Board of Governors of the Federal Reserve System

International Finance Discussion Papers

Number 659

February 2000

HUMAN CAPITAL, UNEMPLOYMENT, AND RELATIVE WAGES IN A GLOBAL ECONOMY

Donald R. Davis and Trevor A. Reeve

HUMAN CAPITAL, UNEMPLOYMENT, AND RELATIVE WAGES
IN A GLOBAL ECONOMY

Donald R. Davis and Trevor A. Reeve*

Abstract: This paper develops a simple framework for examining human capital accumulation, unemployment, and relative wages in a global economy. It builds on the models of Davis (1998a, b) of trade between a flexible wage America and a rigid wage Europe. To this it adds a model of human capital accumulation based on Findlay and Kierzkowski (1983). A variety of comparative statics are examined, including changes in educational capital and population, entry of new countries to the trading world, technical change, and a productivity slowdown. We derive the consequences for the skilled-to-unskilled wage gap, unemployment, and skill composition.

Keywords: international trade, human capital, unemployment, wages.

* Donald Davis, Columbia University and NBER (drd28@columbia.edu); Trevor Reeve, International Finance Division of the Federal Reserve Board (trevor.a.reeve@frb.gov).
Donald Davis is grateful for support for this project from the Harvard Institute for International Development (HIID), and Trevor Reeve acknowledges the support of the National Science Foundation. The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System.

I. Human Capital and the Global Economy

Over the past twenty years both American and European labor markets have experienced serious problems. Yet the manifestations have been distinct. Europe has suffered high and persistent unemployment, reaching double digits in many countries. America has seen the skilled to unskilled wage premium rise sharply. From 1979 to 1989 the relative wage of a worker in the 90th percentile to one in the 10th percentile rose by twenty percent [Freeman and Katz (1995)].

There are good reasons for considering these developments in a common framework. America and Europe are part of a single global economy. The web of trade, bilaterally and with third parties, links their goods markets and so their prices. The goods prices in turn link their factor markets. As well, many of the shocks contributing to these developments are global shocks that affect both America and Europe. One suspects, for example, that an important component of technological shocks in recent years is global. Finally, consideration of the cases in a common framework may be valuable in enforcing consistency among the accounts we provide for each.

Consideration of these disparate labor market developments within a common framework must confront a crucial fact: Labor market institutions differ across countries. This observation plays an important role in interpretations of the recent comparative labor market experience of America and Europe [Freeman and Katz (1995), Krugman (1995), Bertola and Ichino (1995)]. Much of this work has examined the role of institutions one country at a time. This has proved valuable, as it allows a rich examination of local institutions. Yet it also misses an important part of the story, as the consequences of institutional choices differ markedly depending on whether the economies are closed or in a global trading world. This point is developed in the recent work of Davis (1998a, b).

Freeman and Katz (1995) emphasize that within this institutional matrix one wants to consider the consequences of a range of shocks to both relative demand for and supply of factors. For good reasons, much of the attention has focused on the sources of shocks to relative demand, such as technology and trade [Katz and Murphy (1992)]. Yet insofar as many of these shocks are global, they may not help to explain cross-country differences in experience.

An alternative perspective for understanding the diversity of the cross-country experience has emphasized cross-country differences in the evolution of relative supplies of the factors. In particular, Katz, Loveman, and Blanchflower (1995) note that there was a marked deceleration of the growth rate of relative skill supply in the U.S., U.K., and Japan, countries where skill premia grew, while no such deceleration was evident in France, where the wage premium was more stable. The analytic framework that they employ makes local relative wages depend on *local* relative supplies of factors, and takes changes in these relative supplies as exogenous. Within their framework, if substitutability across skill categories is at the low end of the preferred range, then changes in the growth rate of relative supplies may account for much or all of the changes in relative wages in the relevant period.

This apparent dependence of local relative wages on local relative factor supplies is at odds with the preferred framework within the international trade literature for thinking about long run changes in relative factor returns, that of Heckscher-Ohlin[1]. The culprit in this regard

[1] For example, Krugman (1997) writes "In the last few years the impact of international trade on advanced-country wages has been hotly debated. Unusually, serious economists have not by and large argued about theory: with few exceptions they have agreed that a more or less

may appear to be factor price equalization, which implies that factor returns depend on global rather than local relative factor supplies [Leamer (1996)].

There are modifications to the Heckscher-Ohlin theory that could help to provide an account. These include trade barriers, sectoral factor immobility, and imperfect substitutability of American and European goods. However, each of these accounts has undesirable features. Trade barriers among these countries are not high, sectoral factor immobility should not be such a great problem over the stretch of decades under discussion, and (as should be evident from the Dixit-Stiglitz (1977) framework) it is not sufficient to believe that individual goods are imperfect substitutes–one must believe at a deep level that American and European labor of the various classes are different.

However, there is one shortcoming common to both the trade and labor literature in this area. The division of new entrants into skilled and unskilled is treated as an exogenous shock to the economy. When we are thinking about evolution of the labor force over decades, and this with substantial changes in relative wages, this is not really satisfactory. Moreover, when factor supplies are allowed to adjust endogenously, there may well be alternative accounts one can provide of the Katz, Loveman and Blanchflower (1995) observation of the differences between American and European experience. A full accounting of these relative supply changes and their consequences requires careful attention to historical conditions (e.g. baby boom and bust). But the interpretation one places on these findings will be seen to depend crucially on the analytic structure.

---

classical Heckscher-Ohlin-Samuelson model is the best framework to use."

Accordingly, the central analytic contribution of this paper is that it endogenizes the human capital accumulation decision. This has a number of important advantages. The first is that we provide a simple and unified analytic framework in which researchers can consider the interplay of unemployment, relative wages, and relative factor supplies where all are determined endogenously. An interesting analytic feature that emerges is that within this augmented Heckscher-Ohlin framework there are non-factor-supply-based shocks that replicate the correlations between movements in relative wages and (endogenous) relative factor supplies. This suggests the possibility of an upward bias in the Katz, Loveman, and Blanchflower (1995) estimates of the role of relative supply in explaining relative wage movements.

A second advantage of endogenizing the human capital accumulation decision is that it provides a richer framework for considering cross country differences in the evolution of relative wages. As noted, the workhorse for international analysis of these events has been the Heckscher-Ohlin model. In this framework, many of the shocks under consideration (e.g. global technology shocks) move the world from one equilibrium to another, both featuring factor price equalization. Hence they obviously cannot explain the divergence across America and Europe in the evolution of relative wages. This shortcoming has been evident even in the models that allow for unemployment. When we make the human capital accumulation decision explicit, changes in unemployment will have feedback effects on this decision, hence give rise to differences across countries in observed wages and their changes. Thus this provides an opportunity to explain not only changes in unemployment, but also in the evolution of relative wages across countries. And it does so without the necessity of appealing to country-specific policy or technology shocks.

In the present work, America is taken to be a flexible wage economy while Europe is viewed as an economy in which a variety of institutions make wages rigid.[2] This highly stylized representation of the world is borrowed from Davis (1998a), which, in turn, built on Brecher (1974) and Krugman (1995). Endogenizing the skill composition of the labor force is accomplished with the model of human capital accumulation developed in Findlay and Kierzkowski (1983), which follows the education-as-investment approach in modeling the demand for education [Freeman (1986)]. The introduction of a minimum wage and unemployment into the Findlay-Kierzkowski model is in the same spirit as Flug and Galor (1986).[3]

[2] It is well known that the U.K. experience has broadly been similar to that of the U.S. Hence in our stylized characterization, the U.K. should be thought of as part of "America" rather than "Europe."

[3] Real wage rigidity in the context of the Findlay-Kierzkowski (1983) model has previously been considered in Flug and Galor (1986). However the case that they considered imposes severe restrictions that limit its applicability. There are two ways of thinking about these restrictions. One is to think of the policy as having raised the wage to such an extent that no goods price consistent with diversified production in this economy would ever support this wage in a flexible wage world. The alternative interpretation is that the jump in the wage is less dramatic, but they apply this to an economy that was completely specialized in production even before the minimum wage. A second limiting element of their approach is that most of their effort is spent considering the problem from the viewpoint of a small open economy. A drawback is that in almost all cases, this focuses on a world with complete specialization in production. The one case in which production may be diversified is one in which the pattern of production and the level of unemployment are indeterminate. In the one section of the paper in which they do consider a two country large open economy, they again focus on the case with such a high minimum wage that this pushes the implementing country to full specialization. They seem not to have perceived that the case of a more moderate, yet binding, minimum wage could leave both countries diversified in the neighborhood of the initial equilibrium, yielding determinate trade and production patterns at all points in time. Nonetheless, several points of their analysis, notably the conditions under which the labor force composition is unaffected by imposition of a minimum wage, did prove helpful for our own work.

When we examine comparative statics, it will prove useful to characterize the impacts in terms of three *wedges* that separate the experience of America from that of Europe. From above, these are (1) A rise in unemployment in Europe, but not America; (2) A rise in the skill premium in America, but not in Europe; and (3) A slowdown in the growth rate of relative skill abundance in America, but not in Europe. These characterizations are not meant to substitute for a careful empirical inquiry. Our aim is and must be more modest. The approach developed here is highly stylized. The model is simple and the institutional characterization is very sharp. We do not propose a single-cause explanation for the recent factor market developments on both sides of the Atlantic. We hope only to provide a framework that empirical researchers can exploit in a closer examination of these developments.

This paper contains six parts. Section II sets up the basic model in the case of flexible wages and develops an approach to the Findlay-Kierzkowski model focused on factor markets. In Section III we begin by introducing a minimum wage in a closed economy. Then we consider this rigidity in the central case of interest, that of global trade between countries with differing labor market institutions. Section IV uses these models to consider various comparative statics of particular relevance to American and European labor market experience. Section V gathers the principal results and relates them to the three wedges between the experience of America and Europe noted above. Section VI concludes.

II. The Flexible Wage World

The seminal model of Findlay and Kierzkowski (1983) provides the basic structure for the analysis in this section. We provide a simple representation of equilibrium that focuses on factor markets. This will be particularly useful when we consider an economy with a minimum wage. We consider the model in a closed economy and then in an open economy.

A. The Closed Economy

We begin by describing the point in time equilibrium. This is a conventional two-by-two general equilibrium model. Skill, measured in efficiency units, is available in quantity H. Unskilled labor in natural (equals efficiency) units is available in quantity L. These factors are used to produce two goods under constant returns to scale and perfect competition. Good Y will serve as numeraire, so $P \equiv P_X / P_Y$. Good X is assumed to be the relatively skill intensive good at any common factor prices. The production functions for the two goods are thus:

$$X = X(H,L) \qquad Y = Y(H,L) \tag{1}$$

Preferences of agents are assumed identical and homothetic, so that the composition of goods demand depends on relative prices, and is independent of income. With all income devoted to final demand, goods market clearing may be represented by the equality of relative supply and demand.

We now turn to describe the dynamic economy for which this is the stationary steady state. There are N identical individuals born in every period, each with life span T. At birth they make an irrevocable choice between two career paths. E of the newborns seek an education, while the remaining $(N - E)$ enter immediately and for their entire life span into unskilled employment. Each of the E students will spend θ periods in school, and will then work as a skilled worker for the remaining $(T - \theta)$ periods of life. While in school, the E students have access to K units of educational capital, which allows them to accumulate $Q = F(K, E; \theta)$

efficiency units of skill over the period θ. The educational production function is assumed to be constant returns to scale in (K, E) for fixed θ. In the intensive form this is $Q = q\,E = f(k)\,E$, where $k \equiv K/E$ is the amount of educational capital per student, and $q = f(k)$ indicates the number of efficiency units of skill per worker, hence the quality of skilled labor.[4]

Because this is a stationary steady state, the cross section and time series look alike. At any point in time the population may be divided as follows, $NT = E\theta + E\,(T - \theta) + (N - E)\,T$ = Students + Skilled Workers + Unskilled Workers. The stocks of skilled and unskilled workers that serve as inputs are thus $H = q\,E\,(T - \theta)$ and $L = (N - E)T$.

It is necessary to make several distinctions in our characterization of factor returns. The simple case is that of unskilled labor, which receives the per-period wage w_L. We must be more careful when we discuss the returns to skilled labor. Producers focus on the wage that they pay per efficiency unit of skill, denoted $\tilde{w}_H$. The observed (gross) wage adjusts this for the quality of skill, so that $w_H = q\,\tilde{w}_H$. Finally, it is assumed that tuition is paid for the use of the educational capital K equivalent to a competitive factor return. Thus the net return to skilled labor is $\tilde{w}_H\,\partial Q/\partial E$. Often it will be convenient to refer to the relative wage (implicitly the skill premium) with reference to one or more of these concepts of the skilled wage. Define $\omega \equiv w_H / w_L$, and $\tilde{\omega} \equiv \tilde{w}_H / w_L$.

The stock of educational capital K that serves as an input to the educational process is determined exogenously.[5] However the number of students E is endogenous. Since all

---

[4]Skill in this setup can be viewed as a nontraded, produced intermediate input. See Melvin (1969) or Sanyal and Jones (1982).

[5] Making educational capital an endogenous policy choice is consistent with the qualitative conclusions derived here. If, in response to higher unemployment, the policymaker

individuals are identical *ex ante*, and capital markets are assumed perfect, an arbitrage condition assures that the present discounted value of the alternate career paths must be equal. The rate of interest r in equilibrium will equal the constant rate of time preference.

Thus the arbitrage condition can be written as:

$$\textbf{(2)} \qquad \int_{\theta}^{T} \tilde{w}_H\, f(k)\, e^{-rt}dt \;-\; \int_{\theta}^{T} \tilde{w}_H\, k\, f'(k)\, e^{-rt}dt \;=\; \int_{0}^{T} w_L\, e^{-rt}dt$$

Noting that $\partial Q/\partial E = f(k) - k\, f'(k)$, and defining the discount factor $\Delta \equiv [1 - e^{-rT}] / [e^{-r\theta} - e^{-rT}]$, this fundamental arbitrage condition can be written more compactly as:

$$\textbf{(3)} \qquad \frac{\tilde{\omega}}{\Delta} = \frac{1}{\partial Q/\partial E}$$

Sometimes it is more convenient to refer to observed wages. Letting $\eta_{Q,E}$ be the elasticity of Q with respect to E (at fixed K), this condition becomes:

$$\textbf{(4)} \qquad \frac{\omega}{\Delta} = \frac{1}{\eta_{Q,E}}$$

We now turn to the determination of the full equilibrium. Note that for fixed technology, and assuming diversified production, the relative price P stands in a one-to-one increasing relation with the relative efficiency wages $\tilde{\omega}$, in accord with the conventional Stolper-Samuelson relation. The price also determine the levels of the wages, w_L and $\tilde{w}_H$. Let the ratio $h \equiv H / L$.

---

diverts more resources to education, and if there is a rising cost of providing this additional capital, then the wage gap would be further muted, but the core results would remain intact.

A first key relation describes the general equilibrium structure of relative factor demand. This is summarized in the decreasing relation $h_D(\tilde{\omega})$ in Figure 1. A decline in P (so $\tilde{\omega}$) shifts the composition of goods demand from Y towards X. As well, the decline in $\tilde{\omega}$ leads both sectors to adopt more skill intensive techniques. Both elements imply that the structure of relative factor

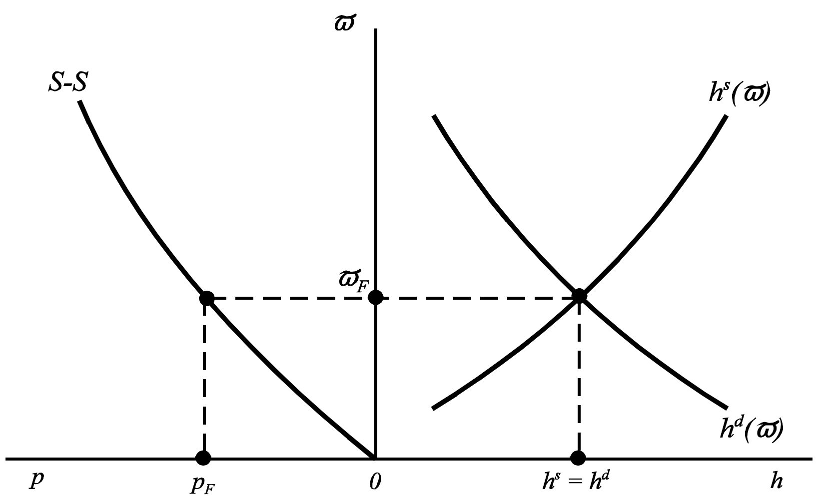

Figure 1: Flexible Wage Closed Economy Equilibrium

demand has shifted toward relatively skilled labor.

The second key relation describes the endogenous response of steady state relative factor supplies to changes in relative rewards, as indicated in the arbitrage equations above. With r, T and θ fixed, Δ is fixed. Hence for fixed K, a rise in $\tilde{\omega}$ requires a rise in E to satisfy the arbitrage condition. This raises the stock of skill while reducing the stock of unskilled labor, raising skill abundance. The full equilibrium of our dynamic system can then be described as $h^D(\tilde{\omega}) = h^S(\tilde{\omega})$ as in Figure 1. The market clearing goods prices are then read off of the Stolper-Samuelson relation.

B. The Trading Equilibrium in a Flexible Wage World

The modern framework for thinking about the Heckscher-Ohlin model under factor price equalization is what Dixit and Norman (1980) have termed the “integrated equilibrium.” It states conditions under which a world with trade in goods alone (but no international factor mobility) replicates the equilibrium that would exist in a fully integrated world. The usual approach is to start with the fully integrated world and ask what partitions of endowments among the countries are consistent with full employment in all countries, goods being produced under the integrated equilibrium techniques, and non-negative quantities of the goods being produced in all countries. The set of such partitions is then termed the Factor Price Equalization (FPE) set.

A similar approach would show that with a mild alteration in restrictions, trade in this world again will replicate the integrated equilibrium. If trade is free and costless, then goods prices will be common. If final goods technologies across the countries are common, and production diversified, then wages in efficiency units will be equalized. If the countries share common structural parameters affecting discounting (r, T, θ), and a common educational production function $F(\cdot,\cdot)$, then they likewise have a common arbitrage condition. Because of the constant returns to scale property of $F(\cdot,\cdot)$, $\partial Q/\partial E$ depends only on the ratio $k = K/E$. This implies that the quality of skilled labor q will be common across the countries, so that observed (not only efficiency) wages will be common. This is true in spite of differences in the relative availability of educational capital, K/N. Thus the availability of skilled labor in each country c is $H^c = q\, E^c\, (T - \theta)$, where $E^c = K^c / k$, and this also provides the stock of unskilled labor as $(N^c - E^c)$. With these definitions in hand, we can use the conventional restrictions on the FPE set (see

Helpman and Krugman (1985)). Using these definitions it is straightforward to show that for countries c and c′:

(5)
$$\frac{L^{c}}{H^{c}} - \frac{L^{c'}}{H^{c'}} = \frac{kT}{q\,(T-\theta)}\left[\frac{N^{c}}{K^{c}} - \frac{N^{c'}}{K^{c'}}\right]$$

Thus the country which is abundant in population N relative to educational capital will likewise be abundant in unskilled relative to skilled labor, so will be the exporter of the labor-intensive good Y. In terms of our diagram, the relative labor demand curve is entirely unchanged, and so also the world relative supply curve that determines equilibrium. However the population abundant country will have a relative supply curve that is less skill abundant than the world, and vice versa for the other country.

Although our work on trade and unemployment will concern countries of the same order of magnitude in terms of income, we will see that institutions in one country will leave the other country facing an infinitely elastic export supply curve. Accordingly, it will prove useful to develop a small open economy version of our model. In a diagram reminiscent of Leamer (1996), relative factor demand becomes infinitely elastic at relative wages $\tilde{\omega}_{W}$, so long as we are in the range of diversified production. As illustrated in Figure 2, this determines the structure of relative factor supply, production, income and absorption.

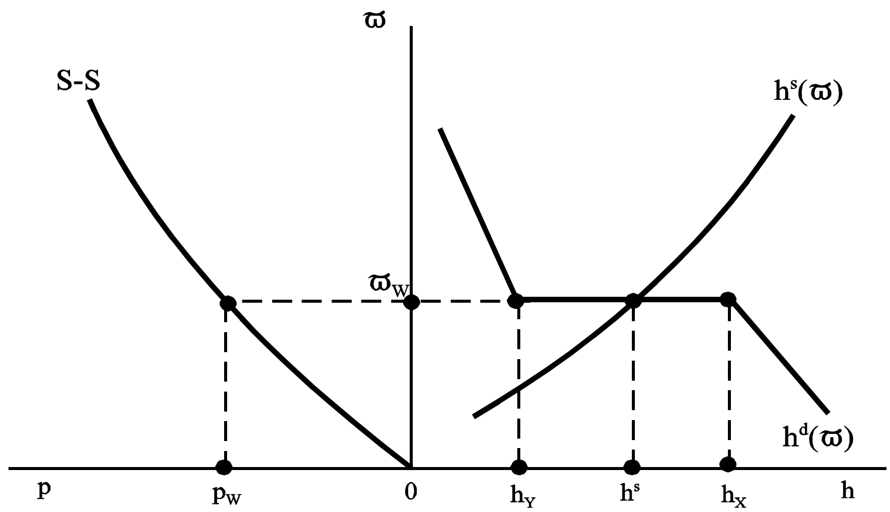

Figure 2: Small Open Economy Equilibrium

III. Minimum Wages, Unemployment, and Labor Force Composition

A. The Closed Economy

We here consider the same model, but now with rigid labor market institutions in the form of an exogenously specified binding minimum wage in terms of the numeraire[6]. We

---

[6] This choice follows Brecher (1974) and Davis (1998a). The modeling is not meant to be taken literally as a characterization of European factor markets, where the institutions are both more subtle and varied. Rather it is a modeling shortcut to introduce rigidity and so induce unemployment. The exogeneity of the minimum wage ignores interesting problems of political economy, as well as the likely feedback from the real economy to the level at which the wage is set. This shortcut is justified by two facts. First, ignoring the political economy vastly simplifies the positive analysis. Second, whatever feedback mechanisms exist are evidently weak, given the high levels of unemployment. Thus ignoring these feedback effects is appropriate here. For alternative methods for generating unemployment in models of international trade, see Brecher and Long (1989), Davidson, Martin, and Matusz (1991), Fernandez (1992), and Hoon (1991).

In addition it might appear to be quite restrictive that we model the rigidity as a fixed minimum wage when we are alluding to factor market developments occurring over the course of decades. This is deceiving. It is a straightforward extension to allow the minimum wage to grow at the same rate as Hicks-neutral technical progress in both sectors, leaving the unemployment consider this first for a closed economy before turning to our central project of considering this for a global trading world. A schematic view of the model is given in Figure 3.

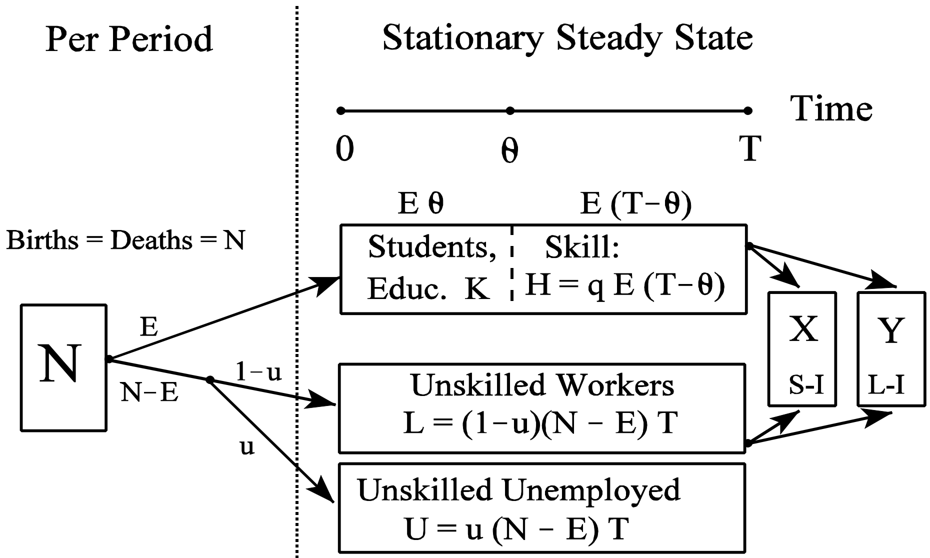

Figure 3: Schematic View of the Model with Unemployment

With no minimum set for skilled labor, it must always be fully employed. However if the flexible wage equilibrium delivers an unskilled wage below the minimum, unemployment must arise. The new equilibrium is determined by two fundamental relations. One reflects arbitrage in the choice whether to be skilled or unskilled, and the other reflects market clearing.

Let (1 − u) be the employment rate for unskilled. Then for our risk-neutral unskilled, (1 − u) w_L is the expected unskilled wage. Our arbitrage condition (3) thus must be revised to:[7]

---

rate unaffected. Implicitly what is at stake is whether the level at which wages are rigid rises more or less slowly than that which would allow unemployment to remain unchanged. We consider the model with an evolving minimum wage only in Section IV.B. where we model the consequences of a productivity slowdown.

[7]The model bears some similarity to the Harris-Todaro (1970) tradition of modeling unemployment in that workers choose their career path (rural vs. urban or unskilled vs. skilled)

(6) $$\frac{\tilde{\omega}_M}{\Delta} = \frac{1-u}{\partial Q/\partial E}$$

With $\tilde{\omega}$ fixed at $\tilde{\omega}_M$ by the minimum wage, this defines a relation between E and u that satisfies the arbitrage condition. We will label this curve AA, and define it as $E = \varphi(u)$, where $\varphi' > 0$.

Equilibrium also requires that goods markets clear. The minimum wage fixes $\tilde{\omega}$, so also P. This in turn determines the structure of relative goods demand. But the structure of relative goods supply, at fixed $\tilde{\omega}$ and P, depends on employment, hence on E and u. We will label this relation MM, and define it as $E = \sigma(u)$. We easily verify that $\sigma' < 0$. A rise in u at fixed E implies a fall in unskilled labor, hence by Rybczynski a decline in output of Y and increase in output of X. Equilibrium with the initial ratio of X to Y can only be restored if E falls. The full

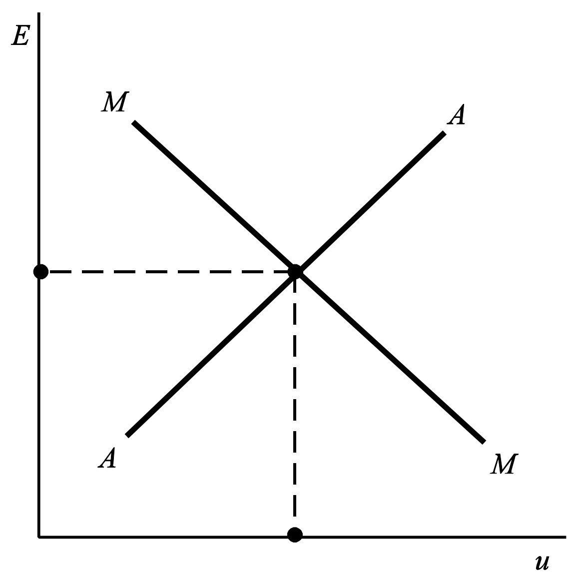

Figure 4: Equilibrium in the Minimum Wage Economy

---

on the basis of expected earnings under the possibility of unemployment.

equilibrium is at the intersection of the AA and MM curves, as depicted in Figure 4.

An alternative perspective comes from looking at the impact of the minimum wage on the structure of relative factor demand and supply. The functional relationship $h^D(\tilde{\omega})$ is not affected by the choice of a minimum wage, so we need only look at the implications for $h^S(\tilde{\omega})$. As in Flug and Galor (1986), we can consider a special case in which both goods demand and production technologies are Cobb-Douglas. The former assures that the division of spending between the two goods is fixed. The latter insures that the factor shares of income within each sector are fixed. These remain true even in the presence of unemployment. Thus in this case the rise in relative income to the unskilled implied by the minimum wage is exactly offset by the reduced probability of employment at the initial E. The minimum wage has no impact in this boundary case on the division between skilled and unskilled. The level of unemployment is thus determined implicitly as that required to bridge the gap between the fixed labor force composition and the relative demand at the minimum wage. At $\tilde{\omega}_M$, unskilled wages are higher than at the flexible $\tilde{\omega}_F$. This situation is depicted in Figure 5.

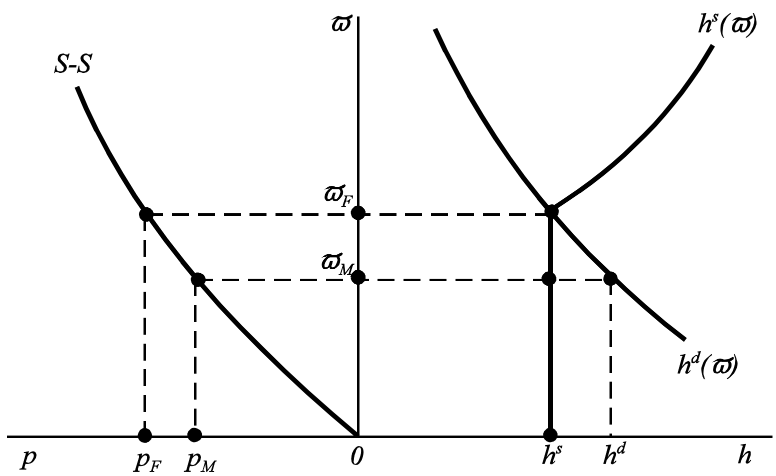

Figure 5: Equilibrium with Cobb-Douglas Demand and Technology in the Minimum Wage Economy

B. The Global Economy with Unemployment

We now turn to consider a global economy. As in Davis (1998a), we assume that our two countries differ in one important respect. The country we will refer to as America has perfectly flexible wages for skilled and unskilled alike. The country we will call Europe has a rigid minimum wage for the unskilled set at the level $\tilde{\omega}^*$.

We consider first the cross country links in factor prices. Free trade with zero transport costs insures that goods prices will be common for our countries. Common technologies and diversified production insure that factor prices in efficiency units will likewise be common. Since for unskilled labor, efficiency and natural units are the same, this implies that employed unskilled in both Europe and America receive the same wage. However, the unemployment that will arise in Europe means that the expected wage of the unskilled is lower there. To compare the position of the skilled across the two countries, it is convenient to examine the arbitrage conditions. In America, they are those of the flexible wage economy, given by equation (3), while in Europe they are those of the minimum wage economy, given by equation (6). From above, the left hand side is common, $\tilde{\omega}/\Delta$. With $u > 0$, this requires that Europe have a lower $\partial Q/\partial E$, so lower $k = K/E$. This in turn implies a wedge in the labor quality, so $q^E < q^A$. Finally, this implies a larger observed wedge between the skilled and unskilled in America than in Europe, $\omega^A > \omega^E$.

We will consider the implications of trade for the evolution of employment and the composition of the labor force in our countries. We begin as in Davis (1998a) with a benchmark in which Europe and America are identical in every respect except for the labor market institutions. If both had flexible labor markets, the composition of their labor forces would be identical, as would all factor prices in efficiency and natural units. If instead Europe in autarky instituted a binding minimum wage while America did not, Europe would enjoy the higher unskilled wage, but would also suffer the consequences of unemployment. In the double Cobb-Douglas case discussed above, they would continue to have the same division between skilled and unskilled. For the moment, hold their labor forces fixed at this initial composition. Davis (1998a) showed that with exogenous factor supplies, a move from autarky to free trade for these two countries would exactly double the European unemployment rate, while raising the American unskilled wage to the European level.

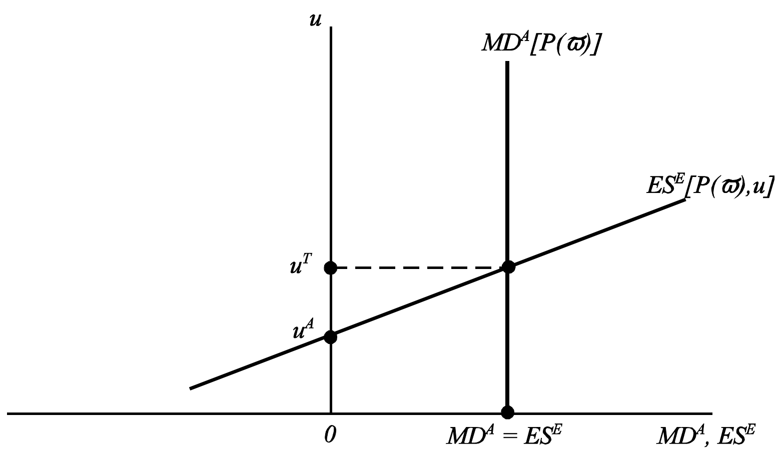

Figure 6: Global Equilibrium with a Minimum Wage in Europe

The trading equilibrium is illustrated in Figure 6. This is an import demand (MD), export supply (ES) diagram, with the twist that the minimum wage implies that the equilibrating variable is not the global goods price but rather unemployment in Europe. The fixed wage fixes the goods price, which in turn fixes American import demand. Higher unemployment rates in Europe imply a reduction in Europe's supply of unskilled labor both directly and via the incentives for schooling. With a fixed relative composition of demand at P, this reduction in European unskilled labor, and consequent increase in skilled labor creates greater export supply of the skill intensive good X. The case illustrated is the benchmark in which America and Europe are identical except for their labor market institutions, and so in which trade raises European unemployment.

Opening to trade raises European unemployment from the autarky level u^A to u^T [see Figure 6]. In this benchmark, this may be more or less than the doubling of unemployment that occurs in the case of inelastic factor supplies. The reason is that the opening to trade places opposing pressures on the labor force composition, and so correspondingly on employment, in Europe. The rise in the unskilled wage in America reduces the incentives to accumulate skill. This will lead to a decline in the skill abundance of the work force relative to the autarky level. This implies increasing relative supply of the unskilled good Y as America's labor force adjusts, putting downward pressure on the relative price of Y (rise in P). This alone places additional pressure for a rise in European unemployment. This is offset by the fact that the sharply higher u has reduced the expected unskilled wage at fixed $\tilde{\omega}$, which is leading the European labor force to seek greater education to escape unemployment. Adjustment in Europe is thus leading to reduced unemployment relative to that without adjustment.[8]

[8] Under a more realistic setting, workers who find themselves unemployed could choose to go back to school in order to become skilled. Allowing for this possibility would tend to squeeze the skill premium further in Europe without altering the qualitative results.

IV. Comparative Statics

Section III.B. developed our principal model, that of trade between a flexible wage America and a minimum wage Europe. We consider here selected comparative statics of interest for the salient factor market developments. We also contrast these results with the counterparts in the closed and/or flexible wage world.

A. Primary Factor Accumulation

An increase in educational capital K in the flexible world economy shifts the relative labor supply curve [see Figure 1]. Equilibrium is characterized by a higher skill abundance, a lower relative skilled wage in efficiency terms, and a reduced relative price of the skill intensive good. From the arbitrage condition (3), the decline in the relative efficiency wage $\tilde{\omega}$ requires that $\partial Q/\partial E$ rise, so k rise. This means that the quality of skilled labor q must likewise rise. From the arbitrage condition (4), the impact on the observed skill premium depends on how $\eta_{Q,E}$ depends on k. Nevertheless, the rise in the unskilled wage w_L with a falling P suffices to show that in welfare terms the unskilled are better off. But then because they are *ex ante* identical, the skilled are better off as well.

An increase in educational capital K in the closed minimum wage economy leaves goods prices and efficiency unit wages unaltered. However it raises the equilibrium skill abundance of the labor force, even as the skill abundance of the employed is unchanged. From the arbitrage condition (6), the consequent fall in the unemployment rate u implies a required rise in $\partial Q/\partial E$ and so also k and q. Thus the observed skill premium rises even as unemployment declines. A key insight coming here is that with relative efficiency wages $\tilde{\omega}$ and prices P fixed, the unemployment rate u becomes a sufficient statistic for the welfare of the unskilled, so also of the skilled.

Let us return now to our two country model of flexible wage America and minimum wage Europe. An increase in educational capital in America shifts its relative factor supply curve. But it does not affect $\tilde{\omega}$ or P. From the arbitrage condition (3), we see that k must remain unchanged, so also America's skill quality q^A. While the composition of the labor force in America is changed, nothing happens to the skill premium in America. In terms of Figure 6, this implies a leftward shift of the American import demand curve. Now we turn to the effects on Europe. The arbitrage condition (6) in Europe, summarized by AA in Figure 4, is unaffected. However the market clearing conditions, MM in Figure 4, shift so that equilibrium occurs with a lower u and E. Thus educational capital accumulation in America has decreased the supply of skill in Europe, while raising its quality. The observed skill premium in Europe rises, although there was no change in this premium in America. Unemployment likewise falls in Europe.

Consider instead if there had been an increment of educational capital in minimum wage Europe. America would have been wholly unaffected. In Europe, both the arbitrage and market clearing (AA and MM) curves in Figure 4 would have shifted left. Both imply a decline in unemployment, although the impact on E is ambiguous. Nevertheless, from the arbitrage condition (6), the fall in u in equilibrium requires a rise in k^E, so labor quality q^E. Thus the observed skill premium in America is unaffected, and Europe's rises, with educational capital accumulation, irrespective of the site of accumulation.

Now consider an increase in the population in America. At fixed K and $\tilde{\omega}$, E is fixed, so all of the additional population becomes unskilled. In America there are no changes in the skill premium. In terms of Figure 6, this implies a rightward shift of the import demand curve. This increment in N^A leaves the European arbitrage condition unchanged, but shifts the MM curve out in Figure 4, leading to higher u and E. This implies a fall in q^E, so a fall in the skill premium in Europe, although that in America was unaffected.

An increase in the population in Europe leaves America wholly unaffected. Since K and $\tilde{\omega}$, remain fixed, the European arbitrage condition remains unchanged. The MM curve will shift out, reflecting the need to shift relative production toward the skill intensive good in order to satisfy local demand with American import demand unchanged. Workers will be worse off in Europe as reflected by the fall in q (increase in E) and the increase in u at fixed $\tilde{\omega}$. Thus, increases in population, regardless of location, increase unemployment in Europe.

B. NICs Shock

The entry of new countries to the world trading economy is frequently advanced as a possible explanation of recent adverse labor market developments[9]. We assume the new countries' comparative advantage lies in the unskilled labor intensive sector. Their emergence can then be modeled as an increase in import demand for good X. If prices were fully flexible, this demand would put upward pressure on the relative price of X. Europe's commitment to the minimum wage prevents such a price movement. With no change in relative prices, relative efficiency unit wages remain unchanged. Hence, America is fully insulated from the demand

[9] For various perspectives, see Wood (1994), Leamer (1996), and Krugman and Lawrence (1993).

shock. In terms of Figure 6, this would be a rightward shift of a joint American-NICs import demand curve for Europe (with no change in America).

Europe, on the other hand, must fully accommodate the increase in demand for X by shifting its production toward the X sector. In terms of Figure 4, the demand shock generates an outward shift in the MM curve. The AA curve is unaffected as there is no change in $\tilde{\omega}$. Both u and E^E increase but q falls, reducing the wage differential in Europe. Thus Europe bears the full cost of adjustment to the shock while America is wholly unaffected.

C. Technological Change

1. Example: Neutral Technical Progress in the Skill Intensive Sector

We now consider the implications of global technical progress for factor returns, employment, and skill composition of the labor force. A detailed consideration of the many possible cases is beyond the scope of this paper [see Davis (1998b)]. We consider here only the example of global neutral technical progress in the X sector. We assume that the minimum wage in Europe binds both before the technical progress and in the full equilibrium. This makes analysis of the effect on America simple. While the impact effect (i.e., at fixed goods prices) of the technical progress in X raises the skilled wage and reduces that of the unskilled, the full equilibrium must see the relative price of X fall so that the unskilled wage in terms of the numeraire is unchanged. This implies that America sees no change in the arbitrage condition, so E^A does not change. Hence neither is there a change in labor quality in America, q^A, so the observed skilled wage w_H.

Analyzing the situation in Europe is a bit more complex. We know that in equilibrium, E^A does not change. For the moment, hold E^E and u fixed as well. Then at the initial goods prices, we know that the neutral technical progress in X must give rise to an excess supply of X, so downward pressure on its price. The case of interest here is what Davis (1998b) terms the *elastic* case — that in which these induced price effects do not suffice to restore the initial unskilled wage. In this case, the equilibrium unemployment rate must rise to make unskilled labor sufficiently scarce to again support the initial wage. In terms of Figure 4, this represents a rightward shift of the MM curve, with the AA curve fixed. In equilibrium, E^E rises, and the quality of European labor q^E falls.

Summarizing, global technical progress in the X sector in the elastic case leaves the skilled wage premium unchanged in America, while reducing it in Europe. The skill composition of the labor force in America is unchanged, while that in Europe rises. Unemployment in Europe rises.

2. Productivity Slowdown

While the story that we have told is explicitly dynamic, two important features of evolution through time have been set to the side. First, we have considered technical change only as a once-and-for-all event, rather than as a continual evolution of productive ability. Second, we have ignored the fact that the level at which wages are rigid likewise evolves over time. Consideration of both of these facts is straightforward, and allows us to consider the consequences of a global productivity slowdown.

Assume, then, that productivity in the two sectors grows at a common rate γ, as indicated by:

$$\textbf{(7)} \qquad X(t) = e^{\gamma t} X(H,L) \qquad Y(t) = e^{\gamma t} Y(H,L)$$

The only modification this introduces into the equilibrium conditions (3) and (6) is through the Δ parameter, which will now equal $[1 - e^{(\gamma - r)T}] / [e^{(\gamma - r)\theta} - e^{(\gamma - r)T}]$. This term is decreasing in the growth rate of total factor productivity, γ. Absent other shocks, this allows the European minimum wage to rise at the rate γ without inducing any changes in unemployment. We assume that European institutions are such that the actual European minimum wage does in fact grow at this rate.

A productivity slowdown will be represented by a discrete fall in the rate of total factor productivity growth, from γ_0 to $\gamma_1 < \gamma_0$, leading to a rise in Δ. From the arbitrage condition (3) for America, it is clear that $\partial Q/\partial E$ must rise, so E must fall. Since earnings will grow at a slower rate as a result of the slowdown, it is not as attractive to go to school since this choice involves postponing income.

Thus, in America, E will fall, reducing the skill intensity of the labor force and increasing the observed skill premium ω. In Europe, the change in the arbitrage condition (6) implies an outward shift of the AA schedule. Moreover, America's production shift toward Y causes the MM schedule to shift outward as well. Overall, Europe experiences higher unemployment, but observed relative wages will depend on what happens to the quality of skilled labor in Europe. This, in turn, will depend on the relative strengths of the disincentive to become educated through the rise in Δ and the incentive to become educated through the rise in u.

V. The Three Wedges

A. Unifying Elements

We will provide a discussion of the analytic elements that unify the comparative static results, and then relate them to the three wedges. We collect our principal results in Table One. We start with a heuristic description of the role of European unemployment. If the European unskilled wage is to attain the minimum, this must be supported by an appropriate relative goods price sufficiently high for the unskilled intensive good. Such a goods price will be an equilibrium only if the unskilled intensive good is sufficiently scarce in relative terms. And this will be true only if employed unskilled labor is itself sufficiently scarce. For given educational capital and population, this determines the required European unemployment rate. This also indicates simply many of the shocks that will induce a rise in the European unemployment rate: they are ones that present incipient excess supply — hence downward pressure on the price — of the unskilled intensive good. These include direct increases in the relative availability in the world of people relative to educational capital, as well as indirect increases in this relative availability via opening to trade with countries that feature a lower relative price for the unskilled good. A distinct, though related, process is at work in the case of neutral technical change in the skill intensive sector. The direct impact of this change depresses the unskilled wage, however these are at least partly offset by a rise in the relative price of the unskilled good. When demand is sufficiently elastic, the magnitude of the price movement is insufficient to compensate unskilled labor. The minimum wage is met only if the unemployment rate rises. Finally, the productivity slowdown works through yet another channel. With growth proceeding at a slower pace, students find smaller compensation for postponing entry to the workforce. This in turn creates a rise in the relative supply of unskilled labor at the initial relative wages, so downward pressure on the unskilled wage. This can be stanched only with a rise in the unemployment rate.

Analysis of relative wage changes for America is straightforward. The high relative skilled wage for America compared with Europe under trade reflects two simple facts, that there is FPE in efficiency units, and that Europeans crowd the available educational capital to escape unemployment, thereby lowering the quality of skill in Europe. The impact of opening trade with Europe on the observed American skill premium is uncertain because the decline in the efficiency unit skill premium is offset by a rise in the quality of American skill. Through most of the comparative statics, including endowment changes in either country, entry of the NICs, or the case of technical progress considered, the American skill premium is unaffected. In all but the last, this is because equilibrium relative goods prices are unaffected by the comparative static, and (conditional on r, T, and θ) this suffices to determine the observed American skill premium. In the case of technical progress considered, a similar result arises because the equilibrium price movements exactly offset the initial disturbance to the zero profit conditions that establish the efficiency unit wages. Finally, in the case of the productivity slowdown, the rise in the American skill premium is required to compensate skilled workers for the reduced incentive to take income in later years relative to the present due to the reduced income gradient.

The analysis of the evolution of American skill abundance is likewise straightforward. Europe's commitment to maintain the minimum wage and associated goods price shield America from the relative wage shocks which would induce adjustments in skill composition. Hence primary endowment shocks in Europe, entry of the NICs, and even the case of technical progress considered leave the American skill composition unaffected. Local primary factor supply shocks do have an impact on American skill composition, as does the productivity slowdown for the reason noted in discussing the movement in the relative wage.

With the exception of the productivity slowdown, all of the comparative statics that we consider that raise unemployment in Europe also reduce the skill premium there. The reason is simply the rebalancing of incentives, with higher unemployment making unskilled employment less attractive, there has to be a reduced skill premium as compensation. The case of the productivity slowdown differs because there are already two competing elements. The slowdown makes postponement of entry to the labor force less attractive, so makes it more attractive to be unskilled, while the higher unemployment by contrast makes being unskilled more attractive. Accordingly it is uncertain which way the relative wages need to move in Europe to rebalance the incentives.

Finally, a large set of external shocks — opening to trade with America or the NICs, increases in American relative unskilled abundance — all lead the skill abundance of European labor to rise. This may be looked on as the labor force composition consequences of the rise in unemployment required to sustain the minimum wage. Essentially similar forces are at work in the case of technical progress considered, where the equilibrium rise in unemployment forces the rise in skill abundance in Europe. A contrary story emerges when the rise in population or decline in educational capital occurs in Europe.

B. The Three Wedges

Earlier we suggested that in considering the results of the model it would be convenient to focus on three stylized wedges or differences in the experience between America and Europe.

These are: (1) A rise in unemployment in Europe, but not America; (2) A rise in the skill premium in America, but not in Europe; and (3) A slowdown in the growth rate of relative skill abundance in America, but not in Europe. Since much of our work, for simplicity, has abstracted from trend changes in the economy, we will interpret these broadly in terms of differences in experience rather than focusing on levels.

Table 1

Benchmark Trade Equilibrium					
LEVELS	$u^E > 0$	$\omega^E < \omega^A$		$h^E > h^A$	
Comparative Statics					
CHANGES	du^E	$d\omega^A$	$d\omega^E$	dh^A	dh^E
Opening to trade	+	+/−	−	−	+
Fall in K^A	+	0	−	−	+
Fall in K^E	+	0	−	0	−
Rise in N^A	+	0	−	−	+
Rise in N^E	+	0	−	0	−
NICs shock	+	0	−	0	+
Technical progress in X	+	0	−	0	+
Productivity Slowdown	+	+	+/−	−	+/−

The first column of Table One illustrates that a broad variety of shocks–European, American, and Global–could in principle have been the source of the rising unemployment affecting Europe but not America. The second and third columns of Table One make an important point not evident in the simpler framework of Davis (1998a, b). The wedge between European and American relative wage evolution can also be accounted for by a wide variety of shocks. Such an account need not rely on idiosyncratic national technology or policy shocks.

The final two columns show that many, though not all, of the shocks could have accounted for the wedge between European and American relative skill evolution. This holds an important lesson. In combination with the earlier results, it shows that the correlations between the contrasting experience of America and Europe in relative wage evolution need not be the consequence of differences in the evolution of relative skill availability, but instead that they may both have a common cause that may be quite independent of direct links to factor availability (e.g., technical progress in X). This suggests, for example, some caution in reading the results of Katz, Loveman and Blanchflower (1995) on the contribution of factor supplies to the relative wage movements.

VI. Conclusion

Factor market developments in recent years in America and Europe have been a source of great concern, though for distinct reasons. In America, the focus has been on a growing skilled-to-unskilled wage gap, while in Europe the focus has been on high and persistent unemployment. A large literature has addressed these problems, including both detailed studies of individual countries, as well as comparative analyses across countries. The country studies have emphasized the importance of local institutional structure in understanding these developments, while the cross-country studies have searched for common themes. Davis (1998a, b) developed a framework which allowed for differences across countries in institutional structure, but which also allowed a complete and rigorous description of the general equilibrium comparative statics in a world in which these countries trade with one another. The results from this approach diverged significantly from those one would obtain considering the cases one-at-a-time.

Previous work in this area has taken the skill composition of the labor force to be exogenous. Yet given that we are considering developments over the course of decades, this is clearly inadequate. Thus, a central thrust of the present paper has been to endogenize the accumulation of human capital. An important advantage of doing this is that if we are to distinguish the candidate theories in accounting for these factor market developments, we need to be able to bring new sources of evidence to bear on the problem. The present paper suggests that empirical researchers may do well to consider the relative evolution of the skill composition of the labor force in the two regions as an additional basis on which to separate the theories. Moreover, allowing for cross-country differences in the quality of skilled labor provides an alternative framework for thinking about the divergent evolution of relative skilled wages in America and Europe that does not rely on local technology or policy shocks [see Davis (1998a, b)].

This paper makes several analytic contributions. First, it develops a new presentation of the Findlay-Kierzkowski (1983) model that focuses on factor markets and links the results to the Dixit-Norman (1980) "integrated equilibrium" framework. Second, we introduce within this setting a full general equilibrium with trade among two countries with divergent factor market institutions — one with rigid wages, the other with flexible wages. Finally, we develop a variety of comparative statics and consider the evolution of relative wages, unemployment, and the skill composition of the labor force.

We do not advance any single-cause account of recent factor market developments. The results from the comparative statics suggests that one or more forces may in combination have contributed to the three wedges in experience between America and Europe we considered. We hope that the exercises we develop will inform the work of empirical researchers who investigate the relative importance of the factors in giving rise to these phenomena.

References

Acemoglu, Daron (1996) "Changes in Unemployment and Wage Inequality: an Alternative Theory and Some Evidence," mimeo, MIT.

Berman, Eli, John Bound, and Zvi Griliches (1994) "Changes in the Demand for Skilled Labor within U.S. Manufacturing: Evidence from the Annual Survey of Manufactures," *Quarterly Journal of Economics*, 109(2): 367-97.

Berman, Eli, John Bound, and Stephen Machin (1998) "Implications of Skill-Biased Technological Change: International Evidence," *Quarterly Journal of Economics*, 113(4): 1245-79.

Bertola, Giuseppe and Andrea Ichino (1995) "Wage Inequality and Unemployment: United States vs. Europe," *NBER Macroeconomics Annual.*

Brecher, Richard A. (1974) "Minimum Wage Rates and the Pure Theory of International Trade," *Quarterly Journal of Economics*, 88(1): 98-116.

Brecher, Richard A. and Ngo Van Long (1989) "Trade Unions in an Open Economy: A General Equilibrium Analysis," *Economic Record*, 65(190): 234-39.

Davidson, Carl, Lawrence Martin, and Steven Matusz (1991) "Multiple Free Trade Equilibria in Micro Models of Unemployment," *Journal of International Economics*, 31:157-69.

Davis, Donald R. (1998a) "Does European Unemployment Prop Up American Wages? National Labor Markets and Global Trade," *American Economic Review*, 88(3): 478-94.

Davis, Donald R. (1998b) "Technology, Unemployment, and Relative Wages in a Global Economy," *European Economic Review*, 42(9): 1613-33.

Dixit, Avinash and Victor Norman (1980) *Theory of International Trade*, Cambridge: Cambridge University Press.

Dixit, Avinash and Joseph Stiglitz (1977) "Monopolistic Competition and Optimum Product Diversity," *American Economic Review*, 67(3): 297-308.

Fernandez, Raquel (1992) "Terms-of-Trade Uncertainty, Incomplete Markets, and Unemployment," *International Economic Review*, 33(4): 881-94.

Findlay, Ronald, and Henryk Kierzkowski (1983) "International Trade and Human Capital: A Simple General Equilibrium Model," *Journal of Political Economy*, 91(6): 957-978.

Flug, Karnit and Oded Galor (1986) "Minimum Wage in a General Equilibrium Model of International Trade and Human Capital," *International Economic Review*, 27(1): 149-164.

Freeman, Richard B. (1986) "Demand for Education," in Ashenfelter and Layard, *Handbook of Labor Economics, Vol. 1*, Amsterdam: Elsevier Science Publishers.

Freeman, Richard B. and Lawrence F. Katz (1995) *Differences and Changes in Wage Structures*, Chicago: University of Chicago Press.

Harris, John R. and Michael P. Todaro (1970) "Migration, Unemployment and Development: A Two-Sector Analysis," *American Economic Review*, 60(1), March 1970, pages 126-42.

Helpman, Elhanan and Paul Krugman (1985) *Market Structure and Foreign Trade*, Cambridge: MIT.

Hoon, Hian Teck (1991) "Comparative Advantage and the Equilibrium Rate of Unemployment," *Economics Letters*, 37: 299-304.

Katz, Lawrence F., Gary W. Loveman, and David G.Blanchflower (1995) "Changes in the Structure of Wages in Four OECD Countries," in Richard B. Freeman and Lawrence F. Katz, *Differences and Changes in Wage Structures*, Chicago: University of Chicago Press.

Katz, Lawrence F. and Kevin M. Murphy (1992), "Changes in Relative Wages, 1963-1987: Supply and Demand Factors," *Quarterly Journal of Economics*, 107(1): 35-78.

Krugman, Paul and Robert Z. Lawrence (1993) "Trade, Jobs, and Wages," NBER Working Paper 4478, September.

Krugman, Paul (1995) "Growing World Trade: Causes and Consequences," mimeo Stanford University, prepared for the Brookings Panel on Economic Activity, April 6-7.

Krugman, Paul (1997) "And Now for Something Completely Different: An Alternative Model of Trade, Education, and Inequality," mimeo, MIT.

Leamer, Edward (1996) "In Search of Stolper-Samuelson Effects Between Trade and U.S. Wages," NBER Working Paper 5427, January.

Melvin, James R. (1969) "Intermediate Goods, the Production Possibility Curve, and Gains from Trade," *Quarterly Journal of Economics*, 83(1): 141-151.

Sanyal, Kalyan K. and Ronald W. Jones (1982) “The Theory of Trade in Middle Products,” *American Economic Review*, 72(1):16-31.

Wood, Adrian (1994) *North-South Trade, Employment, and Inequality*, New York: Oxford University Press.