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Abstract

We investigate the effects of globalisation on the labour market using the factor price frontier. The factor price frontier defines a negative relationship between the real rate of return and the real wage rate. As international capital mobility equalises the real rate of return in all economies, real wages also have to converge. If they do not adjust, unemployment and technical change will result in relatively capital-abundant countries. We estimate the factor price frontier for the United States and for Germany with the Johansen procedure. While the U. S. economy adjusts along a single factor price frontier throughout the sample, there are three distinct frontiers in the German case. The outward shifts of the factor price frontier coincide with significant hikes in unemployment.

JEL Classification: *E24, F21*

Contents

1. Introduction

The striking feature of globalisation today is locational competition for the scarce factor capital. In general, "globalisation refers to the growing economic interdependence of countries worldwide through the increasing volume and variety of cross-border transactions in goods and services and of international capital flows, and also through the ... diffusion of technology." (IMF 1997: 45). However, it is the increasing mobility of capital combined with the integration of relatively labour-abundant countries into the world economy that has added a new quality to globalisation. For the sake of higher rates of return, capital leaves relatively capital-abundant countries in favour of relatively labour-abundant countries. The aim of this paper is to examine the effects of this phenomenon on factor prices and factor employment in relatively capital-abundant countries.

This paper relates to two strains of literature that study the adjustment costs of globalisation in relatively capital-abundant countries: (i) trade and wages, and (ii) international capital mobility. The studies that focus on trade and wages either concentrate on import prices or on trade volumes and their factor content as explanatory variables for domestic wages. Freeman (1995) and the OECD (1997b) provide surveys of the literature. Neither approach finds a large impact of trade on wages, though. Instead, skill-biased technical change seems to drive unemployment in Continental Europe and wage dispersion in the United States or Great Britain.

The influence of international capital mobility is less well studied. Krugman (1995: 333) discusses the implications of breaking up the production process into several geographically separated steps and calls it the "slicing up of the value added chain". Firms relocate labour intensive production steps from relatively capital-abundant to relatively labour-abundant countries. Feenstra and Hanson (1996) find a positive effect of international outsourcing on the wages of non-production workers for the United States in the eighties. So we do see evidence for the immobile factor labour being involved in locational competition for the mobile factor capital (cf. Siebert 1996 and Lorz 1997). This kind of competition has gained importance since the mid-eighties, as capital mobility has increased significantly (Taylor 1996).

Globalisation leads to a convergence of the rate of return through international capital mobility. In our theoretical model, wages have to adjust accordingly. If they do not, firms react by laying off workers, by moving away from low-skilled labour through skill-biased technical change, and by slicing up the value chain. In this sense our results are in line with the literature on trade and wages and the literature on international capital mobility.

The paper is organised as follows: In the second section, we model the effects of locational competition in a neoclassical framework using the factor price frontier. The analysis takes flexible as well as non-flexible labour markets into account. In this analysis, a flexible labour market is characterised by non-rigid wages. In section three, we present some empirical results on factor prices in the United States and Germany and relate them to the development of the employment levels in these two countries. In the concluding section we draw some policy implications.

2. A Neoclassical Framework

The factor price frontier shows the relationship between the real rates of return on the factors used in the production process. The frontier can easily be derived using a neoclassical linearly homogenous production function – with all common assumptions applying – and assuming profit maximising firms as well as competitive markets (cf. Hesse and Linde 1976: 174pp).

We take a production function of the Cobb-Douglas type:

$$Y = F(A,t,K,L) = Ae^{\lambda t} K^{\alpha} L^{1-\alpha} \qquad 0<\alpha<1 \qquad (1)$$

where K and L denote the respective amounts of capital and labour, and Y represents total output. A is an efficiency parameter, and λ denotes the rate of constant exogenous technical progress.

Dividing equation (1) by the amount of labour yields the per-capita production function or, more precisely, the per-worker production function:

$$y=\frac{1}{L}F(A,t,K,L)=f(A,t,k)=Ae^{\lambda t}k^{\alpha} \qquad (2)$$

where y denotes per-worker output and k represents per-worker capital.

The marginal products of capital and labour equal the real rate of return and the real wage rate respectively:

$$\frac{\partial Y}{\partial K}\equiv F_K=L\frac{\partial y}{\partial k}\frac{\partial k}{\partial K}=f_k=\alpha Ae^{\lambda t}k^{\alpha-1}=i \qquad (3)$$

$$\begin{aligned}\frac{\partial Y}{\partial L}\equiv F_L&=f(A,t,k)+L\frac{\partial y}{\partial k}\frac{\partial k}{\partial L}=f(A,t,k)-kf_k\\&=f(A,t,k)-k\cdot i=Ae^{\lambda t}k^{\alpha}-k\cdot i=w\end{aligned} \qquad (4)$$

It can be seen that both marginal productivities depend on the capital intensity. Rearranging equation (3) gives:

$$k(i)=f_k^{-1}=(\alpha A)^{\frac{1}{1-\alpha}}e^{\frac{\lambda t}{1-\alpha}}i^{\frac{-1}{1-\alpha}} \qquad (5)$$

and inserting this result (5) into equation (4) yields the factor price frontier:

$$w(i)=f(A,t,k)-k(i)\cdot i=\frac{1-\alpha}{\alpha}(\alpha A)^{\frac{1}{1-\alpha}}e^{\frac{\lambda t}{1-\alpha}}i^{\frac{-\alpha}{1-\alpha}} \qquad (6)$$

with slope:

$$\frac{\partial w}{\partial i}=-k(i)=-(\alpha A)^{\frac{1}{1-\alpha}}\, e^{\frac{\lambda t}{1-\alpha}}\, i^{\frac{-1}{1-\alpha}} < 0 \qquad (7)$$

Its convexity can be derived from equation (7) using equation (3):

$$\frac{\partial^2 w}{\partial i^2}=-\frac{\partial k}{\partial i}=-\frac{1}{f_{kk}}=\frac{1}{1-\alpha}(\alpha A)^{\frac{1}{1-\alpha}}\, e^{\frac{\lambda t}{1-\alpha}}\, i^{\frac{-(2-\alpha)}{1-\alpha}} >0 \qquad (8)$$

In our further analysis two questions will be of interest. First, how do interest and wage rates change, if the capital-labour ratio changes? Second, how do interest and wage rates change, if we explicitly consider the effects of technical change?

These questions can best be answered by deriving the factor price frontier geometrically (Figure 1). The top right diagram shows the per-worker production function as described by equation (2). For every capital-labour ratio, we get a corresponding wage rate.[1] The bottom right diagram shows the decreasing marginal productivity of capital. For every capital-labour ratio we obtain a corresponding interest rate. Mapping the combinations of interest and wage rates that belong to different capital-labour ratios yields the factor price frontier.

First, we analyse how the rate of return and the wage rate change, if the capital-labour ratio changes, e.g. capital is deepened. An increase in the capital-labour ratio, for example from k_0 to k_2 in the top right diagram, leads to an increase in the wage rate $\overline{ak}$ whilst the rate of return $tan\ \alpha$ decreases. Therefore, as the capital endowment per worker rises, the rate of return-wage ratio falls. For the "labour deep-

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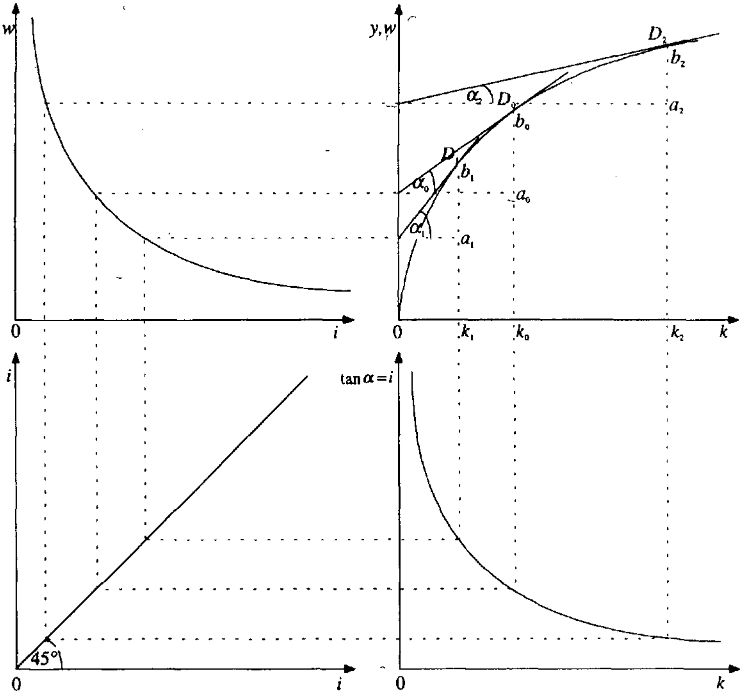
1 $\overline{bk}$ equals the per-worker output y, the ratio $\overline{ab}/\overline{0k}=tan\,\alpha$ equals the rate of return $i=f_k$, and $\overline{ab}$ equals kf_k. So according to equation (4) $\overline{ak}$ equals the wage rate.

ening" case which can be depicted as a shift in the capital-labour ratio from k_0 to k_1, the opposite factor price movements follow.

Figure 1: Factor Price Frontier



The effects can be examined more precisely by looking at the relevant elasticities.

$$\varepsilon_{w,L}=\frac{\partial w}{\partial L}\frac{L}{w}=-\alpha, \qquad \varepsilon_{i,L}=\frac{\partial i}{\partial L}\frac{L}{i}=1-\alpha,$$

$$\varepsilon_{i,K}=\frac{\partial i}{\partial K}\frac{K}{i}=-(1-\alpha), \qquad \varepsilon_{w,K}=\frac{\partial w}{\partial K}\frac{K}{w}=\alpha \tag{9}$$

Thus, if the amount of workers employed in the production process rises by $\Delta L/L$ percent, the wage rate decreases by α percent, and the rate of return increases by $(1-\alpha)$ percent. If employment is reduced, the opposite effects occur. If the capital stock in the production process is raised by $\Delta K/K$ percent, the rate of return decreases by $(1-\alpha)$ percent, and the wage rate increases by α percent.

Second, we explicitly consider the effects of technical progress. In Figure 1, technical progress shifts the per-worker production function as well as the marginal productivity of capital function to the north. As a consequence, the factor price frontier moves to the north-east. From equation (6) it can be seen, that through technical progress it is possible to either increase the wage rate without having to decrease the rate of return (or vice versa), or to increase both the wage rate and the rate of return simultaneously.

It should be noted that technical progress is used in the wide sense of the word. It might reflect not only new plants and machinery but also an improved infrastructure. Similarly, it can be interpreted as a higher amount of human capital per worker.

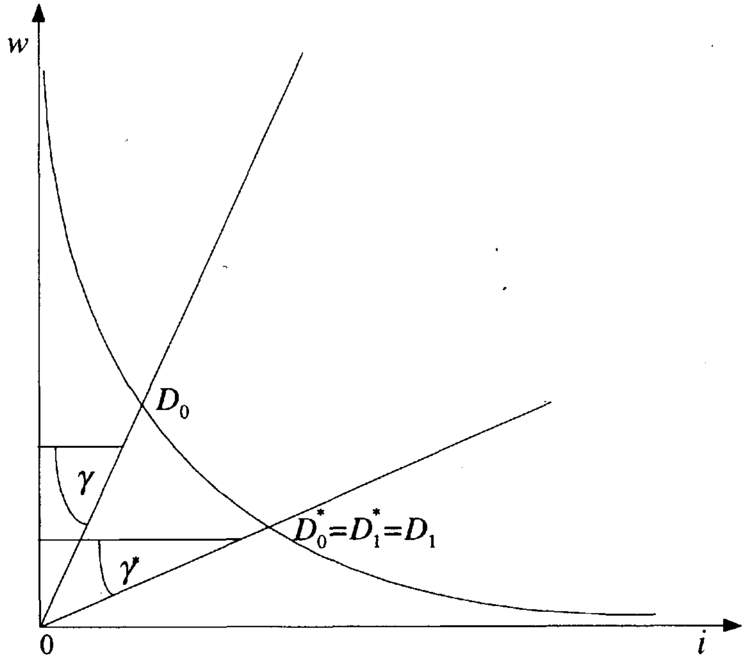
Summing up, two features of the factor price frontier are worth noting. First, a factor price frontier is solely determined by the present state of technology. Technical progress moves the frontier itself. Second, any movement on a factor price frontier is solely determined by the present capital-labour ratio. So, any change in relative factor employment leads to a move on the frontier.

2.1 Flexible Labour Markets

After having introduced the theoretical framework, we now analyse the effects of globalisation. There is a home country that is relatively capital-abundant, and the rest of the world which is relatively labour-abundant. This assumption has been chosen because we are primarily concerned with analysing the effects of locational competition between a highly industrialised country and the rest of the world including emerging markets and transition countries. Furthermore, the home country is small and therefore cannot alter the factor prices abroad. Capital is perfectly mobile across borders, while labour is immobile.

In this section, we assume flexible wages. In the first case – which is shown in Figure 2 – we consider identical technologies but different factor endowments at home and abroad (cf. Siebert 1993: 18). The assumption of identical technologies can be justified by the fact that once a new technology is discovered, it is a public good available to all countries. Consequently, differences in factor prices arise solely due to different factor ratios.

Figure 2: Identical Technologies and Flexible Wages



Initially, the home country is in equilibrium at point D_0, and the rest of the world at point D_0^*. The initial factor price ratios are given by *tan* γ

and *tan* γ^*. Once locational competition starts, capital exits the home country because of the higher rate of return abroad. This leads to a decrease in the home capital-labour ratio and thus to an increase in the rate of return and a fall in the wage rate. Since the home country is assumed to be small, the factor prices abroad remain unchanged. Capital exits the country until the home country's rate of return reaches the international level. Due to the identical production technologies the wage rates also equalise.[2]

In the second case we assume that the production technologies differ between the home country and the rest of the world. This assumption applies to the comparison of an industrialised home country and a rest of the world which is characterised by emerging markets and transition countries. In the short term, these countries cannot completely alter their production process, even when a superior technology is available. This scenario is shown in Figure 3.

Starting from the initial equilibria D_0 and D_0^*, interest rate disparities again trigger a capital flight towards the relatively labour-abundant rest of the world. Just as in the previous scenario, locational competition raises the domestic rate of return until it is as high as the international rate of return. But as a consequence of the differing technologies, the difference in the wage rates is only narrowed, not closed. The same applies for the difference in the relative factor prices *tan* γ and *tan* γ^*. Due to the better technology, labour is still more productive at home than abroad, and therefore receives a higher wage rate. The point D_1 marks the new equilibrium for the home country.

Using the elasticities derived in the preceding section, we get the following result that holds for the identical technologies case as well as for the differing technologies case: If the rate of return abroad is $\Delta i/i$ percent higher than at home, then as soon as we introduce locational

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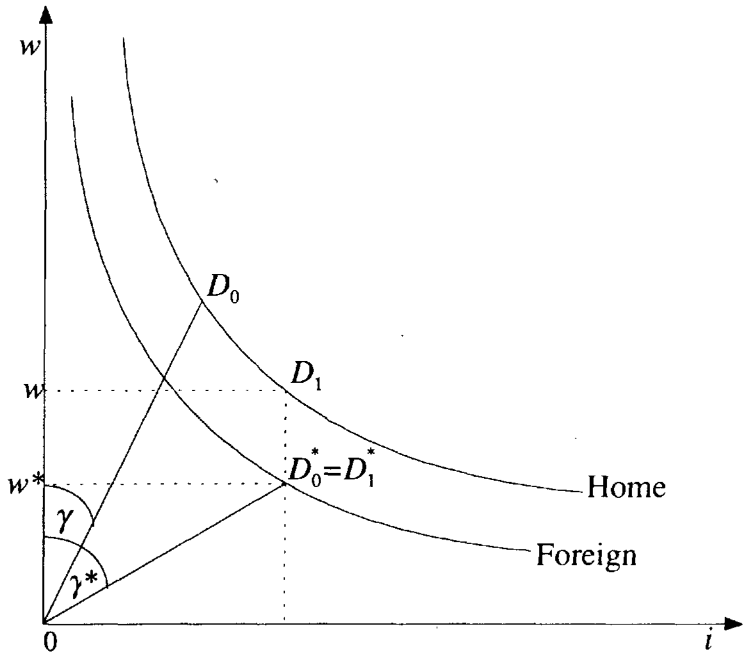
[2] Thus we get a factor price equalisation through factor mobility just as there is a factor price equalisation through trade in a Heckscher-Ohlin framework. Welfare gains can be achieved through factor mobility and trade (cf. Siebert 1994).

competition, $\frac{1}{1-\alpha}\Delta i/i$ percent of the home country's capital exits. Assuming flexible labour markets, the now lower capital-labour ratio leads to a decrease in the wage rate in the home country by $\frac{\alpha}{1-\alpha}\Delta i/i$ percent. Stated differently: In this simple model, in order to avoid unemployment in the home country, workers have to accept a decrease in their pay rolls by $\frac{\alpha}{1-\alpha}\Delta i/i$ percent, where $\Delta i/i$ is the difference between the international and the domestic rate of return.[3]

Figure 3: Different Technologies and Flexible Wages

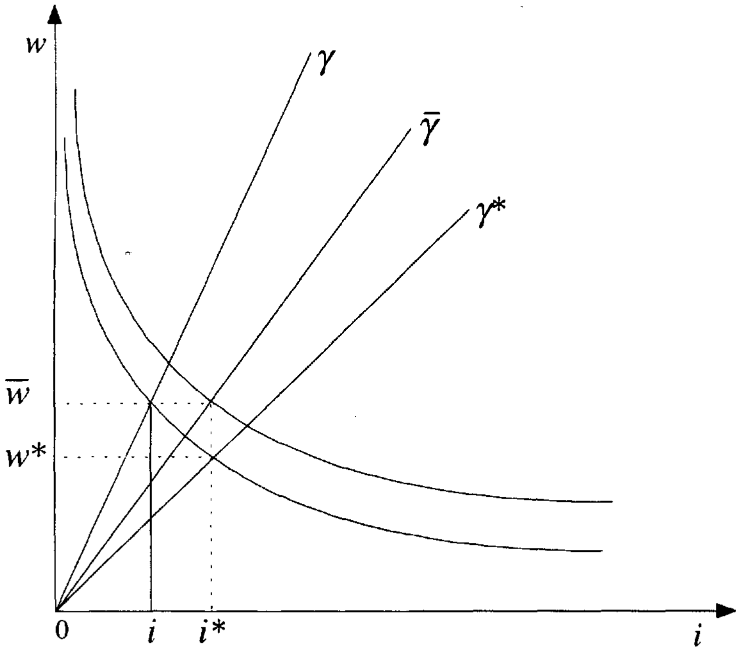


3 A formal proof is given in Appendix A1.

2.2 Non-flexible Labour Markets

In this section we assume that the wage rate is fixed. At a first glance, Figure 4 closely resembles the above cases. But there is an important difference. So far, the domestic rate of return has been set exogenously by the return on capital abroad, and the wage rate has been endogenously determined by the factor price frontier. Now, the wage rate is also exogenously fixed.

Figure 4: Fixed Wages



If the rate of return increases due to locational competition above the initial equilibrium rate i, we get a combination of rate of return i^* and wage rate $\bar{w}$ that lies outside the old factor price frontier. With a given technology it is not possible to simultaneously yield both factors these exogenously determined prices. In our standard two-factor model, laying-off workers is not a solution since it only leads to a move on the frontier, it does not move the frontier itself. So, contrary to traditional insider-outsider models where capital is immobile, a reduction in employment does not lead to a new equilibrium.

To introduce two channels of adjustment – laying-off workers as well as improving technology –, we augment our production function by immobile human capital (Appendix A2). Introducing this additional factor, we get a three-dimensional factor price frontier that defines the relationship between the wage rate and the rate of return on physical capital as well as the rate of return on human capital. Our standard factor price frontier results as a cut through this three-dimensional frontier holding the return on human capital constant. So our geometrical analysis in Figure 4 still applies.

First, we take a look at the adjustment process that is characterised by capital flight and rising unemployment. In our two-factor model, with an exogenous rate of return and an exogenous wage rate, there was no endogenous variable left that allowed for an adjustment process. This is different in a three-factor model, where the additional factor of production provides us with an endogenous variable that can bear the burden of adjustment. As low-skilled workers are laid off, this does not translate into a complete reversal of the initial rise of the rate of return. A new equilibrium with lower employment levels of both capital and labour and an unchanged employment level of human capital evolves: The wage rate remains constant, the rate of return on physical capital rises to the international level, and the rate of return on human capital decreases.[4]

The explanation is straight forward: Entrepreneurs will shift capital abroad, and first lay off those workers who have a relatively poor human capital endowment. Thereby they raise the average human capital endowment of labour and capital. In Figure 4 this can be

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4 A formal proof is given in Appendix A2.

depicted by a shift of the factor price frontier to the north-east. The social cost of this adjustment process is a higher unemployment rate for the low-skilled.

Second, a new equilibrium can be reached by an appropriate improvement in technology. This adjustment resembles the one that has been derived for the two-factor model, where technical progress raises the marginal productivities of the employed factors. Entrepreneurs are forced to engage in a search process in order to be able to pay the exogenously determined factor prices. The implementation of an improved technology is reflected in a shift in the factor price frontier to the north-east.

The advantage of the technology driven adjustment process is that it is – at least theoretically – not accompanied by unemployment. The disadvantage is that this is by its very nature a long-run process. It is also apparent that there are limits to such an "endogenisation of technology" if the factor prices are set too high.

Both adjustment processes might overlap. In the short run, capital flight and rising unemployment move the factor price frontier to the north-east. At the same time a search process for technical progress starts. This search leads eventually to the implementation of a superior technology. Figure 4 shows that the rate of return-wage ratio that evolves $tan\,\bar{\gamma}$ is above the initial ratio $tan\,\gamma$, but still lower than it would be under the assumption of flexible labour markets $tan\,\gamma^*$.

This scenario is not very convincing, though. Looking at the actual experience, we conclude that the adjustment channel of technical change is losing importance. This might sound surprising, since it is common wisdom that the search for improved technology is gaining importance. But this is exactly the point. As entrepreneurs and governments around the world intensify their research effort, it becomes next to impossible for a country to adjust through intensifying its search process even further. As the capability of shifting the factor price frontier by intensifying the search process fades, the whole burden lies on the adjustment channel that is based on capital flight and rising unemployment when wages are non-flexible.

3. Empirical Results

In order to estimate our model, we introduce a stochastic white noise process u in our per-worker production function (2).[5] The subscript t denotes time.

$$y_t = f(A,t,k_t) = Ae^{\lambda t+u_t}\,k_t^{\alpha} \tag{2'}$$

The factor price frontier of equation (6), then becomes the stochastic factor price frontier:

$$w_t(i_t) = f(A,t,k_t) - k_t(i_t)\cdot i_t = \frac{1-\alpha}{\alpha}(\alpha A)^{\frac{1}{1-\alpha}}\,e^{\frac{\lambda t+u_t}{1-\alpha}}\,i_t^{\frac{-\alpha}{1-\alpha}} \tag{6'}$$

which for estimation purposes can be written as:

$$\log w_t = \theta_0 + \theta_1 t + \theta_2 \log i_t + \varepsilon_t \tag{10}$$

with

$$\theta_0 = \log\left[\frac{1-\alpha}{\alpha}(\alpha A)^{\frac{1}{1-\alpha}}\right],\ \theta_1 = \frac{\lambda}{1-\alpha},\ \theta_2 = \frac{-\alpha}{1-\alpha},\ \text{and}\ \varepsilon_t = \frac{1}{1-\alpha}\,u_t.$$

To estimate factor price frontiers for the United States and Germany[6], we use semi-annual data over the period from 1961 to 1996 (OECD 1997a). As a wage measure, an index of gross wages or salaries of full-time workers in the manufacturing sector is used (OECD 1996: 22, 66). As a profit measure, a rate of return on the capital stock in the

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5 $E(u)=0;\ E(uu')=\sigma^2 I$.

6 All data refer to West Germany only.

business sector is used (OECD 1995: A80).[7] Since both measures are nominal, they are deflated by a producer price index also taken from the OECD (1997a). For the actual estimation of equation (10), the natural logarithms of the measures are taken. Table A1[8] summarises some descriptive statistics of the real wage index and the real rate of return. Both variables are integrated of order 1, as can be seen from the Augmented Dickey-Fuller tests. Therefore, we use the Johansen procedure to estimate the factor price frontiers for the United States and Germany.[9]

3.1 The Factor Price Frontier for the United States

Modelling both the real wage index and the real rate of return initially as endogenous, the system is found to contain one cointegration vector (Table A2).[10] This vector contains a constant as well as a linear

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[7] Since the real rate of return is negative for the United States in 74:2 and for Germany in 74:1 and 74:2, the natural logarithm could not be taken for these periods. Instead, values were inserted that are compatible with the movement of the real rate of return: Since the observed negative real rates of return were the minimum in the sample, we set values for the logarithm of the real rate of return that also constituted the minimum of the sample. It was necessary to fill in these periods, because the CATS procedure used for estimation cannot deal with missing observations. By not inserting artificial values for the missing observations, the sample would have been seriously shortened to 75:1 to 96:1.

[8] All tables are presented in Appendix C.

[9] Appendix B gives a brief overview of the Johansen procedure. See also the works cited there.

[10] Before the Johansen procedure can be estimated, the optimum lag length of the VAR has to be determined. To do this, we look at four information criteria: the Aikaike information criterion (AIC), the augmented AIC, the Schwartz criterion, and the Hannan-Quinn criterion. We consider these four standard information criteria, since no single criterium has proven to be superior to the others in all settings (cf. Lütkepohl 1991: 130pp). The information criteria indicate an optimum lag of 1. However, the result is not unequivocal. To better control for autocorrelation, the lag length is increased to 2. Also, there are three dummies included to allow for temporary disturbances during the two oil crisis, and there is a dummy set for the observation 74:2.

trend.[11] Hence, the data supports the theoretical set up of equation (10). Testing for weak exogeneity, we can reject the null hypothesis that the real rate of return is weakly exogenous. The LR statistic is $\chi^2(1) = 15.22$ with the critical value being $\chi^2_{0.05}(1) = 3.84$. The null of weak exogeneity of the real wage index is not rejected. The LR statistic is $\chi^2(1) = 2.34$.

At first this result may seem somewhat surprising. In a small open economy with perfect international capital mobility, we would expect the real rate of return to be exogenously given. The real wage would need to adjust to secure full employment along the factor price frontier. But from a historical perspective, international capital mobility was far from perfect at the beginning of our sample. In fact, only after the mid-eighties has international capital mobility reached the level it had reached before 1900 (cf. Taylor 1996 and IMF 1997). Moreover, although the common perception of the U.S. labour market is that of a flexible market, this picture is strongly influenced by the experience of the eighties and nineties. Unions in the United States were still strong in the sixties; their influence only began to diminish in the seventies. The first half of the seventies were marked by federal wage-price controls. So while we would expect the real wage rate to be endogenous to the system in the late eighties and nineties, it seems reasonable for it to be weakly exogenous before the mid-eighties.

For estimation purposes the finding of weak exogeneity implies that we can condition our system on the exogenous real wage index (cf. Johansen 1992). Thus the real rate of return is the only endogenous

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[11] We test for cointegration rank of the system and the presence of a constant and a linear trend simultaneously according to the Pantula principle (e.g. Harris 1995: 97). Starting with the most restrictive null of $r=0$, no constant, and no linear trend in the cointegration vector, the null is relaxed by first allowing for a constant, second by allowing for a linear trend while r still equals zero. Next r is increased. The model type and the cointegration rank are determined simultaneously as soon as the null is rejected for the first time. The results are not presented here, but are available from the authors upon request. This holds for all other results not explicitly presented in this paper.

variable that remains in the system. Our two-dimensional VAR reduces to a single-equation model. The estimated long-run factor price frontier in the specification of equation (10) is (Table A3):[12]

log real rate of return =

$$5.70 \quad + 0.01 * trend \quad - 3.49 * log\ real\ wage\ index \qquad (10')$$

The estimate for the loading coefficient is –0.32. Hence, deviations from the long-run equilibrium are reduced by 32 percent from one period to another. A one percent increase in the real wage index leads to a 3.49 percent decrease in the real rate of return in the long-run. The estimated parameters of our production function (2') are:

efficiency parameter	A	=	6.04
exogenous technical progress	λ	=	0.02
output elasticity of capital	α	=	0.22

The estimate for α is well in the range of other empirical studies (e.g. Mankiw et al. 1992). This production elasticity α translates into a wage share in manufacturing of 78 percent.[13] Technical progress appears to take place at a somewhat low rate λ. However, it is likely that the linear trend not only catches the influence of an exogenous technical progress, but also the influence of the two oil crisis that can be regarded as a technical regress (cf. Bruno 1984).

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[12] In contrast to a standard application of the Johansen procedure, we had to include a dummy for the 1978/79 oil crisis in the cointegration vector to come up with a Gaussian residual. The long-run dummy was modelled as an exogenous variable in the conditional model. There are more dummies included in the short-run dynamics (Table A3).

[13] Recall the link between the production elasticities and the income distribution (see equation (A6)). The wage share was 75 percent in 1994 and 76 percent in 1990 (data taken from Sachverständigenrat 1996; own calculations). Hence our point-estimate is fairly close to actual figures.

Plotting our estimation results, a single factor price frontier can be detected that moves slowly to the north-east throughout our sample period.[14] This movement reflects exogenous technical progress (Figure 5).[15] The U.S. economy moves back and forth along this frontier with only temporary inward shifts being observed during the oil shocks (cf. Bruno 1984). Thus, the real rate of return and the real wage rate fell as a response to the negative external shocks; both factor prices shared the burden of adjustment. The United States suffered from high unemployment during times of economic restructuring in the seventies and early eighties. However, there is no ratcheting-up of the unemployment rate (Figure 6).

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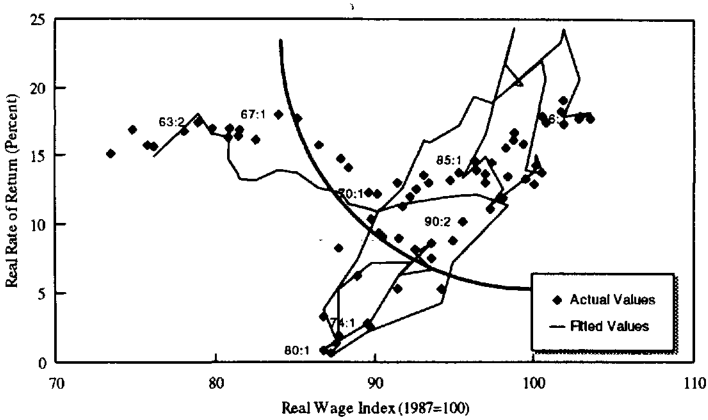
[14] Notice that the real wage index is now plotted on the x-axis, while the real rate of return is plotted on the y-axis. This reflects the fact that the real wage index is weakly exogenous in our empirical research, contrary to our a priori theoretical reasoning.

[15] Technical progress enters the cointegration vector as a deterministic trend that constitutes a third dimension of our factor price frontier, while our graphical representation shows only two dimensions, namely the real wage index and the real rate of return.

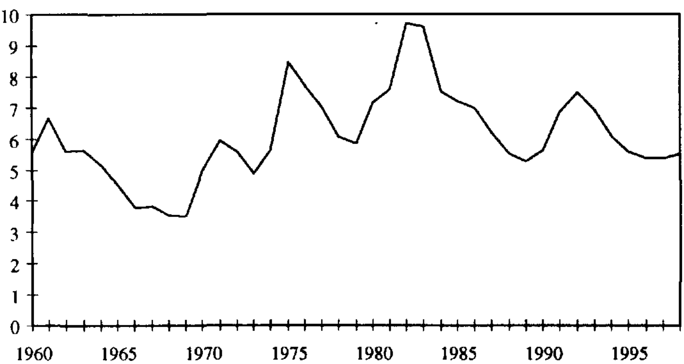
Figure 5 — The Empirical Factor Price Frontier for the United States[a]



[a]*An artificial value is used for the real rate of return in 74:2. Cf. footnote 7.*

Source: OECD (1997a); own calculations.

Figure 6 — The Unemployment Rate of the United States (Percent)[a]



[a]*Figures for 1997 and 1998 are OECD projections.*

Source: OECD (1997a) and OECD (1997b).

3.2 The Factor Price Frontier for Germany

In estimating the factor price frontier for Germany we proceed just as in the U.S. case.[16] The initial specification models the real wage index and the real rate of return as endogenous (Table A4). Testing for a constant and a linear trend according to the Pantula principle arrives at a cointegration rank of one, with the cointegration vector containing a constant and a linear trend. Testing for weak exogeneity, we can reject the null hypothesis that the real rate of return is weakly exogenous. The LR statistic is 15.25 with the critical value being $\chi^2_{0.05}(1) = 3.84$. But we cannot reject the hypothesis that the real wage index is weakly exogenous. The LR statistic is 1.12. The critical value is the same as above. This result implies that the real wage index is determined outside the system just as in the U.S. case.

Again, this unexpected result is well founded in the actual development. Strong unions in Germany were capable of pushing through high annual wage increases in the sixties when labour was scarce, as well as in the seventies and eighties despite rising unemployment. With respect to international capital mobility, the same remarks apply as above.

We estimate a system with a single endogenous variable, the real rate of return conditioned on an exogenous variable, the real wage index, as well as various deterministic variables, included to guarantee Gaussian residuals (Table A5). The estimated long-run factor price frontier in the specification of equation (10) is:[17]

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[16] First, the optimum lag length of the VAR is determined by looking at the four information criteria. They suggest a lag length of 1, but the result is not clear cut. To control for autocorrelation, the lag length is set to 2. Also, we need to include dummies for the 1967 recession, the 1974 and 1979 oil crisis, and for the two observations 74:1 and 74:2 where we had to arbitrarily set values for the real rate of return.

[17] As in the case of the United States, we had to include dummies in the cointegration vector to come up with a Gaussian residual. The long-run factor price frontier relationship was seriously disturbed during the German recession of 1967 as well as during the two oil shocks. The recession of 1967 lowered the

log real rate of return =

$$3.80 + 0.04 * trend - 1.66 * log\ real\ wage\ index \qquad (10'')$$

The estimated loading coefficient is –0.49. Hence, deviations from the long-run equilibrium are reduced by almost 50 percent from one period to the next. Neglecting technical progress, a one percent increase in real wages is associated with a 1.66 percent decrease in the real rate of return.

The estimated parameters of our production function (2') are:

efficiency parameter	A	=	8.08
exogenous technical progress	λ	=	0.01
output elasticity of capital	α	=	0.38

The same remarks as in the U.S. case apply. Our estimate of α is in the range of other empirical studies. The production elasticity α translates into a wage share in manufacturing of 62 percent on average in our sample.[18] The rate of technical progress is low, but this can be traced back to the oil crisis.

The estimated factor price frontier is plotted in Figure 7. Three distinct factor price frontiers can be detected. The first convex factor price frontier holds for the period from 1962 to 1974. The first oil shock is associated with an outward shift of the factor price frontier. The new frontier holds from 1975 to about 1980. We observe another outward

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real rate of return while wages remained constant. Adjustment took place through a reduction in profits and through laying off workers which translated into higher unemployment (Figure 8). The implications for the oil price shocks are not as clear cut, but we do see a significant disturbance of our long-run relationship (Table A5).

[18] The wage share in manufacturing was 69 percent in 1995 and 67 percent in 1990 (data taken from Sachverständigenrat 1996; own calculations). Hence our point-estimate is fairly close to actual figures.

shift of the factor price frontier in the aftermath of the second oil shock. This last frontier holds from 1986 to 1992. After 1992 there is a third outward shift which is probably associated with the effects of globalisation and German unification, but no new factor price frontier has yet emerged.

Thus, the U.S. and the German experience are quite different. In the United States we see a smooth, continuous outward movement of the factor price frontier that is temporarily reversed by the oil shocks. In Germany we see three distinct shifts during times of economic crisis.

The three outward shifts of the German factor price frontier can be explained as follows: During the sixties and early seventies, when labour was scarce, the economy moved from a situation of a high real rate of return and a low real wage rate at the beginning of the German economic miracle to a situation of a decreasing real rate of return and a rising real wage rate (Giersch et al. 1994: 126). The oil shock of 1973/74 marked the end of this development. Investors reacted to this negative supply shock in the face of non-flexible labour markets by laying off low-skilled labour, thereby raising the average human capital of the employed.[19] This was accompanied by the introduction of skill-biased technical progress. Both of these efforts led to an outward shift

[19] Since the mid-seventies, employment by skill level is fairly well documented. Skill-specific unemployment rates for Germany are presented in Figure A2. For Germany we see an annual reduction of low-skilled workers by 4 percent over the period from 1984 to 1994, whereas employment of low-skilled workers remained roughly constant in the United States over the same period. On the other hand, employment of high-skilled workers increased by an annual rate of about 4 percent in both countries (OECD 1997b: 96).

of the factor price frontier and to the first significant hike in unemployment since the beginning of the economic miracle (Figure 8).[20]

The next shift follows a similar pattern. In normal times, wages increased and the economy moved down the factor price frontier. The second oil shock of 1979/80 again led to low-skilled labour being laid off. Just as before this led to an outward shift of the factor price frontier due to an increase in average human capital. The second significant hike of the German unemployment rate in 1980 results from this.

The third shift after 1990 has not yet led to a detectable fourth factor price frontier. It was triggered by the recession following the unification boom and the general effects of globalisation which are characterised by an intensification of international competition.[21] Again, the outward shift that is brought about by releasing low-skilled labour coincides with a hike in the unemployment rate.

To sum up, the simple story runs as follows. In good times, real wages rise and the economy moves down the factor price frontier. In times of economic crisis that require economic adjustment, wages cannot fall, since labour markets in Germany are characterised as non-flexible. Instead, investors have to react by laying off low-skilled labour, which raises the average human capital of the labour force, in order to induce

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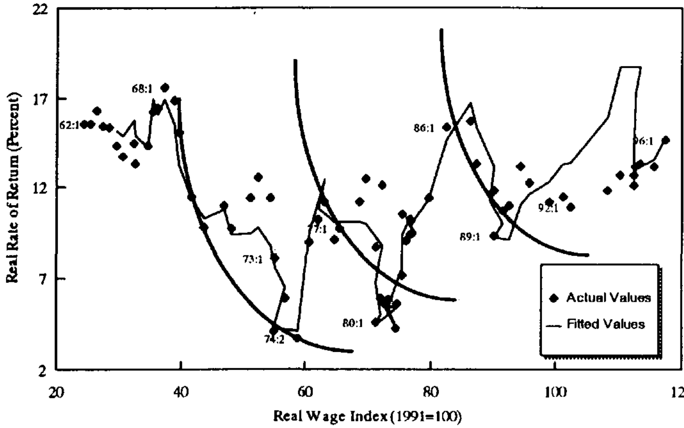
[20] The development of the return on human capital is in accordance with our reasoning in 2.3. The decrease in the return on human capital that was part of the adjustment process translates into an absence of increasing wage dispersion in the real world. As Figure A1 shows, the return on human capital has moved in line with the wage rate for low-skilled labour. There has been no increase in the wage dispersion by skill level due to changes in the relative demand for labour as it is well documented for the United States (e.g. OECD 1997b: 100).

[21] See the development of the German export prices as documented in Siebert (1997).

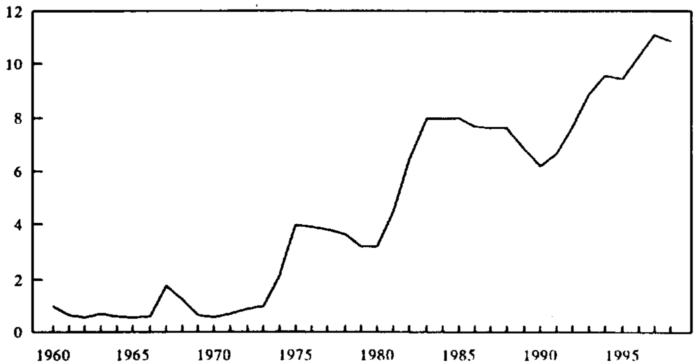
Figure 7 — The Empirical Factor Price Frontier for Germany[a]



[a]Artificial values are used for the real rate of return in 74:1 and 74:2 (Cf. footnote 7).

Source: OECD (1997a); own calculations.

Figure 8 — The German Unemployment Rate (Percent)[a]



[a]Figures for 1997 and 1998 are OECD projections.

Source: OECD (1997a) and OECD (1997b).

an outward shift of the factor price frontier. Other reactions include the introduction of skill-biased technical progress and moving capital abroad for the sake of better investment opportunities. As a consequence we observe a secular rise in the German unemployment rate through three distinct hikes that are closely associated with shifts in the factor price frontier.[22]

4. Conclusion

Using the neoclassical concept of the factor price frontier, we have investigated the effects of globalisation on labour and capital. In a closed economy we would theoretically expect both the wage and interest rates to be set endogenously, being determined by the capital-labour ratio and the technological level. In open economies with fully flexible markets and identical technologies, capital movements across countries would lead to all countries having the same factor prices. Thus, instead of international trade as in a Heckscher-Ohlin setting, it is factor mobility which leads to factor price equalisation. This result no longer holds if the home country has a superior technology. In this case, the real rates of return are equalised through capital mobility, while the real wage at home falls, but still remains higher than abroad.

If an open economy has a non-flexible labour-market, wages cannot adjust to the exogenously given rate of return. By introducing human capital as a third production factor, two channels of adjustment open up: capital flight accompanied by laying off low-skilled workers to increase average human capital on the one hand, and technical progress on the other. Both channels lead to an outward shift of the two-dimensional factor price frontier. It has been argued that technical change is not a feasible option for adjustment. Hence, in an open economy with a non-flexible labour market, capital flight and increased unemployment of low-skilled workers results.

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[22] Blanchard (1997) comes to a similar conclusions about the German labour market development using a different approach. He supports his findings with simulations of a simple labour market model.

The factor price frontier was estimated for the United States and Germany. In both countries the real wage was set autonomously with the real rate of return having to adjust due to strong unions pushing through high wage increases as well as due to restrictive labour market regulations. All other empirical results for the United States and Germany proved to be very different. The United States has moved along a single frontier which shifts out slowly over the sample period, reflecting technical change. Unemployment rises in recessions, but falls again in booms.

Germany on the other hand, has had three distinct outward shifts of its factor price frontier: in the seventies and eighties due to the effects of the two oil shocks and more recently in the aftermath of the unification boom combined with the effects of increased globalisation. In all cases, wages rose during times of economic prosperity, lowering the real rate of return, with investors trying to recapture lost ground when economic performance in Germany declined. For this reason, each outward shift also resulted in a distinctly higher unemployment rate as capital exited the country and skill-biased technical change was introduced.

There are several policy implications that can be drawn from our analysis. In so far as the high unemployment rates in Germany have been caused by strong unions, increased responsibility of course lies with them and there is little that the government can do directly. With ever rising unemployment rates in Germany, the pressure on the unions has increased. Indeed, in the past few years, even if nominal wages have increased, real wages have fallen slightly.[23]

Further, competition on product markets in Germany has to be increased forcing companies to respond to market pressures more quickly and thus improve their productivity through investments in new technology. A recent McKinsey survey compared German productivity levels in six key sectors with the equivalent industries in the United States, Japan or the Netherlands (McKinsey Global Institute 1997). It turned out that German productivity was lower in all six industries as compared to the respective benchmark industry. One of the main

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[23] Data taken from Sachverständigenrat 1996: 428pp; own calculations.

reasons for this was that productivity growth has been constrained by product market regulations. Moreover, industries which faced strong competition were not only the most productive, but were also able to have high employment growth rates. Therefore, one government policy aimed at reducing unemployment should be to lower the level of subsidies paid to firms. It is hoped that with the start of the European Monetary Union planned in 1999 that competition, at least within Europe, will increase and thus lead to rising employment levels.

Although our results are based on the factor price frontier with its very restrictive assumptions, the theory does provide an indicator of the different adjustment processes taking place in the two countries. Any outward shift of the two-dimensional factor price frontier can only be explained exogenously. For this reason, the model of course needs to be modified, with for example, endogenous technical progress. However, such a modification would go beyond the scope of this paper. Further, it is becoming increasingly important to differentiate between high-skilled and low-skilled labour. Even though the theoretical modifications are only minor, the empirical data proved to be problematic, as high-skilled workers were not paid according to their marginal productivity, but instead, at least in Germany, their wage was very closely linked to that of the low-skilled workers. Further research in this area is intended by the authors.

Even though the first few signs of economic recovery in Germany are appearing, the future economic climate is very uncertain due to planned reforms of the health, pension and tax systems as well as general elections next year. This induces companies to hold off investments until the results of these reforms are clearer. For this reason it seems unlikely that there will be a large decrease in Germany's unemployment rate in the short term. Even taking into account improvements achieved by the above planned reforms, this paper clearly shows that with capital becoming increasingly mobile, Germany will also have to make its labour markets more flexible if it is to avoid further sharp increases in unemployment or better still, bring about an actual decline in unemployment.

Appendices

Appendix A1 – Two-Factor Model

In section 2.1 we assume that as locational competition is introduced, the interest rate abroad is $\Delta i_1/i_1$ percent higher than at home.

The capital flight in percent of the capital stock is determined by:

$$\Delta K/K=\varepsilon_{K,i}\Delta i_1/i_1=\frac{1}{\varepsilon_{i,K}}\cdot\Delta i_1/i_1=\frac{-1}{1-\alpha}\Delta i_1/i_1 \qquad \text{(A1)}$$

The decrease in the domestic wage rate in percent follows as:

$$\Delta w_1/w_1=\varepsilon_{w,K}\cdot\varepsilon_{K,i}\cdot\Delta i_1/i_1=\frac{-\alpha}{1-\alpha}\Delta i_1/i_1 \qquad \text{(A2)}$$

In section 2.2, the wage rate is fixed at $\overline{w}$.

So, labour has to be reduced by:

$$\Delta L/L=-\varepsilon_{L,w}\cdot\Delta w_1/w_1=-\frac{1}{\varepsilon_{w,L}}\cdot\Delta w_1/w_1=\frac{1}{\alpha}\Delta w_1/w_1 \qquad \text{(A3)}$$

In our two-factor model, no new equilibrium evolves by lowering the employment of both factors simultaneously. This can be seen from equation (A4): If workers are laid off in order to establish the initial wage level, the interest rate also goes back to its initial level.

$$\Delta i_2/i_2=\varepsilon_{i,L}\cdot\varepsilon_{L,w}\cdot\Delta w_2/w_2=\varepsilon_{i,L}\cdot\varepsilon_{L,w}\left(-\Delta w_1/w_1\right)=\frac{1-\alpha}{\alpha}\cdot\Delta w_1/w_1$$

$$=-\varepsilon_{w,K}\cdot\varepsilon_{K,i}\cdot\varepsilon_{i,L}\cdot\varepsilon_{L,w}\cdot\Delta i_1/i_1=-\Delta i_1/i_1$$

$$\left|\Delta w_2/w_2\right|=\left|\Delta w_1/w_1\right|\Rightarrow\left|\Delta i_2/i_2\right|=\left|\Delta i_1/i_1\right| \qquad \text{(A4)}$$

In an economy which production technology is of the Cobb-Douglas type, the production elasticity of a factor equals the share of income that this factor obtains. This can be shown by:

$$\frac{i \cdot K}{Y} = \frac{F_K \cdot K}{F(A,t,K,L)} = \alpha \qquad \text{(A5)}$$

and

$$\frac{w \cdot L}{Y} = \frac{F_L \cdot L}{F(A,t,K,L)} = 1 - \frac{i \cdot K}{Y} = 1 - \alpha \qquad \text{(A6)}$$

Appendix A2 – Three-Factor Model

In section 2.2 we augment our two-factor model by human capital. Again, we base our analysis on a Cobb-Douglas production function:

$$Y = F(A,t,K,H,L) = Ae^{\lambda t} K^{\alpha} H^{\beta} L^{1-\alpha-\beta} \quad \alpha, \beta > 0 \, ; \, 0 < \alpha + \beta < 1 \qquad \text{(A7)}$$

where H denotes the amount of human capital. Dividing equation (A7) by the amount of labour yields the per-worker production function:

$$y = \frac{1}{L} F(A,t,K,H,L) = f(A,t,k,h) = Ae^{\lambda t} k^{\alpha} h^{\beta} \qquad \text{(A8)}$$

The marginal products of physical capital, human capital, and labour equal the rates of return on physical capital, human capital and the wage rate respectively:

$$\frac{\partial Y}{\partial K} = F_K = f_k = \alpha \cdot A \, e^{\lambda t} \, k^{\alpha - 1} \, h^{\beta} = i \qquad \text{(A9)}$$

$$\frac{\partial Y}{\partial H} = F_H = f_h = \beta \cdot A \, e^{\lambda t} \, k^{\alpha} \, h^{\beta - 1} = r \qquad \text{(A10)}$$

$$\frac{\partial Y}{\partial L} = F_L = f(A,t,k,h) + L\cdot\frac{\partial y}{\partial k}\frac{\partial k}{\partial L} + L\cdot\frac{\partial y}{\partial h}\cdot\frac{\partial h}{\partial L}$$

$$= f(A,t,k,h) - k\cdot f_k - h\cdot f_h$$

$$= f(A,t,k,h) - k\cdot i - h\cdot r = A\,e^{\lambda t}\,k^{\alpha}\,h^{\beta} - k\cdot i - h\cdot r = w \qquad \text{(A11)}$$

Rearranging equation (A9) gives:

$$h^{\beta-1} = \alpha^{\frac{1-\beta}{\beta}}\,A^{\frac{1-\beta}{\beta}}\,e^{\frac{(1-\beta)\lambda t}{\beta}}\,k^{\frac{-(1-\alpha)(1-\beta)}{\beta}}\,i^{\frac{-(1-\beta)}{\beta}} \qquad \text{(A12)}$$

Inserting equation (A12) in equation (A10) yields:

$$r = \alpha^{\frac{1-\beta}{\beta}}\cdot\beta\cdot A^{\frac{1}{\beta}}\,e^{\frac{\lambda t}{\beta}}\,k^{\frac{-(1-\alpha-\beta)}{\beta}}\,i^{\frac{-(1-\beta)}{\beta}} \qquad \text{(A13)}$$

The per-worker stock of physical capital results as:

$$k = \alpha^{\frac{1-\beta}{1-\alpha-\beta}}\,\beta^{\frac{\beta}{1-\alpha-\beta}}\,A^{\frac{1}{1-\alpha-\beta}}\,e^{\frac{\lambda t}{1-\alpha-\beta}}\,i^{\frac{-(1-\beta)}{1-\alpha-\beta}}\,r^{\frac{-\beta}{1-\alpha-\beta}} \qquad \text{(A14)}$$

Rearranging equation (A9) gives:

$$k^{\alpha} = \alpha^{\frac{\alpha}{1-\alpha}}\,A^{\frac{\alpha}{1-\alpha}}\,e^{\frac{\alpha\lambda t}{1-\alpha}}\,h^{\frac{\alpha\beta}{1-\alpha}}\,i^{\frac{\alpha}{1-\alpha}} \qquad \text{(A15)}$$

Inserting equation (A15) in equation (A10) yields:

$$r = \alpha^{\frac{\alpha}{1-\alpha}}\,\beta A^{\frac{1}{1-\alpha}}\,e^{\frac{\lambda t}{1-\alpha}}\,h^{\frac{-(1-\alpha-\beta)}{1-\alpha}}\,i^{\frac{-\alpha}{1-\alpha}} \qquad \text{(A16)}$$

The per-worker stock of human results as:

$$h = \alpha^{\frac{\alpha}{1-\alpha-\beta}}\,\beta^{\frac{1-\alpha}{1-\alpha-\beta}}\,A^{\frac{1}{1-\alpha-\beta}}\,e^{\frac{\lambda t}{1-\alpha-\beta}}\,i^{\frac{-\alpha}{1-\alpha-\beta}}\,r^{\frac{-(1-\alpha)}{1-\alpha-\beta}} \qquad \text{(A17)}$$

Inserting equations (A14) and (A17) in equation (A11) yields the factor price frontier:

$$w = f(A,t,k,h) - k \cdot i - h \cdot r$$
$$= \Psi A^{\frac{1}{1-\alpha-\beta}} \cdot e^{\frac{\lambda t}{1-\alpha-\beta}} \cdot i^{\frac{-\alpha}{1-\alpha-\beta}} \cdot r^{\frac{-\beta}{1-\alpha-\beta}} \qquad \text{(A18)}$$

where

$$\Psi = \left[\alpha^{\frac{\alpha}{1-\alpha-\beta}} \beta^{\frac{\beta}{1-\alpha-\beta}} - \alpha^{\frac{1-\beta}{1-\alpha-\beta}} \beta^{\frac{\beta}{1-\alpha-\beta}} - \alpha^{\frac{\alpha}{1-\alpha-\beta}} \beta^{\frac{1-\alpha}{1-\alpha-\beta}} \right].$$

With slopes:

$$\frac{\partial w}{\partial i} = \Psi \frac{-\alpha}{1-\alpha-\beta} A^{\frac{1}{1-\alpha-\beta}} \cdot e^{\frac{\lambda t}{1-\alpha-\beta}} \cdot i^{\frac{-(1-\beta)}{1-\alpha-\beta}} r^{\frac{-\beta}{1-\alpha-\beta}} < 0 \qquad \text{(A19)}$$

$$\frac{\partial w}{\partial r} = \Psi \frac{-\beta}{1-\alpha-\beta} A^{\frac{1}{1-\alpha-\beta}} \cdot e^{\frac{\lambda t}{1-\alpha-\beta}} \cdot i^{\frac{-\alpha}{1-\alpha-\beta}} \cdot r^{\frac{-(1-\alpha)}{1-\alpha-\beta}} < 0 \qquad \text{(A20)}$$

The convexity of the factor price frontier can easily be verified by looking at the relevant second derivatives.

Straight forward calculations lead to the elasticities:

$$\varepsilon_{i,K} = \frac{\partial i}{\partial K} \cdot \frac{K}{i} = -(1-\alpha) \quad \varepsilon_{r,K} = \frac{\partial r}{\partial K} \cdot \frac{K}{r} = \varepsilon_{w,K} = \frac{\partial w}{\partial K} \cdot \frac{K}{w} = \alpha$$

$$\varepsilon_{r,H} = \frac{\partial r}{\partial H} \cdot \frac{H}{r} = -(1-\beta) \quad \varepsilon_{i,H} = \frac{\partial i}{\partial H} \cdot \frac{H}{i} = \varepsilon_{w,H} = \frac{\partial w}{\partial H} \cdot \frac{H}{w} = \beta$$

$$\varepsilon_{w,L} = \frac{\partial w}{\partial L} \cdot \frac{L}{w} = -(\alpha+\beta) \quad \varepsilon_{i,L} = \frac{\partial i}{\partial L} \cdot \frac{L}{i} = \varepsilon_{r,L} = \frac{\partial r}{\partial L} \cdot \frac{L}{r} = 1-\alpha-\beta \qquad \text{(A21)}$$

In section 2.2 we assume that the interest rate i^* and the wage rate $\overline{w}$ are exogenously determined. Contrary to the two-factor model, the human capital augmented model yields a new equilibrium. As can be seen from equation (A22), after having lowered the employment of both factors, the interest rate goes back to its initial level only for the case $\beta=0$. In this case the three factor-model reduces to our initial two-factor model.

$$\begin{aligned}\Delta i_2/i_2 &= \varepsilon_{i,L}\varepsilon_{L,w}\cdot\Delta w_2/w_2=\varepsilon_{i,L}\cdot\varepsilon_{L,w}\left(-\Delta w_1/w_1\right)\\ &=\frac{1-\alpha-\beta}{\alpha+\beta}\Delta w_1/w_1\\ &=-\varepsilon_{w,K}\cdot\varepsilon_{K,i}\cdot\varepsilon_{i,L}\cdot\varepsilon_{L,w}\cdot\Delta i_1/i_1=\frac{-\alpha(1-\alpha-\beta)}{(\alpha+\beta)(1-\alpha)}\Delta i_1/i_1\\ \left|\Delta w_2/w_2\right| &=\left|\Delta w_1/w_1\right|\Rightarrow\left|\Delta i_2/i_2\right|\leq\left|\Delta i_1/i_1\right|\end{aligned} \tag{A22}$$

The link between production elasticities and the shares of income holds for the three-factor model too as the reader can easily verify.

Appendix B – Econometric Methods

The Johansen procedure is a general method to analyse a p-dimensional vector autoregressive model with Gaussian errors.

$$z_t=A(L)z_t+\mu+\Psi D_t+\varepsilon_t \tag{A23}$$

where $A(L)=A_1L^1+...+A_kL^k$ and L is the lag operator. z_t is a $px1$ vector of stochastic variables whose starting values are fixed. In our case z_t consists of the real wage index and the real rate of return. ε_t are *niid* $(0,\Sigma)$. D_t is a vector of non-stochastic variables, e.g. dummies. For estimation, the model is translated into the error-correction form:

$$\Delta z_t=\Pi z_{t-1}+\Psi D_t+\Gamma(L)\Delta z_t+\varepsilon_t\ , \tag{A24}$$

where

$$\Gamma(L)=\Gamma_1L^1+\Gamma_2L^2+...+\Gamma_{k-1}L^{k-1}.$$

Π can be decomposed according to $\Pi=\alpha\beta'$, where α is the matrix of loading coefficients that describe the speed of adjustment. β contains the cointegration vectors in its columns. Our long-run factor price frontier given by equation (2) is described by $\beta' z_{t-1}$ in this dynamic specification.

Johansen (1988) has proposed a maximum likelihood approach to estimate (A24) that reduces to an eigenvalue problem. The eigenvalues that are calculated in the estimation process are used to test for cointegration. The test for cointegration is a test of the rank of Π. The null hypothesis is $H_0: rk(\Pi)=r$, where r is the number of cointegration vectors in the system. There are two statistics based on the likelihood ratio principle (LR) to test for cointegration. The trace statistic tests the above null against $H_1: rk(\Pi)=p$. The maximum eigenvalue statistic tests the above null against $H_1: rk(\Pi)=r+1$. The test statistics have no standard distribution. Critical values are taken from Monte Carlo simulations and are tabulated (e.g. Osterwald-Lenum 1992)[24].

The process of determining the cointegration rank of the system is iterative. First, $H_0: rk(\Pi)=r=0$ is tested. Then r is increased until H_0 is rejected for the first time. The two statistics can give contradictory results. The trace statistic performs somewhat better in Monte Carlo simulations, hence more weight can be placed on it (Harris 1995: 89).

After having determined the cointegration rank of the system, we want to test for weak exogeneity of either variable. A variable is considered weakly exogenous to the system if the cointegration vectors do not enter the equation determining its first difference (cf. Johansen 1992). This implies that the variable is not determined within the system in the long-run. If a variable is weakly exogenous, the system can be conditioned on this variable, which will in most cases improve its stochastic properties. The test for weak exogeneity of variable i is a likelihood

[24] We use the critical values provided by CATS in the estimation output. The critical values are given for the 10 percent significance level.

ratio test of all zeros in row i of α. The test statistic is χ^2 (number of weakly exogenous variables under H_0) distributed.

Appendix C – Empirical Results

Table A1 – Descriptive Statistics of the Time Series for the United States and Germany

	United States		Germany	
	Log of Real Wage Index	Log of Real Rate of Return	Log of Real Wage Index	Log of Real Rate of Return
Producer Prices	1990 = 100	1990 = 100	1991 = 100	1991 = 100
Base Year	1987	–	1991	–
Mean	4.51	2.37	4.14	2.38
Standard Deviation	0.09	0.71	0.44	0.36
Minimum	4.30	–0.50	3.20	1.30
Maximum	4.64	2.95	4.77	2.86
ADF-Test I(0)[a]	–2.84	–2.73	–2.39	–2.48
ADF-Test I(1)[a]	–7.36	–5.63	–7.69	–6.31

[a]Augmented Dickey Fuller Test. We estimate $\Delta y_t = (\rho - 1) y_{t-1} + \mu + \beta t + \sum_{i=1}^{p} \gamma_i \Delta x_{t-i} + \varepsilon_t$. The statistic is the t-value of $(\rho - 1)$. Critical values are taken from Davidson, MacKinnon (1993) and Hansen (1993).

Source: OECD (1997a); own calculations.

Table A2 – Estimation Results for the United States (Unconditional Model)

Sample period		
Effective sample	1962:2 to 1996:1	
Observations	68	
Degrees of freedom	56	
Cointegration rank	H_0: $r = 0$	H_0: $r = 1$
Maximum Eigenvalue[a]	23.98 (12.39)	6.65 (10.56)
Trace[a]	30.64 (22.95)	6.65 (10.56)
Residuals		
AR(1), LM-Test	$\chi^2(4) = 3.59$	
Normality, Shenton-Bowman Test[b]	$\chi^2(4) = 68.49$	
ARCH[c], LM-Test	$\chi^2(3) = 0.12$	$\chi^2(3) = 0.65$
Test for Weak Exogeneity, LR-Test		
Real Rate of Return	$\chi^2(1) = 15.22$	
Real Wage Index	$\chi^2(1) = 2.34$	

[a]Critical values at the 10 percent level in parentheses. — [b]Mulitvariate version of the Shenton-Bowman test for normality (cf. Hansen and Juselius 1995: 27). — [c]The first test refers to the equation determining the first difference of the real rate of return, the second test refers to the equation determining the first difference of the real wage index.

Table A3 – Estimation Results for the United States (Conditional Model)

Sample period	Effective sample	1962:2 to 1996:1
	Observations	68
	Degrees of freedom	52
Cointegration rank	Maximum Eigenvalue[a]	95.12 (10.56)
(H_0: $r = 0$)	Trace[a]	95.12 (10.56)
Residuals	Autocorrelation (LM-Test)	$\chi^2(1) = 1.16$
	Normality (Shenton-Bowman Test[b])	$\chi^2(2) = 5.96$
	ARCH (LM-Test)	$\chi^2(3) = 6.56$
Loading coefficient		–0.319
Cointegration Vector β[c,d]	Log real rate of return {1}	1.000
	Log real wage index {1}	3.490
	Dummy oil shock 79 {1}	4.090
	Linear trend	–0.015
	Constant	5.695
First differences (short-run)[c]	Log real rate of return {1}	0.156
	Log real rate of return {2}	–0.221
	Log real wage index {0}	7.000
	Dummy oil shock 79 {0}	–0.101
	Log real wage index {1}	1.726
	Dummy oil shock 79 {1}	0.522
	Log real wage index {2}	–4.521
	Dummy oil shock 79 {2}	–0.336
Deterministic variables[c]	Dummy oil shock {0}	–0.299
	Dummy oil shock {0}	–0.679
	Dummy 74:2 {0}	–1.782

[a]Critical values at the 10 percent level in parentheses. — [b]Mulitvariate version of the Shenton-Bowman test for normality (cf. Hansen and Juselius 1995: 27). — [c]The figures in curly brackets indicate the lag. — [d]β has been normalised. The sign of the estimates in β are opposite to the theoretical results because of the ECM formulation.

Table A4 – Estimation Results for Germany (Unconditional Model)

Sample period		
Effective sample	1964:1 to 1996:1	
Observations	65	
Degrees of freedom	53	
Cointegration rank	H_0: $r = 0$	H_0: $r = 1$
Maximum Eigenvalue[a]	22.50 (12.39)	6.80 (10.56)
Trace[a]	29.30 (22.95)	6.80 (10.56)
Residuals		
AR(1), LM-Test	$\chi^2(4) = 7.72$	
Normality, Shenton-Bowman Test[b]	$\chi^2(4) = 2.42$	
ARCH[c], LM-Test	$\chi^2(3) = 8.35$	$\chi^2(3) = 1.50$
Test for Weak Exogeneity, LR-Test		
Real Rate of Return	$\chi^2(1) = 15.25$	
Real Wage Index	$\chi^2(1) = 1.12$	

[a]Critical values at the 10 percent level in parentheses. — [b]Mulitvariate version of the Shenton-Bowman test for normality (cf. Hansen and Juselius 1995: 27). — [c]The first test refers to the equation determining the first difference of the real rate of return, the second test refers to the equation determining the first difference of the real wage index.

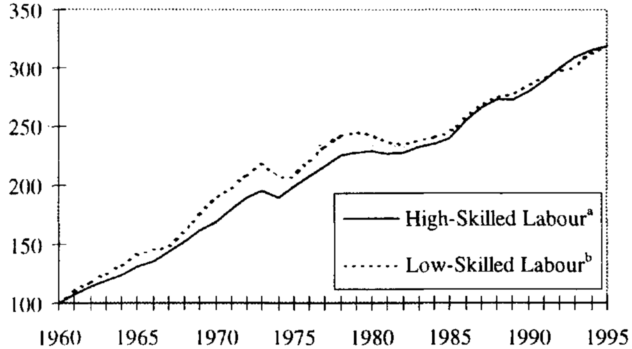
Table A5 – Estimation Results for Germany (Conditional Model)

Sample period	Effective sample	1964:1 to 1996:1
	Observations	65
	Degrees of freedom	43
Cointegration rank	Maximum Eigenvalue[a]	32.04 (10.56)
(H_0: $r = 0$)	Trace[a]	32.04 (10.56)
Residuals	Autocorrelation (LM-Test)	$\chi^2(1) = 2.78$
	Normality (Shenton-Bowman Test[b])	$\chi^2(2) = 0.85$
	ARCH (LM-Test)	$\chi^2(3) = 3.66$
Loading coefficient		–0.489
Cointegration Vector	Log real rate of return {1}	1.000
β c,d	Log real wage index {1}	1.661
	Dummy recession 1967 {1}	–0.029
	Dummy oil shock {1}	–0.040
	Dummy oil shock {1}	–0.321
	Linear trend	–0.039
	Constant	–3.797
First differences (short-run)[c]	Log real rate of return {1}	0.396
	Log real rate of return {2}	0.164
	Log real wage index {0}	4.016
	Dummy recession 1967 {0}	0.136
	Dummy oil shock {0}	–0.078
	Dummy oil shock {0}	–0.208
	Log real wage index {1}	3.273
	Dummy recession 1967 {1}	0.095
	Dummy oil shock {1}	0.105
	Dummy oil shock {1}	–0.052
	Log real wage index {2}	–1.624
	Dummy recession 1967 {2}	0.186
	Dummy oil shock {2}	–0.081
	Dummy oil shock {2}	0.097
Deterministic variable[c]	Dummy 74:1 and 74:2 {0}	–0.004

[a]Critical values at the 10 percent level in parentheses. — [b]Mulitvariate version of the Shenton-Bowman test for normality (cf. Hansen and Juselius 1995: 27). — [c]The figures in curly brackets indicate the lag. — [d]β has been normalised. The sign of the estimates in β are opposite to the theoretical results because of the ECM formulation.

Appendix D – Figures

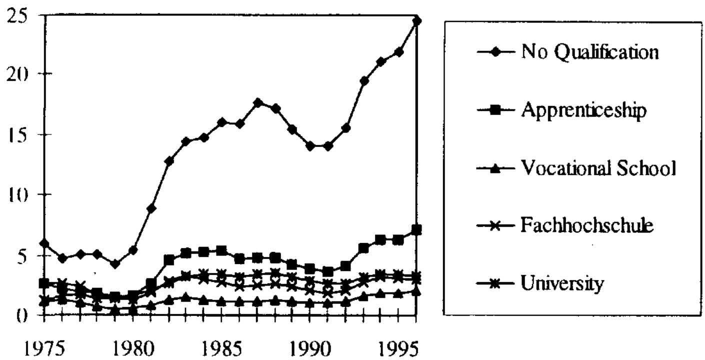
Figure A1 – Wage Differentiation by Skill Level in Germany



[a]Index of gross monthly income of high-skilled white-collar employees in prices of 1990 (1960=100). — [b]Index of gross monthly income of low skilled blue-collar employees in prices of 1990 (1960=100).

Source: Statistisches Bundesamt (1997); own calculations.

Figure A2 – Unemployment by Qualification in Germany (in Percent)[a]



[a]Unemployment rates for males.

Source: Buttler and Tessaring (1993), IAB (1997)

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