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Supply shocks and the factor price frontier: Labour market adjustment in the United States and Germany

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**Wirtschaftswissenschaftliche Fakultät
der Eberhard-Karls-Universität Tübingen**

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Frontier:
Labour Market Adjustment in the
United States and Germany**

Dietmar Hornung, Axel Schimmelpfennig und
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Supply Shocks and the Factor Price Frontier: Labour Market Adjustment in the United States and Germany

by

Dietmar Hornung*, Axel Schimmelpfennig** and Rüdiger Wapler***

January 1998

Abstract

Based on the factor price frontier, we investigate the effects of supply shocks on labour markets in open economies. Two different supply shocks are considered: an oil price shock, and the integration of relatively labour-abundant countries into the world economy. With flexible wages, a negative supply shock leads to a decrease in the wage rate while employment remains constant. With a rigid wage rate, a rise in unemployment of unskilled labour follows. The model explains the shift of relative labour demand towards skilled labour. The theoretical results are confirmed by our estimation of the factor price frontier for the United States and Germany.

JEL Classification: E24, F21

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1. Introduction

At first sight, the economic development of industrialised countries in the seventies and nineties appears to be quite different. The seventies were characterised by two oil shocks, while the nineties are characterised by the integration of relatively labour-abundant countries into the world economy. The the labour market outcome is surprisingly similar, though. In both periods, a secular rise in unemployment resulted for countries with rigid wages, unskilled labour being especially hard hit. For countries with flexible wages, there was no such rise in unemployment, instead there was a tendency for an increase in wage differentiation. Both experiences can be explained within a single framework, the factor price frontier.

The factor price frontier defines a negative, convex relationship between the prices of capital and labour. Bruno (1984) has analysed the effects of the oil price shocks on industrialised countries with a modified factor price frontier that also includes energy as a production factor. Within the two dimensional framework, he views the oil shocks as equivalent to technical regress: the factor price frontier shifts inward, with both factors bearing the costs of adjustment through a reduction in their respective rates of return.

This paper relates to two other strains of literature that study adjustment costs of openness in relatively capital-abundant countries: (i) trade and wages, and (ii) international capital mobility. The trade and wages literature investigates the effects of trade on wages and the skill composition of the employed. Freeman (1995) and the OECD (1997a) provide surveys of the literature. Empirical studies find only a small impact of trade. Instead, skill-biased technical change seems to drive the shift of relative labour demand towards more skilled workers 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 there is evidence for the immobile factor labour being involved in locational competition for the mobile factor capital. This kind of competition has gained importance since the mid-eighties, as capital mobility has increased significantly (Taylor 1996).

The paper is organised as follows: In the second section, we model the effects of supply shocks on open economies using the factor price frontier. The analysis takes flexible as well as non-flexible labour markets into account, where a flexible labour market is characterised by flexible wages. In section three, we estimate factor price frontiers for the United States and Germany with the Johansen procedure. Section four concludes.

2. The Model

2.1 The Factor Price Frontier

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

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

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

$$L = L_S + L_U \quad (2)$$

where Y denotes output, K is the capital stock, and L is total employment. A is an efficiency parameter, t is a deterministic trend, and λ denotes the constant rate of exogenous technical progress. Firms differentiate between skilled workers L_S , and unskilled workers L_U . An increase in the ratio of skilled to unskilled workers L_S/L_U raises the average human capital parameter h .

$$\frac{\partial h}{\partial \frac{L_S}{L_U}} > 0$$

The marginal products of capital and labour equal the real rate of return i and the real wage rate w respectively, where w is a weighted average of the wage rates of skilled and unskilled workers. k denotes capital per worker.

$$\frac{\partial Y}{\partial K} = \alpha A e^{\lambda t} k^{\alpha-1} h^{1-\alpha} = i \quad (3)$$

$$\frac{\partial Y}{\partial L} = (1-\alpha) A e^{\lambda t} k^{\alpha} h^{1-\alpha} [1+\varepsilon\mu] = w \quad (4)$$

$$\text{with } \varepsilon = \frac{\partial h}{\partial \frac{L_s}{L_u}} \frac{\frac{L_s}{L_u}}{h} \text{ and } \mu = \frac{\partial \frac{L_s}{L_u}}{\partial L} \frac{L}{\frac{L_s}{L_u}}$$

Solving equation (3) for k and inserting this result into equation (4) yields the factor price frontier.

$$w(i) = f(A, t, h, k) - k(i) \cdot i = \frac{1-\alpha}{\alpha} (\alpha A)^{\frac{1}{1-\alpha}} e^{\frac{\lambda t}{1-\alpha}} h^* i^{\frac{-\alpha}{1-\alpha}} \quad (5)$$

with

$$h^* = h[1+\varepsilon\mu]$$

The adjusted average human capital parameter h^* is a shift parameter of the factor price frontier. It accounts for the effects of changes of total employment L on h . If the ratio of skilled to unskilled workers is constant, $\mu = 0$ and therefore $h^* = h$. This is the case of the traditional factor price frontier, not accounting for heterogeneous labour.

The factor price frontier defines a negative, convex relationship between the wage rate w and the rate of return i :

$$\frac{\partial w}{\partial i} < 0 \text{ and } \frac{\partial^2 w}{\partial i^2} > 0$$

Changes in the capital intensity k lead to movements on the factor price frontier. An increase in the capital intensity raises the factor price ratio w/i , as the marginal product of labour increases and the marginal product of capital decreases.

$$\frac{\partial w}{\partial k} > 0$$

Technical progress λ as well as a rise in the adjusted average human capital h^* shift the factor price frontier outward. Therefore, it is possible to increase at least one of the factor prices without having to decrease the other.

$$\frac{\partial w}{\partial \lambda} > 0, \quad \frac{\partial i}{\partial \lambda} > 0 \quad \text{and} \quad \frac{\partial w}{\partial h^*} > 0, \quad \frac{\partial i}{\partial h^*} > 0$$

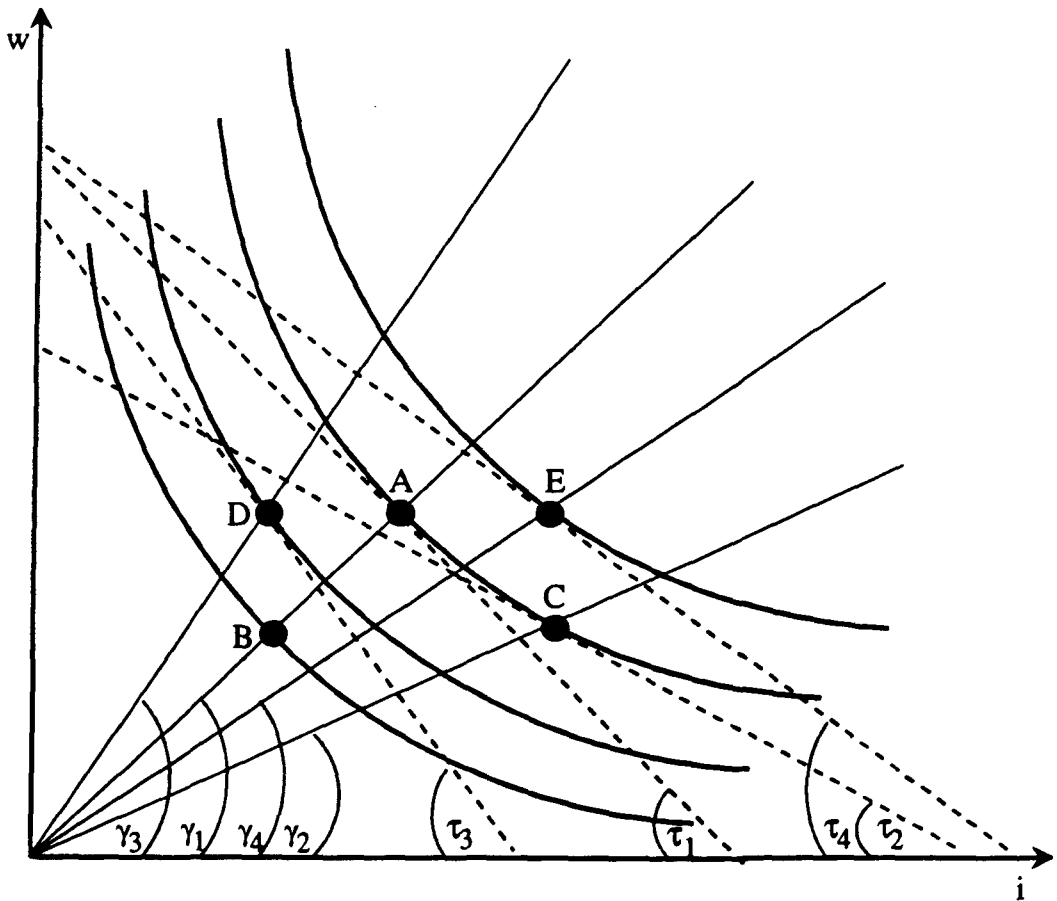
2.2 Shocks to an Open Economy

In an open economy, international supply shocks require domestic adjustment. We consider two scenarios: a flexible domestic labour market, where wages adjust, and a non-flexible domestic labour market, where the average wage rate is rigid. Supply shocks can either affect the prices of production factors that are not explicitly modelled, or the prices of factors that are explicitly modelled. This determines the way a shock is introduced into the model. Capital is assumed to be internationally perfectly mobile, while labour is assumed to be internationally immobile. The home country is small — therefore, the real rate of return is exogenous. The rest of the world is assumed to have a flexible labour market.

First, assuming a flexible domestic labour market, we consider a shock affecting the price of a not explicitly modelled factor. The sudden oil price hikes in the seventies are an example. As shown by Bruno (1984), such a negative shock can be modelled as technical regress, lowering the efficiency parameter A . A rise in the price of an input such as oil leads to a reduction in the amount of this input used. Thereby, the labour and capital productivity is reduced. In Figure 1, an oil price shock translates into an inward shift of the factor price frontier. If the capital intensity $k_I = \tan \tau_I$ remains unchanged, the economy moves from A to B and the factor price ratio $(w/i)_I = \tan \gamma_I$ stays constant. Both factors share the burden of adjustment by accepting a fall in their respective rates of return.¹

¹ Since the oil shock affects the international economy as well, the international rate of return is also lowered; both domestic and international adjustment are identical.

Figure 1 – Shocks in the Factor Price Frontier Framework



Second, again assuming a flexible domestic labour market, we consider a shock affecting the price of a factor explicitly modelled. The integration of relatively labour-abundant countries into the world economy is an example. In these countries, the rate of return will be higher than in the domestic economy, leading to capital movements out of the home country until the rates of return are equalised. In Figure 1, the domestic capital intensity is lowered from $k_1 = \tan \tau_1$ to $k_2 = \tan \tau_2$ and the economy moves from A to C. The domestic rate of return increases and the wage rate decreases as the factor price ratio falls from $(w/i)_1 = \tan \gamma_1$ to $(w/i)_2 = \tan \gamma_2$. For identical technologies at home and abroad, wage rates also equalise.² If the home country has a superior technology, the

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.

domestic wage rate will fall, but stay above the level in countries with inferior technology.

Third, assuming a non-flexible domestic labour market, we consider a shock affecting the price of a not explicitly modelled factor such as the oil shock. Just as in the case of a flexible domestic labour market, this shock triggers a fall in the efficiency parameter A , which leads to an inward shift of the factor price frontier (Figure 1). Assuming internationally identical technologies, B is the point realised by the rest of the world. In order to meet the initial wage rate and the internationally given rate of return, the domestic marginal productivity of labour has to be kept at the initial level without lowering the productivity of capital further. By laying-off unskilled workers, firms raise the average human capital endowment of labour. The higher ratio of skilled to unskilled labour increases the parameter h^* , shifting the factor price frontier outward. The adjustment process also involves capital movements abroad. Otherwise the average labour endowment of capital would fall, lowering the marginal productivity of capital. This effect would dominate the human capital intensification effect.³ Shifting capital abroad leads to a movement on the new frontier as the capital intensity falls to $k_3 = \tan \gamma_3$. D is the domestic equilibrium, awarding both factors their exogenously determined rates of return. The factor price ratio rises from $(w/i)_1 = \tan \gamma_1$ to $(w/i)_3 = \tan \gamma_3$. Laying-off skilled and unskilled workers in the same proportion would not result in a domestic equilibrium, since it only induces movements on the factor price frontier defined by B ; it does not move the frontier itself.⁴

Fourth, still assuming a non-flexible domestic labour market, we consider a shock affecting the price of a factor explicitly modelled, such as the integration of relatively labour abundant countries. Just as in the case of a flexible domestic labour market, such a shock requires an increase in the domestic rate of return to the level abroad. In Figure 1 the economy has to move from the initial point A to

³ For a given technology, the marginal product of a factor is determined by its endowment with complementary inputs. Therefore, laying-off of unskilled workers without a simultaneous reduction in the capital stock leads to a decrease in the rate of return as the marginal productivity of capital falls.

⁴ So, contrary to insider-outsider models where capital is immobile, a reduction in employment does not lead to a new equilibrium.

point E. The capital intensity has to fall to $k = \tan \tau_4$, and the factor price ratio has fall to $(w/i)_4 = \tan \gamma_4$. The new equilibrium in the rest of the world is at point C. As in the third case, this adjustment involves an outward shift of the factor price frontier that can only be induced by increasing average human capital. Hence the adjustment process is again characterised by laying-off unskilled workers and moving capital abroad.

Taking the four cases together, our model explains the secular shift in employment from unskilled to skilled labour that can be observed in all industrial countries since the seventies. In our discussion, we have considered the polar scenarios of flexible and non-flexible labour markets. It follows that the less flexible an economy, the more pronounced will be the shift of relative labour demand towards skilled labour, and the higher the corresponding unemployment rate of unskilled labour.⁵

3. Empirical Results

In order to estimate our model, we introduce a stochastic white noise process u_t in the production function (1).⁶ The subscript t denotes time.

$$Y_t = F(A, t, h_t, K_t, L_t) = A e^{\lambda t + u_t} K_t^\alpha (h_t L_t)^{1-\alpha} \quad (1')$$

The factor price frontier of equation (5) then becomes the stochastic factor price frontier:

$$w_t(i_t) = f(A, t, k_t) - k_t(i_t) \cdot i_t = \frac{1-\alpha}{\alpha} (\alpha A)^{\frac{1}{1-\alpha}} h_t^* e^{\frac{\lambda t + u_t}{1-\alpha}} i_t^{1-\alpha} \quad (5')$$

which for estimation purposes can be written as:

$$\log w_t = \theta_0 + \theta_1 t + \theta_2 \log i_t + \varepsilon_t \quad (6)$$

⁵ For the full picture, one needs to also consider changes in the relative supply of skilled and unskilled labour: The supply shift towards skilled labour adds to the shift in employment due to the shift in relative labour demand that is described in this paper.

⁶ $E(u) = 0$; $E(uu') = \sigma^2 I$.

with

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

To estimate factor price frontiers for the United States and Germany⁷, we use semi-annual data over the period from 1961 to 1996 from the OECD (1997b). 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 business sector is used (OECD 1995: A80). Since both measures are in current prices, they are deflated by a producer price index also taken from the OECD (1997b).⁸ For the actual estimation of equation (6), the natural logarithms of the measures are taken.

Unfortunately, there is no data available to include h^* as a variable in our estimation; skill ratios can only be calculated on an annual basis and for a much smaller sample. Therefore, h^* will be part of the intercept term. Shifts in the intercept are then interpreted as being caused by average human capital in accordance with our theoretical reasoning.

Table A1⁹ 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

⁷ All data refer to West Germany only.

⁸ 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 by not inserting artificial values for the missing observations, the sample would have been seriously shortened to 75:1 to 96:1, excluding the first oil shock.

⁹ All tables are presented in the appendix.

Augmented Dickey-Fuller tests. Therefore, we use the Johansen procedure to estimate the factor price frontiers for the United States and Germany.¹⁰

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).¹¹ This vector contains a constant as well as a linear trend.¹² Hence, the data supports the theoretical set up of equation (6). 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 a flexible labour market, and perfect international capital mobility, the real rate of return is exogenously given. The real wage would need to adjust to secure full employment along the factor price frontier. A weakly endogenous real rate of return can be explained as follows. First, the United States are not a small economy. Second, 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

¹⁰ For an overview of the Johansen procedure see Johansen (1988, 1992), Harris (1995), and Hansen and Juselius (1995). We test at the 10 percent level of significance. CATS in RATS is used for all estimations.

¹¹ 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 AIC, the AAIC, the SC, and the HQ criterion. (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; this appears reasonable for semi-annual data. 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.

¹² 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). 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.

the seventies were marked by federal wage-price controls. Third, 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). 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 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 (6) is:¹³

$$\begin{aligned} \log \text{ real rate of return} = \\ 5.70 + 0.01 * \text{trend} - 3.49 * \log \text{ real wage index} \end{aligned} \quad (6')$$

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 (1') are:

efficiency parameter	A	=	6.042
exogenous technical progress	λ	=	0.003
output elasticity of capital	α	=	0.223

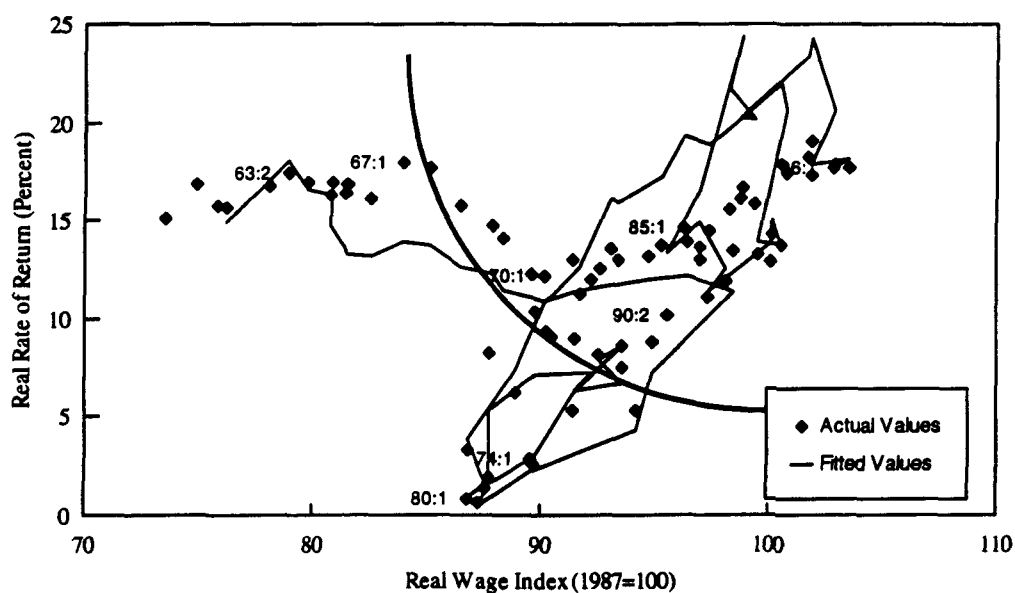
The estimate for α is well in the range of other empirical studies (e.g. Mankiw et al. 1992). This production elasticity α translates into a wage share in manufacturing of 78 percent.¹⁴

¹³ 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 contains all estimation results.

¹⁴ The factor weights in a Cobb-Douglas production function translate into the respective income share. 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 close to actual figures.

Plotting our estimation results, a single factor price frontier can be detected that moves slowly outward throughout our sample period (Figure 2).¹⁵ This movement reflects exogenous technical progress and the increase in average human capital (cf. Berman et. al. 1994).¹⁶ During the two oil shocks, the U.S. factor price frontier shifts temporarily inward. Thus, both factors shared the burden of adjustment, by accepting a fall in their respective factor price. Although the United States suffered from high unemployment during times of economic restructuring in the seventies and early eighties, there is no ratcheting-up of the unemployment rate (Figure A1).

Figure 2 – The Empirical Factor Price Frontier for the United States^a



^aAn artificial value is used for the real rate of return in 74:2. Cf. footnote 8.

Source: OECD (1997b); own calculations.

¹⁵ 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.

¹⁶ 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.

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.¹⁷ 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. This result implies that the real wage index is determined outside the system just as in the U.S. case.

This 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 (6) is:¹⁸

¹⁷ First, the optimum lag length of the VAR is determined by looking at the 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.

¹⁸ 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 real rate of return while wages remained constant. Adjustment took place through a reduction in profits and by laying-off workers which translated into higher unemployment (Figure A1). 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).

log real rate of return =

$$3.80 + 0.04 * trend - 1.66 * log real wage index \quad (6'')$$

Here, a one percent increase in real wages is associated with a 1.66 percent decrease in the real rate of return in the long run. The estimated parameters of our production function (1') are:

efficiency parameter	A	=	8.076
exogenous technical progress	λ	=	0.015
output elasticity of capital	α	=	0.376

The same remarks as in the U.S. case apply. Our estimate of α is in the range of other empirical studies. The output elasticity α translates into a wage share in manufacturing of 62 percent on average in our sample.¹⁹

The estimated factor price frontier is plotted in Figure 3. Three distinct factor price frontiers can be detected. Thus, the U.S. and the German experience are quite different. 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 unskilled labour, thereby raising the average human capital of the employed.²⁰ This was

¹⁹ 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 close to actual figures.

²⁰ Since the mid-seventies, employment by skill level is well documented. Skill-specific unemployment rates for Germany are presented in Figure A2. For Germany we see an annual reduction of unskilled workers by 4 percent over the period from 1984 to 1994, whereas employment of unskilled 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 1997a: 96).

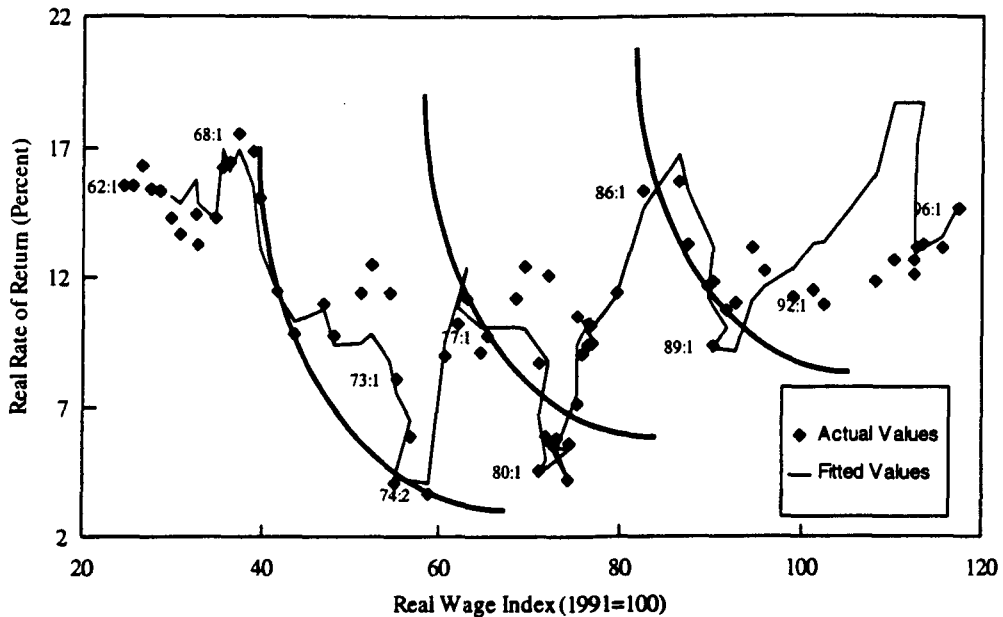
accompanied by the introduction of skill-biased technical progress. Both of these efforts led to an outward shift of the factor price frontier and to the first significant hike in unemployment since the beginning of the economic miracle (Figure A1).

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 unskilled 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 effects of the integration of relatively labour abundant countries into the world economy. Again, the outward shift that is brought about by releasing unskilled labour coincides with a hike in the unemployment rate.

To sum up, the simple story runs as follows. In good times, unions are able to push through increases in the real wage rate 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 unskilled labour, which raises the average human capital of the labour force, in order to induce 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.²¹

²¹ Blanchard (1997) comes to a similar conclusion about the German development, using a different approach.

Figure 3 – The Empirical Factor Price Frontier for Germany^a

^aArtificial values are used for the real rate of return in 74:1 and 74:2 (Cf. footnote 7).

Source: OECD (1997b); own calculations.

4. Conclusion

Using the neoclassical concept of the factor price frontier, we investigated the effects of supply shocks on labour markets. In an economy with a flexible labour market, a negative supply shock leads to a decrease in the wage rate. We considered two different cases. A shock to a factor such as oil moves the factor price frontier inwards, lowering both the wage rate and the rate of return. A shock to the factor labour itself – as experienced nowadays when relatively labour abundant countries enter the world economy – leads to a move on the frontier, lowering the wage rate and simultaneously raising the rate of return. In both cases, the level of employment remains unchanged due to flexible wages.

In an economy with a non-flexible labour market, the wage rate is exogenously fixed. For a supply shock such as the oil shock, firms will react by laying-off unskilled workers and moving capital abroad. The increase in average human capital partially reverses the initial inward shift of the frontier. Both factors can be awarded their exogenously given rates of return. For a supply shock to labour itself – such as the integration of relatively labour abundant countries the

adjustment process is similar. Laying-off unskilled workers and moving capital abroad allows both factors to be awarded their exogenously given rates of return. The shift of relative labour demand towards skilled workers in industrialised countries is therefore partly caused by the adjustment to negative exogenous shocks in an economy with non-flexible labour markets.

The factor price frontier was estimated for the United States and Germany. In both countries the real wage was found to be weakly exogenous. 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 the integration of relatively labour abundant countries into the world economy. 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 mainly unskilled workers were laid off, capital exited the country, and skill-biased technical change was introduced.

The factor price frontier yields unambiguous results. For flexible labour markets a negative supply shock leads to a fall in the wage rate while employment remains constant. For non-flexible labour markets a negative supply shock leads to a hike in unemployment, where the unskilled are especially hard hit. This leads us to conclude that Germany will 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.

Appendix

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

^aAugmented 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).

Source: OECD (1997b); own calculations.

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

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

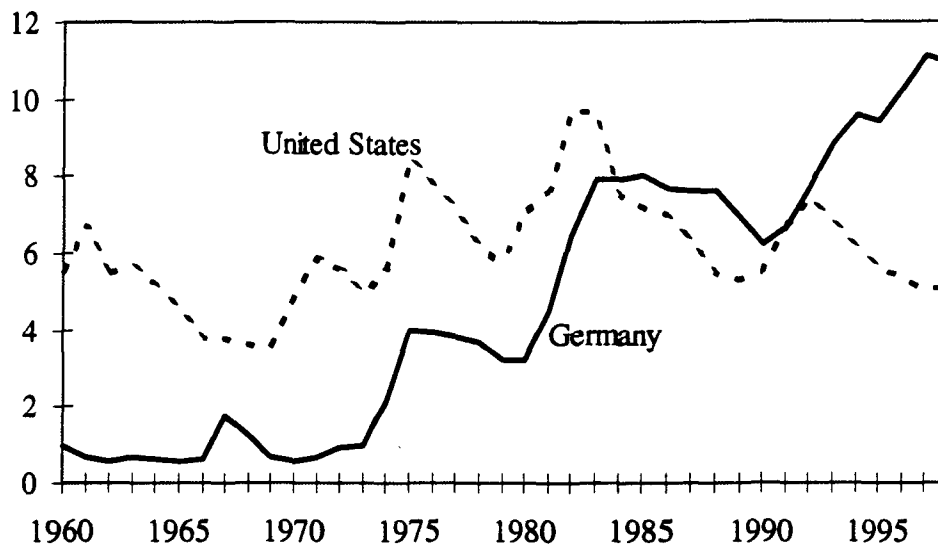
<u>Sample period</u>	Effective sample	1962:2 to 1996:1
	Observations	68
	Degrees of freedom	52
<u>Cointegration rank</u> ($H_0: r = 0$)	Maximum Eigenvalue ^a	95.12 (10.56)
	Trace ^a	95.12 (10.56)
<u>Residuals</u>	Autocorrelation (LM-Test)	$\chi^2(1) = 1.16$
	Normality (Shenton-Bowman Test ^b)	$\chi^2(2) = 5.96$
	ARCH (LM-Test)	$\chi^2(3) = 6.56$
<u>Loading coefficient</u>		-0.319
<u>Cointegration Vector $\beta^{c,d}$</u>	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
<u>First differences</u> (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
<u>Deterministic variables^c</u>	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 Multivariate 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)

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

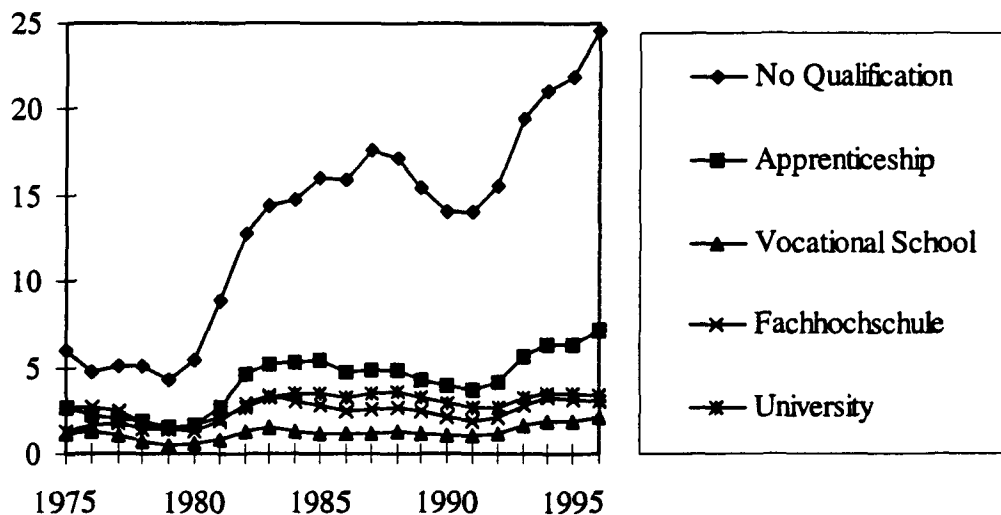
<u>Sample period</u>	Effective sample	1964:1 to 1996:1
	Observations	65
	Degrees of freedom	43
<u>Cointegration rank</u> ($H_0: r = 0$)	Maximum Eigenvalue ^a	32.04 (10.56)
	Trace ^a	32.04 (10.56)
<u>Residuals</u>	Autocorrelation (LM-Test)	$\chi^2(1) = 2.78$
	Normality (Shenton-Bowman Test ^b)	$\chi^2(2) = 0.85$
	ARCH (LM-Test)	$\chi^2(3) = 3.66$
<u>Loading coefficient</u>		-0.489
<u>Cointegration Vector $\beta^{c,d}$</u>	Log real rate of return {1}	1.000
	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
<u>First differences (short-run)^c</u>	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
<u>Deterministic variable^c</u>	Dummy 74:1 and 74:2 {0}	-0.004
^a Critical values at the 10 percent level in parentheses. — ^b Multivariate 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.		

Figure A1 – Unemployment Rates in the United States and Germany^a (Percent)^b

^aFigures for Germany from 1960 to 1990 refer to West-Germany.

^bFigures for 1997 and 1998 are OECD projections.

Source: OECD (1997a, 1997b).

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

^aUnemployment rates for males.

Source: Reinberg (1997).

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