NBER WORKING PAPER SERIES

CROSS-COUNTRY INEQUALITY TRENDS

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Working Paper 8832
http://www.nber.org/papers/w8832

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
March 2002

I thank Larry Katz and Timothy Smeeding, and seminar participants at Cornell and MIT for comments and Alexis Leon for outstanding research assistance, and the NSF and the Russell Sage foundation for financial support. The views expressed herein are those of the author and not necessarily those of the National Bureau of Economic Research.

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JEL No. J30, J31

ABSTRACT

The economics profession has made considerable progress in understanding the increase in wage inequality in the U.S. and the UK over the past several decades, but currently lacks a consensus on why inequality did not increase, or increased much less, in (continental) Europe over the same time period. I review the two most popular explanations for these differential trends: that relative supply of skills increased faster in Europe, and that European labor market institutions prevented inequality from increasing. I argue that these two explanations go some way towards accounting for the differential cross-country inequality trends, but do not provide an entirely satisfactory explanation. In addition, it appears that relative demand for skills increased differentially across countries. Motivated by this reasoning, I develop a simple theory where labor market institutions creating wage compression in Europe also encourage more investment in technologies increasing the productivity of less-skilled workers, thus implying less skill-biased technical change in Europe than in the U.S.

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1 Introduction

While over the 1980s wage inequality and returns to education increased sharply in the U.S. and the UK, there was less of an increase, or even no change, in continental European economies (see, for example, Freeman and Katz, 1995, Nickell and Bell, 1996, Blanchflower, Loveman, and Katz, 1995).

Table 1 illustrates these trends by showing an estimate of the education premium and the log differences of the 90th and the 10th percentiles of the wage distribution for a number of countries from the Luxembourg Income Studies dataset (and for the U.S. from the CPS, see Section 4 and the Appendix for data details). The table also replicates the estimates of the 90-10 differential for a number of countries from Table 2 of the survey by Freeman and Katz (1995) for comparison. The numbers show that U.S. inequality and skill premia were higher at the end of the 1970s than in most other countries, and from there on, they increased faster than in these other cases (perhaps with the exception of Israel).

These cross-country trends are well known. There is also a fairly widespread consensus that U.S. wage inequality rose because the relative demand for skills increased faster than the relative supply (e.g., Katz and Murphy, 1992, Berman, Bound and Griliches, 1994, Katz and Autor, 2000, Acemoglu, 2002). So why haven't the same technological developments increased skill premia in much of continental Europe?

There are three broad types of answers:

1. The relative supply of skills increased faster in Europe.

2. European wage-setting institutions prevented wage inequality from increasing.

3. For exogenous or endogenous reasons, technical change has been less skill biased in Europe.

The first two explanations have been the most popular among economists, and I refer to them as the "traditional explanations". Both of these explanations fit nicely into the relative-supply-demand framework, which has been a very useful tool in understanding the U.S. wage inequality patterns. They both suggest that the lack of increase in inequality in Europe should have been associated with a relatively faster increase in the employment of more skilled workers. Table 1 also shows that during the 1980s the relative employment of skilled workers increased faster in a number of European countries than in the U.S. Is this more rapid increase in skilled employment sufficient to account for the stability of the European wage structure?

I use a version of the relative-supply-demand framework to investigate this question. The evidence suggests that these explanations account for a significant component of the differential inequality trends (in fact, for substantially more than the author had originally conjectured!). Nevertheless, it also appears that the relative demand for skills did not increase as much in many European economies as it did in the U.S. and the UK. More specifically, I find that the relative-supply-demand framework, with the same relative demand shifts across countries, does a reasonable job of explaining some of the differences in the cross-country inequality trends, for example, for Finland and Norway. Nevertheless, there are a number of cases, in particular, Belgium, Denmark, and Sweden, and also to some degree Israel, where skill premia increased much less than predicted by this approach. I therefore conclude that the traditional explanations do not seem to provide an entirely satisfactory explanation for the differential inequality trends across countries. Instead, it appears that the U.S. and European relative demand curves did not shift in the same way over the past 20 years.[1]

Given data quality and compatibility issues, this evidence has to be interpreted with caution. Nevertheless, it suggests that we should be thinking of explanations featuring differences in technical change or technology adoption across these countries. In the last part of the paper, I propose a possible explanation for why relative demand for skills may not have increased as much in Europe as in the U.S. The basic idea is that institutional wage compression in Europe makes firms more willing to adopt technologies

[1]Berman, Bound and Machin (1998) look at patterns of skill-upgrading in various industries and conclude that there has been skill-biased technical change in all of the OECD countries in their sample. However, their results do not imply that these shifts have occurred at the same rate or with the same intensity across countries. In fact, to infer the overall rate of skill-biased technical change from industry data would require a variety of strong assumptions.

complementary to unskilled workers, making technical change less skill biased there.

The paper proceeds as follows. In the next section, I review the three explanations suggested above. In Section 3, I develop a simple framework to quantitatively investigate whether cross-country inequality trends can be explained by the relative-supply-demand framework assuming similar changes in relative demand for skills across countries. In Section 4, I use data from the Luxembourg Income Studies and undertake such an investigation. I find that although the differential behavior of relative supplies between the U.S. and continental Europe explains much of the differences, there is also evidence that the relative demand for skills did not increase as much in continental Europe. In Section 5, I make a preliminary attempt at developing a simple theory where relative demands change differentially across countries. Section 6 concludes.

2 Review of the Arguments

2.1 Traditional Explanations of Differential Inequality Trends

The traditional approaches explain the differential cross-country inequality trends by differences in the behavior of relative supplies. The first explanation claims that the more rapid increase in the relative supply of skills in Europe accounts for the lack of increase in inequality there. The second explanation, on the other hand, emphasizes the role of European wage-setting institutions. According to this explanation, it is not the differential growth of skilled workers in the population, but the differential behavior of skilled employment that is responsible for differences in inequality trends across countries. More specifically, firms respond to wage compression by reducing their demand for unskilled workers, and the employment of skilled workers (relative to that of unskilled workers) increases in Europe compared to the U.S. As a result, the market equilibriates with a lower employment of unskilled workers compensating for their relatively higher wages in Europe.

Figure 1 illustrates the first explanation using a standard relative-supply-demand diagram, with relative supply on the horizontal axis and the relative wage of skilled workers, ω, on the vertical axis. For simplicity, I drew the relative supply of skills as vertical. The diagram shows that an increase in the demand for skills, for a given supply of skills, will lead to higher wage inequality. At a simple level, we can think of this economy as corresponding to the U.S., where the consensus is that because of skill-biased technical change or increased trade with less skill-abundant countries, the relative demand for skills grew faster than the relative supply during the recent decades. As a result of the increase in the relative demand for skills, the skill premium rises from ω^{Pre} to $\omega^{\text{US-Post}}$.

Now imagine that continental Europe is also affected by the same relative demand shifts, but the relative supply of skills also increases. This captures the essence of the first explanation, where the supply of skills increases faster in continental Europe than in the U.S. Then the "European" equilibrium will be at a point like E which may not exhibit greater inequality than before. In fact, Figure 1 depicts the case in which there is no change in the skill premium in Europe.[2]

Probably the more popular explanation among economists and commentators is the second one above (e.g., Krugman, 1994, OECD, 1994, Blau and Kahn, 1996). To capture this story, imagine that wage-setting institutions in Europe prevent wage inequality from increasing—for example, because of union bargaining, unemployment benefits, or minimum wages that keep the earnings of low-skill workers in line with those of high-skill workers. This can be represented as an institutional wage-setting line different from the relative supply curve as drawn in Figure 2. (To make the story stark, I drew the institutional wage-setting line as horizontal). The equilibrium now has to be along this institutional wage-setting line, and consquently *off the relative supply curve*, causing unemployment. Now, even in the absence of an increase in the relative supply of skills, the skill premium might not increase; instead there will be equilibrium unemployment. In the figure, relative unemployment caused by the increase in the demand for skills is shown as the gap between the relative supply of skills and the intersection between relative demand and institutional wage-setting line. Notice that in the simplest version of the story, there is full employment of skilled workers, and the indicated gap simply

[2]See, among others, Katz, Loveman and Blanchflower (1995), Murphy, Riddell and Romer (1998) and Card and Lemieux (2001).

reflects unskilled unemployment. The fact that unemployment increased in Europe relative to the U.S. is often interpreted as evidence in favor of this explanation.[3]

Notice that both of these explanations are "supply-side". Firms are along their relative demand curves, and different supply behavior or institutional characteristics of the European economies pick different points along the relative demand curves.

This relative-supply-demand framework is not only a parsimonious specification, but also enables an empirical investigation of whether these two approaches can provide a satisfactory explanation for the behavior of skill premia in continental Europe. If we know the elasticity of substitution between skilled and unskilled workers, we can investigate whether the observed differences in the growth of relative employment of skilled workers are large enough to account for the differential behavior of wage inequality in Europe. In Section 3, I develop a framework for undertaking such an investigation, and in Section 4, I present some empirical results using this framework.

2.2 Differential Changes in the Relative Demand for Skills

An alternative to the traditional explanations involves differential changes in the relative demand for skills across countries. These differential changes could reflect four distinct forces:[4]

1. Different countries could develop their own technologies, with different degrees of

[3] But in contrast to the prediction of this simple story, unemployment in Europe increased for all groups, not simply for the low-education workers. See, for example, Nickell and Bell (1994), Card, Kramartz and Lemieux (1996) and Krueger and Pischke (1998). Nevertheless, some of the increase in unemployment among the high-education workers in Europe may reflect the effect of wage compression within education groups on job creation (e.g., if firms are forced to pay the same wages to low-skill college graduates as the high-skill college graduates, they may stop hiring the low-skill college graduates, increasing unemployment among college graduates).

[4] Yet another alternative is to introduce labor market imperfections that would also force firms to function off their "relative demand curves" (the model of Section 5 features labor market imperfections, but firms are still along their relative demand curves). An example would be efficient-bargaining between firms and unions. Nevertheless, even if firms are off their relative demand curves, they will be located along some equilibrium locus, and in this case we have to explain why this equilibrium locus is shifting differentially. I am not aware of any analysis of cross-country inequality trends using a model where firms are off their relative demand curves. Here I will develop an explanation that keeps firms along their relative demand curves, but suggest why the relative demand curves may have changed differentially across countries.

skill bias.

2. Some countries could be lagging behind the world technology frontier, and may not have adopted the most recent skill-biased technologies.

3. While all countries face the same technology frontier, some may have adopted more skill-biased technologies from this frontier.

4. Different countries have experienced different degrees of trade opening, affecting the demand for skills differentially.

Although the fourth explanation is the simplest, the current consensus is that increased international trade played a limited role in the increase in the relative demand for skills of the recent decades (see the surveys by Katz and Autor, 2000, and Acemoglu, 2002). Therefore, I focus on the technological reasons for differential changes in the relative demand for skills. Plausibly, many advanced economies develop some of their own technologies. In Acemoglu (1999b), I analyzed a model where differences in local conditions make it profitable for countries to develop some of their own technologies. In this context, I showed that greater trade with skill-scarce LDCs may cause skill-biased technical change in the U.S., while inducing the development of more skill-replacing technologies in Europe. Nevertheless, it appears plausible that most OECD economies have access, and even relatively rapid access, to the same set of technologies. This suggests that the most likely reason for why the relative demand for skills may have behaved differently in continental Europe is not differential development of new technologies or slow technology diffusion, but different incentives to adopt available technologies.

In the last section of the paper, I make a preliminary attempt to develop such a theory of differential adoption of available technologies.[5] Here I briefly summarize the main idea, leaving the details to that section. The basic idea of the theory I propose

[5] An alternative theory of differential cross-country inequality trends is developed by Beaudry and Green (2000). They construct a model in which capital scarcity is more harmful to unskilled workers. The introduction of a new technology increases the demand for capital, and hurts unskilled workers. In Europe, capital is relatively more abundant than in the U.S., so the relative earnings of unskilled workers do not decline as much.

is to link the incentives to adopt new technologies to the degree of compression in the wage structure, which is in part determined by labor market institutions. In particular, institutional wage compression in Europe makes firms more willing to adopt technologies complementary to unskilled workers, inducing less skill-biased technical change there. This theory is based on three premises:

1. There is some degree of rent-sharing between firms and workers, for example, because of bargaining over quasi-rents.

2. The skill bias of technologies is determined by firms' technology choices.

3. A variety of labor market institutions tend to increase the wages of low-skill workers in Europe, especially relative to the wages of comparable workers in the U.S.

All three premises are plausible. The finding of high correlation between wages and firms' profitability or investments both in union and non-union sectors (e.g., Katz and Summers, 1989, Groshen, 1991, Blanchflower, Oswald, and Sanfey, 1997) support the view that there is some amount of rent-sharing. That technology adoption is endogenous is close to the heart of many economists, and in previous work (e.g., Acemoglu, 1998, and especially,1999a, 2000), I developed this theme in detail and showed how it can help us understand the behavior of the demand for skills and wage inequality in the U.S. Finally, the view that minimum wages, unions and social insurance programs create wage compression in Europe and increase the pay of low-skill workers is widely shared by most economists, and supported by existing evidence (e.g., OECD, 1994, Blau and Kahn, 1996).

The new implication of combining these three premises is that firms in Europe may find it more profitable to adopt new technologies with unskilled workers than their American counterparts. This is because with wage compression, firms are forced to pay higher wages to unskilled workers than they would otherwise do (that is, greater than the "bargained" wage). This creates an additional incentive for these firms to increase the productivity of unskilled workers: they are already paying high wages, and additional investments will not necessarily translate into higher wages. Put differently, the labor market institutions that push the wages of these workers up make their employers *the residual claimant* of the increase in productivity due to technology adoption, encouraging the adoption of technologies complementary to unskilled workers in Europe.[6]

A simple numerical example illustrates this point more clearly. Suppose that a worker's productivity is 10 without technology adoption, and 20 when the new technology is adopted. Assume also that wages are equal to half of the worker's productivity, and technology adoption costs 6 (incurred solely by the firm). Now without technology adoption, the firm's profits are equal to $1/2 \times 10 = 5$, while with technology adoption, they are $1/2 \times 20 - 6 = 4$. The firm, therefore, prefers not to adopt the new technology because of the subsequent rent-sharing. Next suppose that a minimum wage legislation requires the worker to be paid at least 9. This implies that the worker will be paid 9 unless his productivity is above 18. The firm's profits without technology now change to $10 - 9 = 1$, since it has to pay 9 to the worker because of the minimum wage. In contrast, its profits with technology adoption are still 4. Therefore, the firm now prefers to adopt the new technology. The reason for this change is clear: because of the minimum wage laws, the firm was already forced to pay high wages to the worker, even when his marginal product was low, so it became the effective residual claimant of the increase in productivity due to technology adoption.

This reasoning implies that there may be greater incentives to invest in technologies complementing workers whose wages are being pushed up by labor market institutions. Since European labor market institutions increase the pay of low-skill workers, technology may be endogenously less skill biased in Europe than in the U.S.

An additional implicationn of this model is that institutional wage compression will make job creation less profitable in Europe, thus as in the second explanation above, we expect unemployment in Europe to increase relative to the U.S. Interestingly, in this story, the rise in unemployment can be across the board rather than fall disproportionately on the unskilled, which is consistent with the evidence (see the references in

[6]This reasoning is similar to the intuition for why firms find it profitable to invest in the training of their employees in the presence of labor market imperfections in Acemoglu and Pischke (1999). It also relies on the notion that firms obtain some "rents" from the employment relationship. In the absence of such rents, firms would simply lay off workers when their wages are pushed up.

footnote 3).

Therefore, the overall macro predictions of this approach are consistent with cross-county trends. However, as yet there is no detailed evidence supporting this theory, and an empirical investigation of these ideas may be an interesting area for future research.

3 Cross-Country Relative Demand Shifts

3.1 The Relative-Supply-Demand Framework

I now develop the relative-supply-demand framework in more detail for a quantitative evaluation of the traditional explanations. Consider the following simple model (see, e.g., Welch, 1970, Katz and Murphy, 1992, or Acemoglu, 2002): there are two types of workers, unskilled (low-education) workers and skilled (high-education) workers. I denote the employment of unskilled and skilled workers in country j at time t by $L^j(t)$ and $H^j(t)$. These employment levels may vary across countries and over time both because of differences in the education levels of the population, and also because, in the presence of labor market distortions, there may be unemployment.

The aggregate production function for economy j takes the constant elasticity of substitution (CES) form

$$Y^j(t) = \left[\left(A_l^j(t) L^j(t)\right)^\rho + \left(A_h^j(t) H^j(t)\right)^\rho\right]^{1/\rho}, \tag{1}$$

where $\rho \leq 1$, and $A_l^j(t)$ and $A_h^j(t)$ are factor-augmenting technology terms, which are, for now, allowed to vary across countries. The elasticity of substitution between skilled and unskilled workers in this production function is $\sigma \equiv 1/(1-\rho)$.

The marginal product of the two factors can be written as

$$MP_L^j(t) = \left(A_l^j(t)\right)^\rho \left[\left(A_l^j(t)\right)^\rho + \left(A_h^j(t)\right)^\rho \left(H^j(t)/L^j(t)\right)^\rho\right]^{(1-\rho)/\rho}, \tag{2}$$

and

$$MP_H^j = \left(A_h^j(t)\right)^\rho \left[\left(A_l^j(t)\right)^\rho \left(H^j(t)/L^j(t)\right)^{-\rho} + \left(A_h^j(t)\right)^\rho\right]^{(1-\rho)/\rho}.$$

Suppose that wages are related linearly to marginal product: $w_H^j(t) = \beta MP_H^j(t)$ and $w_L^j(t) = \beta MP_L^j(t)$. The case where $\beta = 1$ corresponds to workers being paid their full marginal product, with no rent sharing. Irrespective of the value of β, we have

$$\omega^j(t) \equiv \frac{w_H^j(t)}{w_L^j(t)} = \frac{MP_H^j(t)}{MP_L^j(t)}.$$

That is, in this specification firms will be along their relative demand curves.

Throughout the paper, I will think of $\omega^j(t)$ both as a measure of skill premium (such as returns to schooling) and as a measure of inequality. This is motivated by a reasoning whereby even among observationally equivalent workers some will be more "skilled", and they will earn higher wages commensurate with their skills and the market price of skills as reflected by $\omega^j(t)$ (see Juhn, Murphy and Pierce, 1993, Acemoglu, 2002). In practice, of course, there are many other factors, in addition to, or instead of, the skill premium, determining wage dispersion among observationally identical workers.

Alternatively, as long as firms are along their relative demand curve, the skill premium will be

$$\omega^j(t) = \left(\frac{A_h^j(t)}{A_l^j(t)}\right)^{\rho} \left(\frac{H^j(t)}{L^j(t)}\right)^{-(1-\rho)} = \left(\frac{A_h^j(t)}{A_l^j(t)}\right)^{(\sigma-1)/\sigma} \left(\frac{H^j(t)}{L^j(t)}\right)^{-1/\sigma}. \tag{3}$$

Equation (3) can be rewritten in a more convenient form by taking logs,

$$\ln \omega^j(t) = \frac{\sigma-1}{\sigma} \ln\left(\frac{A_h^j(t)}{A_l^j(t)}\right) - \frac{1}{\sigma} \ln\left(\frac{H^j(t)}{L^j(t)}\right). \tag{4}$$

This equation shows that the skill premium is decreasing in the relative supply of skilled workers, $H^j(t)/L^j(t)$, except in the special case where $\sigma \to \infty$ (where skilled and unskilled workers are perfect substitutes).

Another important point to note from this equation is that as long as $\sigma > 1$, i.e., as long as skilled and unskilled workers are gross substitutes, an increase in $A_h^j(t)/A_l^j(t)$ corresponds to skill-biased technical change and raises the skill premium and wage inequality. Interestingly, when $\sigma < 1$, it is a decline in $A_h^j(t)/A_l^j(t)$ that corresponds to skill-biased technical change (see Acemoglu, 2002). But the case with $\sigma < 1$ is not of great empirical relevance in the context of skilled and unskilled workers, since almost all existing estimates suggest that $\sigma > 1$ (e.g., Freeman, 1986).

Let us start with a relatively weak form of the common technology assumption. In particular, suppose that

$$A_h^j(t) = \eta_h^j \theta^j(t) A_h(t) \text{ and } A_l^j(t) = \eta_l^j \theta^j(t) A_l(t). \tag{5}$$

This assumption can be interpreted as follows. There is a world technology represented by $A_h(t)$ and $A_l(t)$, which potentially becomes more or less skill-biased over time. Countries may differ in their ability to use the world technology efficiently, and this is captured by the term $\theta^j(t)$. Although the ability to use world technology is time varying, it is symmetric between the two sectors. In addition, countries may have different comparative advantages in the two sectors as captured by the terms η_h^j and η_l^j (though these are assumed to be time invariant).

Substituting (5) into (4), we obtain

$$\ln \omega^j(t) = c^j + \ln a(t) - \frac{1}{\sigma} \ln\left(\frac{H^j(t)}{L^j(t)}\right), \tag{6}$$

where $\ln a(t) \equiv \frac{\sigma-1}{\sigma} \ln(A_h(t)/A_l(t))$ is the measure of skill-biased technical change, and $c^j \equiv \frac{\sigma-1}{\sigma}\eta_h^j/\eta_l^j$.

Then, using U.S. data we can construct an estimate for the change in $\ln a(t)$, denoted by $\Delta \ln \hat{a}(t)$, using an estimate for the elasticity of substitution, σ as:

$$\Delta \ln \hat{a}(t) = \Delta \ln \omega^0(t) + \frac{1}{\sigma} \Delta \ln\left(\frac{H^0(t)}{L^0(t)}\right),$$

where $j = 0$ refers to the U.S. Although the elasticity of substitution between skilled and unskilled workers, σ, is difficult to pin down precisely, there is a fairly well-established consensus that it is greater than 1, perhaps around 1.4, but possibly as large as 2 (see, e.g., Freeman, 1986, Katz and Murphy, 1992, Angrist, 1995, Card and Lemieux, 2001). Hence, in the empirical exercise I will use $\sigma = 1.4$ and $\sigma = 2$ as two reference values.

Now define Δ_k as the k-period difference operator, i.e.,

$$\Delta_k x \equiv x(t) - x(t-k).$$

Then, predicted changes in the skill premium for country j between between $t-k$ and

t are given by:[7]

$$\Delta_k \ln \hat{\omega}^j(t) = \Delta_k \ln \hat{a}(t) - \frac{1}{\sigma}\Delta_k \ln\left(\frac{H^j(t)}{L^j(t)}\right). \tag{7}$$

The implicit assumption in this exercise is that there is no delay in the adoption of new technologies across countries. Instead, it is quite possible that some of the new skill-biased technologies developed or adopted in the U.S. are only introduced in continental Europe with a lag. That is, instead of (5), we would have

$$A_h^j(t) = \eta_h^j \theta^j(t) A_h\left(t - k^j\right) \text{ and } A_l^j(t) = \eta_l^j \theta^j(t) A_l\left(t - k^j\right), \tag{8}$$

implying that there is a delay of k^j periods for country j in the adoption of frontier technologies.

Motivated by the possibility of such delays, as an alternative method I use U.S. data from 1974 to 1997 to recover estimates of $\Delta \ln \hat{a}(t)$, and calculate the average annual growth rate of $\ln \hat{a}(t)$, denoted by $\tilde{g}$. I then construct an alternate estimate for the predicted change in the skill premium in country j between dates $t-k$ and t as:

$$\Delta_k \ln \tilde{\omega}^j(t) = \tilde{g}k - \frac{1}{\sigma}\Delta_k \ln\left(\frac{H^j(t)}{L^j(t)}\right) \tag{9}$$

In this exercise, I use 1974 as the starting point, since it is five years prior to the earliest observation for any other country from the LIS data, and five years appears as a reasonable time lag for diffusion of technologies among the OECD countries. I use 1997 as the final year, since this is the final year for which there is LIS data for a country in my sample.

Whether the relative-supply-demand framework provides a satisfactory explanation for cross-country inequality trends can then be investigated by comparing the predicted skill premium changes, the $\Delta_k \ln \hat{\omega}^j(t)$'s from (7) and the $\Delta_k \ln \tilde{\omega}^j(t)$'s from (9), to the actual changes, the $\Delta_k \ln \omega^j(t)$'s.

[7] Equivalently, we can write:

$$\bar{\Delta} \ln \omega^j(t) = -\frac{1}{\sigma}\bar{\Delta} \ln\left(\frac{H^j(t)}{L^j(t)}\right).$$

where $\bar{\Delta} \ln x^j(t) \equiv \Delta \ln x^j(t) - \Delta \ln x^0(t)$ with $j = 0$ as the U.S., and investigate whether this equation provides a good fit to the data.

4 Can Differences in Relative Supplies Explain Inequality Differences?

4.1 Data

I now undertake a preliminary investigation of whether differences in the behavior relative supplies can explain the differential inequality trends across countries. More specifically, I investigate whether equations (7) and (9) provide a good description of the cross-country inequality trends, I use data from Luxembourg Income Study (LIS) dataset (see, for example, Gottschalk and Smeeding, 1997, for an investigation of cross-country income inequality using this dataset, and Gottschalk and Joyce, 1998, for an investigation of differences in wage inequality). Because LIS data for different countries refer to different years, I combine these with the March Current Population Surveys (CPS) for the corresponding years.

There are a number of difficulties in using the LIS for this purpose. First, information on years of schooling or education is missing for a number of countries. In particular, there is no consistent education information for the UK and Sweden, and for the Netherlands, the education categories change over the sample period in a way that makes it difficult to construct comparable relative supply numbers. Second, for some countries, for example, Belgium and France, incomes are reported after taxes. Third, because the LIS sample is limited to household heads, relative supplies have to be constructed for heads of households instead of the whole population. Finally, because weeks worked information is missing for some countries, annual earnings have to be used to construct skill (college) premia. These difficulties notwithstanding, the LIS provides a convenient data set for a preliminary look at whether differences in relative supplies could account for the differential inequality trends.

The skill premia are obtained from a log-wage regression analysis using annual earnings of full-time-full-year male household heads aged of 18-64. The "college premium" is estimated as the coefficient on the dummy for college education. Following other authors, in the case where there is no education information, I use information on occupation (this is the case for the UK and Sweden, see the Appendix). The regression also contains other education dummies, a quartic in age (since experience cannot be constructed for every country), and a race or immigrant dummy when applicable (see the Appendix). For the CPS calculations, when earnings are top coded, they are assigned the value of 1.5 times the tope code.[8]

The 90-10 wage differential is simply the log difference between the earnings of the household head at the 90th percentile and those of the household head at the 10th percentile (again the sample is limited to full-time-full-year male heads of households).

Relative supplies are constructed adapting the method of Autor, Katz and Krueger (1998) to the data available here. In particular, it is the ratio of number of college-equivalents divided by the number of noncollege-equivalents. Here, I define college and noncollege equivalents as follows:

college equivalents=college graduates+0.5×workers with some college, and

noncollege equivalents=high school dropouts and graduates+0.5×workers with some college.

When college information is not available, occupations are used for this calculation (see the Appendix). Moreover, for the Netherlands and Germany, there is no separate category for those with some college.[9] Presumably, workers with some college are already included either with those with secondary education or among those with college education. This may create problems with the relative supply estimates from these two countries. For all these calculations, I use a sample of male heads of households rather than the whole population, since the LIS only has information for heads of households. To the extent that there are differential trends over the years across different countries in female labor force participation, this limitation of the LIS may create biases in the analysis here.

[8]Because the sample is narrower than usual (in particular, it excludes women), is not weighted by weeks worked, and includes age instead of experience controls, the college premium for the U.S. is estimated to be lower than usual.

[9]For Germany, we only use data from 1989 and 1994. The survey also includes data for 1981 and 1984, but the 1981 survey is the first LIS survey, and data quality is low and LIS advises against the use of this survey. The 1984 survey has a very different classification of education, and implausibly few people outside the categories of high school and high school and less. Although I report overall wage inequality numbers from the survey in Table 1, I do not use it for calculating returns to schooling or relative supplies.

Because there are a number of problems with the French data (for example, incomes are reported after taxes, there is no education variable for the first two surveys, and it is not possible to limit the sample to full-time-full year workers), I exclude France from the analysis. I also exclude Luxembourg since the sample size is small.

4.2 Empirical Results

Figures 3a-c and 4a-c show the results of the empirical exercise. Figures 3a-c depict the estimates obtained from (7) for two values of the elasticity of substitution, $\sigma = 1.4$ and $\sigma = 2$, while Figures 4a-c show the estimates from (9), again for the same two values of the elasticity of substitution. In all cases, the change estimates, $\Delta_k \ln \hat{\omega}^j (t)$ and the $\Delta_k \ln \tilde{\omega}^j (t)$, are translated into level estimates by choosing the first year estimate for each country to be the same as the actual skill premium for that country.

A number of patterns are apparent from the figures, irrespective of which method and which estimate of the elasticity of substitution are used. First, for Australia and and Canada, the predicted skill premia estimates are close to the actual estimates, while for the UK, the college premium increases more than predicted. Therefore, there is no evidence that the relative-supply-demand framework with common technology trends is predicting too large an increase in the skill premia among the Anglo-Saxon countries. This conclusion is consistent with the results of Katz, Loveman, and Blanchflower (1995), Murphy, Riddell and Romer (1998) and Card and Lemieux (2001). The predicted skill premia estimates are also close to the actual estimates for Finland and Norway.

Second, for the Netherlands, the predicted skill premia decline, whereas the actual skill premia remain approximately constant. This reflects substantial increase in the relative supplies of skills in this country. Given the shortcomings of the LIS data for the Netherlands noted above, increases in the relative supply of skills are likely to be overstated, and these results need to be interpreted with caution. Next, for Germany, Norway and Finland the predicted and actual skill premia move more or less in tandem. Hence, the relative-supply-demand framework with common technology changes appears to perform well for these countries, though it has to be borne in mind that German relative supply changes may be overstated in the LIS data.

Finally, for Belgium, Denmark, and Sweden, the predicted skill premia estimates increase substantially while actual skill premia are approximately constant or actually declined. For Israel, the same result is obtained using the first method, but not the second. Given the quality of the LIS data, these results have to be viewed as preliminary, and more work using detailed microdata from these countries is necessary to reach firmer conclusions. Nevertheless, the results suggest that for a significant fraction of the continental European countries in the sample, the relative-supply-demand framework with common technology trends does not provide an entirely satisfactory explanation for the differential behavior of skill premia. Instead, it appears that relative demand for skills increased substantially less in Belgium, Denmark and Sweden than in the U.S. or other Anglo-Saxon countries.

5 A Model of Differential Technology Responses

I now develop a simple theory which links the adoption of skill-biased technologies to labor market institutions, and provides an explanation for why technical change may have been less skilled-biased in Europe than in the U.S. This theory builds on a framework I developed in Acemoglu (1999a), and combines it with some of the insights of the literature on training investments in the presence of labor market frictions (e.g., Acemoglu, 1997, Acemoglu and Pischke, 1998, 1999).

The basic idea is that in a labor market with wage bargaining, the incentives of firms to invest in new technologies is affected by the degree of wage compression. In particular, greater wage compression may increase firms' incentives to raise the productivity of low-skill workers. I then suggest that the greater institutional wage compression in Europe may have encouraged firms to adopt certain technologies with low-skill workers that U.S. firms did not adopt.

Throughout, I will keep the presentation at a heuristic level. The reader is referred to Acemoglu (1999a) for a fuller discussion of a similar model (but without an analysis of the impact of differences in wage-setting institutions on technology choices).

5.1 The Environment

There is a continuum 1 of workers that are infinitely lived and maximize the net present value of income discounted at the rate r. A fraction ϕ of these workers are skilled, and have human capital h_s, while the remaining workers are unskilled with human capital $h_u < h_s$.

Jobs in this economy are created via costly search as in the models by Diamond (1982), Mortensen (1982), and Pissarides (1990). When there are V vacancies and U unemployed workers, there will be $M(U, V)$ new matches created. Notice that what matters is the total number of unemployed workers (skilled plus unskilled), and as a result, both skilled and unskilled workers will have the same matching rates. I assume that the function M exhibits constant returns to scale, so matching rates are determined simply by the tightness of the labor market, $\theta = \frac{V}{U}$. The probability of matching with a worker for a vacancy is $q(\theta)$ where q is a decreasing function. The probability of matching rate for an unemployed worker, in turn, is $\theta q(\theta)$, which is assumed to be increasing in θ. I also assume that matches between firms and workers come to an end at the exogenous probability s.

Firms incur a setup cost γ_t when they post a vacancy at time t. Once they match with a worker, they decide what type of a job to create. In Acemoglu (1999a), I analyzed the more realistic (and involved) case where firms decide the type of job before matching. Here I focus on the case where this decision is made after matching in order to simplify the analysis. Specifically, at time t, a firm matched with a worker of human capital h can either produce

$$A_t h \tag{10}$$

units of the final good, without incurring any additional costs, or it can undertake an additional investment of cost k_t and produce

$$(1 + \alpha) A_t h, \tag{11}$$

where $\alpha > 0$.

One possible interpretation of the choice between the two technologies is that firms can either use last period's technology at no cost, or adopt the frontier technology by incurring an additional cost every period.

Notice that the multiplicative nature of the production function in (11) makes new technology complementary to skills.

Also in terms of the framework discussed in the previous section, the elasticity of substitution between skilled and unskilled workers is infinity, and wage inequality is unaffected by relative supplies. This is to simplify the discussion and focus on differential technology responses of different economies.

5.2 Analysis

The discounted net present value of a firm with technology adoption decision $x_t \in \{0, 1\}$ and matched with a worker of skill $h \in \{h_u, h_s\}$ can be written as

$$J_t\left(x_t, h\right) = A_t h + x_t\left(\alpha A_t h - k_t\right) - w_t\left(x_t, h\right) + \frac{1}{1+r}\left[sV_{t+1} + (1-s)\max_{x_{t+1}} J_{t+1}\left(x_{t+1}, h\right)\right] \tag{12}$$

where $w_t\left(x_t, h\right)$ is the wage as a function of the technology decision and the skill level of the worker, and V_{t+1} is the value of a vacancy at time $t+1$. The wage may depend on the technology decision because of bargaining over the quasi-rents created by search frictions. The term sV_{t+1} is added because with probability s, there is a separation, and the firm becomes an unfilled vacancy. Finally, the last term is the continuation value conditional on no separation, and I have imposed that there will be no voluntary separations. This will be the case in steady state, and I will focus on the steady state allocation for simplicity.[10]

Next suppose that A_t and k_t grow exogenously at a constant rate, g, i.e.,

$$\begin{aligned} A_t &= (1+g)^t A \\ k_t &= (1+g)^t k. \end{aligned} \tag{13}$$

[10] Away from the steady state, workers may want to end the relationship with a firm that does not adopt the new technology voluntarily, and I'm ignoring this case in writing equation (12). In any case, such voluntary separations would never happen along the equilibrium path, since the technology adoption decisions are taken every period, so the firm would never choose not to adopt the new technology when it knows that this will result in a quit.

In addition, assume that wages are equal to a fraction β of the worker's ex post product:[11]

$$w_t(x_t, h) = \beta(1 + x_t\alpha) A_t h. \tag{14}$$

The important assumption incorporated in this expression is that wage determination takes place after the firm *sinks* the cost of new technology. This is reasonable in practice given the impossibility of writing binding wage contracts, and that, while wages are negotiated throughout the duration of the employment relationship, many of the technology-related decisions are made before or at the beginning of this relationship.

Using (14) and the fact that both productivity and costs are growing at the rate g as specified by (13), we can rewrite the steady-state value of a job that always adopts the new technology ($x = 1$) and that of a job that never adopts the new technology ($x = 0$):

$$J(x, h) = \delta[(1 - \beta)(1 + x\alpha) Ah - xk] \tag{15}$$

where $\delta \equiv \frac{(1-s)(1+g)}{1+r}$ is the effective discount factor, taking into account time preference, separation probability and productivity growth.

Notice that the firm only receives a fraction $1 - \beta$ of the output, though it incurs the full cost of investment. As a result, firms will tend to underinvest in technology. This is a standard result, going back at least to Grout (1984), and also emphasized in the context of search equilibrium by Acemoglu (1996).

It is straightforward to see that, in steady state, firms will choose to adopt the new technology with a worker of skill level h if and only if $J(x = 1, h) > J(x = 0, h)$, or if

$$(1 - \beta)\alpha Ah > k. \tag{16}$$

The fact that the left-hand side of this expression is increasing in h reiterates that new technologies are complementary to skills, and therefore more likely to be adopted with skilled workers.

Next, consider the case:

$$(1 - \beta)\alpha Ah_u > k. \tag{17}$$

[11] More formally, I'm assuming that wages are determined by outside-option bargaining as in Rubenstein (1982) and Shaked and Sutton (1984) (see Acemoglu, 1996, for a justification in the search equilibrium context).

This condition ensures that firms are happy to adopt a new technology even with unskilled workers. Clearly (17) immediately implies that $(1-\beta)\,\alpha A h_s > k$. So the new technology will be adopted with skilled workers as well. Then, wages will be given by

$$w_t^u = \beta\,(1+\alpha)\,A_t h_u \text{ and } w_t^s = \beta\,(1+\alpha)\,A_t h_s, \tag{18}$$

so the skill premium (or the measure wage inequality) in each period is simply

$$\omega_t \equiv \frac{w_t^s}{w_t^u} = \frac{h_s}{h_u}.$$

In this equilibrium, there is steady technical change, and wages are increasing at a constant rate. But wage inequality remains stable, because all new technologies are implemented both with skilled and unskilled workers, so technical change is "neutral" towards skills.

It is also straightforward to characterize the equilibrium tightness of the labor market and the unemployment rate. In particular, given condition (18), the value of a vacancy at time t can be written as:[12]

$$\begin{aligned} V_t &= -\gamma_t + q\,(\theta_t)\Big[\phi \max_x \{J_t\,(x=1,h_s)\,;J_t\,(x=0,h_s)\} \\ &+ (1-\phi)\max_x \{J_t\,(x=1,h_u)\,;J_t\,(x=0,h_u)\}\Big] + (1-q\,(\theta_t))\max\{V_{t+1};0\} \end{aligned} \tag{19}$$

Here γ_t is the cost of opening a vacancy. With probability $q\,(\theta_t)$, the vacancy matches with a worker, and with probability ϕ, this worker is skilled, and with probability $1-\phi$, he is unskilled. The firm then decides whether to adopt the new technology or not as captured by the "max" operators. With probability $1-q\,(\theta_t)$, there is no match, and then the firm decides whether to keep the vacancy, obtaining the value V_{t+1} or shut down.

Assume that the cost of vacancy γ_t also grows at the rate g, that is, $\gamma_t = (1+g)^t\,\gamma$, and impose free entry, which implies that $V_t = V_{t+1} = 0$. Then, using (15), we obtain that in steady state:

$$V = -\gamma + q\left(\theta^{\text{Pre}}\right)\left[\delta\left((1-\beta)\,(1+\alpha)\,A - k\right)(\phi h_s + (1-\phi)\,h_u)\right] = 0, \tag{20}$$

[12]Without loss of any generality, I'm using the timing convention that a vacancy that gets filled this period can start production in this period.

where θ^{Pre} is the steady-state tightness of the labor market, with the superscript "Pre" denoting the fact that this refers to the case before the technology shock. This tightness and the whole equilibrium allocation are defined uniquely.

Next, the steady state unemployment rate for both skilled and unskilled workers is:[13]

$$u = \frac{s}{s + \theta q(\theta)}. \tag{21}$$

The important point is that both skilled and unskilled workers have the same unemployment rate, and that this unemployment rate is a decreasing function of θ: unemployment will be lower when the labor market is tighter.

5.3 Change in Technology Regime

Now imagine that the economy is hit by an adverse shock at time T, increasing k_T to $k'_T > k_T$.[14] From this point onwards, both k and A grow at at the same rate as before, i.e., $A_{T+t} = (1+g)^t A_T$ and $k_{T+t} = (1+g)^t k'_T$. Assume also that following this technology shock, we have:

$$(1-\beta)\,\alpha A_T h_s > k'_T > (1-\beta)\,\alpha A_T h_u. \tag{22}$$

Condition (22) implies that firms, from this point onwards, will continue to adopt the new technology with skilled workers, *but not* with unskilled workers. That is, the new technology adoption condition (16) is now satisfied for skilled workers only. As a result, wages at any time $t \geq T$ are now

$$w_t^u = \beta A_t h_u \text{ and } w_t^s = \beta(1+\alpha) A_t h_s,$$

so after this technology shock, wage inequality increases to

$$\omega'_t \equiv \frac{w_t^s}{w_t^u} = (1+\alpha)\frac{h_s}{h_u}.$$

[13] This unemployment rate equation follows by equating to the flow out of unemployment, $\theta q(\theta) u$, to the flow into unemployment, $(1-s) u$. The fact that both types of workers have the same unemployment rate is a consequence of the simplifying assumption that all search is undirected, and no matches are turned down. It is straightforward, but cumbersome to generalize the model by adding some heterogeneity, or by allowing firms to turn down workers as in Acemoglu (1999a).

[14] Notice that I am taking the technology shock to be an increase in the cost of new investment. This is consistent with the fact that all the countries in question experienced a TFP slowdown over this time period. Nevertheless, many other economists view the 1980s as a period of more rapid technological change (e.g., Greenwood and Yorukoglu, 1997, Hornstein and Krusell, 1996). See Gordon (1998), Jorgensen and Stiroh (2000) and the discussion in Acemoglu (2002).

In addition, unemployment for both types of workers increases. To see this note that the free-entry condition now changes to

$$V = -\gamma + q\left(\theta^{\text{US-Post}}\right)\left[\delta\left(\phi\left(\left(1-\beta\right)\left(1+\alpha\right)A - k\right)h_s + \left(1-\phi\right)\left(1-\beta\right)Ah_u\right)\right] = 0, \quad (23)$$

which incorporates the fact that now firms will not adopt the new technology with unskilled workers. The steady-state labor market tightness is denoted by $\theta^{\text{US-Post}}$, since it refers to the equilibrium after the change in technology in the model economy supposed to approximate the U.S.

Comparing this expression to (20) shows that, as a consequence of the technology change, opening a vacancy is now less profitable (i.e. the term in square brackets has fallen). So θ, the tightness of the labor market, has to decline to satisfy (23)—that is, $\theta^{\text{US-Post}} < \theta^{\text{Pre}}$. This implies, from equation (21), that the unemployment rate will increase.[15]

So at a very simple level, this model illustrates how a technological shock might increase wage inequality by changing the technology adoption decisions of firms. After the change in technology, firms find it profitable to invest in new technologies only with skilled workers, and as a result, the relative productivity of skilled workers and the skill premium increase.

5.4 Change in the Technology Regime in the "European" Equilibrium

Now, consider a different environment, meant to proxy at a very crude level the continental European labor market. In this environment, there is institutionally imposed wage compression, for example because there is a minimum wage at a level that is binding for unskilled workers. This contrast captures in a stylistic way the differences between the American and continental European labor markets. For example, Blau and Kahn (1996) provide evidence in favor of the hypothesis that labor market regulations compress wage differences at the bottom of the distribution in Europe. They show that

[15] This is consistent with the fact that unemployment both among low and high education workers in the U.S. increased during the 1980s (see Acemoglu, 1999a).

although wage differentials between the 90th and the 50th wage percentiles are similar across countries, the differential between the 50th and 10th percentiles is much larger in the U.S. than Europe. Union wage setting, which extends wage floors across firms, or relatively high minimum wages, as well as more generous social insurance programs, are probably at the root of this wage compression.

Denote the minimum wage in effect at time t by $\underline{w}_t$. Since the economy is growing, the minimum wage has to grow as well—otherwise, it would quickly become irrelevant. So I assume $\underline{w}_t = (1+g)^t \underline{w}$.

Also to illustrate the main point, it is most convenient to assume that at time $t = 0$:

$$\beta (1+\alpha) Ah_u > \underline{w} > \beta Ah_u \text{ and } \beta Ah_s > \underline{w}. \tag{24}$$

That is, the minimum wage is binding for a firm that hires an unskilled worker and does not adopt the new technology. In contrast, it is not binding for a firm that adopts the new technology with an unskilled worker. And it is never binding for a firm employing a skilled worker. Since both productivity and minimum wages grow at the same constant rate, (24) ensures the same configuration at all t

In the presence of the minimum wage law, the wage equation (14) cannot apply, since (24) implies that some workers would be paid less than the minimum. Hence, consider a straightforward generalization of this wage equation to:[16]

$$w_t(x_t, h) = \max \{\beta (1 + x_t \alpha) A_t h, \underline{w}_t\}. \tag{25}$$

So if the "equilibrium bargained wage" in the absence of the minimum wage is below the minimum, the worker is simply paid the minimum. Since nothing has changed for skilled workers, the condition for the new technology to be adopted is the same as in the unregulated economy, i.e., $(1-\beta)(1+\alpha) Ah_s > k$.

But the technology decision for unskilled workers has changed. In particular, now the minimum wage will be binding for a firm employing an unskilled worker with the old technology, so

$$J(x = 0, h_u) = \delta (Ah_u - \underline{w}). \tag{26}$$

[16] This wage rule follows from is straightforward application of the Rubinstein (1982) bargaining model with outside options (see Shaked and Sutton, 1984).

In contrast, the value of the firm that adopts the new technology with an unskilled worker is still given by

$$J(x=1,h_u)=\delta\left((1-\beta)(1+\alpha)Ah_u-k\right), \tag{27}$$

because, when the firm adopts the new technology, the minimum wage is not binding. Comparing the expressions (26) and (27) shows that the firm will find it profitable to introduce the new technology with an unskilled worker if

$$(1-\beta)\alpha Ah_u-k>\beta Ah_u-\underline{w}. \tag{28}$$

Assumption (24), which meant that the minimum wage was binding for unskilled workers, also immediately ensures that the right hand-side of (28) is negative. Consequently, the condition for this economy to adopt new technologies with unskilled workers is less restrictive than for the unregulated economy (recall the unregulated economy adopts the new technology when $(1-\beta)\alpha Ah_u-k>0$).

The intuition is as follows: the institutions already force the firm to pay an unskilled worker a higher wage than what the firm and the worker would have bargained to. This implies that the firm can invest more and increase production, without this increased productivity being translated into higher wages. Wage compression is therefore making the firm *the residual claimant* of the increase in the productivity of the worker.

This reasoning is similar to the intuition for why firms find it profitable to invest in the general training of their employees in the presence of labor market imperfections in Acemoglu and Pischke (1999). Also as in Acemoglu and Pischke (1999), labor market rents for firms are crucial for this result. With $\beta=1$, that is, when there are no rents for firms, if institutions pushed the wages of unskilled workers up, firms would lay off all unskilled workers.[17]

Now imagine a situation in which firms invest in new technology with both skilled and unskilled workers, even in the absence of the minimum wage. Then, a fortiori, firms in the "European" equilibrium will also invest in new technology with both types of workers. Next, as discussed in subsection 5.3, imagine a change in technology regime

[17] Of course, in this case we also need $\gamma=0$ for firms to break even in the first place.

at time T, increasing the cost of investment from k_T to k'_T, such that in the absence of the minimum wage, firms stop investing in the new technology with unskilled workers. Because the minimum wage increases the incentives to invest in new technology with unskilled workers, it is quite possible that the economy with wage compression will continue to do so. In particular, if

$$(1-\beta)\,\alpha A_T h_u - \beta A_T h_u + \underline{w} > k'_T > (1-\beta)\,\alpha A_T h_u, \tag{29}$$

the new technology will be adopted with unskilled workers in Europe, but not in the U.S. Therefore, this model offers a possible explanation for why technical change may have been less skill biased in Europe than in the U.S. over the past 20 years. Interestingly, in this simple model, not only is there less skill-biased technical change in Europe than in the U.S., but in fact, there is none. As a result, while the skill premium increases in the U.S., it remains unchanged in Europe.[18]

In light of these results, it is interesting that the brief empirical investigation above indicated similar relative demand shifts in other Anglo-Saxon countries. Since there is little wage compression in these Anglo-Saxon countries, the analysis here suggests that firms there should have no further incentives to adopt new technologies with unskilled workers than U.S. firms. Relative demand shifts in favor of skilled workers should be slower only in economies with significant institutional wage compression, such as the continental European economies.

What about unemployment in the "European" equilibrium after the change in the technology regime? Since firms are now adopting the new technology with both skilled and unskilled workers, the free-entry condition becomes

$$V = -\gamma + q\left(\theta^{\text{E-Post}}\right)\left[\delta\left(\left((1-\beta)\,(1+\alpha)\,A - k\right)\left(\phi h_s + (1-\phi)\,h_u\right)\right)\right] = 0. \tag{30}$$

Recall that in the absence of the minimum wage, firms did not find it profitable to adopt the new technology with unskilled workers, so the term in square brackets is lower

[18] The reader might note that the assumption of rent-sharing in the U.S. economy is important for these results. Without rent-sharing, whenever the European economy with wage compression finds it profitable to adopt the new technology, so will U.S. firms. This is not essential for the overall argument, however. It is possible to generalize (and complicate) the model such that wage compression forces European firms to invest in new technologies with unskilled workers, even when the competitive economy would not introduce these new technologies.

in (30) than the comparable term in expression (23). Therefore, $\theta^{\text{US-Post}}$ implied by (23) has to be higher than $\theta^{\text{E-Post}}$ implied by (30), and the technology shock will increase unemployment more in Europe than in the U.S. The intuition for this result is that wage compression is forcing firms to adopt new technologies with unskilled workers, while without wage compression firms would have preferred not to adopt these technologies. This implies that wage compression reduces profits from employing unskilled workers. Since each vacancy may be matched with either a skilled or an unskilled worker, wage compression discourages job creation in general, increasing both skilled and unskilled unemployment. This pattern of high unemployment both among the skilled and the unskilled in Europe is consistent with the broad facts.[19]

As a result, the theory presented here is consistent with the differential inequality trends across countries, the differential behavior of the relative demand for skills, as documented in the first part of this paper, and with the fact that unemployment in Europe increased relative to that in the U.S. over the 1980s. But as yet, there is no micro evidence supporting the underlying mechanism of this story.

6 Concluding Remarks

Despite the social importance of inequality trends, and their prominence in academic debates, the economics profession currently lacks a consensus on why, over the past several decades, inequality increased in the U.S. and the UK, but not in continental Europe.

In this paper, I reviewed the two traditional explanations for these patterns, that relative supply of skills increased faster in Europe and European labor market institutions prevented inequality from increasing, and I developed a simple framework to quantitatively assess whether these explanations are satisfactory. I concluded that, although these traditional explanations account for a large fraction of the differential cross-country

[19]Notice that if the model is modified so that firms can open separate vacancies for skilled and unskilled workers, only unskilled unemployment will increase. Nevertheless, it is important to see that the model, under some assumptions, can generate increases in the unemployment rates for both types of workers, contrasting with standard reasoning based on the Krugman hypothesis, which unambiguously predicts that it is unskilled unemployment that should increase.

inequality trends, they do not provide an entirely satisfactory approach. Instead, it appears that relative demand for skills increased differentially across countries.

Motivated by this fact, I developed a simple theory where labor market institutions creating wage compression in Europe also encourage more investment in technologies increasing the productivity of less-skilled workers. This may have led to a smaller increase in the demand for skills over the past 20 years in Europe than in the U.S.

I showed that this explanation based on the effect of labor market institutions on technology adoption is consistent with the differential inequality trends, the differential behavior of the relative demand for skills documented in the first part of the paper, and the differential behavior of unemployment rates in Europe and the U.S.

These macro facts of course do not establish that this theory is along the correct lines, and there can be many other potential theories explaining why relative demands change differentially across countries. There are therefore both important theoretical and empirical avenues to pursue. I hope that this paper will stimulate others to investigate alternative approaches with differential degrees of skill-biased technology across countries (resulting from differential adoption decisions).

On the empirical front, work using microdata is necessary to investigate more carefully whether differences in relative supplies, with similar shifts in relative demands, can account for the differences in these cross-country inequality trends. Future work could also look at whether there is any direct evidence that technical change has been less skill biased in Europe than in the U.S. One possibility is to look at the rates of technology adoption and/or at rates of TFP growth and capital accumulation in unskill-intensive industries in Europe relative to similar industries in the U.S. (using skill-intensive industries in both set of countries as a control group). Alternatively, one could undertake a direct investigation of whether certain advanced technologies, such as personal computers, computer-assisted or numerically-controlled machines, used seldom with unskilled workers in the U.S., were introduced with unskilled workers in Europe. Finally, it may also be fruitful to use data on industry-level skill-upgrading across different countries and expand the approach used inn Berman, Bound and Machin (1998) to obtain alternative estimates of relative demand shifts across countries.

On the theory front, it would be useful to investigate alternative explanations for why relative demand for skills may have changed differentially in different countries, including theories where the economy may function off its relative demand curve.

Finally, the current paper has focused on the causes of differential inequality trends among OECD economies. Another important and potentially exciting area is the study of inequality trends in middle-income and low-income nations. Berman and Machin (2001) document rapid increase in the demand for skills in middle-income countries, and a number of studies find increasing inequality in many developing countries (e.g., Freeman and Oostendorp, 2000, or Duryea and Szekely, 2000). An investigation of the causes of the increase in inequality in developing countries over this same period is also an important research area.

7 Data Appendix

The samples come from the Luxembourg Income Studies Database (LIS). The LIS data is a collection of micro datasets obtained from annual income surveys in various countries. While these surveys are similar in form to the Current Population Survey for the United States and extensive effort has been made to make information on income and household characteristics comparable across countries, important problems of comparability remain. In order to maintain consistency across countries, several restrictive criteria have been used when defining variables and samples. Following Gottschalk and Joyce (1997), who also used LIS data, a simple count of the number of workers, not weighted by weeks worked, is used as a measure of supply from each educational group. Moreover, the data is restricted to male heads of households, since the earnings of other individuals is not available for all survey years in all countries. Countries for which data on gross wages were not available were discarded, as were data from countries with only one survey in the LIS data base. In addition, for the reasons explained in the text, we do not use the German surveys for 1981 and 1984. As a result, at the end this study uses data from Australia (1985 and 89), Belgium (1985, 88, 92 and 96), Canada (1987, 91, 94 and 97), Denmark (1987, 92, 95 and 97), Finland (1987, 91 and 95), Germany (1989 and 94), Israel (1979, 86 and 92), the Netherlands (1983, 87, 91 and 94), Norway (1986, 91 and 95), Sweden (1981, 87, 92 and 95), the United Kingdom (1979, 86, 91 and 95). Data for the United States in all those years comes from the March CPSs.

The college premium is, generally, the coefficient on workers with a college degree or more relative to high school graduates in a regression of log real annual gross wages. Specifically, four education categories were constructed, conceptually corresponding to less-than 12 years of education (high school dropouts), 12 years (high school graduates), 13 to 15 years (some college), and 16 or more years (college graduates) for the U.S. The recoding into these groups is straightforward in countries and years where the education variable is measured in years of schooling (these are: Israel, Canada and Finland, at least for some years), but somewhat more problematic for countries where the education variable is already grouped (all the rest, except Sweden and the United

Kingdom). Since no education information is available in the LIS data base for Sweden and the United Kingdom, returns to broad occupations are used rather than education. Three occupation groups are constructed for those samples, roughly corresponding to professional and managerial workers, blue collar workers and a residual category which includes lower-level white-collar workers. The regression also includes dummies for the remaining education/occupation cattegories and a quartic in age—since the exact number of years of schooling would have to be inputed for most surveys, a quartic in age, and not experience, is used as a control in the wage regression. Only full-time, full-year workers aged 18 to 64 are used in these computations. Full-time workers are defined as those whose hours of work per week were no less than 35, and full-year workers are defined as those who worked at least 48 weeks per year. The samples also leave out those observations with the lowest 1 percent earnings. Finally, earnings for top coded observations are calculated as the value of the top code times 1.5.

The relative supply of skills is calculated from samples that include all wage and salary workers between the ages of 18 and 64. It is defined as the ratio of college-equivalents to non-college equivalents. Following, Autor, Katz and Krueger (1998), these are: college equivalents = college graduates + 0.5×workers with some college, and non-college equivalents = 0.5×workers with some college + high school graduates + high school dropouts. For the Netherlands, it was impossible to distinguish between workers with some college and workers with a college degree, so for this country, as for Sweden and the UK where only occupational categories were available, only three groups were used in the relative supply computations.

8 References

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Table 1. Panel A

Log 90^{th}-10^{th} wage differential for male workers, selected countries

	Estimates using LIS data						Estimates reported by Freeman and Katz, 1995			
	Early 80s	*Mid 80s*	*Late 80s*	*Early 90s*	*Mid 90s*	*Late 90s*	*Early 80s*	*Mid 80s*	*Late 80s*	*Early 90s*
Australia		.834	.920				.69	.76	.77	.80
Belgium		.780	.773	.762	.697					
Canada			1.116	1.182	1.160	1.254	1.25	1.39	1.34	1.38
Denmark			.913	1.307	1.096	1.059				
Finland			.899	.893	.862					
Germany	.819	.894	1.186		1.043			.96	.91	
Israel	1.280	1.481		1.557						
Netherlands	.876		.907	.864	.843		1.01			1.01
Norway		.810		.913	1.122					
Sweden	.867		.920	.864	.880		.77	.72	.72	.77
U.Kingdom	.930	1.093		1.109	1.143		.88	1.04	1.10	1.16
U. States	1.253	1.409	1.427	1.442	1.551	1.465	1.23	1.36	1.38	1.40

NOTE: The data for the left panel come from the Luxembourg Income Studies Database, a collection of micro datasets obtained from annual income surveys.

The log 90^{th}-10^{th} wage differential is the difference between the 90^{th} and the 10^{th} percentiles of the log wage distribution for male workers.

In the left half of the Panel, *Early 80s* refers to 1981, with the exception of Israel and the United Kingdom, where it refers to 1979 and the Netherlands, where it refers to 1983. *Mid 80s* refers to 1985 for Austria, Belgium and the United States, and to 1986 for Israel, Norway and the UK. *Late 80s* refers to 1987 except for Belgium and the US, where it refers to 1988, and for Austria and Germany, where it refers to 1989. *Early 90s* refers to 1991, except for Belgium, Denmark, Israel and Sweden, where it refers to 1992. *Mid 90s* refers to 1995, except for Canada, Germany and the Netherlands, where it refers to 1994, and to Belgium, where it refers to 1996. *Late 90s* refers to 1997.

The right half of the Panel uses data from Table 2 of Freeman and Katz (1995). Here, *Early 80s* refers to 1979, except for Canada and Sweden, where it refers to 1981. *Mid 80s* refers to 1984, except for Australia and Sweden, where it refers to 1985, and for Canada, where it refers to 1986. *Late 80s* refers to 1987, except in Canada and Sweden, where it refers to 1988. *Early 1990s* refers to 1990, except in Sweden, where it refers to 1991.

Table 1. Panel B

Estimated skill premia and relative supplies for male workers, selected countries

	Skill wage premia						Relative skill supplies					
	Early 80s	*Mid 80s*	*Late 80s*	*Early 90s*	*Mid 90s*	*Late 90s*	*Early 80s*	*Mid 80s*	*Late 80s*	*Early 90s*	*Mid 90s*	*Late 90s*
Australia		.253	.286					.520	.590			
Belgium		.350	.312	.350	.311			.202	.217	.246	.264	
Canada			.265	.359	.311	.321			.449	.583	.664	.711
Denmark			.335	.336	.279	.247			.225	.264	.247	.230
Finland			.347	.383	.373				.141	.156	.194	
Germany			.290		.301				.158		.189	
Israel	.267	.339		.231			.298	.366		.496		
Netherlands	.307		.202	.254	.266		.104		.245	.334	.349	
Norway		.183		.248	.179			.213		.271	.287	
Sweden	.560		.592	.363	.319		.130		.163	.181	.190	
U.Kingdom	.250	.279		.304	.354		.457	.579		.757	.902	
U. States	.271	.362	.387	.454	.514	.518	.541	.594	.609	.634	.704	.743

NOTE: The data come from the Luxembourg Income Studies Database, a collection of micro datasets obtained from annual income surveys.

The skill wage premium is generally the coefficient on workers with a college degree or more relative to high school graduates in a regression of log real annual gross wages on four education categories and a quartic in age for full-time, full-year workers aged 18 to 64 –except in Sweden and the United Kingdom, where returns to broad occupations are used rather than education because no education information is available in the LIS data base for those countries. (See Appendix for more detailed information).

The relative skill supply is the ratio of college-equivalents to non-college equivalents (where college equivalents = college graduates + 0.5*workers with some college, and non-college equivalents = 0.5*workers with some college + high school graduates + high school dropouts). For the Netherlands, it was impossible to distinguish between workers with some college and workers with a college degree, so for this country, as for Sweden and the UK where only occupational categories were available, only three groups were used in the relative supply computations.

Early 80s, *Mid 80s*, etc. refer to the same years as in the left side of Panel A.

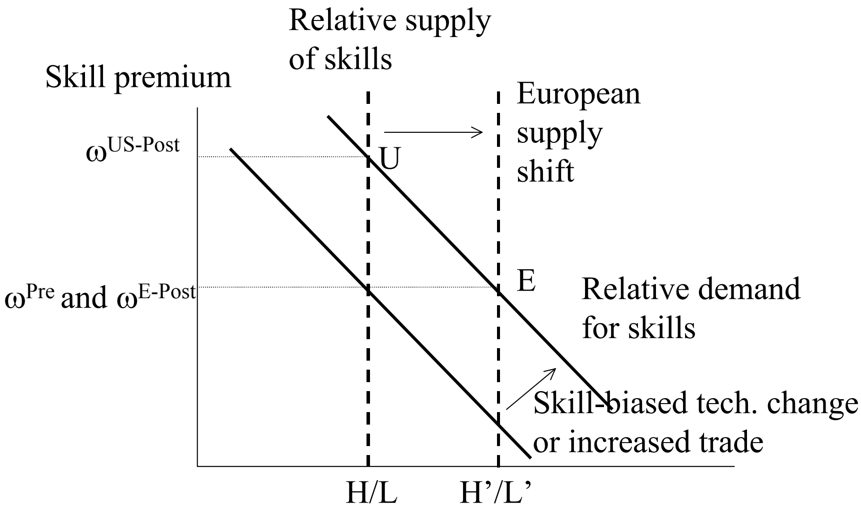

Figure 1: Differential inequality trends due to differential relative supply changes.

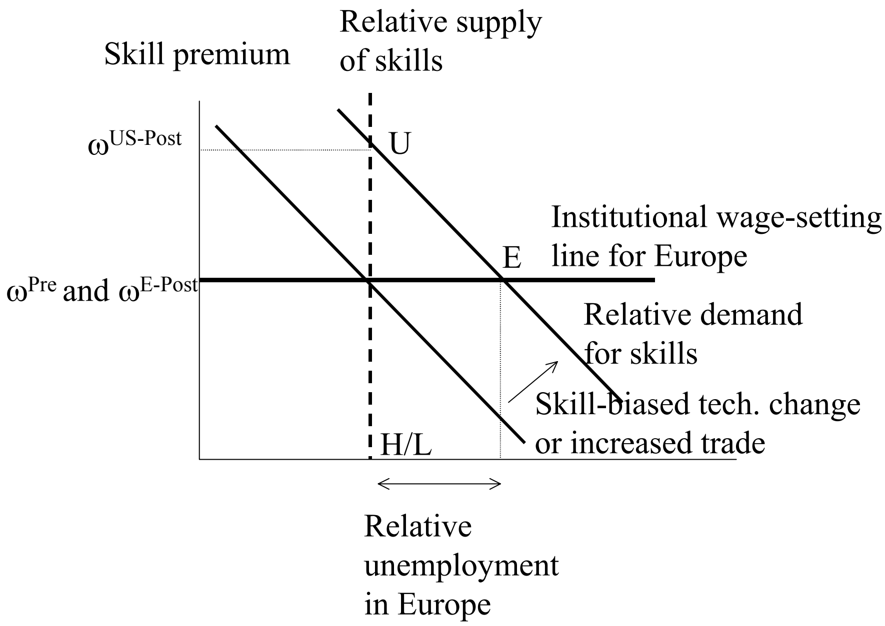

Figure 2: Differential inequality trends because of differences in labor market institutions.

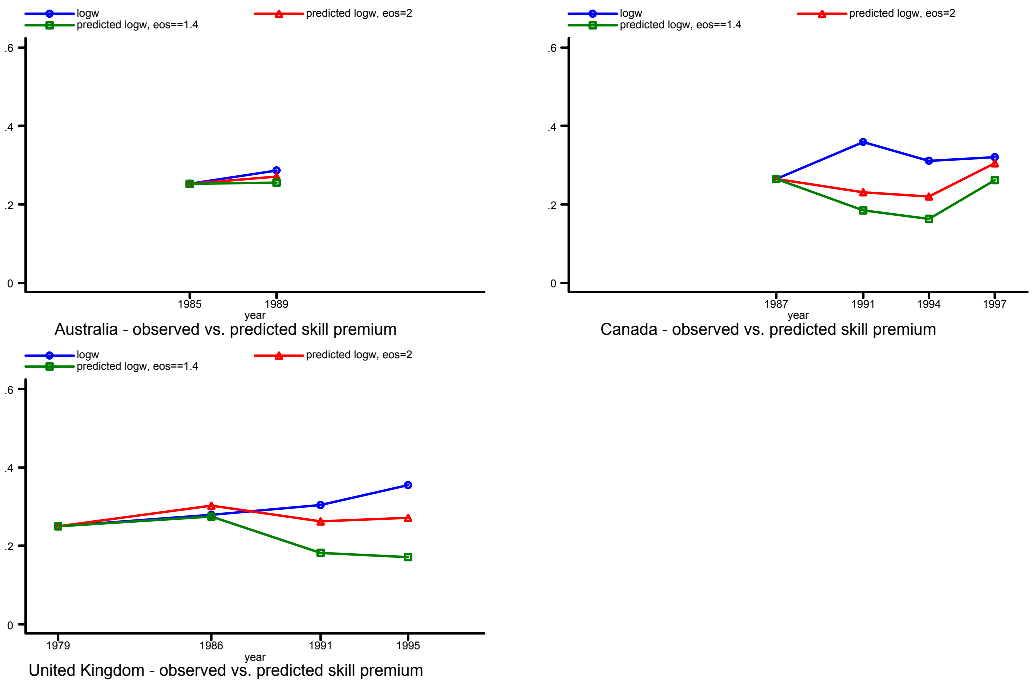

Figure 3a: Actual skill premia and predicted skill premia from equation (7) for $\sigma = 1.4$ and $\sigma = 2$.

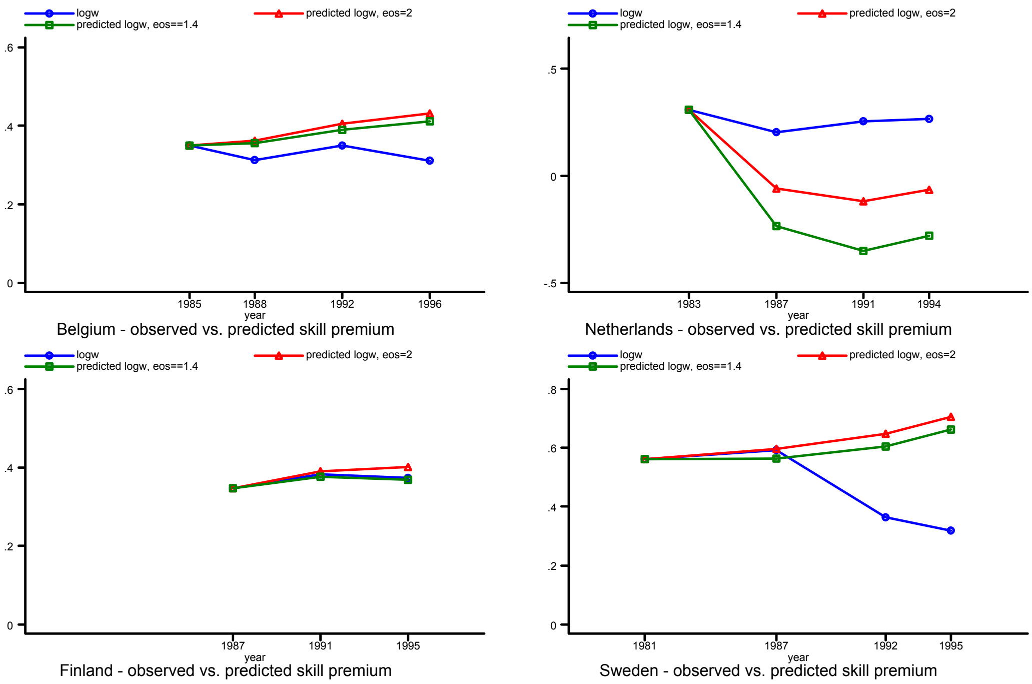

Figure 3b: Actual skill premia and predicted skill premia from equation (7) for $\sigma = 1.4$ and $\sigma = 2$.

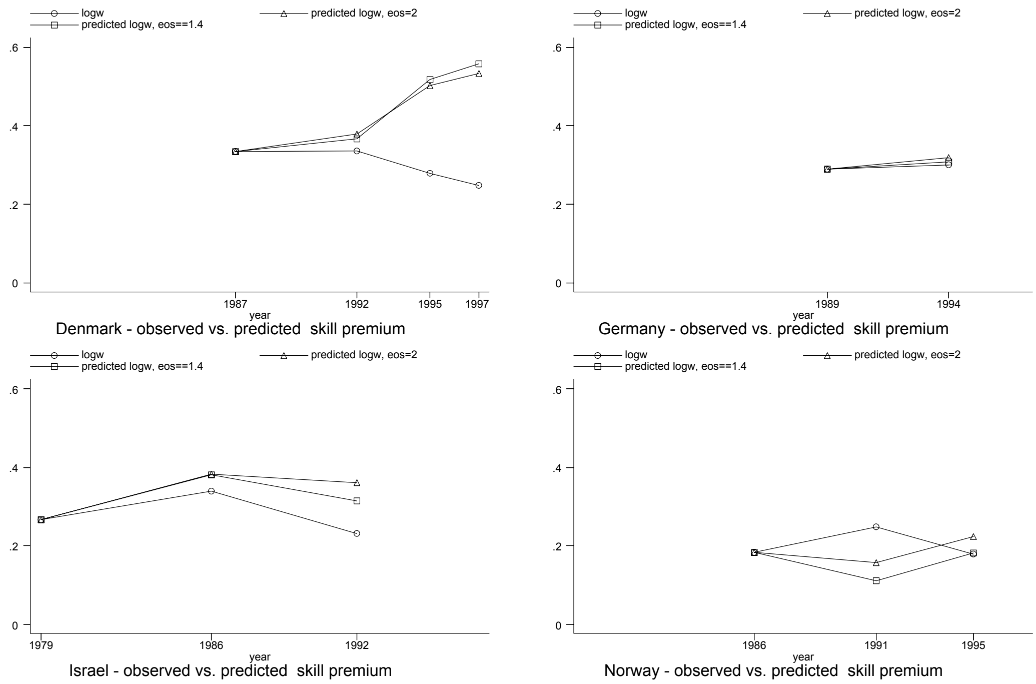

Figure 3c: Actual skill premia and predicted skill premia from equation (7) for $\sigma = 1.4$ and $\sigma = 2$.

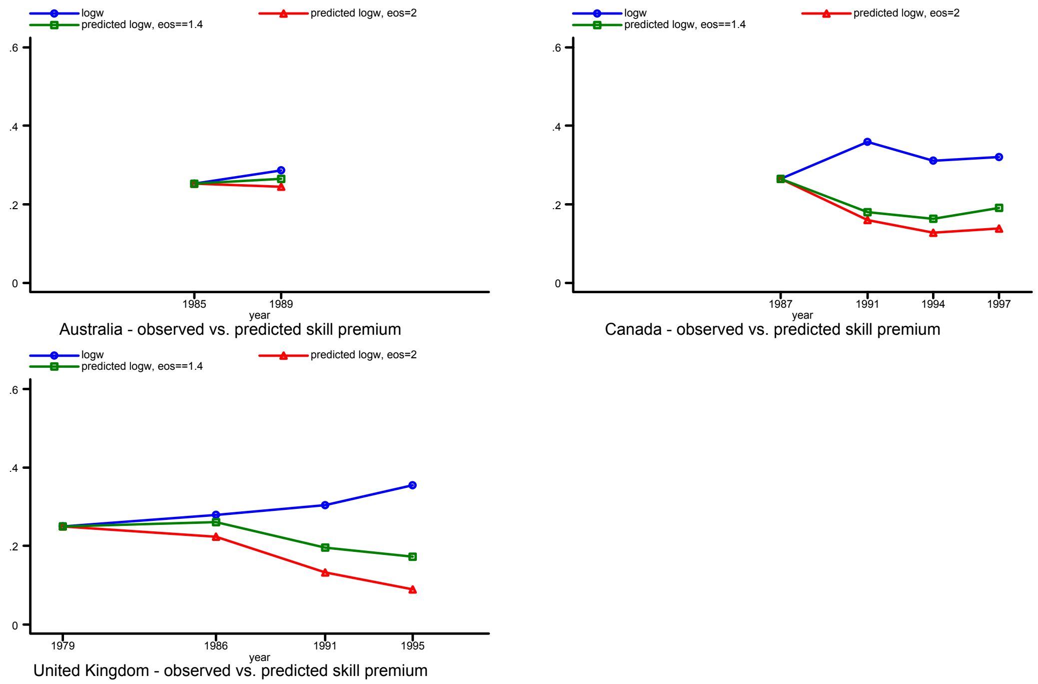

Figure 4a: Actual skill premia and predicted skill premia from equation (9) for $\sigma = 1.4$ and $\sigma = 2$.

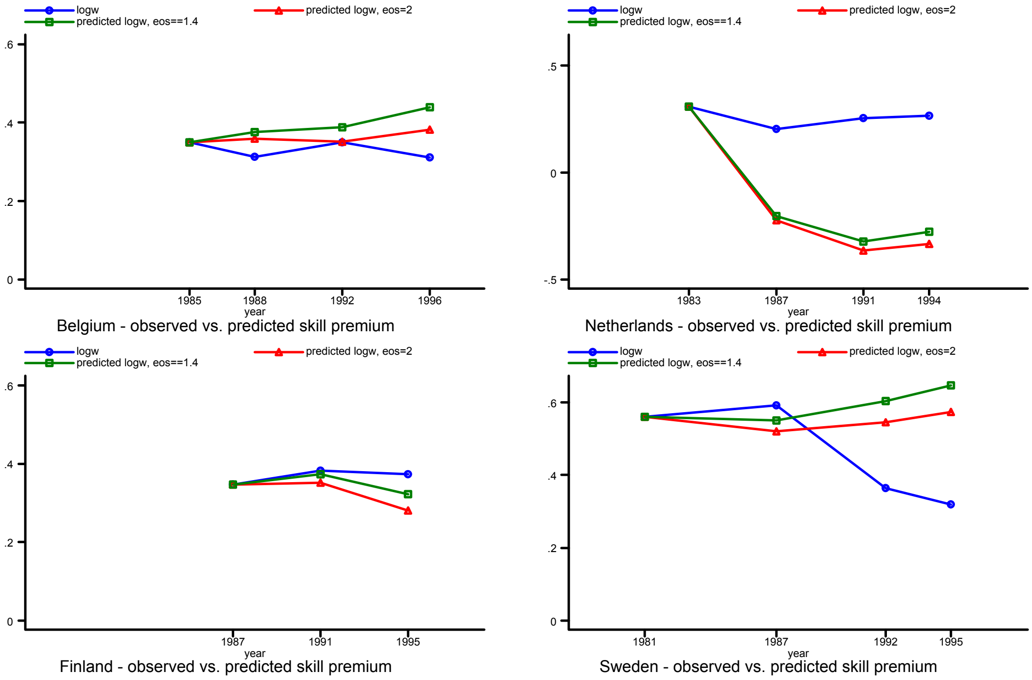

Figure 4b: Actual skill premia and predicted skill premia from equation (9) for $\sigma = 1.4$ and $\sigma = 2$.

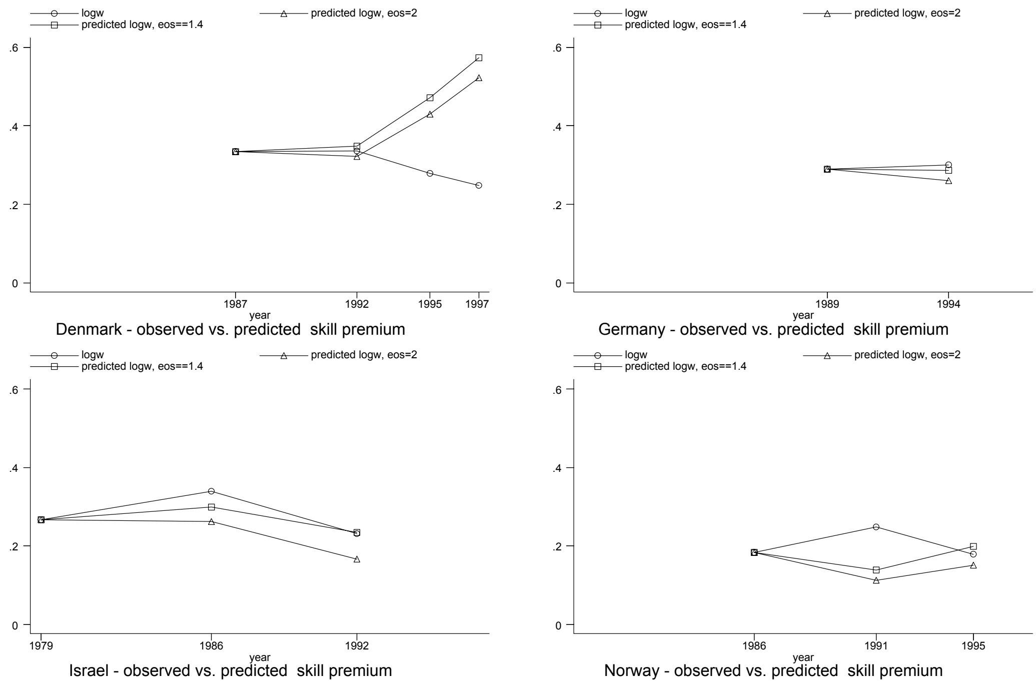

Figure 4c: Actual skill premia and predicted skill premia from equation (9) for $\sigma = 1.4$ and $\sigma = 2$.