MEMORANDUM

No 38/99

Relative Unemployment Rates and Skill-Biased Technological Change

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ISSN: 0801-1117

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This series is published by the
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Department of Economics

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14 December, 1999

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Knut Røed[*]

Abstract

A popular explanation for the European unemployment problem is that relative wages have failed to adjust to changes in relative productivities. Many economists reject this hypothesis on the ground that the ratios of low- to high-skill unemployment have not increased. Building on a search model, I show that relative unemployment rates are affected by skill-neutral, as well as skill-biased shocks; hence stable ratios are, at least theoretically, consistent with a mix of skill-biased and skill-neutral shocks. However, I question the extent to which the relevant skills are observable. Micro evidence from Norway indicates that rising inequality in the unemployment distribution has little to do with educational attainment.

Keywords: Unemployment, Job search, Wage compression, Skill-bias.

JEL Classification: J31, J64.

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1 Introduction

One of the most fashionable explanations for the current European unemployment problem is the following: During the past two or three decades, the market value of low-skill workers fell significantly. In the United States, this development was directly converted into a parallel decline in low-skill wages, with only minor changes in the rate of unemployment. In Europe, the downwards adjustment in low-skill wages was prevented by a centralised and egalitarian wage setting system. The egalitarian wage structure was more or less preserved, but at the cost of much higher unemployment among the less skilled.

The beauty of this theory is that one single and intuitively appealing idea can explain simultaneously and consistently, the major labour market trends in both the United States (a spectacular increase in wage inequality) and in Europe (a spectacular increase in unemployment). But is it true? According to Krugman (1994, p. 50), it is already conventional wisdom. And circumstantial evidence does appear to confirm the theory. The rate of unemployment has typically risen most in the countries with the smallest increase in wage inequality (OECD, 1994). And the higher level of unemployment in Europe is far from equally distributed among the workers. While long-term unemployment (unemployment for more than a year) accounts for less than 10 per cent of total unemployment in the United States, it typically accounts for 40-50 per cent in the major European countries (OECD, 1997, p. 180). But there is some hard evidence that apparently doesn't fit in. The skill-biased technological change hypothesis is usually taken to imply that unemployment is relatively much more concentrated (and has also increased more) among the low-skilled in Europe (where low-skill wages have not adjusted) than in the United States (where they have). To the extent that skills can be proxied by observed characteristics such as education, this is not supported by empirical evidence. Nickell and Bell (1995,1996) and Jackman et.al. (1997) report ratios of the low-education unemployment rate to the high-education unemployment rate for several countries, revealing that higher relative unemployment rates for the low-skilled are just as prevalent in the United States as in the major European countries. Hence, they conclude that skill-biased technological change does not explain much of the European unemployment problem. Nickell and Bell (1995, p. 56) estimate that skill-biased shocks explain about 19 per cent of the total rise in unemployment from the 1970s to the 1980s in some major European countries, 'leaving the other 81 per cent to be explained by neutral shocks'.

Is it possible to reconcile these apparently conflicting pieces of evidence? In order to answer that question, one has to be more precise about the perceived nature of skill-biased technological change. How does skill-biased technological change affect the demand for labour, and who are the unfortunate losers? The typical approach taken in empirical work is to identify the high-skilled (winners) and the low-skilled (losers) either by educational attainment or by occupation (white-collar/blue collar). This may be the appropriate way to do it if one believes that it is in terms of these broadly defined observable groups that skill-biased technological change operates. High-skilled and low-skilled workers are in this case viewed as qualitatively different, and hence *complementary*, factors of production (Jackman et. al., 1997; Nickell and Bell, 1995). Skill-biased technological change is assumed to alter the production technique such that the elasticity of output with respect to a highly educated (or white collar) worker increases, while the elasticity with respect to a poorly educated (or blue collar) worker decreases. An alternative interpretation of skill-biased technological change is that such changes tend to magnify existing skill differentials among workers that perform the same (or similar) tasks. With the aid of modern information technology, an efficient worker becomes even more efficient, while a worker with poor skills may lack the (cognitive) abilities required to take advantage of the new technology. With this interpretation in mind, the high-skilled and the low-skilled workers would be considered *substitutes*, rather than complements. Some workers are simply more efficient than others, and the essence of skill-biased technological change is that it tends to enlarge these differences.

What is the right way to think about it? Given that the 'conventional wisdom' considers United States as the benchmark country in which the market forces have been allowed to operate more or less freely, some guidance may be found in the way US wage differentials have developed. To some extent, increased inequality in the United States reflects higher returns to education. But the most conspicuous feature of the development in the United States is the increase in *within-group* inequality. Katz and Murphy (1992, pp. 43-45) and Gottschalk (1997, pp. 31-33) find that it is primarily the 'residual' wage inequality, i.e. the inequality that remains after observed characteristics are accounted for, that has expanded in the United States over the past decades. Measured by the gap between the ninetieth and tenth percentile of the wage distribution, both these studies find that the unexplained part of the increase in inequality accounts for more than half of the overall increase. Thus, even among workers of same age, experience, education, race and gender, inequality has expanded enormously[1]. So, when Nickell and Bell (1995) find that only 19 per cent of the rise in unemployment can be explained on the basis of skill-biased shocks related to educational attainment, this does *not* necessarily imply that the remaining 81 per cent is explained by neutral shocks. It may simply reflect that the skill-biased technological change that increases the return to education (as measured by some crude, and not always consistent, classification system) accounts for a similarly low fraction of the overall skill-biased technological change.

The European experience with respect to trends in between-group and within-group wage inequality is mixed. An overview of relevant empirical evidence is provided by Gottschalk and Smeeding (1997, p. 654): United Kingdom, and to a lesser degree Sweden, have experienced a US-type increase in both within-group and between-group inequality. France and the Netherlands have experienced a similar development as the United States with respect to between-group inequality, but the increase in within-group inequality is much smaller. Germany, Italy and Finland seem to have experienced no increase in wage inequality whatsoever. The bottom line is that skill-biased technological changes that are exclusively related to educational attainment can only account for a relatively small part of the story. Hence, if one restricts the search for changes in relative labour demand to workers with different educational attainment, one can only hope to explain a correspondingly small part of the European unemployment experience, even if the 'conventional wisdom' turns out to be true.

The fact that increased wage dispersion fails to be appropriately accounted for by observed characteristics implies of course that it is a difficult task to identify the presumed victims to skill-biased technological change in the European labour market. But even to the extent that it is possible to identify these workers, it is not obvious how skill-biased or skill-neutral shocks should be expected to affect the unemployment rates of the various groups. In particular, it is not obvious that the *ratio* of low- to high-skill unemployment is the relevant indicator of skill-biased change. Such an indicator would for example entail that if high-skill unemployment increases with one percentage point from 1 to 2 per

[1] Buchinsky (1994, p. 453) finds that while increased within-group inequality reflected longer tails at both ends of the wage distribution in the 1960s and 1970s, the more recent growth in inequality primarily reflects a longer tail at the low end of the wage distribution.

cent, while low-skill unemployment increases with 6 percentage points from 6 to 12 per cent, this is interpreted as a skill-neutral change. An alternative way to think about it is to take the *sources* of the change in unemployment as the starting point. A number of economic forces contribute to the existence of unemployment, such as pure frictions, mismatch, high replacement ratios or excessive wages. Some of these forces are more naturally interpreted as skill-neutral than others. For example, a uniform increase in separation rates due to a higher general level of idiosyncratic shocks may be classified as a skill-neutral shock. But would the *outcome* of such a shock look skill-neutral? Would the ratio of low- to high-skill unemployment be left unchanged? A first guess is that this ratio must fall, as the skill neutral forces account for a larger share of aggregate unemployment than before. Accordingly, if the tremendous rise in European unemployment was completely driven by skill-neutral shocks, we should perhaps have observed declining ratios of low- to high-skill unemployment.

There are additional reasons for being cautious about using ratios of unemployment rates for various groups to evaluate the relevance of skill bias in labour demand. First, the skill distribution may vary substantially from country to country, implying that the definitions of 'skills' also vary. Evidence reported by Nickell and Layard (1999, p. 3046), for example, suggests that European workers with minimal compulsory education are much more skilled (in terms of literacy levels) than US workers with the same educational attainment. Secondly, relative unemployment rates may conceal important differences with respect to the pattern of unemployment incidence and unemployment duration. A comparison of the United States and France illustrates this point. For prime aged males, the ratio of low- to high-skill unemployment (as measured by educational attainment) turns out to be almost exactly the same, i.e. around 4.2 in both countries (Cohen et. al., 1997, p. 270). But if one takes a closer look at this striking similarity, it turns out that it probably conceals more than it reveals. In the United States, the high relative unemployment rates for the low-skilled is purely a phenomenon of *incidence*. The job loss rate for the low-skilled is more than four times higher than for the high-skilled. The average duration of unemployment is in fact *shorter for the low-skilled than for the high-skilled*. In France on the other hand, the high relative unemployment rates for the low-skilled is caused by differences both in incidence and duration. The average duration of unemployment for the low-skilled is more than 50 per cent longer than for the high-skilled[2].

The aim of this paper is to derive a model that can clarify the relationship between skills, wages and unemployment. The model offers a theory primarily about the relationship between wage formation and unemployment duration. The event of becoming unemployed is treated as driven by exogenous forces[3]. The next section outlines the main features of the model. Section three discusses wage setting in a competitive framework, while section four discusses the possibility of centralised interventions, motivated by egalitarian considerations. Section five considers the effects of various skill-biased and skill-neutral shocks. Section six takes a brief look at some micro evidence from Norway, which is one of the European countries with the most compressed and the least expanding wage distribution (OECD, 1996). Section seven concludes.

2 The Model

I start out with a model of trade in the labour market of the type discussed by Pissarides (1990), and extend it in two directions. The first extension is the incorporation of individual (as well as match specific) productivity differences. The second is the introduction of egalitarian interventions in the wage setting mechanism. The set-up is as follows: Workers and firms must get together through a search and matching process in order to establish production of a composite good. There is a constant return technology, but some workers and some matches are more productive than others are. For simplicity, I assume that there are two skill types, $i=H,L$, and the output associated with a consummated match is given by eP_i, where $P_H>P_L$, and e is a randomly distributed match specific productivity component with distribution function $F(e)$. Hence, the two skill types are perfect substitutes. Individual skills and match-specific productivity are perfectly observable. To fix ideas, one may think of individual skills as reflecting experience, educational level and the grades obtained at various stages of the educational

[2] For workers above 50 years of age, the difference is even more marked. In the United States, the low-skilled exit twice as fast from unemployment as the high skilled. In France, the high-skilled exit three times as fast as the low-skilled.

[3] The empirical relevance of this assumption is of course dubious, but it is true, particularly in European countries, that firms cannot optimise freely with respect to firing decisions. Cross-country variations in employment protection legislation probably drive a significant fraction of the cross-country variation in unemployment incidence. The forming of a new employer-employee relationship on the other hand, is always the result of deliberate choices made by firms and workers.

career, and match specific productivity as reflecting the degree to which the type of human capital can be put to good use in the particular job. The size of the labour force is fixed and normalised to unity for each skill group, and workers have infinite lives.

The number of jobs for low- and high-skilled workers is determined optimally by the firms under the assumption of free entry. There is a cost attached to keeping a job vacant per unit time equal to a constant c, plus a fraction β of the productivity level for the required worker. The nature of the vacancy cost is not modelled explicitly, but it may be thought of as advertisement costs, capital costs or costs related to forgone output. Existing employment relationships are split at an exogenously given separation rate s_i, such that s_L ³ s_H. Workers with low skills may have a higher turnover if, for example, their lack of human capital weakens their attachment to firms. Unemployed job seekers are matched with potential employers at the rate x_i, which depends on the tightness of the labour market. When a contact is established, the match-specific productivity drawing, e, is revealed, and a wage, $w_i(e)$, is determined. Given a functional relationship between the individual wage and the match specific productivity drawing, both the firm and the worker determine a reservation level of this drawing (e_{ir}^{f} and e_{ir}^{w} respectively). If the two reservation productivities differ, the binding one, e_{ir}, is the higher of the two, i.e. $e_{ir} = \max(e_{ir}^{w}, e_{ir}^{f})$. If $e < e_{ir}$, the match is dissolved. An unemployed worker receives a transfer payment of b, plus a fraction α of individual productivity (this may alternatively be interpreted as the utility derived from leisure). Opportunity costs are positively related to productivity (α>0) if high skills give extra advantages in home production or leisure, or if unemployment benefits are correlated with expected income.

I assume that wages are either determined in a decentralised market, which implies some form of bilateral bargaining between workers and firms once a match is established; or set by some central authority that modifies the competitive wage in a more egalitarian direction. I first outline the main features of the model, for the general assumption that individual wages depend on individual and match specific productivity. I then turn to the implications of the alternative wage setting schemes. Consider first a worker of type i. The discounted value of being unemployed, U_i, is implicitly given by the Bellman equation

$$rU_i = b + a\,P_i + q_i\left(E_i^e - U_i\right), \tag{1}$$

where r is the discount rate, q_i is the transition rate into acceptable jobs, and E_i^e is the expected value of such a job. More precisely, $E_i^e = E\left[E_i(e) \mid e \geq e_{ir}\right]$, where $E_i(e)$ is the discounted value of a job with the productivity drawing e. $E_i(e)$ is implicitly given by

$$rE_i(e) = w_i(e) + s_i\left(U_i - E_i(e)\right). \tag{2}$$

Taking conditional expectations in equation (2), inserting the resulting E_i^e in equation (1) and solving yields

$$rU_i = \frac{r+s_i}{r+s_i+q_i}\left(b + a\,P_i\right) + \frac{q_i}{r+s_i+q_i} w_i^e, \tag{3}$$

where $w_i^e = E\left[w_i(e) \mid e \geq e_{ir}\right]$. Hence, the rate of return associated with being unemployed is a weighted average of the instant utility derived from unemployment and the expected wage once an acceptable wage offer arrives. A job is accepted if it offers a wage that at least matches the value of continued unemployment. Hence, the reservation level of match specific productivity for a worker of type i is given by

$$w_i\left(e_{ir}^w\right) = rU_i. \tag{4}$$

Now consider the decisions faced by the firm. For simplicity, I assume that each firm hires only one worker. Since there is free entry, vacancies are posted in both markets as long as they are profitable. Hence, in equilibrium, the value of a vacancy is zero. Accordingly, the value of an operating firm with productivity eP_i, denoted $J_i(e)$, is implicitly given by

$$rJ_i(e) = eP_i - w_i(e) - s_i J_i(e). \tag{5}$$

It follows directly that the reservation level of match specific productivity the firm satisfies

$$w_i\left(e_{ir}^f\right) = eP_i. \tag{6}$$

The probability that a match specific productivity drawing satisfies the binding reservation productivity $e_{ir} = \max(e_{ir}^w, e_{ir}^f)$ is equal to $1-F(e_{ir})$.

The matching process either takes place in a common matching market, or in separate markets for high-skilled and low-skilled workers. For the sake of analytical tractability, I adopt the separate market assumption. The reasonableness of this assumption depends on the nature of skill-differences. Note however that if it is possible for the firms to announce skill-specific vacancies in a credible way, a completely common matching market may not be sustainable. The reason is that even though competition drives down the value of a 'common market' vacancy to zero, it is possible that there is a rent associated with the posting of vacancy particularly aimed at the high-skilled[4]. The number of matches made between unemployed workers and vacant jobs in each market is given by the constant returns to scale functions $X(u_i,v_i)$, where v_i is the rate of vacancies, u_i is the rate of unemployment, and where $X(0,v_i)=X(u_i,0)=0$. The rate at which unemployed workers get in touch with vacant jobs x_i depends on the rate of vacancies relative to unemployment, i.e.

$$x_i = \frac{X(u_i, v_i)}{u_i} \equiv x(q_i), \quad x' > 0, \quad x'' < 0, \tag{7}$$

where $q_i=v_i/u_i$ is a measure of labour market tightness. The rate at which unemployed workers obtain jobs, q_i, is accordingly given by $q_i = \left(1 - F(e_{ir})\right) x_i$. In a steady state, the rate of inflow to each unemployment pool equals the rate of outflow:

$$s_i(1-u_i) = u_i q_i, \qquad i=1,2. \tag{8}$$

These are the so-called Beveridge curves for each market. The ratio of low-skill unemployment to high-skill unemployment is given by

$$\frac{u_L}{u_H} = \frac{s_L}{s_H}\left(\frac{q_H + s_H}{q_L + s_L}\right). \tag{9}$$

This ratio may be larger than one, either because low-skilled workers have a higher incidence of unemployment ($s_L>s_H$), or because they have longer unemployment durations ($q_L<q_H$).

Now consider the determination of the number of jobs in each market. Firms post vacancies as long as expected discounted profits exceed expected costs. The costs depend on expected duration until a vacancy of type *i* is filled, which in turn depends on the tightness of that labour market. The more vacant jobs come into the market, the more costly it is to fill each vacancy. In equilibrium the number of jobs is determined such that the expected value of a filled job exactly equals the expected costs of getting it filled. The expected duration until an acceptable worker of type *i* arrives is equal to q_i/q_i, and since the cost of keeping the vacancy open is $c+bP_i$ per unit time, the equilibrium condition reads:

$$J_i^e \equiv E\left[J_i \mid e \geq e_{ir}, i\right] = (c + b\,P_i)\frac{q_i}{q_i}. \tag{10}$$

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[4] On the other hand, the announcement of a skill-specific vacancy may not be credible, because if a low-skill worker shows up instead, it is profitable for the firm to hire this worker as well. Hence, an assumption of separate matching markets embodies the idea that it is possible to recruit high-skilled workers more or less directly, or that it

Equation (10) is a Job creation condition for skill-type *i*. Its properties depend crucially on how wages are determined. For given individual wages, equation (8) and (10) determine the rates of vacancies and the rates of high-skill and low-skill unemployment. Note that equation (10) does not apply in the case of a common matching market, in which case it is replaced by a condition on the expected value of a job unconditioned on individual productivity.

3 Wage Determination and Equilibrium in a Competitive Economy

Once a match is established between a worker and a firm, there is potentially a rent to be shared between them. I assume that this rent is shared according to a generalised bilateral Nash-bargaining, in which the relative bargaining strength is exogenously determined. The workers share is thus determined as

$$E_i(e) - U_i = \frac{d}{1-d} J_i(e)\,, \tag{11}$$

where d is the bargaining strength of the worker. It is immediately seen that the worker and the firm in this case have the same reservation productivity, i.e. $e_{ir} = e_{ir}^f = e_{ir}^w$. The condition for a match to be consummated is simply that the total surplus is non-negative, and this requires that the productivity is at least as high as the workers' opportunity costs. Taking conditional expectations in (11) yields:

$$E_i^e - U_i = \frac{d}{1-d} J_i^e\,. \tag{12}$$

Equation (10) and (12) can now be used to eliminate $(E_i^e - U_i)$ from the right hand side of equation (1). Combining the resulting new version of (1) with (2), (5) and (12) yields a very simple wage equation in terms of observable variables:

$$w_i(e) = d(e\,P_i + (c + b\,P_i)q_i) + (1-d)(b + a\,P_i)\,. \tag{13}$$

The common reservation level of match specific productivity e_{ir} is (by using (4) or (6)):

$$e_{ir} = \frac{d\,(c + b\,P_i)q_i + (1-d)(b + a\,P_i)}{(1-d)P_i}\,. \tag{14}$$

Hence, the particular distribution of ε affects the reservation productivity only through its effect on labour market tightness. The two transition rates are given by:

$$q_i = \left(1 - F\left(\frac{(1-d)(b + a\;P_i) + d\;(c + b\,P_i)q_i}{(1-d)P_i}\right)\right)x(q_i)\,. \tag{15}$$

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is profitable for firms to reject low-skill applicants due to reputation considerations.

The higher is the individual productivity, the lower is in general the match specific reservation productivity and, for a given level of labour market tightness, the shorter is the spell of unemployment. This relationship operates through two channels. The first is that if $b>0$, high-skilled and low-skilled workers face different replacement ratios because the opportunity cost has a productivity-independent component. The second is that if $c>0$, it is, relative to output, more costly to recruit a low-skilled worker, because the vacancy cost has a productivity-independent component. It follows that if $b=c=0$, such that both opportunity costs and recruitment costs are proportional to productivity, then the reservation level of match specific productivity would be the same for all workers.

In equilibrium, the expected value of a job in each sector is equal to the expected cost of creating it. From (5) and (10), I obtain:

$$\frac{E\left[eP_i - w_i(e) \mid e \geq e_{ir}\right]}{r+s_i} = (c+bP_i)\frac{q_i}{\left(1-F(e_{ir})\right)x_i}. \tag{16}$$

The left hand side of (16) is the expected value of a job of type i. It is strictly decreasing in labour market tightness, q_i, because a tighter labour market pushes wages upwards (13). The right hand side of (16) is the expected cost of recruiting a worker with skill i. It is strictly increasing in labour market tightness, because a tighter labour market implies that it takes longer time to recruit a worker. It follows that (16) determines the equilibrium labour market tightness in the two markets uniquely. Given that, the rates of unemployment are determined by (8). Hence, the model has a recursive structure.

Since the surplus from a match is shared between the worker and the firm, workers with high productivity are more valuable to the firm than workers with low productivity (ceteris paribus). But in equilibrium, the ex ante value of a high-skilled and a low-skilled worker must be equal. Hence, labour market tightness is higher and unemployment is lower for the high-skilled. This is the case even when $b=c=0$. The reason is that more high-skill vacancies are posted, so that the matching process, from the worker's point of view, becomes quicker.

To sum up, I have identified three possible mechanisms that may yield higher unemployment among the low-skilled, even in a highly competitive economy.

1. The rates of turnover (s_i) may differ, because more human capital implies a stronger attachment to the firm. Higher turnover leads directly to a higher incidence of unemployment. It may also affect unemployment duration, but here there are two conflicting effects at work. The higher turnover reduces the value of a match (l.h.s. of (16)), hence lower labour market tightness is needed to bring discounted profits in line with expected recruitment costs. This implies that unemployed workers must search longer. On the other hand, the reservation productivity falls, as workers become less choosy.

2. Unemployment may be higher among the low-skilled because the match specific reservation productivity is higher. This is the case if either opportunity costs or recruitment costs are higher, relative to productivity, for the low-skilled than for the high-skilled.

3. High-skilled workers are (ceteris paribus) more profitable than low-skilled workers. This extra surplus is eliminated through the posting of vacancies, which in turns yields a higher level of labour market tightness in the high-skill market. As a result, high-skilled workers are matched more quickly to potential employers.

4 Egalitarian Wage Setting

Assume now that wages are influenced by some authority at the industry or national level, e.g. through a bargaining between the associations of employers and employees. Their intervention may be driven by two different motives. The first is to prevent poverty, i.e. to raise the lowest wages in the wage distribution. The second is to obtain a more egalitarian wage distribution in general. In the analytical model, I introduce a statutory minimum wage to capture the former motive, and a uniform wage for each sector to capture the latter. In reality, of course, wage compression occurs through a much more complicated process, often involving some kind of wage scale that yields a functional relationship between e.g. education and experience and the wage rate. But the relevant economic forces at work, as well as some of their qualitatively important effects, may be identified in the much simpler framework offered in this section[5]. In order to simplify the analysis further, I assume throughout this section that $a = b = 0$, i.e. that opportunity- and recruitment costs are independent of productivity.

[5] The case of a wage scale that compresses the decentralised wage distribution is considered in a somewhat simpler setting (without match specific heterogeneity) in Røed (1998).

Consider first the case of a statutory minimum wage $\underline{w}$. The existence of a minimum wage implies of course that matches with total productivity below $\underline{w}$ is dissolved, even if both the firm and the worker would have preferred to start production with a lower wage. Hence, to the extent that the minimum wage bites, it reduces the range of acceptable match specific productivity drawings. A minimum wage only affects the wage bargaining to the extent that it is higher than the reservation wage determined in the competitive equilibrium. According to (13) and (14), the reservation wages in the decentralised equilibrium are given by:

$$rU_i = b + \frac{d}{1-d}\alpha q_i \,. \tag{17}$$

Assume that the minimum wage is determined such that it does affect wage setting for the low-skilled, but not for the high-skilled, i.e.

$$\frac{d}{1-d}cq_L + b < \underline{w} < \frac{d}{1-d}\alpha q_H + b \,. \tag{18}$$

This implies that unemployment and wages for the high-skilled are determined exactly as in the previous section. But how does the introduction of a minimum wage affect the low-skilled? Since the two break points are unaffected by the minimum wage[6], the minimum wage affects the wage directly only if it binds. As long as the original sharing rule remains feasible, it also remains the solution to the bargaining problem (independence of irrelevant alternatives). Hence, the low-skill wage is determined as

$$w_L(e) = \max\left(d(e\,P_L + cq_L) + (1-d)b, \underline{w}\right). \tag{19}$$

However, the minimum wage reduces the expected value of a filled job from the firm's point of view. As a result, it reduces the optimal number of jobs and the equilibrium level of labour market tightness. Let φ denote the conditional probability that the minimum wage binds. The level of labour market tightness in the low-skill market is then determined by the condition:

$$\frac{E\left[e\,P_L \mid e \geq \frac{\underline{w}}{P_L}\right] - j\,\underline{w} - (1-j)\left(E\left[w_L \mid d(e\,P_L + cq_L) + (1-d)b \geq \underline{w}\right]\right)}{r + s_L} = \frac{\alpha q_L}{\left(1 - F(\frac{\underline{w}}{P_L})\right) x\left(q_L\right)}, \tag{20}$$

where

[6] The worker still needs the co-operation of the firm in order to get more than U_i. Even though U_i is endogenously determined through the bargaining in all firms, it is exogenous from the point of view of individual agents.

$$j = \frac{F\left(\frac{\bar{w} - d\alpha q_L - (1-d)b}{d P_L}\right) - F\left(\frac{\bar{w}}{P_L}\right)}{1 - F\left(\frac{\bar{w}}{P_L}\right)}. \tag{21}$$

The lower equilibrium level of labour market tightness reduces the wage for low-skilled workers with a bargained wage above the minimum wage. Consequently, compared to the competitive case, a minimum wage yields a more even wage distribution among the low-skilled. On the other hand, it increases unemployment among the low-skilled, both because it raises the reservation level of match specific productivity and because it reduces the equilibrium level of labour market tightness.

Now consider the case in which all workers with the same *individual* skills are entitled to the same wage $\bar{w}_i > b$. Assume also that the difference between $\bar{w}_H$ and $\bar{w}_L$ is smaller than the difference between average high-skill- and low-skill wages in the competitive economy. Hence, redistribution takes place both within and across the two skill groups. Facing fixed wages, the workers in both sectors are indifferent between different matches, hence the firm's reservation level of match specific productivity always binds. This reservation productivity e_{ir} is the productivity that makes the value of output equal to the wage, i.e. $e_{ir} P_i = \bar{w}_i$. In principle, a centrally determined wage may, if it is sufficiently low, reduce expected unemployment duration and thereby reduce the rate of unemployment. The reason is that it removes the monopoly power exercised by the workers in a bilateral match (and hence reduces their reservation wage down to the level of the unemployment benefit). This is more likely to be true for the high-skilled, as the tighter market for their labour services gives them more monopoly power in a pure bilateral bargaining. Labour market tightness for each of the two labour markets is determined as:

$$\frac{E\left[eP_i - \bar{w}_i \mid e \geq \frac{\bar{w}_i}{P_i}\right]}{r + s_i} = \frac{\alpha q_i}{\left(1 - F\left(\frac{\bar{w}_i}{P_i}\right)\right) x\left(q_i\right)}. \tag{22}$$

5 Skill-Biased and Skill-Neutral Shocks - Some Numerical Examples

The modelling framework provided in the previous section may be used to illustrate how various skill-biased or skill-neutral shocks are likely to affect the two unemployment rates, as well as their ratio, under the various wage setting regimes.

Assume that match specific heterogeneity ε is distributed according to a uniform distribution with expectation equal to unity and variance equal to $\frac{1}{3}s^2$, and that the matching function is Cobb-Douglas, such that $x(q_i) = Aq_i^k$. Even with these simplifying assumptions in place, it is in general difficult to derive analytical reduced form equations for labour market tightness and unemployment. However, for a given set of parameter values, the equilibrium solutions can be calculated numerically. In this section, I first calculate equilibrium unemployment rates, labour market tightness and wages under the alternative wage setting regimes, given a *reference* set of exogenous parameters. I then consider how various changes in the parameter set affect the steady state equilibria.

The *reference* economy is characterised by the following properties: A randomly selected worker with a randomly selected match specific productivity drawing has an expected productivity of two units of output per unit time. The expected productivity of a high-skill worker (P_H) is 2.5 units, while the expected productivity of a low-skill worker (P_L) is 1.5 units. Match specific productivity (ε) varies between 0.5 and 1.5, implying that total productivity ranges from 0.75 to 3.75. The unemployment benefit (b) is 0.5, i.e. two thirds of the lowest possible output level. The bargaining power of the worker (δ) is equal to the bargaining power of the firm. The match elasticity (κ) is set to 0.5, in line with typical estimates obtained by e.g. Blanchard and Diamond (1989). In order to focus on the issues explained by the model in this paper, the two separation rates (s_H and s_L) are assumed to be equal. In the case of a minimum wage, the minimum wage is assumed to lie slightly below the average competitive wage for low-skilled. In the case of uniform wages, these are assumed to lie slightly above the average competitive wage for the low-skilled and slightly below the average competitive wage for the high-skilled, to capture the idea that redistribution also takes place across individual skill levels. Apart from these properties, the parameter values in the reference set are determined somewhat arbitrary, such that the two rates of unemployment obtain "reasonable" values.

Table 1 presents the labour market outcomes in the various regimes for the set of reference parameters. Low-skill unemployment is higher than high-skill unemployment in all the regimes. In the case of competitive wage setting, the reason is that low-skilled face higher replacement (and recruitment cost) ratios, as the income support level (and vacancy cost) is fixed. The difference in unemployment rates is reinforced by the imposition of a minimum wage, as it reduces labour market tightness, as well as the acceptance rate in the low-skill sector. The minimum wage also reduces wages for low-skilled workers that are not directly affected by it, as it becomes less profitable to create jobs in this sector. The difference in unemployment rates is clearly largest in the case of uniform wage rates, as the wage compression between high- and low-skilled affects the two rates of unemployment in opposite directions. In the high-skill sector, unemployment is reduced, as workers lose monopoly power and it becomes more profitable to create jobs. Aggregate unemployment is lower than in the minimum wage regime.

Table 1
Labour Market Equilibrium with Equal Separation Rates.
Reference Parameter Set:
P_H=2.5, P_L=1.5, m=2, s=0.5, b=0.5, c=0.5, s_H=0.015, s_L=0.015, d=0.5, r=0.055, k=0.5, A=0.2

Variable	*Competitive wage setting*	*Minimum wage $\underline{w}$=1.5*	*Uniform wages $\bar{w}_L = 1.5, \bar{w}_H = 2.3$*
Unemployment low-skilled u_L	*8.2%*	*13.0%*	*12.3%*
Unemployment high-skilled u_H	*5.8%*	*5.8%*	*5.1%*
Aggregate unemployment	*7.0%*	*9.4%*	*8.7%*
Unemployment ratio u_L/u_H	*1.41*	*2.24*	*2.41*
Accept. rate low-skilled 1-F(e_{Lr})	*74%*	*50%*	*50%*
Accept. rate high-skilled 1-F(e_{Hr})	*70%*	*70%*	*58%*
Tightness low-skilled q_L	*1.3*	*1.0*	*1.1*
Tightness high-skilled q_H	*3.0*	*3.0*	*5.8*
Reservation wage low-skilled	*1.15*	*1.5*	
Highest wage low-skilled	*1.70*	*1.63*	
Reservation wage high-skilled	*2.01*	*2.01*	
Highest wage high-skilled	*2.88*	*2.88*	

I now take a closer look at how various changes in the parameters affect the ratio of low- to high-skill unemployment, under the three alternative wage setting regimes, see Table 2. I consider changes in the productivity distribution or in the degree of wage compression as skill-biased shocks. Other changes are considered skill-neutral. In a competitive environment, skill-neutral shocks also tend to be skill-neutral in terms of their general equilibrium outcome. Relative unemployment rates are hardly affected at all. In the case of centralised egalitarian wage setting, things may be slightly different. Higher separation rates for all reduces the ratio of low-skill to high-skill unemployment in the numerical example, as the 'common' risk of becoming unemployed plays a larger role relative to the different rates of exit. In the minimum wage regime, lower matching-efficiency tends to increase the relative unemployment rate for the low skilled, as these workers need more matches in order to obtain one that is acceptable. A higher general level of wage pressure or a higher level of the unemployment benefit reduces the ratio of low- to high-skill unemployment, as the workers subject to the minimum wage do not get their share in bargained wage increases, hence the impact of higher wage pressure is relatively stronger in the high-skill sector (this result is void if the minimum wage is linked to average wages).

Table 2
Aggregate Unemployment Rate and Ratio of Low-skill to High-skill Unemployment when Reference Parameter Set is Modified

	Competitive wage		*Minimum wage*		*Uniform wages*	
	u	u_L/u_H	u	u_L/u_H	u	u_L/u_H
Reference Economy:	*7.0%*	*1.41*	*9.4%*	*2.24*	*8.7%*	*2.41*
Modification:						
Skill-Neutral changes:						
Separation rates (s_i) +10%	*7.7%*	*1.41*	*10.3%*	*2.22*	*9.7%*	*2.39*
Match efficiency (A) -10%	*7.7%*	*1.43*	*10.7%*	*2.40*	*10.5%*	*2.37*
Worker barg. power (d) +10%	*7.7%*	*1.41*	*10.2%*	*2.18*		
Unif. wages ($\bar{w}_H$ and $\bar{w}_L$) +5%					*11.3%*	*2.48*
Unemp. benefit (b) +10%	*7.2%*	*1.44*	*9.5%*	*2.22*	*8.7%*	*2.41*
Vacancy cost (c) +10%	*7.4%*	*1.41*	*10.0%*	*2.28*	*9.5%*	*2.38*
Skill-Biased changes:						
Prod. diff. (P_H-P_L)+20%	*7.2%*	*1.52*	*12.7%*	*3.45*	*11.7%*	*4.58*
Minimum wage +.05 units			*10.2%*	*2.52*		
Equality ($\bar{w}_H:-5\%, \bar{w}_L:+5\%$)					*10.1%*	*3.93*

Skill-biased shocks tend to increase the ratio of low- to high-skill unemployment in all regimes. But the effects are much stronger in the case of centralised egalitarian wage interventions. Skill-biased technological change that makes high-skill workers more productive and low-skill workers less productive, increase low-skill unemployment and reduce high-skill unemployment. In the case of a minimum wage, or in the case of a fixed wage differential between high- and low-skilled, these effects may be quite large. A narrowing of the wage differential yields similar results.

6 Some Micro Evidence from Norway

Given the relatively low level of unemployment (total unemployment peaked at 9 per cent in 1993), Norway may be viewed as an exception from the Europe style labour market, rather than a prototype.

However, Norway has one of the most compressed and stable wage distributions in Europe (OECD, 1996), hence if the failure of relative wages to adjust to global changes in the relative value of skills was the driving force behind the European unemployment problem, this should definitely not have passed unnoticed in Norway. The availability of micro-based unemployment data is unique in Norway, and the evidence provided in this section is based on a complete monthly record of all registered unemployment spells in Norway from 1989 to 1997 (a detailed description of the data is given in Røed and Zhang, 1999).

Figure 1 displays the monthly absolute and relative unemployment-population ratios as well as outflow rates for prime aged males (35-55 years)[7] with different degrees of educational attainment. Panel (a) conveys the standard message that unemployment is higher for low-skilled than for high-skilled. However, panel (b) indicates that this phenomenon is more related to incidence than duration. There are no apparent trends in relative performance over time. In short, there is absolutely no sign of low-education workers getting more and more stuck in unemployment, relative to other workers.

However, as argued in the introduction to this paper, it is far from obvious that educational attainment is the true distinguishing feature of the 'technological losers' in the labour market. In fact, the potential effects of skill-biased technological change may not be strongly correlated with any conceivable observed characteristics. An important feature of Europe style wage compression (including Norway) is that it operates at many levels, and collective wage agreements often set education- or skill-specific minimum wages. In that case, there are some unfortunate workers that lose out to others, but we don't know who they are. One way to find out whether or not this idea is empirically relevant is to take a look at the overall distribution of unemployment exposure. The typical measure reported by the OECD and by national labour market authorities is the 'fraction of long-term unemployed'. But there are two serious shortcomings associated with this measure. First, as the aggregate outflow rate falls (unemployment rises), the fraction of long-term unemployed rises, even if all workers have identical outflow probabilities, hence this measure cannot be used to compare the distribution of unemployment

[7] I restrict attention to this group for two reasons. First, as it is difficult to obtain precise information about the size of the labour force for each education group and I therefore report unemployment-population ratios, it is preferable to focus on a group of people that has a high and stable labour force participation rate. Secondly, by focusing on prime-aged workers, the education-effects are purified in relation to potential age cohort effects.

across periods with different levels of unemployment. And secondly, many workers experience repeated spell of unemployment, and these spells are often strongly interconnected.

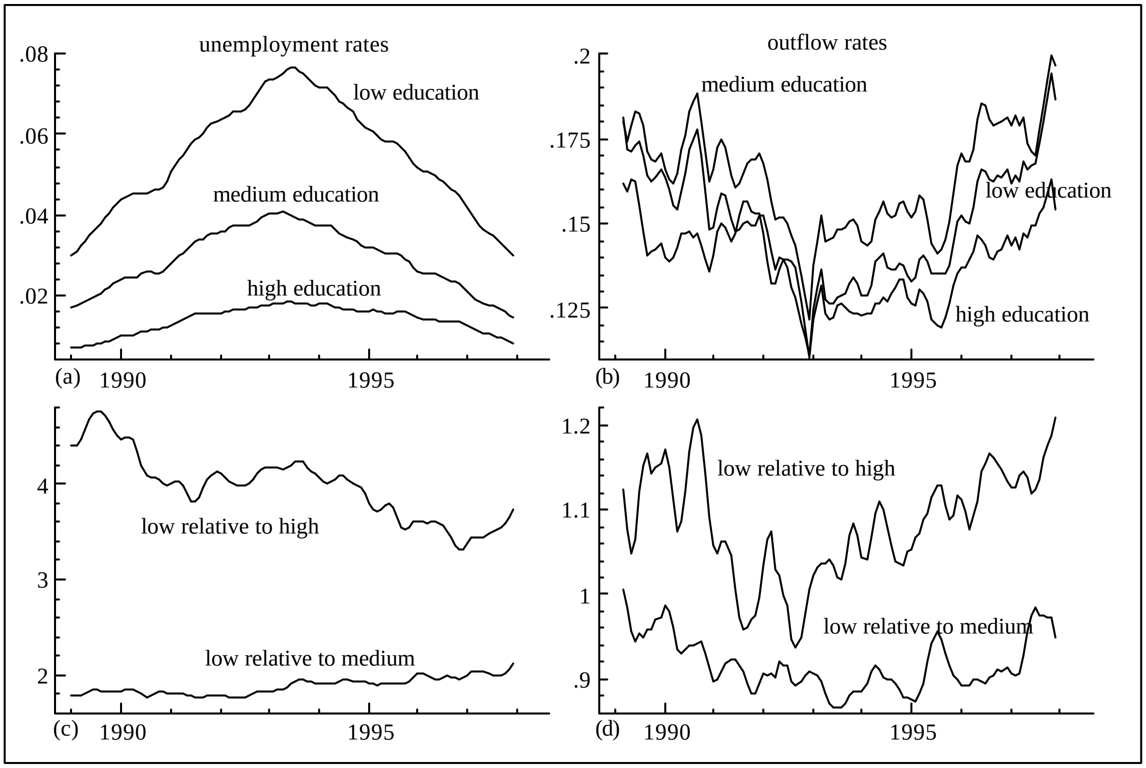

Figure 1. Unemployment- and outflow rates for prime aged males. Norway, 1989-97.
Note: Numbers are calculated for men aged 35-55 in each year. Panel (a) and (c) display absolute and relative unemployment-population ratios. Panel (b) and (d) display absolute and relative outflow rates. The series are seasonally adjusted. Low education is 10 years or less (primary school), medium education is 11-12 years (completed secondary school) and high education is 13 years or more (college/university).

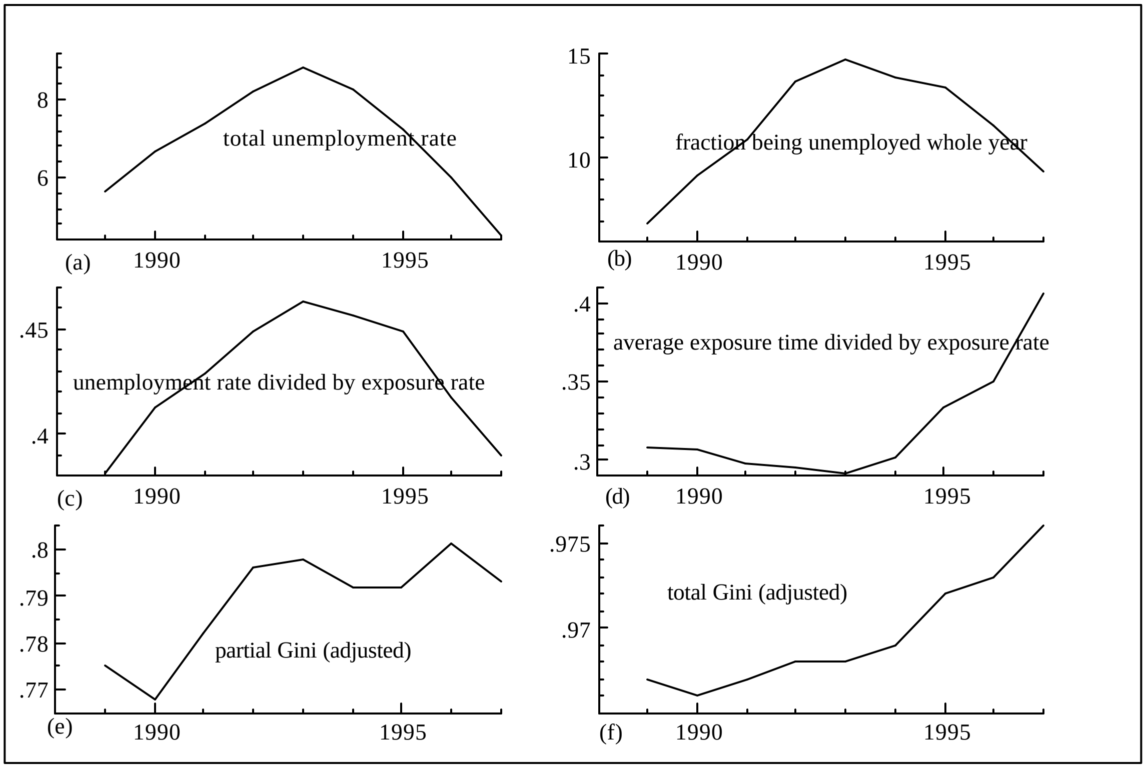

Figure 2. Unemployment and inequality. Norway, 1989-1997.
Note: Panel (a) displays average monthly unemployment rates for each year, including participants in labour market programs. Panel (b) displays the fraction of the unemployed being unemployed throughout the whole year. Panel (c) displays the average monthly unemployment rate divided the fraction of the labour force that was exposed to at least some unemployment during the year. Panel (d) displays the average number of unemployment months among the unemployed divided by the fraction being exposed. Panel (e) displays the Gini-coefficient associated with the distribution of the total number of unemployment-months among the unemployed (divided by its maximum). Panel (f) displays the same Gini-coefficient associated with the distribution of unemployment-months in the whole labour force.

Figure 2 displays some alternative unemployment inequality measures for Norway 1989-1997. The first two panels simply display the aggregate rate of unemployment (including participants in labour market programs) and the fraction of the total number of unemployed in each year that were unemployed all the time. One indication that something of interest did happen during this period is that while aggregate unemployment fell by more than 20 per cent from 1989 to 1997 (from 5.7 to 4.5 per cent of the labour force) the fraction of 'permanently unemployed' rose by 35 per cent (from 6.9 to 9.3 per cent of the unemployed). Panel (c) displays the average monthly rate of unemployment, divided by the fraction of the labour force that were exposed to at least some unemployment during the year (the exposure rate). This measure is equal to one in the extreme case of maximum inequality (the same workers are unemployed throughout the year). The measure seems to track the rate of unemployment very closely, indicating that the exposure probability is more stable over the cycle than the exposure volume. A comparison of years with similar rates of unemployment reveals however that unemployment has become more unequally distributed. This is seen even more clearly in panel (d), which displays the average total number of unemployment-months among the unemployed divided by the exposure rate. The two lower panels offer two alternative adjusted Gini-coefficients for the distribution of the total number of unemployment-months experienced in Norway in each year. The *partial* Gini-coefficient measures the degree of inequality among the unemployed only, while the *total* Gini-coefficient measures the degree of inequality in the whole labour force (including persons with zero unemployment). A problem with the crude Gini-coefficients is that their maximum values change from period to period (and is never equal to one), depending on the total level of unemployment (it is not possible for one person to have all the unemployment months). For this reason, Gini-coefficients are reported relative to their hypothetical maximum in each year (adjusted Gini-coefficients)[8]. Both Gini-coefficients clearly indicate rising inequality in the distribution of unemployment.

7 Concluding Remarks

Two types of evidence have been offered in the literature that cast doubt on the hypothesis that the European unemployment problem is explained by a combination of skill-biased changes in labour demand and inflexible relative wages. The first is that the ratio of low- to high-skill unemployment is no higher in many European countries than in the United States. The second is that the same ratio does not display any rising trend within Europe. This paper has focused on two questions. First, given that we are able to distinguish technological 'winners' from 'losers', is it appropriate to evaluate the empirical relevance of the skill-biased labour demand hypothesis by comparing relative unemployment rates? And second, is it appropriate to use educational attainment as the distinguishing feature for whether workers are more or less exposed to unemployment due to productivity changes and rigid relative wages.

The answer to the first question is basically *yes*: Stable relative unemployment rates do indicate the absence of important skill-biased shocks. Even though relative unemployment rates are affected by

[8] For the total Gini, the hypothetical maximum is calculated as the Gini-coefficient obtained when the total amount of unemployment is distributed on as few persons as possible (being unemployed all the time). For the partial Gini, it is calculated as the Gini-coefficient obtained when the total amount of unemployment is distributed such that all unemployed are either unemployed for one or for 12 months.

skill-neutral as well as skill-biased shocks, the search model developed in this paper, and the associated numerical examples, indicate that the effects on relative unemployment rates of skill-neutral shocks are almost negligible compared to those following from skill-biased shocks. The answer to the second question seems to be *no*: Educational attainment is not likely to be the most relevant distinguishing feature of technological winners and losers. Micro evidence from Norway indicates that the distribution of unemployment has become more unequal, even though relative unemployment- and outflow rates for different educational groups do not display any important changes. This suggest that appropriate tests for the empirical relevance of the skill-biased labour demand hypothesis either require more sophisticated methods for identifying the presumed victims, or a further development of data and measures that can be used to evaluate the overall distribution of unemployment. In particular, the development of comparable measures of inequality in the unemployment distribution across countries (apart from the fraction of long-term unemployed) should be given high priority.

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