs (λ) are endogenous, for they depend on output and wages. A division between European and non-European trade is made because competition from the Asian NICs has been of special interest in the recent debate. If trade has an impact we would expect $\delta, \varepsilon < 0$.

Equating prices from the first-order conditions with those of the demand function yields:

$$B^i Y^{i\phi} M_{eu}^{i\delta} M_{neu}^{i\varepsilon} = \lambda^i /(\phi^i + 1).$$

Taking growth rates of this equation, the marginal productivity conditions and the expression for λ gives us four linear equations for four endogenous variables: the growth rates of wages (w), capital (K), marginal costs (λ) and sectoral output ($Q = nY^i$). The exogenous variables are the growth rates of A, B, L, r, M_{eu} and M_{neu}. Parameters are α, β, θ, η, a, b, c, d, δ, ε and ϕ. Solving the system for the growth rate of wages yields:

$$\hat{w}^i = e_0 + e_2\hat{r} + e_{1a}\hat{M}_{eu}^i + e_{1b}\hat{M}_{neu}^i + e_3\hat{A}^i + e_4\hat{L}^i$$

with

$$e_0 = \frac{-\hat{B}[\frac{\eta(2\alpha+2\beta)-1}{1-\alpha-\beta}+1]}{\eta[1-\alpha-\frac{\beta}{1-\alpha-\beta}]+\alpha(\phi+1)-1},$$

$$e_{1a} = \frac{-\delta[\frac{\eta(2\alpha+2\beta)-1}{1-\alpha-\beta}+1]}{\eta[1-\alpha-\frac{\beta}{1-\alpha-\beta}]+\alpha(\phi+1)-1},$$

$$e_{1b} = \frac{-\varepsilon[\frac{\eta(2\alpha+2\beta)-1}{1-\alpha-\beta}+1]}{\eta[1-\alpha-\frac{\beta}{1-\alpha-\beta}]+\alpha(\phi+1)-1},$$

$$e_2 = \frac{\alpha[\eta\frac{\alpha+\beta}{1-\alpha+\beta}+(\phi+1)]}{\eta[1-\alpha-\frac{\beta}{1-\alpha-\beta}]+\alpha(\phi+1)-1},$$

$$e_3 = \frac{-\theta[\eta\frac{\alpha+\beta}{1-\alpha+\beta}+(\phi+1)]}{\eta[1-\alpha-\frac{\beta}{1-\alpha-\beta}]+\alpha(\phi+1)-1},$$

$$e_4 = \frac{-\eta(1-\alpha-\beta)+1-(\alpha+\beta)(\phi+1)}{\eta[1-\alpha-\frac{\beta}{1-\alpha-\beta}]+\alpha(\phi+1)-1}.$$

In this equation, compared to that of the perfect competition case, imports are the exogenous variable that replace prices. The exogenous shift variable B can go either way. If it is decreasing, competition is increased. Then the demand function is shifted towards lower prices. As these coefficients are anything but easy to overlook, it is useful to consider first the case of no externalities, $\eta = 0$. In this case the numerator of e_4 becomes $1 - (\alpha + \beta)(\phi + 1) > 0$, which must be positive because its negative value is exactly equal to the second-order condition of the monopolist. Therefore the denominator with no externalities would have to be negative, leaving us with a negative coefficient. However, the empirics below give us mostly positive coefficients. Therefore it is most convenient to make the following assumptions under which the second-order conditions are not violated and the empirics can be understood. Let us assume the sufficient conditions that $\eta > 0$, $2(\alpha + \beta) - 1 > 0$ and $(1 - \alpha - \beta)$ is positive and sufficiently small to make the denominators of all coefficients negative. Then the second-order condition of the monopolist is not violated, e_4 is negative for sufficiently small externalities and positive for large externalities and therefore it can have any sign. Moreover, all the terms in square brackets in the numerators of e_{0-4} are positive if $(\phi + 1) > 0$ (as required by the first-order condition of the monopolist). The expected coefficients for both import terms (e_{1a} and e_{1b}) and the interest rate (e_2) are non-positive and that of technical change (e_3) is non-negative; e_0 and e_4 can have any sign.

3. DATA AND ECONOMETRIC METHODS

The estimated equations have been derived from the firms' rules for cost minimization and profit maximization and then have been aggregated into sectoral equations under the assumption of a given number of identical firms. We have data at the sectoral level.

Having constructed a model that differs from those of standard international trade models in textbooks by the production externality and the international capital movements, we have to relate a non-monetary model to data that stem from a monetary world. This requires dividing the data for wages and sectoral prices by the gross domestic product (GDP) price level of the country in question. Moreover, nominal interest rates have to be deflated by subtraction of the growth rate of the GDP deflator. We start from national nominal interest rates because, in spite of our assumptions, it is not clear that national capital markets are perfect. Although we have not modelled capital market imperfections explicitly, national rates seem to be the more adequate data.

We will test for structural breaks. The question whether employment drives wages or wages drive employment will be 'answered' using Granger causality tests. The regression equations will be estimated by ordinary least squares (OLS),[4] without the aforementioned coefficient restrictions (at least initially). This technique is applied so that a heteroscedasticity-consistent covariance matrix arises.[5] A description of the data can be found in the appendix to this chapter. At this point, only the choice of R&D expenditures as a proxy of technical change will be elaborated upon.

Basically, there are two sets of indicators that can serve as a proxy of technical change: R&D data and patent statistics. However, both have their drawbacks. R&D data are an input measure of the innovation process. Not all R&D inputs lead to innovations, and also the efficiency with which inputs are used influences the amount of successful R&D efforts. Thus more R&D expenditures do not necessarily imply more innovative activities. On the other hand, patent statistics are an output measure of the innovation process. Not all innovations are patented, and not all patents are put to effective and/or commercial use.[6] Moreover, the propensity to patent differs among countries.[7] In addition, neither R&D expenditures nor patent data refer exclusively to process innovation as our model does. At least product innovations for consumers should (but cannot) be excluded. Another problem associated with using R&D statistics as a technology indicator is that series containing labour or capital data will mostly include, to some extent, labour and capital used as an input to R&D. Thus adding R&D as a separate factor in the analysis could create a sort of 'double-counting'. However, there is mixed evidence on the question whether and how far the consequences of this reach. For example, while Schankerman (1981) and Hall and Mairesse (1992) state that corrections for double-counting should be made,[8] Verspagen (1995) finds only very limited effects. We will not touch upon this issue either, assuming the bias that arises because of double-counting to be negligibly small (which seems reasonable, given that the capital variable drops out of the regression equations).[9]

Nevertheless, the decision to use R&D expenditures as a proxy of technical change was mainly motivated by data availability, which was greater for R&D data.

4. RESULTS AND INTERPRETATIONS

In the first sub-section below we will discuss the estimation results for the perfect competition model. The results for the imperfect competition model are examined in the second sub-section.

The Case of Perfect Competition

We begin with the basic regression output.[10] At first, a constant term is included in the regressions to capture the mean effect of (possibly) missing variables (such as additional productive factors). We expect γ_1 and γ_3 to have a positive sign, γ_2 to have a negative one, whereas γ_4 and γ_0 (which will be used to denote the constant term) can have either sign.[11] The constant term is (statistically) significant at the 5 per cent level for all of Germany, almost all of Italy (except for textiles, footwear and leather products and the basic metals sector), whereas it is only significant for total manufacturing and wood, cork and furniture in France, the French, British and Spanish paper and printing industry and the Spanish chemical industry. For the Netherlands and the USA, a rather mixed picture emerges (with chemicals, total manufacturing, stone, clay and glass and paper and printing being the significant sectors for the Netherlands and food, drink and tobacco, basic metals, total manufacturing, wood, cork and furniture and other manufacturing industries for the USA). Reasons for this outcome may be that labour market aspects (such as changes in union power, falling real values of the minimum wage, an upgrading of skills and compensation policies of firms), incomplete capacity utilization, developments in the non-traded sector, or additional production factors (such as land and natural resources) are at work (which are all not present in our model).

Many of the variables do have their expected signs to some degree, but are often not significant, as is typical of the whole literature discussed above. An exception is the labour variable, which is generally both positive and significant (only the British food, drink and tobacco and other manufacturing industries have a negative coefficient). This might point to increasing returns at the sectoral level.[12]

It is likely that there are structural breaks underlying the results. Such breaks may stem especially from the movement from negative to positive real interest rates at the beginning of the 1980s.[13] For Great Britain, Germany, Italy and the Netherlands, such a change in sign occurs in 1981. In France it occurs in 1980, whereas in Spain and the USA a change in sign of the real interest rate takes place in 1976 and 1986, respectively. Moreover, the high dollar value of 1985 may have induced another structural break. To test for these notions, a Chow break test[14] is applied to both the aforementioned year of the sign change of the real interest rate and the dollar value.[15]

Only a limited number of breaks is found. They arise for total manufacturing and wood, cork and furniture in France, the chemical industry in France and the UK, fabricated metals products in France and Italy, leather products in Italy and the UK, and the German other manufacturing industries. Of these sectors, three seem to have been affected by the dollar value of the mid-1980s: total manufacturing in France and the two British sectors.[16] It was decided to let the estimation period for all the aforementioned sectors start in either 1980, 1981 or 1986 instead of (mostly) 1974 and to redo the estimation.

Redoing the estimations leads us to the conclusion that structural breaks do not seem to be at the heart of the unexpected signs and large sizes of some of the variables in our model. Factors that remain are the significance of the constant term (in some equations) and the fact that we have not yet imposed the coefficient restriction derived in the theoretical part. We now leave out the constant term for those sectors for which it is statistically insignificant at the 5 per cent level and then test whether the proposed restriction is in place.[17]

The omission of the constant term alters our results somewhat (leading, among others, to several smaller (yet more significant) values of the labour variable),[18] but the overall results are quite similar to the ones already reached. Besides, we see that at the 5 per cent significance level, the coefficient restriction can be accepted only twice. We find significant results for the British chemical industry and Dutch fabricated metal products. Only for these sectors, if we get plausible estimates for $\alpha/(1-\eta)$ and $\beta/(1-\eta)$, can we say something about the presence of increasing returns. We can do so by checking whether $(\alpha+\beta)/(1-\eta) - 1 \leq$ or ≥ 0 holds. It is unlikely that plausible estimates arise for both these sectors, because not all coefficients have the expected sign: for example, for fabricated metals products in the Netherlands, the interest variable turns up with a positive coefficient. In fact, inferring values for $\alpha/(1-\eta)$, $\beta/(1-\eta)$ and $\theta/(1-\eta)$ does lead to estimates for these two sectors $\alpha/(1-\eta)$ equals either -0.010 or 0.019, $\beta/(1-\eta)$ -0.083 or 1.71 and $\theta/(1-\eta)$ -0.011 or 0.430).[19] Negative values indicate $\eta > 1$), which may seem to be somewhat implausibly high. Together with the theoretical part, this may indicate the presence of an aggregation problem (or omitted variables).

Of all variables, labour is for a large part significantly different from zero, whereas, especially for the price and interest variables, there are many unexpected entries as far as sign and significance are concerned. However, statements about increasing or decreasing returns to scale cannot be made any more, since the restriction that would give rise to such an outcome is not accepted. It can only be said that a significant and mostly positive relationship exists between sectoral wage growth and employment growth in almost all sectors and countries under consideration.[20] One might suggest that specific factors matter, although the less plausible results for the other variables possibly overstate the importance of such a conclusion.

The question remains in what direction the relationship between employment and wages holds. Do wages determine employment or does employment determine wages? Tentatively, this question will be 'answered' by means of Granger causality tests. These tests[21] examine whether the occurrence of a certain event (variable) X precedes the occurrence of another event (variable) Y over a certain period of time. Stated differently, it is tested whether variable Y is temporally dependent upon variable X. Thus it is not causality in a strict sense that is analysed here: it is the order in which events happen that matters.[22] Besides, Granger causality is like a two-way street: only when X Granger causes Y, and Y does not (at the same time) Granger cause X, may we say that there is temporal dependence of Y upon X. More specifically, the following model is estimated:

$$Y_t = \delta_0 + \sum\nolimits_p \alpha_p Y_{t-p} + \sum\nolimits_q \beta_q X_{t-q} + \varepsilon_t,$$

where p,q are predetermined lag orders, and ε_t is a random disturbance term.

The null hypothesis that X does not Granger cause Y is that $\beta_q = 0 \forall q$ (while, simultaneously, Y should not Granger cause X: $\alpha_p = 0 \forall p$). The size of p and q is mostly agreed upon a priori on theoretical grounds. Here we will assume, letting Y_t denote sectoral wage growth and X_t the corresponding growth of labour, that p and q range from one to three. Tests were carried out with both one and two lags, but this did not alter our basic results very much.[23]

Employment Granger causes wage growth in a limited number of cases: only for the British fabricated metal products and food, drink and tobacco are significant results found (at a 5 per cent level of significance). However, wages determine employment growth more often: for three British sectors (chemicals, textiles, footwear and leather products and basic metals) this turns out to be the case. Two other significant results emerge, namely for Spanish leather products and for the Italian paper and printing industry. For wood, cork and furniture in Germany and total manufacturing in Great Britain, there are statistically significant relationships in both directions: wages determine employment and, by the same token, employment determines wages. Nevertheless, the conclusion in these cases is the same as for all sectors not mentioned: the Granger causality test is inconclusive.

It is quite interesting that, when significant results are found, they occur most often for Great Britain. There seems to be no apparent reason for this outcome, however.

In the five cases where wages Granger cause employment growth, the estimation is redone, with wage growth now being an explanatory variable and labour growth the dependent one. As far as the value of the coefficients is concerned, this simply means rewriting the equations already estimated.[24] However, the fit does change, as does the significance of the coefficients. Tests for structural breaks have to be redone too. Also, in the first stage, a constant term is included in the regression equation. For the sectors for which it does not differ significantly from zero at the 5 per cent level of significance,[25] it is dropped and the modified model is re-estimated.

Note that the desired sign of the explanatory variables switches when moving from wage growth to labour growth as the dependent variable. Only for the relationship between wages and labour does it remain the same. Even then, there are many wrong signs to be found.[26] The interest variable does not have the correct sign for any sector. The technology variable has the wrong sign for three sectors: chemicals in the UK and textiles, footwear and leather products in both the UK and Spain. The price variable has the wrong sign for the two non-UK sectors. Thus there is no sector for which all variables have the desired sign. Therefore no new insights on coefficients are created here either.[27] However, below we will report on all reversed causality cases independent of the outcome of the Granger causality analyses.

For those sectors where all coefficients have the expected sign,[28] it might be illuminating to examine how far the explanatory variables attribute to the explanation (of variation in) the dependent variable.[29] This means conducting a sort of 'growth accounting' exercise.

There are 17 sectors for which we found the expected signs. None of them is located in Germany. All sectors are shown in Table 11.1. Except for chemicals, most industries in the table are the more traditional ones. The basic procedure we follow for the 17 sectors where all variables have the expected signs is to take the regression coefficients of corresponding B3 and pre-multiply them by the means of the corresponding explanatory variables (calculated as an average of the entire estimation period).[30] Then this figure is divided by the mean of the dependent variable over the same period and multiplied by 100 to arrive at percentages. Finally, to obtain country figures, unweighted means of these percentages are taken for all sectors in Table 11.1 within a certain country.

If we leave out total manufacturing,[31] and check the relative importance of all variables in explaining wage growth in a certain country in the way described above, we reach the results presented in Table 11.2. For Italy and the Netherlands, no results at the country level are calculated because of the relevance of just one sector.

Table 11.1 *Sectors with correct expected signs*

Country	Sector
USA	Chemicals
	Basic metals
	Paper and printing
	Wood, cork and furniture
France	Chemicals
	Stone, clay and glass
	Wood, cork and furniture
Great Britain	Chemicals
	Food, drink and tobacco
	Paper and printing
	Other manufacturing industries
Netherlands	Total manufacturing
Italy	Textiles, footwear and leather
Spain	Basic metals
	Food, drink and tobacco
	Total manufacturing
	Wood, cork and furniture

Perhaps the first impression Table 11.2 gives rise to is that a large part of the explanation of wage growth is attributed to both the constant term (in the UK) and the residual (in France). This implies that for these countries a significant part of wage behaviour is not captured by our model, as discussed above.[32]

Table 11.2 *Relative importance of explanatory variables in explaining per country wage growth (per cent)*

	Variables					
	Constant	Technology	Capital	Trade	Labour	Residual
USA	19.7	16.9	–3.1	–3.5	57.5	12.3
France	0.0	28.8	30.9	–3.0	79.7	–36.4
UK	40.7	23.8	–18.3	31.8	16.6	5.4
Spain	0.0	22.5	19.8	–6.7	55.8	8.7

Note: In regressions *without* a constant term the residuals do not necessarily have to sum to zero. Therefore, a certain weight is assigned to them in these cases.

However, it does not mean that we cannot draw any (at least, preliminary) conclusion from the table. It is evident that, for most countries here, a large part of wage growth is determined by employment growth: labour supply is a dominating factor in three countries (all but the UK). In the UK, a substantial part is contributed by terms of trade changes.[33] The UK is also the only country where terms of trade are more influential than technology. Looking at the overall results, we may conclude that technology is a more important factor than trade in determining (national) wages in three countries. Labour supply is an even more important factor. Again, specific factors seem to matter. This raises the question of what we can see at the sectoral level.[34]

We can derive from Table 11.3a below for the whole period under consideration (and from Table 11.3b for the 1980s onwards – the results of which will be indicated in the text in brackets) that 12 (12) out of the 17 sectors included in the 'growth accounting' exercise have negative terms of trade growth, indicating that there may be an international problem. In seven (seven) sectors we have falling and in ten (ten) we have increasing wages (according to the last column). In only four (four) sectors do R&D expendi-

Table 11.3a *Growth rates of explanatory and dependent variables over the estimation period given by sample (SMPL)*

Sector	SMPL	Technology	Capital	Trade	Labour	Wages
USAZ35	74–93	0.0455	0.3643	–0.0019	0.0063	0.0179
USAZMB	74–93	–0.0049	0.3643	0.0015	–0.0286	–0.0222
USAZOP	74–93	0.0522	0.3643	0.0052	0.0108	0.0179
USAZOW	74–93	0.0209	0.3643	–0.0056	0.0000	0.0046
FRAZOG	74–91	0.0215	0.5437	0.0010	–0.0244	–0.0037
FRAZ35	80–91	0.0458	–0.2758	–0.0079	–0.0060	0.0030
FRAZOW	80–91	0.0779	–0.2758	–0.0051	–0.0235	–0.0082
GBRZLF	74–92	–0.0886	0.2590	–0.0047	–0.0212	0.0046
GBRZOO	74–92	–0.0019	0.2590	0.0359	–0.0253	0.0209
GBRZOP	74–92	–0.0022	0.2590	0.0060	–0.0101	0.0107
GBRZ35	86–92	0.0692	0.4908	–0.0210	–0.0070	0.0264
NLDZMT	74–93	0.0187	–0.2920	–0.0095	–0.0123	0.0028
ESPZMB	80–91	0.0173	–9.5446	–0.0339	–0.0399	–0.0323
ESPZMT	80–91	0.1139	–9.5446	–0.0089	–0.0138	–0.0078
ESPZOW	80–91	0.5935	–9.5446	–0.0047	–0.0189	–0.0173
ESPZLF	80–91	0.1110	–9.5446	–0.0188	–0.0085	0.0092
ITAZLX	81–94	0.3001	0.1873	–0.0176	–0.0197	–0.0107

Note: See appendix for a list of abbreviations used.

Table 11.3b Growth rates of explanatory and dependent variables over the estimation period given by SMPL, 1980s onwards

Sector	SMPL	Technology	Capital	Trade	Labour	Wages
USAZ35	81–93	0.0508	0.1435	–0.0153	0.0037	0.0143
USAZMB	81–93	–0.0311	0.1435	–0.0244	–0.0377	–0.0371
USAZOP	81–93	0.0500	0.1435	0.0083	0.0108	0.0214
USAZOW	81–93	0.0179	0.1435	–0.0023	0.0052	0.0091
FRAZOG	80–91	0.0234	–0.2758	–0.0023	–0.0279	–0.0129
FRAZ35	80–91	0.0458	–0.2758	–0.0079	–0.0060	0.0030
FRAZOW	80–91	0.0779	–0.2758	–0.0051	–0.0235	–0.0082
GBRZLF	81–92	–0.0581	0.1612	0.0040	–0.0276	0.0052
GBRZOO	81–92	–0.0646	0.1612	0.0546	–0.0285	0.0417
GBRZOP	81–92	–0.0018	0.1612	0.0034	–0.0138	0.0153
GBRZ35	86–92	0.0692	0.4908	–0.0210	–0.0070	0.0264
NLDZMT	81–93	0.0209	0.0287	0.0030	–0.0072	0.0034
ESPZMB	81–91	0.0116	–10.2546	–0.0367	–0.0449	–0.0410
ESPZMT	81–91	0.1085	–10.2546	–0.0162	–0.0138	–0.0134
ESPZOW	81–91	0.6157	–10.2546	–0.0124	–0.0182	–0.0265
ESPZLF	81–91	0.0940	–10.2546	–0.0200	–0.0063	0.0016
ITAZLX	81–94	0.3001	0.1873	–0.0176	–0.0197	–0.0107

tures have a negative growth rate. R&D therefore has a positive effect on wages in both periods. Interest rates have risen in ten (ten) sectors and therefore have decreased wage growth.[35] With three (three) exceptions, labour supply has fallen and therefore – given the positive sign of the correlation – there is decreased wage growth.[36]

From Table 11.4a (and Table 11.4b for the more recent period of the 1980s, the results of which are again given in brackets), which shows us a similar table as Table 11.2 but then at the sectoral level, it follows that in four (seven) out of the 17 combination of countries and sectors the terms of trade have a larger impact than technology. This means that technology matters more often over the whole period but terms of trade changes are more influential in the recent period. Out of these four (seven) sectors, two (four) have falling terms of trade. Thus at the sectoral level international trade is quite important. These two sectors are located in Spain (basic metals) and the USA (wood, cork and furniture). In the 1980s more Spanish sectors have terms of trade losses but there is also one additional sector in the USA (basic metals). However, of the two (four) sectors one (four) have falling wages.

Table 11.4a Relative importance of dependent and explanatory variables in explaining per sector wage growth (per cent)

Sector	Constant	Technology	Capital	Trade	Labour	Residual
USAZ35	0.0	53.3	–2.5	–0.4	30.0	19.7
USAZMB	–38.8	1.0	2.8	–0.4	135.4	0.0
USAZOP	0.0	4.7	–2.5	3.0	65.1	29.6
USAZOW	117.7	8.8	–10.0	–16.0	–0.5	0.0
FRAZOG	0.0	–72.8	86.4	–13.6	251.7	–151.7
FRAZ35	0.0	198.8	49.5	–6.4	–121.7	–20.1
FRAZOW	0.0	–10.8	–12.3	8.1	188.8	–73.7
GBRZLF	0.0	–17.7	–6.5	–5.9	107.4	22.7
GBRZOO	0.0	–0.9	–6.4	120.4	7.6	–20.8
GBRZOP	162.8	–2.0	–12.2	24.0	–72.5	0.0
GBRZ35	0.0	115.8	–48.2	–11.2	23.8	19.9
NLDZMT	422.7	64.4	8.7	–6.3	–389.5	0.0
ESPZMB	0.0	–1.6	–3.5	7.3	109.9	–12.2
ESPZMT	0.0	–67.4	–3.4	42.8	151.4	–23.4
ESPZOW	0.0	–12.5	–1.1	8.0	90.4	15.2
ESPZLF	0.0	81.5	63.9	–35.5	–32.8	23.0
ITAZLX	0.0	–5.3	3.2	4.8	109.0	–11.8

The more recent period therefore is (much) less favourable (in terms of losses) than the whole period and the terms of trade are catching up with technology in importance.[37]

In 11 (12) of the 17 national sectors, labour has the strongest impact; in only four (four) cases is it technology and in two (one) is it trade. In the more recent period, labour has become even more important than it already was over the entire period. When counting variables that rank second we find six (six) times technology, twice (six times) trade, three times (twice) labour and six (three) times capital movements by interest changes. The overall impression therefore is that labour supply matters most, technology second and trade and interest rates last (in that order), but in the more recent period terms of trade have completely caught up with technology. All evaluations have been made without taking the constant term or the residual into account.

A similar exercise can be carried out by switching the roles of wage and labour growth in the regression equation and redoing the entire analysis up to this point.[38] Then we would find ten sectors where all variables have the expected signs (five of which had not been included before), as shown in

Table 11.4b Relative importance of dependent and explanatory variables in explaining per sector wage growth (per cent), 1980s onwards

Sector	Constant	Technology	Capital	Trade	Labour	Residual
USAZ35	0.0	74.4	–1.3	–4.1	21.9	9.0
USAZMB	–23.2	3.7	0.7	4.1	106.5	8.2
USAZOP	0.0	3.8	–0.8	4.0	54.4	38.7
USAZOW	59.2	3.8	–2.0	–3.4	56.9	–14.5
FRAZOG	0.0	–22.8	–12.6	8.8	83.0	43.6
FRAZ35	0.0	198.8	49.5	–6.4	–121.7	–20.1
FRAZOW	0.0	–10.8	–12.3	8.1	188.8	–73.7
GBRZLF	0.0	–10.3	–3.6	4.4	124.2	–14.7
GBRZOO	0.0	–14.7	–2.0	91.8	4.3	20.6
GBRZOP	113.9	–1.2	–5.3	9.6	–69.4	52.4
GBRZ35	0.0	115.8	–48.2	–11.2	23.8	19.9
NLDZMT	353.2	60.0	–0.7	1.7	–190.3	–123.9
ESPZMB	0.0	–0.8	–2.9	6.3	97.6	–0.2
ESPZMT	0.0	–37.6	–2.1	45.6	88.7	5.4
ESPZOW	0.0	–8.5	–0.7	13.8	56.8	38.6
ESPZLF	0.0	387.6	385.6	–212.0	–136.2	–325.1
ITAZLX	0.0	–5.3	3.2	4.8	109.0	–11.8

Table 11.5 Sectors with correct expected signs when the roles of labour and wages are interchanged

Country	Sector
USA	Chemicals
	Fabricated metal products
	Food, drink and tobacco
	Textiles, footwear and leather products
	Basic metals
	Total manufacturing
	Wood, cork and furniture
France	Wood, cork and furniture
Great Britain	Paper and printing
Spain	Other manufacturing industries

Table 11.5. Note that the majority of the sectors (seven out of ten) are located in the USA.

It is interesting to see what proportion of labour growth is explained by the other variables, as done before. At the national level a result can only be presented for the USA, for there is too limited a number of sectors available for the other countries. Table 11.6 lists the relevant statistics.

Table 11.6 Relative importance of explanatory variables in explaining per country wage growth (per cent)

	Variables					
	Constant	Technology	Capital	Trade	Wages	Residual
USA	71.1	523.1	–209.9	–167.1	–3 251.2	3 133.9
USA (excl. ZOW)	85.3	–9.1	–2.3	–16.4	20.1	22.5

Looking at Table 11.6, the large percentages we find for all variables besides the constant term indicate that there may be an outlier between the sectors at hand. This is indeed the case for wood, cork and furniture. Dropping this sector yields the result that the most important variable in determining labour growth in the USA is wage growth (leaving aside the constant term and the residual). Trade, technology and capital (in that order) all play a less important role.

Again, at the sectoral level some insights can be gained by analysing both the periods starting from the 1970s and the 1980s. Therefore, in Tables 11.7a and 11.7b the growth rates for the variables under consideration are shown for these periods.

A general conclusion that can be drawn when comparing the two tables is that the period of the 1980s is less favourable in many respects: for example, more sectors suffer from adverse terms of trade (eight instead of seven) and wage growth (four instead of three). Although R&D growth is greater in the 1980s than in the 1970s for some sectors (paper and printing in the UK, chemicals in the USA and other manufacturing industries in Spain), mostly it is less than in the earlier period.

Table 11.8a (and Table 11.8b for the 1980s, the results of which will again be presented in brackets) is a sectoral version of Table 11.6 (but now for all countries). We can derive that, in three (five) of the ten sectors, terms of trade have a larger influence on labour growth than technology. Technology thus matters more over the whole period, but since the 1980s the terms of trade have caught up in importance. This conclusion is in accordance with the one we obtained above.

Table 11.7a *Growth rates of explanatory and dependent variables over the estimation period given by SMPL*

Sector	SMPL	Technology	Capital	Trade	Labour	Wages
GBRZOP	74–92	–0.0022	0.2590	0.0060	–0.0101	0.0107
USAZ38	74–93	0.0126	0.3643	–0.0157	–0.0036	0.0062
USAZLX	74–93	0.0320	0.3643	–0.0265	–0.0199	–0.0145
USAZMB	74–93	–0.0049	0.3643	0.0015	–0.0286	–0.0222
USAZMT	74–93	0.0187	0.3643	–0.0085	–0.0045	0.0047
FRAZOW	80–91	0.0779	–0.2758	–0.0051	–0.0235	–0.0082
USAZ35	74–93	0.0455	0.3643	–0.0019	0.0063	0.0179
USAZLF	74–93	0.0294	0.3643	0.0023	–0.0020	0.0048
USAZOW	74–93	0.0209	0.3643	–0.0056	0.0000	0.0046
ESPZOO	80–91	0.5407	-9.5446	–0.0489	–0.0129	0.0017

Table 11.7b *Growth rates of explanatory and dependent variables over the estimation period given by SMPL, 1980s onwards*

Sector	SMPL	Technology	Capital	Trade	Labour	Wages
GBRZOP	81–92	–0.0018	0.1612	0.0034	–0.0138	0.0153
USAZ38	81–93	0.0081	0.1435	–0.0216	–0.0123	0.0001
USAZLX	81–93	0.0470	0.1435	–0.0207	–0.0197	–0.0104
USAZMB	81–93	–0.0311	0.1435	–0.0244	–0.0377	–0.0371
USAZMT	81–93	0.0158	0.1435	–0.0137	–0.0083	0.0013
FRAZOW	80–91	0.0779	–0.2758	–0.0051	–0.0235	–0.0082
USAZ35	81–93	0.0508	0.1435	–0.0153	0.0037	0.0143
USAZLF	81–93	0.0241	0.1435	0.0102	–0.0019	0.0033
USAZOW	81–93	0.0179	0.1435	–0.0023	0.0052	0.0091
ESPZOO	81–91	0.5679	–10.2546	–0.0707	–0.0107	–0.0067

In nine (eight) of the sectors wages have the largest impact. Technology comes first once (zero times), whereas capital and terms of trade hold the first position zero (zero) and zero times (twice) respectively. The influence of the terms of trade on labour growth has thus grown over time. When counting the variables that rank second, we get five (five) times technology, four (three) times trade, one (one) capital movements and zero times (once) wages. It will by now not come as a surprise that such results are achieved. Wage growth is the most dominant factor in explaining labour growth, with technology in second place, trade third and capital last. The roles of tech-

Table 11.8a *Relative importance of dependent and explanatory variables in explaining per sector labour growth (per cent)*

Sector	Constant	Technology	Capital	Trade	Wages	Residual
GBRZOP	112.9	–0.6	–1.6	20.1	–30.8	0.0
USAZ38	337.3	8.0	–14.7	–62.8	–167.9	0.0
USAZLX	54.9	5.1	–0.7	–22.3	63.1	0.0
USAZMB	34.5	–0.8	–1.8	0.2	67.9	0.0
USAZMT	205.8	11.6	–8.5	–9.1	–99.8	0.0
FRAZOW	0.0	8.7	3.8	–0.1	38.9	48.8
USAZ35	0.0	–120.0	5.8	1.7	256.0	–43.5
USAZLF	0.0	62.1	–0.2	1.0	–118.9	155.9
USAZOW	0.0	3 184.2	–1 247.8	–920.2	–19 607.3	18 691.2
ESPZOO	0.0	45.4	5.3	–44.5	–12.4	106.3

Table 11.8b *Relative importance of dependent and explanatory variables in explaining per sector labour growth (per cent), 1980s onwards*

Sector	Constant	Technology	Capital	Trade	Wages	Residual
GBRZOP	82.6	–0.4	–0.7	8.4	–32.2	42.3
USAZ38	99.7	1.5	–1.7	–25.6	–0.7	26.9
USAZLX	55.6	7.5	–0.3	–17.7	45.6	9.2
USAZMB	26.2	–4.0	–0.5	–2.1	86.4	–6.0
USAZMT	110.7	5.2	–1.8	–7.8	–14.8	8.5
FRAZOW	0.0	8.7	3.8	–0.1	38.9	48.8
USAZ35	0.0	–229.0	3.9	23.8	349.8	–48.5
USAZLF	0.0	53.6	–0.1	4.8	–86.1	127.8
USAZOW	0.0	–11.4	2.1	1.6	163.5	–55.7
ESPZOO	0.0	57.7	6.8	–77.8	59.0	54.3

nology and trade switch when we look at the more recent period of the 1980s.

We have already stated that the perfect competition version of our model leaves something to be desired, for increasing returns at the firm level cannot be excluded from consideration. Yet, despite its deficiencies, it is clear that the model's results are quite robust: specific factors do indeed seem to matter for wage and/or labour growth, whereas the influence of the terms of trade on the results has risen over time (when set against the role of technology).

Nevertheless, it is equally clear that there still is a need to analyse an imperfect competition version of the model.

The Case of Imperfect Competition

The approach that is followed in the case of imperfect competition is very similar to the one followed in the perfect competition case. We first ran OLS regressions[39] on the basic model, which, from a theoretical point of view, already contains a constant term. As explained in section 2, we expect e_{1a} and e_{1b} to have a negative sign, while e_0 and e_4 can have either sign; e_3 is highly likely to be positive.

We see that the constant term (e_0) differs significantly from zero at the 5 per cent significance level only 19 times. These are all positive entries. Negative entries turn up only ten times. A similar conclusion holds with respect to the coefficients of the import variables (e_{1a} and e_{1b}): the coefficient for EU imports differs significantly from zero five times, which are all positive entries but two. It has the desired sign 29 times. Non-European imports turn up significantly nine times (of which three entries are negative), with a total of 27 negative signs. Thus non-European imports, including those of the Asian NICs (may) have a substantial impact on wage growth in some sectors. Given the construction of e_{1a} and e_{1b}, they should have the same sign. This happens only 22 times (with five cases in which they are both negative).[40]

The imperfect competition version of our model thus picks up some factors that were (unjustly) left out at the perfect competition stage. To see whether the fit can be improved even further, we tested whether there are structural breaks underlying the results. Thus Chow structural break tests were applied for (mostly) the years 1981 and 1986 to check whether such breaks were indeed present.[41] *Structural breaks were found for nine sectors: four British* (chemicals, food, drink and tobacco, leather products and total manufacturing), one American (basic metals), two Italian (chemicals and fabricated metal products) and two Dutch ones (basic metals and total manufacturing). For only three of them did we also find structural breaks in the perfect competition case.[42] The estimation for these sectors was redone, with the estimation period now mostly starting in 1986.[43] The results are split into two groups: the cases where employment growth determines wage growth and the cases where wage growth determines employment growth.[44]

Some changes occur for the aforementioned sectors. We find both correct sign switches (for example, in the case of the interest variable for Italian chemicals, the European import variable for total manufacturing in the Netherlands and its non-European counterpart for basic metals in the USA and the Netherlands), and incorrect ones – sometimes even within the same sectors (for example, in the case of the interest and non-European import variable for total manufacturing in the Netherlands and the latter variable for total manufacturing in the UK). So, overall, no very new insights on coefficients are created here either.

Nevertheless, it remains quite difficult to be more specific about the results without actually knowing the values of the parameters α, β, δ, ε, θ, η, ϕ and $\hat{\beta}$. This would be possible if we could solve the system of equations we get for e_{0-4} numerically. We would then start with a system of six equations for eight unknowns, which can only be solved if we could reduce the number of unknowns to six or lower. We found no way of doing so. Therefore the only thing we can do is to perform another 'growth accounting' exercise using the latest estimates. First, however, we have to determine which sectors should be included in such an exercise.

We may recall from section 2 that there are several conditions which have to hold in order to fulfil the requirements of the model. Most of them are about (combinations of) single parameters (such as $\eta > 0$ and $2(\alpha + \beta) - 1 > 0$), which cannot be checked so easily. By looking at the coefficients of the two import variables (e_{1a} and e_{1b}), however, we can indirectly see whether δ, $\varepsilon < 0$. If we take the 62 sectors for which labour growth explains wage growth, we find negative coefficients for e_{1a} and e_{1b} on only five occasions. Furthermore, we can impose certain constraints on the parameter values so that e_3 is non-negative, e_2 is non-positive and e_0 and e_4 can take on any value (cf. section 2). Of the five sectors we got when checking the sign of the import variables, we therefore have three sectors left: total manufacturing in the USA, fabricated metal products in the Netherlands, and food, drink and tobacco in Spain. For these three sectors a similar 'growth accounting' exercise as in the previous section can be conducted. No such exercise will be conducted at the national level, since we have too few observations available within each country to do so.

Growth rates at the sectoral level are presented in Tables 11.9a (for the whole period) and 11.9b (for the period starting from the 1980s). Again, they yield the same conclusion reached in the perfect competition case: the period of the 1980s is less favourable in many respects. Most variables have lower growth rates in the later period (except for fabricated metal products in the Netherlands, where five out of the six variables have higher growth rates).

The final growth accounting results for both periods are given in Tables 11.10a and 11.10b. What we see (the results for the 1980s are in brackets) is that wage growth is dominated by labour growth in all but one sector (food, drink and tobacco in Spain, in both periods). There EU trade (non-EU trade) is the most important. In answering the question whether technology or trade (EU and non-EU) drives wage growth most, we find technology once (once) and trade twice (twice). When looking at variables that rank in second place, we find technology once (once), trade once (twice) and capital movements

Table 11.9a Growth rates of explanatory and dependent variables over the estimation period given by SMPL

Sector	SMPL	Technology	Capital	EU trade	Non-EU trade	Labour	Wages
USAZMT	74–92	0.0227	0.3942	0.0434	0.0671	–0.0047	0.0041
NLDZ38	74–92	0.0153	–0.2976	0.0354	0.0677	–0.0099	0.0037
ESPZLF	80–91	0.1110	–9.5446	0.1244	0.0275	–0.0085	0.0092

Table 11.9b Growth rates of explanatory and dependent variables over the estimation period given by SMPL, 1980s onwards

Sector	SMPL	Technology	Capital	EU trade	Non-EU trade	Labour	Wages
USAZMT	81–92	0.0218	0.1724	0.0395	0.0551	–0.0090	0.0001
NLDZ38	81–92	0.0177	0.0464	0.0440	0.0778	–0.0061	0.0033
ESPZLF	81–91	0.0940	–10.2546	0.1363	0.0556	–0.0063	0.0016

Table 11.10a Relative importance of dependent and explanatory variables in explaining per sector wage growth (per cent)

Sector	SMPL	Constant	Technology	Capital	EU trade	Non-EU trade	Labour	Residual
USAZMT	74–92	200.5	50.2	–14.6	–13.7	–9.8	–112.7	0.0
NLDZ38	74–92	544.7	19.8	21.0	–74.4	–116.5	–294.6	0.0
ESPZLF	80–91	125.5	64.3	99.8	–99.9	–66.8	–22.9	0.0

Table 11.10b Relative importance of dependent and explanatory variables in explaining per sector wage growth (per cent), 1980s onwards

Sector	SMPL	Constant	Technology	Capital	EU trade	Non-EU trade	Labour	Residual
USAZMT	81–92	9 514.0	2 287.5	–302.2	–589.7	–384.0	–10 226.1	–199.5
NLDZ38	81–92	625.4	26.3	–3.8	–106.0	–153.6	–206.5	–81.8
ESPZLF	81–91	705.2	306.1	602.7	–614.8	–760.5	–95.3	–43.3

once (zero times). Overall, the importance of technology seems to have been rather steady over time, the influence of trade has increased slightly, whereas labour matters most here too. Again the constant term and the residual have not been taken into consideration.

The results for the five sectors for which the role of labour and wages has been interchanged on the basis of Granger causality tests do not change the conclusions reached above. No sector fulfils all the previous requirements. Although the small number of sectors for which all requirements are met may cast some doubt on the validity of our entire model, we should not forget the fact that we are still – and always will be – faced with an aggregation problem from the assumption of identical firms within one sector which clearly may have distorted our results (even if the model was correct in itself). Yet altering the role of wage and labour growth in all equations may be an interesting route to follow, for in that way we can check the robustness of some of the conclusions reached previously.[45] In doing so, we find expected signs of the parameters for eight sectors: fabricated metal products in the USA, the UK and the Netherlands, food, drink and tobacco in Spain and the USA, total manufacturing in the USA, chemicals in Italy, and stone, clay and glass in Spain. We will perform another 'growth accounting' exercise for these sectors. Tables 11.11a and 11.11b list the relevant growth rates.

From the above growth rates we can conclude that, for the eight sectors included, the recent period of the 1980s is less favourable for most variables: they have lower growth rates more often than over the entire period (with the exception perhaps of the two trade variables). In particular the mean wage growth rate has fallen for all sectors, except fabricated metal products in the UK in the last period (where we considered the same sample period). Thus we can reinforce the conclusions already made before. This raises the ques-

Table 11.11a *Growth rates of explanatory and dependent variables over the estimation period given by SMPL*

Sector	SMPL	Technology	Capital	EU trade	Non-EU trade	Labour	Wages
USAZ38	74–92	0.0193	0.3942	0.0531	0.0850	–0.0031	0.0063
USAZLF	74–92	0.0339	0.3942	0.0172	0.0053	–0.0026	0.0040
USAZMT	74–92	0.0227	0.3942	0.0434	0.0671	–0.004	0.0041
GBRZ38	86–92	–0.0537	0.4908	0.0241	0.0315	–0.0150	–0.0024
ITAZ35	74–92	0.0520	0.6333	0.0442	0.0773	–0.0018	0.0156
NLDZ38	74–92	0.0153	–0.2976	0.0354	0.0677	–0.0099	0.0037
ESPZLF	80–92	0.1110	–9.5446	0.1244	0.0275	–0.0085	0.0092
ESPZOG	80–92	0.0470	–9.5446	0.0675	0.1094	–0.0221	–0.0159

Table 11.11b Growth rates of explanatory and dependent variables over the estimation period given by SMPL, 1980s onwards

Sector	SMPL	Technology	Capital	EU trade	Non-EU trade	Labour	Wages
USAZ38	81–92	0.0183	0.1724	0.0461	0.0799	–0.0121	–0.0003
USAZLF	81–92	0.0308	0.1724	0.0118	–0.0011	–0.0028	0.0020
USAZMT	81–92	0.0218	0.1724	0.0395	0.0551	–0.0090	0.0001
GBRZ38	86–92	–0.0537	0.4908	0.0241	0.0315	–0.0150	–0.0024
ITAZ35	80–92	0.0487	0.2304	0.0003	–0.0164	–0.0066	0.0108
NLDZ38	80–92	0.0177	0.0464	0.0440	0.0778	–0.0061	0.0033
ESPZLF	81–91	0.0940	–10.2546	0.1363	0.0556	–0.0063	0.0016
ESPZOG	81–91	0.0341	–10.2546	0.0728	0.1121	–0.0219	–0.0200

Table 11.12a Relative importance of dependent and explanatory variables in explaining per sector labour growth (per cent)

Sector	SMPL	Constant	Technology	Capital	EU trade	Non-EU trade	Labour	Residual
USAZ38	74–92	480.2	114.4	–44.4	–54.4	–215.9	–179.9	0.0
USAZLF	74–92	136.1	66.7	–6.5	–28.6	–7.6	–60.1	0.0
USAZMT	74–92	264.4	52.0	–20.3	–28.0	–101.0	–67.1	0.0
GBRZ38	86–92	663.5	–407.5	–102.1	–27.3	–34.4	7.9	0.0
ITAZ35	74–92	499.7	124.4	–6.5	–1.6	–46.3	–469.8	0.0
NLDZ38	74–92	164.5	3.9	6.5	–35.6	–14.9	–24.4	0.0
ESPZLF	80–92	262.9	79.5	62.5	–191.7	–35.4	–77.8	0.0
ESPZOG	80–92	63.6	16.9	15.3	–62.3	–0.3	66.8	0.0

Table 11.12b Relative importance of dependent and explanatory variables in explaining per sector labour growth (per cent), 1980s onwards

Sector	SMPL	Constant	Technology	Capital	EU trade	Non-EU trade	Labour	Residual
USAZ38	81–92	121.9	27.5	–4.9	–12.0	–51.5	2.4	16.6
USAZLF	81–92	125.0	55.6	–2.6	–18.2	1.4	–27.1	–34.2
USAZMT	81–92	138.2	26.1	–4.6	–13.3	–43.4	–0.7	–2.2
GBRZ38	86–92	663.5	–407.5	–102.1	–27.3	–34.4	7.9	0.0
ITAZ35	80–92	133.8	31.2	–0.6	0.0	2.6	–87.4	20.4
NLDZ38	80–92	269.4	7.3	–1.7	–72.3	–28.0	–34.8	–40.0
ESPZLF	81–91	355.2	91.0	90.7	–283.8	–96.7	–18.7	–37.7
ESPZOG	81–91	64.4	12.4	16.6	–68.0	–0.3	85.2	–10.4

tion of what we find when analysing the impact of all variables on wage growth (in percentages). Tables 11.12a and 11.12b give an indication.

Wage growth has the largest impact on labour growth in two (two) out of the eight sectors. Trade explains a larger percentage of labour growth than technology in five (five) sectors. Given that non-EU trade sometimes even exhibits the most explanatory power (in three (three) cases during both periods), we may sustain the hypothesis that competition from the Asian NICs may have had a substantial impact over the years. There are not many differences when comparing the period of the 1970s and that of the 1980s as far as shifts in variables and their explanatory power with regard to labour growth are concerned.

Combining the sectors we worked with above with the 22 non-overlapping sectors we found in the perfect competition case, we have a group of 26 sectors (excluding overlap) for which either a perfect or an imperfect competition approach gives expected signs. The evidence that can be obtained from the imperfect competition model is that the main conclusions of the perfect competition model are endorsed. Specific factors are important and the role of both technology and trade in explaining wage and/or labour growth changes (with trade being influential in both periods) has clearly come forward.

5. POLICY CONCLUSIONS

Protectionism or compensation mechanisms are probably the first policy instruments firms and sectoral institutions point to when trying to counterbalance the (financial) effects from losses from trade. From a model point of view, the effects of such measures are difficult to determine, for under perfect competition and the small country assumption protectionism is damaging. However, even from a theoretical perspective mechanisms like protectionism do seem somewhat short-sighted, for firms are not encouraged (enough) to strengthen their international competitive position over time, which may easily find them falling behind more and more (leading to rising compensation from governments). Case study evidence also indicates that protectionism may have adverse effects. For example, one policy action has been the Trade Adjustment Assistance Program in the USA. Sachs and Shatz (1994) show that the sectoral distribution of compensation from that programme are strongly correlated with the underlying sectoral distribution of employment losses (so that losing sectors are compensated adequately – which might make losing more attractive). Moreover, in our analysis of both the perfect and imperfect competition cases we found a total of nine sectors that have a negative effect from adverse terms of trade or import movements and decreasing wages. These sectors are listed in Table 11.13.

Table 11.13 Sectors that have adverse effects from trade and decreasing wage growth

Country	Sector
USA	Textiles, footwear and leather products
	Basic metals
France	Stone, clay and glass
	Wood, cork and furniture
Italy	Textiles, footwear and leather products
Spain	Basic metals
	Total manufacturing
	Other manufacturing industries
	Wood, cork and furniture

Given the aforementioned policy measures and looking at these nine sectors, we could ask the crucial question whether income policies for the short run and R&D subsidies for the long run would be a better means than protectionism of helping sectors to cope with negative trade effects. As international trade has gained in importance since the 1980s, this question has become more urgent for several sectors (especially for leather products in the USA and other manufacturing industries in Spain). However, we should also study the forces playing within each of these sectors separately before reaching a definite conclusion.

Of course, tax reductions for the less skilled or low-income brackets are one variation on income policies that would invoke a problem at the household level rather than at the firm level. However, it should be clear that behind the given interest rate there is a critical issue of interest rate determination and behind the given sectoral labour supply and wages there are labour market imperfections. Given the dominance of the labour supply variable in both the perfect and the imperfect competition version of our model, it seems reasonable to search for a diagnosis and a solution to trade problems in the labour market sphere (for example, by ensuring a better match between the skills necessary to perform a certain job and the skills workers have, or by easing the hiring and firing conditions of workers). Here specific factors have turned out to be a robust variable that is more important than both technology and trade.

6. LIMITATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

The major drawback of a trade-theoretic approach is that international trade models are not related to models explaining unemployment, and vice versa. This is the reason why economists currently have to choose between a closed economy labour market imperfections approach and a trade approach. The integration of the two must be left for further research (provided that major intertemporal changes in the labour market situation occur). Moreover, owing to the simplifying assumption of constant price elasticities of demand and therefore of mark-ups over marginal costs, we cannot include their change across the business cycle without considerably complicating the model.

An incentive for further research from our analysis follows from three results. First, in the perfect competition case the constant term in our model was absent but the empirics tell us we should have one (thus indicating that there are possibly other explanatory variables that should have been included in the model). Second, the model would predict relations between the coefficients, but the corresponding constraint has been rejected by statistical tests. Third, we could move from the firm level to the sectoral level only under the assumption of identical firms, which in all likelihood is fairly unrealistic. This aggregation problem will (probably) remain even when switching to different types of production functions with constant or variable elasticities of substitution. Yet, even if our model and estimation results are rather too crude to give a 'robust' answer to the question of what factor drives sectoral wage growth most strongly (technology or trade), our results do have their relevance. In particular, the supply of specific factors turned out to matter in both models (with the results being very robust in that respect) and the changing role of international trade (becoming more important than technology in the 1980s according to the perfect competition model) has been clearly illustrated.

NOTES

1. Parts of this chapter have been presented at the ESF conference, 'Economic growth in closed and open economies', Lucca, September 1997, the TSER group seminars on technology and employment, Paris, October 1997 and May 1998, and the conference, 'Unemployment in Europe', Maastricht, October 1997. We especially would like to thank Bruno Amable, Donatella Gatti, Huw Lloyd-Ellis, Erik de Regt, Giovanni Russo, Luc Soete and Winfried Vogt for their comments. The usual disclaimer applies.
2. Note that the estimation of Jones's (1970) dynamic version of the zero profit conditions uses data on factor shares (see Baldwin and Cain, 1997), which consist of a cost term in the numerator and revenue terms in the denominator. If we (empirically) have zero profits on average across time, we might guess from a business cycle perspective that there are

losses in recessions and positive profits in booms. This yields higher than average values of cost shares in recessions and lower values in booms. In time-series estimates this may bias the results, in particular in view of the possibility that capital and labour shares may be affected unequally because of the irreversibility (or costly reversibility) of the investment of capital which makes it difficult to reduce its cost in a recession.

3. In the standard partial equilibrium labour market diagram, an increase in the labour supply would decrease wages. However, the increase in employment has an indirect effect via the marginal productivity of capital, which is increased by higher employment and therefore more capital is attracted from the world market. With the increase in capital, labour demand also increases, which will increase wages. Under increasing (decreasing) returns to scale, the indirect demand effect is stronger (weaker) than the direct supply effect.
4. Applying non-linear least squares (NLS) or maximum likelihood (ML) (while simultaneously imposing the coefficient restriction derived in the theoretical part) would have been an option, were it not that we would then be implying that the coefficient restriction already holds a priori. Thus, given the reservations expressed above, OLS seems to be preferable. Pooling data (across sectors, countries or both) would have been an option too, but it was dropped when relatively few interpretable results emerged. See also notes 19 and 40.
5. White's method (1980) is used to achieve this.
6. Scherer (1983) and Griliches (1990) examine more closely the points in favour and against using either R&D or patent statistics as an indicator of technical change.
7. Cf. Scherer (1983) and Feldman and Florida (1994). See Caniëls (1998) for European evidence of this.
8. With the estimated return to R&D being downward biased.
9. In the appendix, additional remarks on this subject are made.
10. Three sectors were excluded because of missing R&D data: the Dutch and Italian wood, cork and furniture sectors and the Dutch other manufacturing industries.
11. The sign of γ_4 depends on the presence of increasing returns to capital and labour at the sectoral level; see section 2. The fact that it can take on either sign is illustrated by Efendioglu and von Tunzelmann (1998) and Spiezia and Vivarelli (1998).
12. An alternative interpretation that is somewhat independent of our model could be that the economy is moving along an upward-sloping labour supply curve – a view found in the work of Bovenberg (see Bovenberg, 1995, for details).
13. From a model point of view, the period characterized by positive real interest rates is the only one of interest, because only then does the model hold. It is assumed, however, that when no structural breaks are found, the influence of negative real interest rates on the regression results is negligibly small.
14. See Chow (1960) for details.
15. It is reckoned that econometrically more sophisticated methods exist to assess points in time at which structural breaks occur (see, for example, Gallant and Fuller, 1973). However, we concentrate on the years which we assume to be the most influential.
16. The British chemical industry is also affected by the sign switch of the real interest rate at the beginning of the 1980s.
17. All regressions were also carried out with a time variable included. This variable was always insignificantly different from zero at a 5 per cent significance level (which is not that surprising since we are working with series expressed in first differences).
18. The technology variable now has the desired sign more often and (especially) becomes more significant. This might point to the fact that R&D expenditures are rather a flawed indicator of technical change. However, putting the technology variable into the residual would then again seem too drastic an action, for it would, in a statistical sense, lead to omitted variable bias.
19. If all coefficient definitions given in the theoretical part are substituted into the regression equation and the model is re-estimated by means of NLS, these $\alpha/(1-\eta)$, $\beta/(1-\eta)$ and $\theta/(1-\eta)$ estimates follow. Of course, it would have been preferable to solve the system numerically. This did not yield any result, for then it is implicitly assumed that the

imposed coefficient restriction holds *exactly*, whereas our test examines whether it holds *within a certain margin*.

20. Exceptions (with respect to significance) are all British sectors except textiles, footwear and leather products, stone, clay and glass, paper and printing and wood, cork and furniture, the French food, drink and tobacco, stone, clay and glass and other manufacturing industries, food, drink and tobacco in the Netherlands and Spain and the Dutch basic metals sector.
21. First introduced by Granger (1969). Sims (1972) and others provided tests (mostly) along the same lines, but the Granger causality test is the one most commonly used.
22. See Eels (1991) for a more elaborate analysis.
23. Do note that it is short-run causality that we test for here. If we had wanted to detect long-run causality, the existence of a cointegration equation between labour and wage growth should have been proven. Given that we found no evidence thereof when testing (possibly because of the somewhat limited number of observations available), the current approach is chosen.
24. Note that it is not necessary to test the validity of the derived coefficient restriction again, for the same reason (as long as the estimation period remains the same). Here we have to perform this test anew for two sectors: chemicals and leather products in the UK. For the latter sector, the coefficient restriction is accepted, so new estimates for $\alpha/(1-\eta)$, $\beta/(1-\eta)$ and $\theta/(1-\eta)$ can be generated. See also note 27.
25. As turned out to be the case for British and Spanish textiles, footwear and leather products and the Italian paper and printing industry.
26. This is not surprising since coefficients that already had the wrong sign when wages were taken as the dependent variable will have the same now too (as long as the constant term remains either absent or present and the estimation period remains the same).
27. This is why we find no reasonable estimates for $\alpha/(1-\eta)$, $\beta/(1-\eta)$, $\theta/(1-\eta)$ in the case of leather products in the UK (where we did accept the coefficient restriction): $\alpha/(1-\eta)$ equals $2.93.10^{-3}$, $\beta/(1-\eta)$ 1.50 and $\theta/(1-\eta)$ −0.128.
28. At first, we will only look at cases where employment determines wage growth. If we had reversed the position of the wage and labour variables in the regression equation and redone the entire analysis up to this point, we would have ended up with ten sectors to work with (instead of the 17 we have now); see Table 11.5 below. Compared to the 17 sectors we find here (see Table 11.1), we have an overlap for five sectors: three American (chemicals, basic metals and wood, cork and furniture), one French (chemicals) and a British one (paper and printing). So if we include both relationships (where labour growth determines wage growth and vice versa), we would have 22 sectors to continue with. Later we will consider the other five.
29. Ideally, we would have preferred looking at variables that both have the expected sign and are statistically significant. However, this is not the case for any sector (as in all of the international trade literature). Since we do want to give an indication whether either terms of trade or technology drives wage growth most, the present approach is opted for.
30. Alternatively, we could have taken medians or calculated an average based on just the first and last period. However, given the way in which the OLS estimates are obtained, calculating means over the entire estimation period is to be preferred.
31. It is an aggregate across all other sectors and including it would create a bias.
32. Which was to be expected, given our previous results.
33. Leaving aside the constant term.
34. A similar exercise was carried out for the period starting (mostly) from 1980 or 1981. There, we looked at sectors which had (by and large) falling growth rates of wages. With the *same* regression coefficients (which, in a rough sense, is a valid approach, for structural breaks have already been taken into account), we found results that were almost identical to the ones obtained in Table 11.2. However, the results for total manufacturing in the Netherlands and food, drink and tobacco in Spain became worse, with, respectively, −123.9 per cent and −325.1 per cent of wage growth now being attributed to the residual. On the contrary, we found improved results for France, where technology now emerged as the most prominent factor in wage determination. Moreover, in Spain capital became the

most important explanatory factor. Yet, overall, labour still turned out to be the most influential factor in national wage formation. More results at the sectoral level are discussed (and shown) later on. A similar approach will be followed in the case of imperfect competiton.

35. The extremely high value for the mean growth rate of the Spanish interest rate is due to an outlier in 1986. Possibly, this outlier is caused by the alliance of Spain to the EU (and it was therefore explicitly taken along in our exercise).
36. In seven (seven) cases the growth rates of L and w have opposite signs, but have positive regression coefficients. The inclusion of other explanatory variables and interaction effects between them play an important role in this 'switch' in sign.
37. This conclusion is independent of the fact that the residual sometimes explains a large part of wage growth (for example for wood, cork and furniture in France). Even if we had included a constant term in the regressions for these sectors (and checked whether all variables had the correct signs), the economic interpretation of the results would have remained virtually the same.
38. No regression outputs or intermediate results for the reversed relationship are included in the main text. However, they can be obtained from the authors upon request. One may claim that, since wages (which now appear as an explanatory variable) are determined endogenously, the use of instrumental variables is advisable in order to reach more accurate regression results. Since the outcome of instrumental variables techniques is highly dependent on the number and quality of the instruments included in the analysis, we feel that the present approach has certain advantages. A pooling exercise was carried out here, too, finally supporting this feeling. The fact that no definite answer could be given to the question of the existence of a long-run relationship between wage and labour growth makes using this 'reversed causality' equation for *all* sectors an interesting route to follow (to consider all possible relationships). See also note 23.
39. NLS and ML regressions were also tried (with either the results from the OLS regressions or zero as starting values), but this yielded hardly any result (convergence only occurred when running NLS regressions from zero. If we had continued with these figures, the results presented below would remain roughly the same).
40. The 'conflict' in sign between the two import variables may lead us to the conclusion that even the current specification leaves something to be desired. Do note, however, that this sign 'conflict' may be due to multicollinearity: the two import variables have a correlation that is mostly larger than 60 (and often exceeds 80). Although there are solutions to multicollinearity (for example, dropping one of the collinear variables), this is not an option in the present context, for it would imply an explicit change of the theoretical variable.
41. Why these years were chosen was explained at the beginning of section 4.
42. These sectors are the British chemicals and leather products industries, and fabricated metal products in Italy.
43. Exceptions are the British food, drink and tobacco sector and the Italian chemicals and Dutch basic metal industries. For these sectors, the estimation period started in 1981 instead of 1986.
44. The results of Granger causality tests we carried out are still valid. For the sectors where we found structural breaks, this implies that in two British cases (chemicals and leather products) labour is taken as the independent variable and wages as an explanatory one, and the entire estimation procedure has to be redone (including testing for structural breaks). So, in effect, the structural break tests that were carried out change the results for only seven sectors instead of nine.
45. No intermediate results will be shown here either, but they are available from one of the authors upon request. See also notes 33 and 39.

REFERENCES

Baldwin, R.E. and G.G. Cain (1997), 'Shifts in U.S. Relative Wages: The Role of Trade, Technology and Factor Endowments', NBER WP 5934.

Bovenberg, L. (1995), 'Environmental Taxation and Employment', *De Economist*, 143, 2.

Caniëls, M.C.J. (1998), 'The Geographic Distribution of Patents and Value Added across European Regions', MERIT Research Memorandum 98-004.

Chow, G.C. (1960), 'Tests of Equality between Sets of Coefficients in Two Linear Regressions', *Econometrica*, 28, 591–605.

Eels, E. (1991), *Probabilistic Causality*, Cambridge: Cambridge University Press.

Efendioglu, U.D. and G.N. Von Tunzelmann (1998), 'Technology and Employment in Postwar Europe: Short-Run Dynamics and Long-Run Patterns', TSER Working Paper, May.

Feldman, M.P. and R. Florida (1994), 'The Geographic Sources of Innovation: Technological Infrastructure and Product Innovation in the United States', *Annals of the Association of American Geographers*, 84, 210–29.

Francois, J.F. (1996), 'Trade, Labour Force Growth and Wages', *Economic Journal*, 106, 1586–609.

Freeman, R.B. (1995), 'Are your Wages set in Beijing?', *Journal of Economic Perspectives*, 9, 15–32.

Gallant, A.R. and W.A. Fuller (1973), 'Fitting Segmented Polynomial Regression Models whose Joint Points have to be Estimated', *Journal of the American Statistical Association*, 68, 144–7.

Granger, C.W.J. (1969), 'Investigating Causal Relations by Econometric Models and Cross-spectral Methods', *Econometrica*, 44, 424–38.

Griliches, Z. (1990), 'Patent Statistics as Economic Indicators: A Survey', *Journal of Economic Literature*, 28, 1661–707.

Hall, B.H. and J. Mairesse (1992), 'Productivity and R&D at the Firm Level', NBER Working Paper 3956.

Helpman, E. and P.R. Krugman (1989), *Trade Policy and Market Structure*, Cambridge: MIT Press.

International Financial Statistics Yearbook 1990 (1990), Washington, DC: International Monetary Fund Publication Services.

International Financial Statistics Yearbook 1995 (1995), Washington, DC: International Monetary Fund Publication Services.

Jones, R.W. (1970), 'The Role of Technology in the Theory of International Trade', in R. Vernon (ed.), *The Technology Factor in International Trade*, New York: NBER.

Krugman, P.R. (1994), 'Competitiveness: A Dangerous Obsession', *Foreign Affairs*, March/April.

Krugman, P. and R. Lawrence (1993), 'Trade, Jobs and Wages', NBER WP W4478.

Krugman, P.R. and M. Obstfeld (1997), *International Economics*, 4th edn, Reading, MA: Addison-Wesley.

Lawrence, R.Z. and M.J. Slaughter (1993), 'International Trade and American Wages in the 1980s: Giant Sucking Sound or Small Hiccup?', *Brookings Papers on Economic Activity*, 2, 161–226.

Leamer, E.E. (1993), 'Wage Effects of a U.S. Mexican Free Trade Agreement', in P.M. Garber (ed.), *The Mexico–U.S. Free Trade Agreement*, Cambridge, MA: MIT Press.

Leamer, E.E. (1994), 'Trade, Wages and Revolving Door Ideas', NBER Working Papers Series, no. 4716.
Leamer, E.E. (1996), 'Wage Inequality from International Competition and Technological Change: Theory and Country Experience', *American Economic Review*, AEA Papers and Proceedings, May.
Lücke, M. (1997), 'European Trade with Lower-income Countries and the Relative Wages of the Unskilled: An Exploratory Analysis for West Germany and the UK', Kiel University WP 819.
Oliveira Martins, J. (1994), 'Market Structure, Trade and Industry Wages', *OECD Economic Studies* No. 22, Spring, 131–54.
Oscarsson, E. (1997), 'Trade and Relative Wages in Sweden 1968–91', Department of Economics, Stockholm University Research Memorandum, January.
Richardson, J.D. (1995), 'Income Inequality and Trade: How to Think, What to Conclude', *Journal of Economic Perspectives*, 9, 33–55.
Sachs, J.D. and H.J. Shatz (1994), 'Trade and Jobs in U.S. Manufacturing', *Brookings Papers on Economic Activity*, 1, 1–84.
Schankerman, M. (1981), 'The Effects of Double-counting and Expensing on the Measured Returns to R&D', *Review of Economics and Statistics*, 63, 454–8.
Scherer, F.M. (1983), 'The Propensity to Patent', *International Journal of Industrial Organization*, 1, 107–28.
Sims, C.A. (1972), 'Money, Income and Causality', *American Economic Review*, 62, 540–55.
Spiezia, V. and M. Vivarelli (1998), 'Growth, Technical Change and Employment: Some Evidence from G-7 Manufacturing Industries', TSER Working Paper, May.
Verspagen, B. (1995), 'R&D and Productivity: A Broad Cross-Section Cross-Country Look', *Journal of Productivity Analysis*, 6, 117–35.
White, H. (1980), 'A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity', *Econometrica*, 48, 817–38.
Wood, A. (1994), *North–South Trade, Employment and Inequality*, Oxford: Clarendon Press.
Wood, A. (1995), 'How Trade Hurt Unskilled Workers', *Journal of Economic Perspectives*, 9, 57–80.

APPENDIX: DATA DESCRIPTION

All data except the Spanish, data on long-term interest rates and data on technical change are taken from the OECD's ISDB database. Employment data contain the number of employees, excluding the self-employed. Wages include all payments made to wage and salary earners (which also exclude the self-employed), including social security payments. Both sectoral and national prices are also calculated from the ISDB database, via value added at market prices (with 1985 as a base year). Technically speaking, it would have been preferable to use value added at factor costs to construct price levels, for this would exclude taxes and subsidies, which may differ between countries. Only for Great Britain was value added available at factor costs in the database (and subsequently used). All variables are expressed in national price levels.

Interest data are taken from the *International Financial Statistics Yearbook* published by the IMF (from 1990 and 1995 publications). The long-term government bond yield was taken as a proxy for the long-term interest rate (as suggested by the IMF itself: see the *International Financial Statistics Yearbook 1995*, pp. xv–xvi).

As a proxy of technical change, R&D expenditures are used. (One may claim that, because R&D personnel are included in the labour variable, our regression results are biased, since we are also using R&D expenditures as a separate variable. However, this only means that there may be some collinearity between the technology and labour variable, which is justified from a theoretical point of view. Regression results do not become biased because of collinearity. See also section 3 of the main text.) These data are taken from the OECD's ANBERD database. For Spain, employment, wage and sectoral price levels are calculated from the OECD's STAN database. Spanish employment figures do include the self-employed. R&D data are again taken from ANBERD, whereas both national price levels (the GDP deflator) and the interest rate data are taken from the *International Financial Statistics Yearbook*. All import data (for all countries) come from the OECD's BITRA database.

The sectors included in the analysis are the two-digit ISIC sectors 31 to 39, which define total manufacturing (ISIC sector 30). In the remainder, we will denote these sectors by means of an abbreviation. These abbreviations are shown in Table 11A.1.

The country codes used are shown in Table 11A.2.

In the regression analyses three sectors were dropped because of missing R&D data: the Dutch and Italian wood, cork and furniture sector, and the Dutch other manufacturing industries.

Table 11A.1 Sector classification and abbreviations

ISIC code	Abbreviation	Sector description
30	ZMT	Total manufacturing
31	ZLF	Food, drink and tobacco
32	ZLX	Textiles, footwear and leather
33	ZOW	Wood, cork and furniture
34	ZOP	Paper and printing
35	Z35	Chemicals
36	ZOG	Stone, clay and glass
37	ZMB	Basic metals
38	Z38	Fabricated metal products, machinery and equipment
39	ZOO	Other manufacturing industries

Table 11A.2 Country codes

Country	Country code
USA	USA
Former West Germany	DEU
France	FRA
Great-Britain	GBR
Netherlands	NLD
Italy	ITA
Spain	ESP