The University of Nottingham

research paper series

Theory and Methods

Research Paper 2006/12

Trade, Technology and Unemployment:

The Role of Supply Side Adjustment

by

Udo Kreickemeier

The Centre acknowledges financial support from The Leverhulme Trust under Programme Grant F114/BF

GEP

Leverhulme Centre for Research on Globalisation and Economic Policy

The Author
Udo Kreickemeier is a Lecturer in the School of Economics, University of Nottingham, and an Internal Research Fellow of GEP.

Acknowledgements
Financial support from The Leverhulme Trust under Programme Grant F114/BF is gratefully acknowledged.

Trade, Technology and Unemployment:
The Role of Supply Side Adjustment

by

Udo Kreickemeier

Abstract

This paper analyses trade in an asymmetric 2x2x2 world, where the two countries ("Europe" and "America") differ in their preferences towards wage inequality. Fair wage considerations compress wage differentials in both countries, leading to involuntary unemployment of unskilled workers in equilibrium. European workers are more averse to wage inequality, and Europe is characterised by lower wage differentials as well as higher unemployment. Allowing for endogenous skill formation in both countries, the effects of a globalisation shock – modelled as the entry of newly industrializing countries into the trading world – and a global technology shock on skill premia and employment levels are derived. In contrast to a model with exogenous factor supplies, global shocks have an effect on international wage and unemployment differentials.

JEL classification: F11, F15, F16

Keywords: Globalisation, Unemployment, Fair Wages, Human Capital

Outline

Non-Technical Summary

There is by now a vast body of literature about link between international trade, technological change and relative wages. A smaller number of papers, such as Krugman (1995), Davis (1998a,b), Oslington (2002), Kreickemeier and Nelson (2006), look at unemployment rather than wage effects of globalisation and technological change. In all these papers, the "EU versus U.S." dichotomy figures prominently, where typically it is assumed that labour markets in the U.S. are more flexible than those in Europe, and hence employment effects of economic shocks are larger in Europe than in the U.S.

As all these papers use a modified Heckscher-Ohlin (HO) framework, and hence factor supplies are assumed perfectly inelastic, the focus is on the effect that changes in labour demand have on labour market outcomes, neglecting any adjustments on the labour supply side. However, economic incentives for these adjustments should be expected to be strong: A negative primary shock for unskilled workers, stemming either from globalisation or from technological change, gives an additional incentive to acquire skills. The present paper focuses on exactly this effect and its implications for equilibrium unemployment and wage inequality. It does this by modifying the HO production model with exogenous factor supplies to allow for endogenous formation of human capital, following the classic paper by Findlay and Kierzkowski (1983). Due to workers' fairness preferences, as in the fair wage model of Akerlof and Yellen (1990), firms pay non-market clearing wages, and there is unemployment of unskilled workers in equilibrium.

By linking the Findlay-Kierzkowski and Akerlof-Yellen models, this paper provides a rich but tractable framework within which the effects of globalisation and technology shocks on labour markets can be derived. Introducing supply side adjustments in labour markets via the possibility of human capital accumulation is shown to change results quite dramatically in comparison to the standard HO framework. For example, it turns out that every shock that compresses the wage differential in the HO model (with or without fair wages) widens the wage differential in the present setup. It is shown furthermore that global shocks lead to divergent wage paths between countries that are integrated through trade but have different labour market characteristics. This is another contrast to the standard HO model, where factor price equalisation prevails as long as both countries produce both goods.

1 Introduction

Heckscher-Ohlin trade theory has played a prominent role in the recent debate on the impact of globalisation and technology shocks on labour markets in industrialised countries. Arguably, this debate has sparked the theory's comeback as a standard framework of analysis in international trade. As Krugman (2000) succinctly puts it: "...the Stolper-Samuelson theorem [...] has moved from midterm exams into the heart of real-world debates over economic policy." This is ironic given that the effect of globalisation on involuntary unemployment appears to be a major concern to policy makers and the general public, while one of the core assumptions of the Heckscher-Ohlin (HO) framework are fully flexible factor prices, implying factor market clearing at all times.

Only a small subset of the contributions to this literature allows for involuntary unemployment. Those that do are motivated by analysing the effect that differing labour market institutions between Europe and the U.S. have on the outcomes of globalisation or technology shocks. Krugman (1995), Davis (1998a, b), and Oslington (2002) model this institutional difference by assuming that labour markets in the U.S. are fully flexible, while there is a binding wage floor for unskilled labour in Europe. In Kreickemeier and Nelson (2006), there is involuntary unemployment due to fairness considerations in both countries, but fairness preferences and therefore unemployment rates differ between them.

As all these papers use a modified HO framework, and hence factor supplies are assumed perfectly inelastic, the focus is on the effect that changes in labour demand have on labour market outcomes, neglecting any adjustments on the labour supply side. However, economic incentives for these adjustments should be expected to be strong: A negative primary shock for unskilled workers, stemming either from globalisation or from technological change, gives an additional incentive to acquire skills.[1] The present paper focuses on exactly this effect and its implications for equilibrium unemployment and wage inequality. It does this by modifying the HO production model with exogenous factor supplies to allow for endogenous formation of human capital, following the classic paper by Findlay and Kierzkowski (1983).

[1] For empirical evidence about an increase in the relative supply skill see Baldwin and Cain (2000) for the U.S. and Acemoglu (2003) for a larger sample of countries.

As in Nelson and Kreickemeier (2006), involuntary unemployment is modelled as stemming from a source for which there is considerable microeconomic evidence across virtually all sectors as well as experimental evidence: the fair wage model.[2] Beginning with Solow (1979), Akerlof (1982), and Akerlof and Yellen (1988, 1990) a sizable literature has developed deriving efficiency wages from a fairness constraint. The basic idea is that worker effort is a function of the perceived fairness of the wage: $\varepsilon_k = f(w_k/w_k^*)$, where ε_k is effort, w_k is the wage of worker type k and the star denotes the wage perceived as fair by workers of type k. Like all efficiency wage models, firms are induced to pay wages above the market clearing wage, resulting in equilibrium unemployment. From both a theoretical and empirical point of view, the difficult thing is identifying a plausible and observable basis for the evaluation by workers of the fairness of a wage offer. In this paper we follow Akerlof and Yellen (1990) in supposing that there are two types of labour (skilled and unskilled) and that the fair wage has two determinants: the market wage of the other group, and their own expected wage if they become separated from their job (taking into account the possibility that they might be unemployed). In equilibrium, the factor with the higher wage is fully employed, while there is involuntary unemployment for the factor with the lower wage.

By linking the Findlay-Kierzkowski and Akerlof-Yellen models, this paper provides a rich but tractable framework within which the effects of globalisation and technology shocks on labour markets can be derived. Introducing supply side adjustments in labour markets via the possibility of human capital accumulation is shown to change results quite dramatically in comparison to the standard HO framework. For example, it turns out that every shock that compresses the wage differential in the HO model (with or without fair wages) widens the wage differential in the present setup. It is shown furthermore that global shocks lead to divergent wage paths between countries that are integrated through trade but have different labour market characteristics. This is another contrast to the one-cone HO model, where factor price equalisation prevails as long as both countries are diversified in production.

[2]Recent reviews of the evidence can be found in Howitt (2002) and Bewley (2005). Both stress the wide extent and strength of evidence supporting the fair wage model from a range of sources including: surveys of managers and workers; firm-level studies of pay and termination patterns; experiments; and common sense/personnel management textbooks.

Davis and Reeve (2002) combine the minimum wage model of Davis (1998a, b) with the Findlay and Kierzkowski (1983) model. In their paper, the American labour market is insulated from the globalisation shock, as in Davis (1998a), and European workers bear the full burden of adjustment. With our less stark asymmetry in labour market characteristics this insulation result no longer holds.[3] Endogenising the employment level in both countries allows us to look at the impact of global shocks on the unemployment differential between countries, a question that is not of independent interest if the unemployment rate in one of the countries is zero throughout. In addition, the fair wage model turns out to be a more convenient framework than the minimum wage model once technology shocks are analysed. This is because the sign of relative wage effects in the fair wage model – but not in the minimum wage model – is independent from the choice of the numeraire.

The structure of the paper is as follows. In section 2, the equilibrium of a closed economy with fair wages and endogenous determination of the level of human capital is derived. Section 3 describes equilibrium in an asymmetric two country world where the countries are integrated through trade and differ in their fairness preferences. In section 4, the effects of a globalisation shock and a global technology shock on relative wages, unemployment rates, and the unemployment and wage differentials between the two countries are derived. Section 5 concludes.

2 General Equilibrium in a Closed Economy

The setup follows the model of Findlay and Kierzkowski (1983). It is assumed that at each point in time N identical individuals are born that each live for $T > 1$ periods. At birth they decide whether to remain unskilled and take up work immediately or to train for a certain length of time and then, being skilled now, work until they die. Once they have chosen a career path, individuals have no option to change. While this assumption is clearly unrealistic as it excludes re-training, it makes the model tractable. The composition of the work force can nevertheless change over time, as every cohort can make the career path choice anew. Hence, in contrast

[3] See Nickell (1997) for an argument, and supporting data, to the effect that US and European labour markets are not nearly as distinctive as common beliefs suggest. In particular, unemployment rates between the US and Continental European countries are not dramatically different.

to a Heckscher-Ohlin framework with given endowments of skilled and unskilled workers, the Findlay-Kierzkowski model allows for labour supply adjustments to economic shocks.

The length of education is assumed to be exogenous, and without further loss of generality it is normalised to one. At each point in time the economy is populated by $L = WT$ unskilled workers, a fraction $(1-U)$ of which is employed, $H = E(T-1)$ skilled workers, and E students. $W = N - E$ denotes the number of people who at each instant take up work immediately after birth. Skill formation occurs according to the Cobb-Douglas production function $Q = K^a E^{1-a}$, where K is the exogenous capital stock specific to the education sector. More conveniently, the knowledge production function is written in per capita terms as

$$q = k^a \tag{1}$$

with $k = K/E$ as the educational capital per student and $q = Q/E$ as the number of skill units per student.[4]

As in Findlay and Kierzkowski (1983), the equilibrium composition of the work force is determined by the condition that the present values of expected net lifetime incomes for skilled and unskilled labour are equal. The wage for unskilled workers is denoted by w_L. The gross wage for skilled workers varies with their skill level, and for a worker with skill level q it is given by qw_H, where w_H is the wage for one efficiency unit of skilled labour. Assuming that educational capital is paid its value marginal product, the net wage of skilled workers is equal to $(1-a)qw_H$. As explained below, the equilibrium of the present model is characterised by full employment of skilled labour, while there is unemployment of unskilled labour. Let the unemployment rate for unskilled labour be denoted by U. Using this, the career path indifference condition becomes

$$\int_1^T (1-a)qw_H e^{-rt}dt = \int_0^T w_L(1-U)e^{-rt}dt,$$

where r is the rate of interest, which equals the exogenous rate of time preference and is therefore constant in equilibrium. This condition can be rewritten as $(1-a)qw_H = w_L(1-U)\Delta$ or, more

[4]Decreasing marginal returns to skill acquisition are one important feature driving the results in our model. Instead by a fixed stock of educational capital, one could imagine coming this from heterogeneity of agents with respect to ability; however this would sit uneasily with our fair wage structure that emphasises the relative wage rate of only two groups of workers, each of which is homogenous.

conveniently, as

$$\frac{\omega}{q} = \frac{1-a}{(1-U)\Delta} \tag{2}$$

with $\omega \equiv w_L/w_H$, and $\Delta \equiv (1-e^{-rT})/(e^{-r}-e^{-rT}) > 1$ as the ratio between expected net wage rates for skilled and unskilled workers in equilibrium.[5] Δ being larger than one reflects the two facts that skilled workers receive their net wage for a shorter period of time and later in their lifetime. Following the assumptions we have made earlier, Δ is a constant. As a is a parameter, the career path in difference condition (2) can be read as a relation between the unskilled unemployment rate and – alternatively – the gross *or* net wage differential for labour in physical units.[6]

Let h denote the economy-wide skill intensity of production, measured in efficiency units. We then have, for given values of the exogenous variables K, N, and T, the definitory relation

$$h \equiv \phi(U,q,k) = \frac{q}{1-U}\frac{H}{L} = \frac{q}{1-U}\frac{\frac{K}{k}(T-1)}{\left(N-\frac{K}{k}\right)T}, \tag{3}$$

using $E \equiv K/k$ as well as the definitions of H and L given above.

The economy is assumed to produce the two goods X and Y, with skilled and unskilled labour as the only inputs. Good Y serves as the numeraire and is assumed to be unskilled labour intensive relative to X at all common factor price ratios. Product markets are perfectly competitive, and production functions in both sectors exhibit constant returns to scale. Finally, preferences over goods are assumed to be homothetic with both X and Y being essential in consumption. With p as the relative price of X the zero profit conditions for the two sectors are given by the equality of goods prices to unit costs, i.e.

$$c_X(w_L,w_H) = p \qquad\qquad c_Y(w_L,w_H) = 1.$$

[5] See Findlay and Kierzkowski (1983) for a step-by-step derivation of the analogous equation to (2) in the full employment variant of the model. All that distinguishes the present case from theirs is the replacement of w_L by $w_L(1-U)$.

[6] This is where the assumption of a Cobb-Douglas production function in the education sector simplifies the analysis. With a more general production function, the share of educational capital in educational output would depend on k, and the career path indifference condition (2) would give only a relation between the *net* wage differential and the unemployment rate.

Hence, as in the standard Heckscher-Ohlin model factor prices – which in the case of skilled labour refer to the price for an efficiency unit – depend only on the relative goods price. We can therefore write

$$\omega = \psi(p) \qquad \text{with} \qquad \psi'(p) < 0 \tag{4}$$

where the sign of ψ' is implied by the Stolper-Samuelson theorem in combination with the factor intensity assumption. The condition for goods market equilibrium can be written as

$$p = \lambda(h) \qquad \text{with} \qquad \lambda'(h) < 0. \tag{5}$$

For any value of h, (5) gives the equilibrium relative goods price. The sign of λ' follows from the assumptions of good X being skill intensive and consumers having homothetic preferences. Under these assumptions, the Heckscher-Ohlin theorem ensures that the higher the skill-to-labour ratio of a country, the lower is its autarky price of the skill intensive good.

Involuntary unemployment is explained by a variant of the fair wage model developed by Akerlof and Yellen (1990). At each point in time, the two factors unskilled labour L and skilled labour H are supplied inelastically. Both types of workers are able to choose their effort at work, and they supply effort according to the effort functions

$$\begin{aligned} \varepsilon_L &= \min\left(\frac{w_L}{w_L^*}, 1\right) \\ \varepsilon_H &= \min\left(\frac{qw_H}{qw_H^*}, 1\right) \end{aligned} \tag{6}$$

where w_L^* and qw_H^* are the fair wages for L and H, respectively. This means that workers provide the normal level of effort, which is normalised to one, if they are paid at least their fair wage.

Firms are wage setters but they are assumed to treat the fair wage, which is determined in general equilibrium, parametrically. Under this assumption, profit maximisation can be thought of as a two-stage process, just as in the standard efficiency wage model of Solow (1979). In step one, firms set the wage rate for each type of labour k to minimise the wage paid for an efficiency unit, which is w_k/ε_k. In step two, they hire workers up to the point where the value marginal product of labour is equal to the wage set in step one. It can be seen from (6) that

the wage rate for an efficiency unit of labour (skilled or unskilled) stays constant (at qw_H^* and w_L^*, respectively) if a firm pays a wage below the fair wage. We can therefore safely assume, following Akerlof and Yellen (1990), that firms choose to pay wages at least as high as the fair wage for the respective factor.

As for the determination of the respective fair wage for the two groups, we follow Akerlof and Yellen (1990) in assuming that they are weighted averages with both an intragroup reference and an intergroup reference element to it.[7] The intragroup element for workers of both qualification levels is given by the respective remuneration they could expect if they were separated from their job, taking into account that they might be unemployed with a probability that is equal to the factor-specific rate of unemployment. In Akerlof and Yellen (1990) the intergroup reference element in the fair wage determination is given by the market wage of the respective other group. There is nothing in our model that would necessitate to change the specification as far as the determination of the skilled workers' fair wage is concerned. Hence, we have

$$qw_H^* = \theta w_L + (1-\theta)(1-U_H)qw_H \tag{7}$$

where U_H is the factor-specific rate of unemployment, and θ is a parameter strictly between zero and one. For the determination of the unskilled workers' fair wage, matters are complicated by the fact that q, which should be interpreted as the quality of skilled workers, is endogenous and potentially variable. It seems reasonable to allow for the possibility that q *ceteris paribus* has an influence on the fair wage notion of unskilled workers. This idea is captured by writing the determination of the fair wage for unskilled workers

$$w_L^* = \theta q w_H \left(1 + \frac{f(\theta)}{q}\right) + (1-\theta)(1-U_L)w_L \tag{8}$$

with $f(\theta) > 0$ and $f'(\theta) > 0$. With $f(\theta) = 0$, (8) would become fully symmetric to (7), and unskilled workers do not care about the quality of skilled workers in the determination of their fair wage. The assumption $f(\theta) > 0$ implies that a higher quality of skilled workers *ceteris paribus* decreases the wage that unskilled workers consider to be fair: For a given unemployment rate, unskilled workers are willing to put up with a higher relative wage for skilled workers if the quality of these workers is higher. The assumption $f'(\theta) > 0$ captures the idea that the

[7] See Akerlof and Yellen (1990) for a collection of empirical evidence supporting this approach.

fair wage of unskilled workers is more sensitive to a change in the quality of skilled labour if unskilled workers put a higher weight on the skilled wage when determining their fair wage. This assumption seems reasonable as it implies that those workers that care more about the wage their skilled colleagues get care more about the quality of these workers as well.[8]

It would be true in a full employment version of the present model that the wage for skilled workers exceeds that of unskilled workers, i.e. $qw_H > w_L$ in this case. The argument runs as follows: With career path indifference, net wages of skilled workers have to exceed expected net wages of unskilled workers in order to compensate for the time spent in education. For skilled workers, net wages are lower than gross wages due to the monetary cost of education, while net wages equal gross wages for unskilled workers. Hence, $qw_H > w_L$ holds under full employment. Using this result, it is straightforward to see that the following must hold in the equilibrium of the fair wage model:

$$U_L > U_H = 0$$
$$qw_H > qw_H^* > w_L = w_L^*$$
$$\varepsilon_L = \varepsilon_H = 1$$

i.e., there is a strictly positive rate of unemployment $U = U_L$ for unskilled workers but full employment for skilled workers, the fair wage is binding only for unskilled workers, and both types of workers provide the normal effort.[9] These results are the same as in the model of Akerlof and Yellen (1990), but for the fact that in their framework one has to *assume* that skilled labour

[8] One might question in the context of the present model the assumption that the fairness notion is based on (per period) wages, given that the discounted net income streams for both types of workers are equal in equilibrium. There is however no evidence that lifetime incomes are important for workers' fair wage ideas. And having one standard for career choice and another for fairness considerations seems reasonable if one thinks of the career choice as arising in a situation where wages and unemployment are what they are due to the existence of fairness preferences.

[9] A strictly positive unemployment rate U_L ensures that the fair wage of unskilled workers – which is also their market wage – is below the market wage of skilled workers in equilibrium. For skilled workers, the fair wage can never be binding because it is a weighted average of two variables that would both be smaller than the fair wage itself were this wage paid in equilibrium. With qw_H^* non-binding, qw_H does not affect skilled workers' effort, and it adjusts to ensure market clearing.

is the higher paid factor whereas it is derived endogenously in the present setup.

With (7) non-binding, an equilibrium relationship between the wage differential, the rate of unemployment, and the quality of skilled workers can be derived by setting $w_L^* = w_L$ in (8) and solving for ω/q:

$$\frac{\omega}{q} = \frac{\theta}{\theta + (1-\theta)U}\left(1 + \frac{f(\theta)}{q}\right). \tag{9}$$

Following Akerlof and Yellen (1990), (9) is called the *fair wage constraint*. This completes the description of general equilibrium in the closed economy, which is given by equations (1) to (5) and (9), determining the endogenous variables U, ω, h, p, q, and k. It is convenient to illustrate the determination of equilibrium in a four-quadrant diagram, analogous to the one employed by Kreickemeier and Nelson (2006) to derive the equilibrium for a Heckscher-Ohlin economy with fair wages. As a preliminary step, we use the fact that the career path indifference condition (2) and the fair wage constraint (9) depend only on ω, q, and U, and can therefore be used to derive functional relationships between any two of those three variables. In particular, we get

$$\omega \equiv \alpha(U,\theta) = \frac{\theta f(\theta)(1-a)}{[\theta(\Delta+a-1)+1-a]U - \theta(\Delta+a-1)} \tag{10}$$

and

$$q \equiv \beta(U,\theta) = \frac{\theta f(\theta)\Delta(1-U)}{[\theta(\Delta+a-1)+1-a]U - \theta(\Delta+a-1)}. \tag{11}$$

The functions $\alpha(U,\theta)$ and $\beta(U,\theta)$ can be seen to be downward sloping and convex in $\omega - U$ space and $q - U$ space, respectively. Furthermore, from (10), there is a lower bound to ω, which is equal to $\theta f(\theta)$.[10] A lower bound to U is given by $U_{\text{inf}} = \theta(\Delta+a-1)/[\theta(\Delta+a-1)+1-a]$.[11]

For the graphical representation in figure 1, we focus on four out of the six endogenous variables, namely, p, ω, U and h. Relations between h and p as well as p and ω are given by goods market equilibrium condition (5) and zero profit condition (4), respectively. A relation between ω and U is given by (10). To derive a relation between U and h we substitute for k in (3) by the inverse knowledge production function $k = q^{1/a}$, and then use (11) to substitute for

[10] For $\omega < \theta f(\theta)$, we would get $U > 1$ in (10).

[11] For $U < U_{\text{inf}}$, we would get $\omega < 0$ in (10) and $q < 0$ in (11).

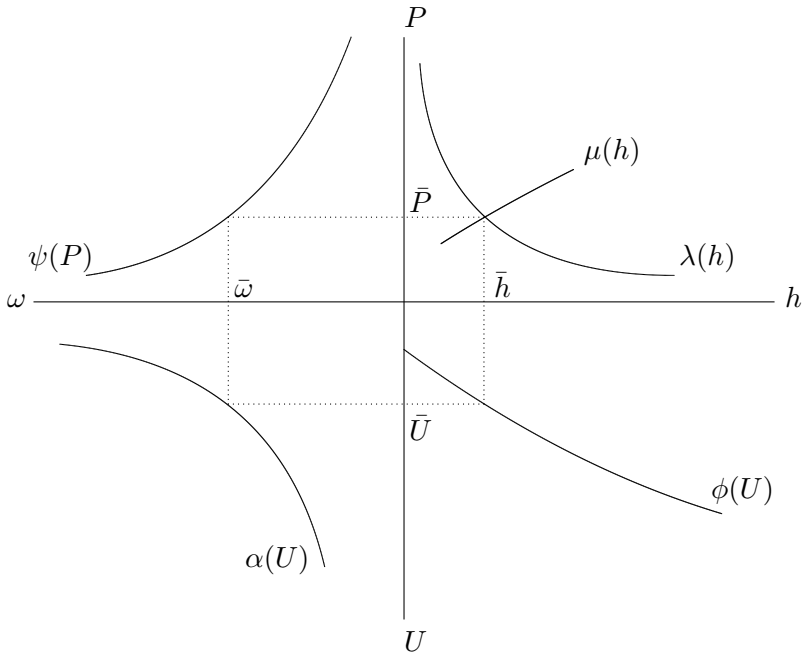

Figure 1: The Closed Economy Equilibrium

q. This gives us

$$h \equiv \phi(U, \beta(U)) = \frac{K(T-1)}{T} \frac{[\beta(U,\theta)]^{\frac{a-1}{a}}}{(1-U)\left(N - K\left[\beta(U,\theta)\right]^{-\frac{1}{a}}\right)} \tag{12}$$

which now depends only on model parameters and U. We find

$$\frac{d\phi}{dU} = \frac{\partial \phi}{\partial U} + \frac{\partial \phi}{\partial q}\frac{\partial \beta}{\partial U} > 0,$$

and furthermore $U = \theta(\Delta + a - 1)/[\theta(\Delta + a - 1) + 1 - a]$ at $h = 0$, and $U \to 1$ as $h \to \infty$. The graphical representations of (5), (4), (10) and (3′) in quadrants I to IV are now straightforward and need no further elaboration. The upward sloping curve in quadrant I, labelled $\mu(h)$, is implied by (4), (10) and (3′): For a given zero-profit relation (4), it gives combinations of h and P which are compatible with unskilled workers supplying the profit maximizing level of effort along the fair wage constraint, while being indifferent between being skilled and unskilled. It can be easily verified that there is a unique equilibrium for the closed economy, with the equilibrium

values of the respective variables being denoted by a "$^-$". The remaining endogenous variables q and k follow immediately from the career path indifference condition (2) and the production function (1).

3 The Asymmetric Two-Country World

Based on the description of the closed fair wage economy in the previous section, we can now derive equilibrium for an asymmetric two-country world of "Europe" and "America". The different preferences in America and Europe towards wage inequality are captured here by assuming that $0 < \theta^A < \theta^E < 1$, where θ^A and θ^E apply to America and Europe, respectively. This implies, as can be seen from (8), that for a given rate of unemployment and a given wage for skilled labour, European unskilled workers' fair wage is higher than the fair wage of their American colleagues. Put differently, European unskilled workers *ceteris paribus* require the skill premium to be smaller if they are to supply their full effort.[12]

In order to focus on the effect of the international differences in fairness preferences, it is assumed that preferences over goods, the rate of time preference, and production functions for X, Y and Q are the same in both countries. We focus on equilibria where both countries produce both goods and trade them freely with each other. Given these assumptions, factor prices for efficiency units of skilled and unskilled labour will be equalised internationally. Crucially however, as the quality of skilled workers may be different between countries, factor prices for physical units of skilled labour need not be equalised. The two-country equilibrium is formally described by

$$q_i = k_i^a \qquad i = E, A \qquad (1')$$

$$\frac{\omega}{q_i} = \frac{1-a}{(1-U_i)\Delta} \qquad i = E, A \qquad (2')$$

[12]This is a milder version of the dichotomy assumed in the small open economy model of Agell and Lundborg (1995). They assume – using a fair wage mechanism different from the one employed here – that relative factor prices have an influence on the effort provided by workers in "Europana", while workers in "Americana" do not care about relative factor prices. Differences in fairness preferences between the U.S. and Europe also feature prominently in Alesina and Angeletos (2005).

$$h = \frac{\left(q_A \frac{K_A}{k_A} + q_E \frac{K_E}{k_E}\right)(T-1)}{\left[\left(N_A - \frac{K_A}{k_A}\right)(1-U_A) + \left(N_E - \frac{K_E}{k_E}\right)(1-U_E)\right]T} \tag{3'}$$

$$\frac{\omega}{q_i} = \frac{\theta_i}{\theta_i + (1-\theta_i)U_i}\left(1 + \frac{f(\theta_i)}{q_i}\right) \qquad i = E, A \tag{9'}$$

as well as (4) and (5). The subscript E denotes variables specific to Europe, and subscript A those specific to America. Equations (1′) describe the knowledge production in Europe and America, respectively. Equations (2′) are the conditions for equality of expected lifetime incomes for skilled and unskilled workers in Europe and America. The average skill intensity of world production is given by (3′), and Equations (9′) are the fair wage constraint for Europe and America, respectively. Together, these nine equations determine the endogenous variables p, ω, h, k_E, k_A, q_E, q_A, U_E and U_A.

We can now adapt figure 1 to the two-country case by focusing on the variables h, p, ω, U_E and U_A. This is done in figure 2, where quadrants I and II are unchanged in comparison to the one-country case. In quadrant III, (10) is replaced by the two analogous equations $\alpha(U_E, \theta_E)$ and $\alpha(U_A, \theta_A)$. Solving these equations for U_A and U_E, respectively, and using $\omega_A = \omega_E = \omega$, we get

$$\frac{U_E}{U_A} = \left(\frac{\theta_A(\Delta + a - 1) + 1 - a}{\theta_E(\Delta + a - 1) + 1 - a}\right)\frac{\theta_E f(\theta_E)(1-a) + \theta_E(\Delta + a - 1)\omega}{\theta_A f(\theta_A)(1-a) + \theta_A(\Delta + a - 1)\omega} \tag{13}$$

It is shown in the appendix that $U_E/U_A > 1$ for all possible values of ω and that furthermore $\partial(U_E/U_A)/\partial\omega < 0$. Hence, the international differential in unemployment rates for unskilled workers increases whenever $1/\omega$, the skill premium for labour in efficiency units, increases.

While both unemployment rates can be read off the U axis, the locus in quadrant IV can obviously map only one of these variables – we choose U_E – into h, which is now to be interpreted as the average skill intensity of world production, measured in efficiency units. It is clear from (3′) that h depends on six endogenous variables, U_E, U_A, q_E, q_A, k_E and k_A. When varying one of them, U_E, we therefore have to take into account the endogenous adjustment of the other five. In analogy to (12), the ks are substituted for by the inverse knowledge production functions, and the qs are substituted for by the analogues of (11). We can furthermore derive a functional relationship $U_A = \delta(U_E, \theta_A, \theta_E)$ by setting $\alpha(U_A, \theta_A) = \alpha(U_E, \theta_E)$ and solving for U_A. Looking

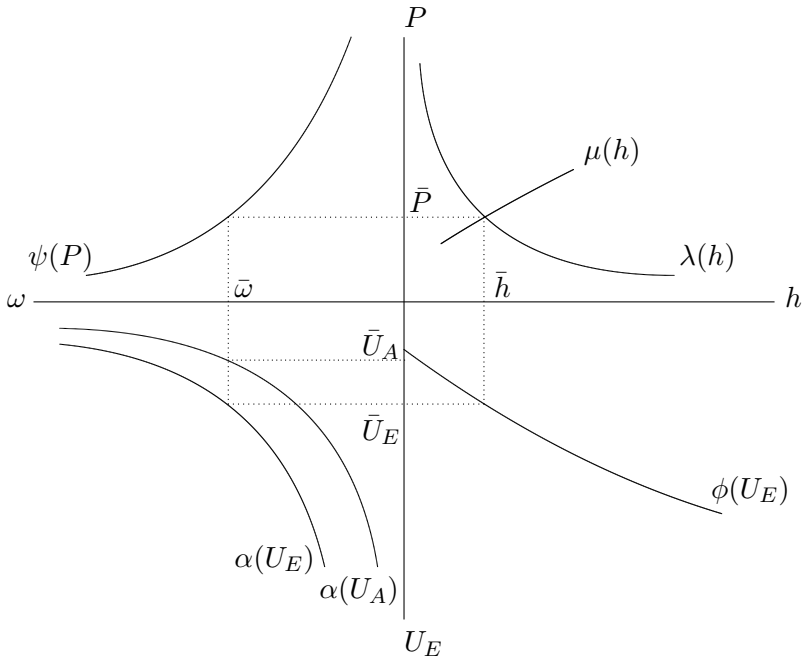

Figure 2: The Integrated Two-Country World

at figure 2, it is immediate that $\partial\delta/\partial U_E > 0$.[13] The locus in quadrant IV is now given by

$$\begin{aligned} h \equiv & \phi(U_E, \beta_E(U_E), \delta(U_E), \beta_A[\delta(U_E)]) \\ = & \frac{T-1}{T} \frac{K_E \left[\beta_E(U_E)\right]^{\frac{a-1}{a}} + K_A \left\{\beta_A[\delta(U_E)]\right\}^{\frac{a-1}{a}}}{(1-U_E)\left(N_E - K_E \left[\beta_E(U_E)\right]^{-\frac{1}{a}}\right) + \left[1-\delta(U_E)\right]\left(N_A - K_A \left\{\beta_A[\delta(U_E)]\right\}^{-\frac{1}{a}}\right)}, \end{aligned} \tag{14}$$

with

$$\frac{d\phi}{dU_E} = \frac{\partial\phi}{\partial U_E} + \frac{\partial\phi}{\partial q_E}\frac{\partial\beta_E}{\partial U_E} + \frac{\partial\phi}{\partial U_A}\frac{\partial\delta}{\partial U_E} + \frac{\partial\phi}{\partial q_A}\frac{\partial\beta_A}{\partial U_A}\frac{\partial\delta}{\partial U_E} > 0.$$

The higher unemployment rate in Europe implies, using the career path indifference condition $(2')$, that the skill premium – measured in terms of gross or net wages – is smaller in Europe than in America. The economic intuition is straightforward: With the higher unemployment rate in Europe, a lower skill premium in terms of net wages is needed in order to keep workers indifferent between being skilled or unskilled. With identical Cobb-Douglas education technology in both

[13] For a formal proof, see the appendix.

countries, the wedge between gross and net wages is the same, and the argument carries over to gross wage differentials as well. It is also immediate from $(2')$ that the quality q of skilled workers is lower in Europe than in America: With factor price equalisation in terms of factor efficiency units, this is the only possible reason for a lower skill premium in Europe. These results are summarised in the following proposition:

Proposition 1. *In equilibrium, the unemployment rate among unskilled workers is higher in Europe than in America, and the skill premium, along with the quality of skilled workers, is lower.*

In addition, we have:

Corollary 1. *Wages of skilled workers are higher in America than in Europe.*

Proof. Wages for unskilled workers are equalised through trade. This, together with proposition 1 immediately gives the result. □

4 Comparative Statics

4.1 Trade with NICs

Consider now a globalisation shock hitting the integrated two-country world. The shock is modelled as opening up to trade with a third country (the rest of world) that at the relative goods price of the two-country world is a net supplier of the unskilled labour intensive good. Formally, equation (5) is replaced by

$$p = \lambda(h, G) \qquad \text{with} \qquad \frac{\partial \lambda}{\partial h} < 0, \quad \frac{\partial \lambda}{\partial G} > 0 \tag{15}$$

where G represents the degree of globalisation vis-a-vis net suppliers of unskilled labour intensive goods that the fair wage economy faces. The modelling is very general in that it allows for the degree of globalisation to be determined by the rest of the world. For example, China becoming an exporter of unskilled labour intensive goods on a relevant scale would be one possible development captured by an increase in G. *Ceteris paribus*, this increases the relative price of the skill intensive good in the previously closed fair wage economy.

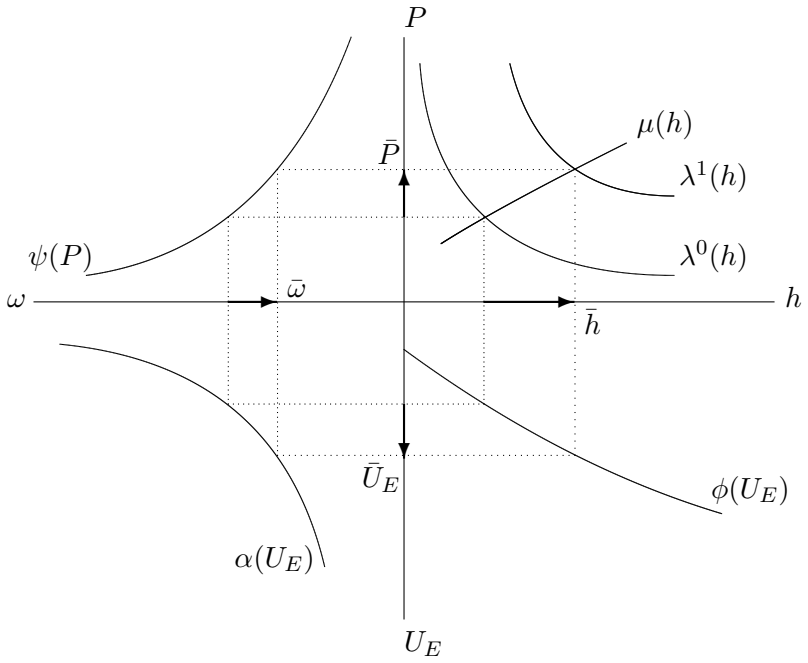

Figure 3: The Entry of NICs into World Trade

In figure 3, the entry of NICs into world trade shifts the goods-market-equilibrium relation outwards, i.e. from position λ^0 to position λ^1. The vertical distance between the two curves measures the amount by which this change would make P, the relative world market price of the skill intensive good, go up for a given average skill intensity of production in the integrated two-country world. The effect of the NIC shock on the model variables is shown by arrows. In order to avoid clutter, $\alpha(U_A)$ is omitted from figure 3, but the change in American unskilled unemployment follows immediately from the discussion relating to figure 2 in the previous section. The results are summarised as follows:

Proposition 2. *The entry of NICs into the world trading system leads to a strong increase in unskilled unemployment rates in Europe and a weak increase in unskilled unemployment rates in America, thereby widening the unemployment differential between the countries. Skill premia decrease strongly in Europe and weakly in America, thereby increasing the international wage differential for skilled workers.*

Noteworthily, the sign of the effect of a globalisation shock on skill premia is reversed in the present model as compared to both the standard HO model and the HO-cum-fair-wage (HOFW) model analysed in Kreickemeier and Nelson (2006), while the change in unemployment rates has the same sign as in the HOFW model. The economic intuition for this difference is clear: In HOFW model, a negative shock to unskilled labour, resulting in higher unemployment, leads unskilled workers to accept a relatively lower wage as their outside options become worse. In the present model, an increase in unemployment gives an incentive to become skilled, and in the new equilibrium with a higher unemployment rate the relative wage of unskilled must be higher in order to have newborns again indifferent between being skilled and unskilled. The combination of a higher unemployment rate and a higher relative wage of unskilled workers is compatible with a binding fair wage constraint because the quality of skilled workers falls. The result can furthermore be illustrated in figure 4. The initial equilibrium is given by the intersection between career path indifference condition CPI and fair wage constraint FWC^0 at $(\overline{\omega/q})^0$ and $\bar{U}^0$, where in drawing the fair wage constraint q is held fixed at its equilibrium value. The adverse primary shock to unskilled labour, by increasing U, gives an incentive for skill accumulation, and the ensuing decrease in the quality of skilled workers leads to an upward shift in the fair wage constraint. The new equilibrium is at $(\overline{\omega/q})^1$ and $\bar{U}^1$.

Another key difference to the HOFW model is that the globalisation shock can account for divergent unemployment paths in the present framework.[14] In particular, a negative shock to unskilled workers such as the globalisation shock, leads to an increase in the differential between unemployment rates for unskilled workers between Europe and America.

4.2 Global Technology Shock

When analysing the effect of technological change on unemployment rates and wage premia, it turns out to be useful to split the overall effect into three partial effects. The *impact effect* describes the effect of technological progress (TP) on the factor price differential in efficiency units at constant relative goods prices. Now, holding employment levels as well as the composition

[14] This is trivially true as well in the minimum wage models used by Davis (1998a) and Davis and Reeve (2002), where unemployment in America is zero, and a globalisation shock increases the European unemployment rate.

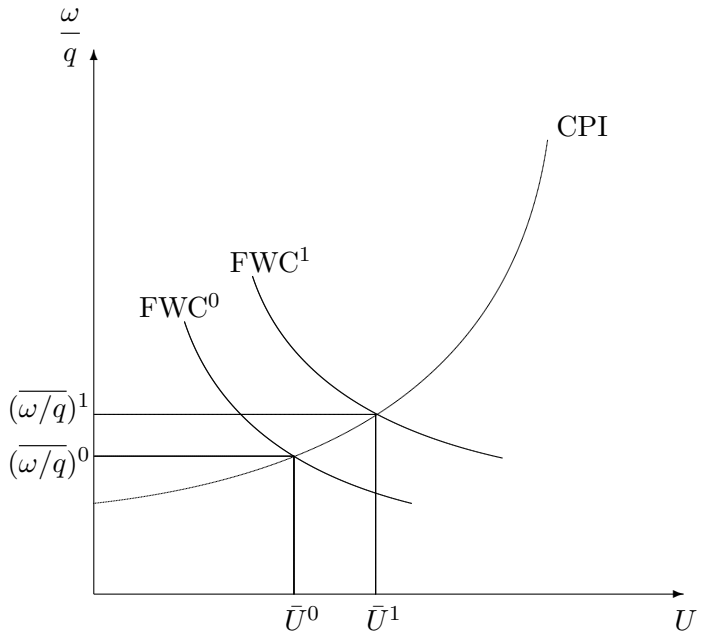

Figure 4: Equilibrium relation between unemployment and the skill premium

of the work force constant, a goods price change is needed to bring about goods market equilibrium. The resulting change in the relative wage for efficiency units is labelled *relative price effect*. If and only if the sum of these effects is non-zero, the career path indifference condition is violated, and the composition of the workforce changes. This third effect is labelled *workforce composition effect*. Distinguishing these three effects is useful because the first two are identical to the standard HO model with full employment.[15] We can therefore relate our analysis in a straightforward way to the comprehensive analysis of technological change in the HO model by Xu (2001).

In order to facilitate the comparison between our results and the analysis in Xu (2001), we introduce the following terminology.

Definition 1. *The case where the relative price effect of TP is sufficiently large to reverse*

[15]These two effects depend only on zero profit conditions (4) and the goods market equilibrium condition (5), and neither condition depends labour market characteristics.

the impact effect of TP on the factor price differential is called the "inelastic case". If the relative price effect is sufficiently small to preserve the sign of the impact effect, we call this the "elastic case". The case where the relative price effect exactly offsets the impact effect is labelled "borderline case".

This terminology is meaningful insofar as *ceteris paribus* an increase in the elasticity of substitution in demand decreases the relative price effect. As shown in Xu (2001), the distinction made in this definition corresponds to the elasticity of substitution in demand being smaller than, larger than and equal to one, respectively, for the case of global technological change that is Hicks-neutral. With non-neutral technological change, the borderline case occurs for an elasticity of substitution which is different from one. With skill-using TP in the skill intensive or labour-using TP in the labour intensive sector, the elasticity of substitution in the borderline case is smaller than one. In the other two cases (skill-using TP in the labour-intensive sector and labour-using TP in the skill-intensive sector) it is larger than one.[16]

Using the above definition, we have the following result.

Proposition 3. *In the elastic case, global technical progress in the skill intensive (labour intensive) sector leads to an increase (decrease) in the unemployment rate of unskilled labour in America and Europe and to a widening (shrinking) unemployment differential between the two countries. In the inelastic case, these effects are reversed. In the borderline case, unemployment rates in both countries are unchanged.*

The result is proved using figure 5. Curves labelled "0" belong to the pre-TP equilibrium, curves labelled "1" to the post-TP equilibrium. For concreteness, in the figure TP is assumed to occur in the labour intensive sector, and the price adjustment is assumed to be such that relative factor prices as well as the skill intensity of production are constant. In other words, figure 5 depicts the borderline case.

The effect of TP in the labour-intensive sector is to shift the zero-profit relation in quadrant II outwards, from ψ^0 to ψ^1. As both types of labour are paid the value of their marginal product, this move is independent from labour market characteristics. Given the construction of $\mu(h)$ in

[16] See Xu (2001), table 2.

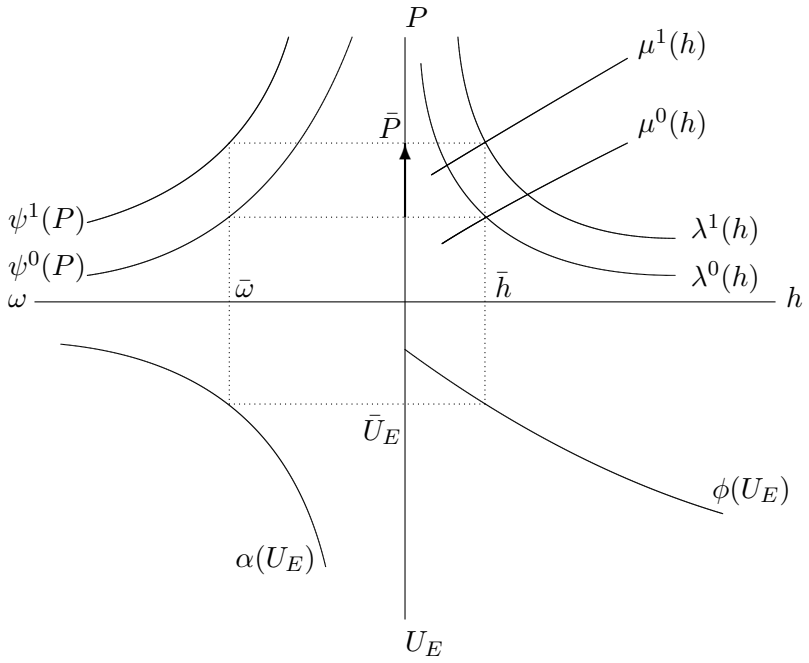

Figure 5: Global Technological Change

quadrant I explained above, it is clear that this curve shifts upward by the same amount as the zero profit condition, in the case depicted from μ^0 to μ^1. For every type of TP in the labour intensive sector, the goods market equilibrium condition in quadrant I is shifted outwards, the extent depending on both the bias of TP and the elasticity of substitution in demand. Again, labour market characteristics play no role here. Therefore, the effect of TP in an economy with constant employment levels for both types of labour can be derived from figure 5 by holding the skill intensity constant at $\bar{h}$. This is what allows us to relate the results in our model to those derived by Xu (2001). In the borderline case depicted, the relative price of the skill intensive good rises to the extent shown by the arrow, and the equilibrium values of ω, U and h remain unchanged.

As the shift in μ only depends on the type of TP (but not on demand parameters), post-TP equilibria have to lie on μ^1. In the elastic case, the goods market equilibrium schedule λ moves to an intermediate position between λ^0 and λ^1, while in the inelastic case it moves to

a position beyond λ^1. The respective schedules have not been added to the figure in order to avoid clutter. Working through the adjustment process in figure 5 for these cases, the results stated in proposition 3 follow immediately.

From the career path indifference conditions $(2')$, the skill premium for physical units of labour in each country increases if the unemployment rate decreases. In addition, the international wage differential for skilled workers increases if the unemployment differential increases. These effects are analogous to those derived in the section on the effects of globalisation.

5 Conclusion

The workforce in most industrialised countries has become more skilled over the past decades. This common trend has been accompanied by country-specific developments of unemployment rates and wage inequality. While it has been popular in the academic literature on this topic, neither of these trends makes the one-cone Heckscher-Ohlin model an obvious framework for analysis: Factor supplies are exogenous, and even with country-specific labour market imperfections the basic factor price equalisation property of the model means that one needs technology shocks with a country-specific component to explain divergent wage paths. Similarly, accounting for country specific unemployment paths is difficult if one focuses on strictly positive positive unemployment in all countries.

The current paper provides a tractable model that arguably does better than the Heckscher-Ohlin framework in accounting for the observed trends. It shows that global shocks can have differential effects on both unemployment and wage rates in America and Europe if an asymmetric two-country version of the fair wage model by Akerlof and Yellen (1990) is linked with the Findlay-Kierzkowski model, which allows for endogenous changes of factor supplies in a HO framework. In this framework, the quality of skilled workers is country specific, and hence diversified production in both countries is compatible with non-equalised factor prices for skilled workers between countries.

Allowing for supply side adjustment has furthermore be seen to be important in the fair wage context considered here: Endogenising the skill composition of the workforce reverses – rather than dampens – the relative wage effects of globalisation and technology shocks. The

reason for this lies in the fundamentally different role that the change in the unemployment rate plays in the fair wage model with and without human capital accumulation. With exogenous factor supplies, an increase in the unskilled unemployment rate (by worsening the outside option of unskilled workers) leads to unskilled workers accepting a higher skill premium. However, given the opportunity to become skilled, a new generation of unskilled workers request the skill premium to be lower in order to remain unskilled in the presence of an increase in unskilled unemployment.

Appendix

Proof of $\partial(U_E/U_A)/\partial\omega < 0$

We can solve (10) for U_A and U_E, respectively, and divide the two to get

$$\frac{U_E}{U_A} = \left(\frac{\theta_A(\Delta+a-1)+1-a}{\theta_E(\Delta+a-1)+1-a}\right)\frac{\theta_E f(\theta_E)(1-a)+\theta_E(\Delta+a-1)\omega}{\theta_A f(\theta_A)(1-a)+\theta_A(\Delta+a-1)\omega} \tag{16}$$

It has been shown above that the minimum value for ω (at $U=1$) is $\theta f(\theta)$. Given that ω is equal between the two countries, and that $\theta_E > \theta_A$, the minimum level of ω for the two-country world is $\theta_E f(\theta_E)$ (implying $U_E = 1$). Setting either $\omega = \theta_E f(\theta_E)$ in (16) or $U_E = 1$ in (20), we get

$$\left.\frac{U_E}{U_A}\right|_{U_E=1} = \frac{\theta_A(\Delta+a-1)+1-a}{\theta_A(\Delta+a-1)+(1-a)\frac{\theta_A f(\theta_A)}{\theta_E f(\theta_E)}} > 1 \tag{17}$$

As $\omega \to \infty$, U_E/U_A approaches the differential of the two lower bounds for U, which yields

$$\left.\frac{U_E}{U_A}\right|_{U_E \to U_E^{\inf}} = \frac{\theta_A(\Delta+a-1)+1-a}{\theta_A(\Delta+a-1)+(1-a)\frac{\theta_A}{\theta_E}}, \tag{18}$$

which is smaller than the unemployment differential at $\omega = \theta_E f(\theta_E)$, but still larger than 1. Differentiating (16) with respect to ω yields

$$\frac{\partial\left(\frac{U_E}{U_A}\right)}{\partial\omega} = \left(\frac{\theta_A(\Delta+a-1)+1-a}{\theta_E(\Delta+a-1)+1-a}\right)\frac{\theta_A\theta_E(\Delta+a-1)(1-a)[f(\theta_A)-f(\theta_E)]}{[\theta_A f(\theta_A)(1-a)+\theta_A(\Delta+a-1)\omega]^2} < 0, \tag{19}$$

and hence the unemployment differential shrinks monotonically as ω increases.

Proof of $\partial\delta/\partial U_E > 0$

Plugging θ_A and θ_E into equation (10) and setting the two equal (because $\omega_A = \omega_E$ under diversification), we get

$$\begin{aligned} U_A &\equiv \delta(U_E, \theta_A, \theta_E) \\ &= \frac{\theta_A f(\theta_A)(\theta_E(\Delta+a-1)+1-a)}{\theta_E f(\theta_E)(\theta_A(\Delta+a-1)+1-a)}U_E + \frac{\theta_A(\Delta+a-1)[f(\theta_E)-f(\theta_A)]}{f(\theta_E)(\theta_A(\Delta+a-1)+1-a)} \end{aligned} \tag{20}$$

Using $a < 1$, $\Delta > 1$ and $f(\cdot) > 0$, $\partial\delta/\partial U_E > 0$ follows immediately.

References

Acemoglu, D. (2003), "Cross-Country Inequality Trends", *Economic Journal*, 113, F121-F149.

Agell, J. and Lundborg, P. (1995), "Fair Wages in an Open Economy", *Economica*, 62, 335-351.

Akerlof, G. (1982), "Labor Contracts as Partial Gift Exchange", *Quarterly Journal of Economics*, 97, 543-569.

Akerlof, G. and Yellen, J. (1988), "Fairness and Unemployment", *American Economic Review*, 78, 44-49.

Akerlof, G. and Yellen, J. (1990), "The Fair Wage-Effort Hypothesis and Unemployment", *Quarterly Journal of Economics*, 105, 255-283.

Alesina, A. and G. Angeletos (2005), "Fairness and Redistribution", *American Economic Review*, 95, 960-980.

Baldwin, R. and Cain, G. (2000), "Shifts in Relative U.S. Wages: The Role of Trade, Technology, and Factor Endowments", *Review of Economics and Statistics*, 82, 580-595.

Bewley, T. (2005), "Fairness, Reciprocity, and Wage Rigidity", in H. Gintis, S. Bowles, R. Boyd and E. Fehr (eds.) *Moral Sentiments and Material Interests: The Foundations of Cooperation in Economic Life* (Cambridge: MIT Press) 303-338.

Davis, D. (1998a), "Does European Unemployment Prop up American Wages? National Labor Markets and Global Trade", *American Economic Review*, 88, 478-494.

Davis, D. (1998b), "Technology, Unemployment, and Relative Wages in a Global Economy", *European Economic Review*, 42, 1613-1633.

Davis, D. and Reeve, T. (2002), "Human Capital, Unemployment and Relative Wages in a Global Economy", in D. Greenaway et al. (eds.) *Trade, Investment, Migration and Labour Market Adjustment* (Basingstoke: Palgrave Macmillan) 7-27.

Findlay, R. and Kierzkowski, H. (1983), "International Trade and Human Capital: A Simple General Equilibrium Model", *Journal of Political Economy*, 91, 957-978.

Howitt, P. (2002), "Looking Inside the Labor Market: A Review Article", *Journal of Economic Literature*, 40, 125-138.

Kreickemeier, U. and Nelson, D. (2006), "Fair Wages, Unemployment and Technological Change in a Global Economy", *Journal of International Economics*, forthcoming.

Krugman, P. (1995), "Growing World Trade: Causes and Consequences", *Brookings Papers on Economic Activity*, n.V., 327-362.

Krugman, P. (2000), "Technology, Trade and Factor Prices", *Journal of International Economics*, 50, 51-71.

Nickell, S. (1997), "Unemployment and Labor Market Rigidities: Europe versus the United States", *Journal of Economic Perspectives*, 11, 55-74.

Oslington, P. (2002), "Factor Market Linkages in a Global Economy", *Economics Letters*, 76, 85-93.

Solow, R. (1979), "Another Possible Source of Wage Stickiness", *Journal of Macroeconomics*, 1, 79-82.

Xu, B., 2001, "Factor Bias, Sector Bias, and the Effects of Technical Progress on Relative Factor Prices", *Journal of International Economics*, 54, 5–25.