Skill supply, supervision requirements and unemployment of low-skilled labor

Josef Falkinger and Volker Grossmann
University of Zurich, Zurich, Switzerland

Keywords *Work organization, Labour, Supervision, Unemployment*

Abstract *This paper presents a model with flexible wages in which unemployment of low-skilled labor is possible in equilibrium, whereas high-skilled workers are fully employed. Thus, the model can explain why even in countries with flexible labor markets and full employment of skilled labor an employment problem exists at the bottom of the skill spectrum. The model is used to evaluate the impact of technological change and increased skill supply on the employment of low-skilled workers. It is shown that a switch to technologies with higher skill requirements unambiguously leads to a rise in unemployment of low-skilled workers. An increase in the supply of high-skilled labor has a positive effect on the employment level of low-skilled labor.*

1. Introduction

In this century the supply of skilled labor has substantially increased across countries, in particular since the second world war. Despite this boom in supply the wage of high-skilled workers has not been eroded. On the contrary, labor market evidence has shown rising wage inequality between low-skilled and high-skilled labor during the last decade. Thus, a strong increase in the demand for high skills must have accompanied the growing supply. The most widely accepted explanation is the hypothesis of skill-biased technological change (see for example Gregg and Manning (1997), Acemoglu (1998), or Heckman, Lochner and Taber *et al.* (1998) for recent theoretical or empirical contributions about the mutual impacts of skill supply and technical change). However, the rising gap between the wages of high-skilled workers and the wages of low-skilled workers is only one indication that the relative opportunities of workers in the labor market have changed. The other fact is that unemployment (or non-employment) is relatively high among low-skilled workers. This is not only so in European countries which may be seen as trading a more equal distribution of wages for higher unemployment (Krugman, 1994). Strikingly enough, in countries with flexible labor markets a high percentage of low-skilled workers are also jobless. Despite falling wages, non-employment rates for low-skilled

This is a revised version of the paper "Skills, unemployment and the costs of organizing jobs" presented at the EALE conference in Regensburg 1999. The authors are grateful to the participants of their session for helpful comments. They would especially like to thank Thomas Zwick for helpful discussions and an anonymous referee for very thoughtful and valuable comments.

International Journal of Manpower, Vol. 22 No. 1/2, 2001, pp. 69-82.

workers have risen up to 35 per cent in the USA and the UK (see Murphy and Topel, 1997; Nickell and Bell, 1997).

Given the increased supply of skilled labor, one might be inclined to attribute this deteriorating employment situation to the substitution of low-skilled by high-skilled labor. But the evidence on wage inequality, showing that increased demand of skilled labor has more than outweighed its increased supply, should warn us not to jump to conclusions. There are at least two candidates for explaining what was going on in the labor market: the increased supply of skilled labor on the one hand, and biased technological change on the other hand. It is the purpose of this paper to show how these factors influence the employment level of low-skilled workers. We do this by applying the model developed in Falkinger and Grossmann (1999) in which we have segmented labor markets for low-skilled and high-skilled workers. That model permits the singling out of effects on employment of low-skilled workers arising from technological changes which may have worsened the employment problem for low-skilled workers in spite of complementarities between high-skilled and low-skilled labor. Our central point is a more differentiated look at the organization of work. Labor is not only an input in production, but also an input in the provision of the non-production services that are necessary to organize production. A change in the techniques of production and methods of organization can affect the relative productivity of low-skilled and high-skilled labor in production processes. This is how skill-biased technological change is usually modeled in the theoretical literature. Hoever, technical and organizational change also has an impact on the relationship between non-production work and labor in production. Since high-skilled workers are employable in non-production, as well as in production whereas low-skilled labor is typically used only in production, a change of non-production requirements implies a shift in the relative demand for skilled and unskilled labor. The present paper focuses on this channel when analyzing the effects of skilled labor supply and technological change on the level of employment of low-skilled workers. Our theoretical framework is thus directly related to the empirical literature about the technology bias which is based on evidence that the ratio of (high-skilled) non-production workers to (low-skilled) production workers has increased across countries and industries (e.g. Berman *et al.*, 1994; 1998; Machin *et al.*, 1996; Machin and van Reenen, 1998). Production is organized in firms. Non-production resources are required to coordinate and to supervise the work of the different workers. Such non-production activities are not restricted to the central staff at the top of a firm. They are also provided by foremen, senior workers or heads of teams who oversee less experienced or less autonomous coworkers. The recent literature on the reorganization of work emphasizes that new forms of organization save central staff by decentralizing decision making and problem solving. Obviously, a qualified workforce is essential for such organizational reforms. "The new, smaller, customer-oriented teams require versatility, cognitive and social competence, as well as judgment" (Snower, 1999, p. 9). As long as only a few firms or industries switch to the new methods of work organization, they can pick a selection of workers who are able

to fulfill these requirements without problem. The sometimes euphoric case studies on modern organization are based on this partial view. From a general equilibrium point of view, however, the relevant problem is how less able workers can be employed under the changed methods of production and organization. (A macroeconomic theory about the general equilibrium consequences of the organization of work is presented in Falkinger (2000).) The new type of work organization may imply high supervision and training requirements if applied to the whole labor force. Alternatively, firms may find that workers who are less versatile, less autonomous or less able to learn and to communicate cannot be profitably integrated into their organization. Then low-skilled workers remain without jobs.

In the next section we present a model in which the relationship between used methods of organization ("technology" in a broad sense), non-production requirements ("supervision" in a broad sense) and employment of low-skilled workers can be analyzed in a rigorous way. In section 3, a simple graphical tool for the comparative-static analysis of the employment equilibrium and the equilibrium ratio of non-production to production work is developed. This tool is applied for answering the question of how technological change on the one hand and increased supply of skilled labor on the other hand affect employment of low-skilled workers and average supervision costs in the macroeconomic equilibrium. Section 4 summarizes the results.

2. The model

There is an exogenous number n of identical firms in monopolistic competition, producing differentiated goods. These firms use high-skilled and low-skilled workers in production. Furthermore, high-skilled workers are required for the supervision and training of low-skilled workers, i.e. for the coordination of work tasks and the organization of work places[1]. Introducing these non-production (labor) costs recognizes that modern production requires an organization of work in firms (Weitzman, 1982). The supervision requirement in each firm is positively related to the number of work places provided, i.e. there are no fixed costs of setting up a firm[2]. However, after work places are organized and production starts, non-production costs are sunk, i.e. supervision costs are not reflected in output prices. This crucial assumption can be justified as follows. First, the provision of work places naturally has to be started before production and competition takes place. More precisely, we assume that there are two stages of firm behavior. At stage 1, firms choose their organizational capacity by hiring the profit-maximizing number of non-production workers ("supervisors"). These non-production workers remain employed at stage 2, where production and competition takes place, and get the wage of high-skilled labor resulting in the monopolistic competition equilibrium at stage 2. At stage 2, firms enter competition with the provided organizational capacity. They choose the profit-maximizing level of production, output prices and employment of (skilled and unskilled) production workers. Whereas the costs of production workers are variable, the costs of non-production workers cannot

be varied at stage 2 since the firms' levels of non-production employment are decided and fixed at stage 1. Since monopolistically competitive firms set prices as mark-up on marginal production costs only, the fixed costs of non-production workers are not regarded in setting prices. Firms rationally anticipate the profit margin that can be achieved at stage 2 and choose the profit-maximizing level of non-production employment at stage 1 based on this expectation.

In contrast to the monopolistic competition model of Dixit and Stiglitz (1977), the number of firms n is exogenous in our model. In the Dixit-Stiglitz model, the number of firms is endogenously determined by free entry, and particularly depends on the fixed costs of setting up a firm. In equilibrium, output prices are equal to average costs, i.e. profits are equal to zero. This is an equilibrium since entry of an additional firm would lead to negative profits of all firms. In a completely analogous way, in our model, instead of entry of new firms, the existing firms expand employment (capacity) as long as profits are positive. Thus, it is the level of employment (of low-skilled labor) rather than the number of firms which is endogenously determined in our model. The number of firms plays no role since, as shown below, profits are equal to zero for any number of firms (in an unemployment equilibrium) and neither total output nor aggregate employment levels depend on n[3]. This is because, as assumed below, both the production and the organization technology are linear and *ex ante* there are no fixed costs. Monopolistic competition and thus mark-up pricing on marginal production costs arises because *ex post* at stage 2 organization costs are sunk.

Both high-skilled and low-skilled labor are supplied inelastically in amounts $\overline{H}$ and $\overline{L}$, respectively. The labor market for both groups of workers is perfectly competitive and wages are flexible. The low-skilled labor force may be heterogeneous in skills which cannot be attributed to the marginal productivity of single workers, such as communication skills (or other social skills) and the ability to work in teams. As frequently recognized, these kinds of skills have become increasingly important in modern production (e.g. Snower, 1999). If there is such heterogeneity among the low-skilled, a lower average level of social skills implies higher supervision requirements per worker. This is because less skilled workers are more likely to make mistakes and thus have to be supervised more intensively.

Preferences of households for the differentiated goods are assumed to be nomothetic such that a representative consumer exists.

2.1 Demand for goods

Preferences are represented by the CES-utility function

$$U(y_1, \ldots, y_n) = V\left(\left[\sum_{i=1}^{n} y_i^{\rho}\right]^{1/\rho}\right) \tag{1}$$

where $0 < \rho < 1$, $V'(\cdot) > 0$, $V''(\cdot) \leq 0$ and y_i denotes the quantity of good y_i. Let p_i be the price of good i and Y the aggregate money income of the economy. The representative household maximizes (1) with respect to $y_1, \ldots y_n$ subject to the budget constraint $\sum_i p_i y_i \leq Y$. Thus, aggregate demand y_i^D for good i is given by

$$y_i^D = \left(\frac{p_i}{P}\right)^{-\sigma} \frac{Y}{nP}, \tag{2}$$

where $\sigma \equiv 1/(1-\rho) > 1$ is the elasticity of substitution between different goods and $P \equiv (\sum_i p_i^{1-\sigma})^{1/(1-\sigma)}$ is the aggregate price index.

2.2 Technology and supervision requirements

Let the production function F of each firm i be linear, homogenous, concave and increasing in its arguments, i.e.

$$y_i = F(h_i,\ l_i) \equiv l_i f(\kappa_i), \tag{3}$$

where h_i, l_i is the quantity of high-skilled and low-skilled labor, respectively, in production, and we defined $f(\cdot) \equiv F(\cdot, 1)$ and $\kappa_i \equiv h_i/l_i$. Note that $f'(\cdot > 0$ and $f''(\cdot) \leq 0$.

In order to employ l_i low-skilled workers in production,

$$S_i = g(L,\ \gamma) l_i, \tag{4}$$

high-skilled non-production workers/supervisors are needed in firm i. γ is a shift parameter and $L \equiv \sum_i l_i$ is the aggregate employment level of low-skilled workers. The supervision requirement per low-skilled worker $S_i/l_i = g(L, \gamma)$ is non-decreasing in the aggregate employment level, i.e. $\partial g/\partial L \geq 0$. The underlying assumptions in case of $\partial g/\partial L > 0$ are the following. First, there is heterogeneity among the low-skilled with respect to ("social" or "interactive") skills which cannot be attributed to single workers (i.e. which cannot be accounted for by wage differentiation), and second, more able workers are employed first. Differences in social skills may not be perceived by single firms, but, in the aggregate, average supervision requirements increase if also less able workers are employed, i.e. due to an external effect. This is because in a symmetric equilibrium in the production stage (which will be derived below), each firm gets the same average quality of workers. Thus, higher aggregate employment L means that also less able workers are employed in each firm. Note that the symmetric equilibrium in the production stage 2 is anticipated by firms while setting up work places in stage 1. The parameter indicates the supervision requirements for a given distribution of social skills. These supervision requirements depend on technological conditions, i.e. the organization of work and the complexity of work tasks. We assume that $\partial g/\partial \gamma > 0$, at least for a sufficiently high employment level L, i.e. for $L > \tilde{L} \geq 0$. For instance, consider a reorganization of work in teams due to an efficiency-enhancing adoption of modern information technologies which

implies higher requirements of social or interactive abilities. In our model, this would be represented by an increase in γ. Although supervision requirements may be reduced for the most socially able workers, who have no problem to bear more responsibility in teams compared with a traditional organization of work, such a reorganization would increase average supervision requirements if also the least able workers would be employed in teams. This idea is reflected in Figure 1.

For $L < \tilde{L}$ the supervision requirement per worker is smaller for the modern production indicated by γ_1 compared to the traditional production indicated by γ_0. However, if also workers with less social skills are integrated in teams, i.e. if $L > \tilde{L}$, the average supervision requirement becomes higher in modern production.

2.3 Behavior of firms

We begin with the analysis of the production stage 2.

Taking wages w_H and w_L of high-skilled and low-skilled workers, respectively, as given, cost minimization implies the wage differential

$$\frac{w_H}{w_L} = \frac{\partial F/\partial h_i}{\partial F/\partial l_i} = \frac{f'(\kappa_i)}{f(\kappa_i) - \kappa_i f'(\kappa_i)} \equiv \omega. \tag{5}$$

Thus, we obtain $\kappa_i = \kappa$ for all i, and ω is a non-increasing function of κ[4]. Furthermore, marginal production costs $c_i = c$ are constant due to the linear homogenous production function and can be written as

$$c = \frac{w_H h_i + w_L l_i}{y_i} = \frac{w_L(\omega\kappa + 1)}{f(\kappa)}, \tag{6}$$

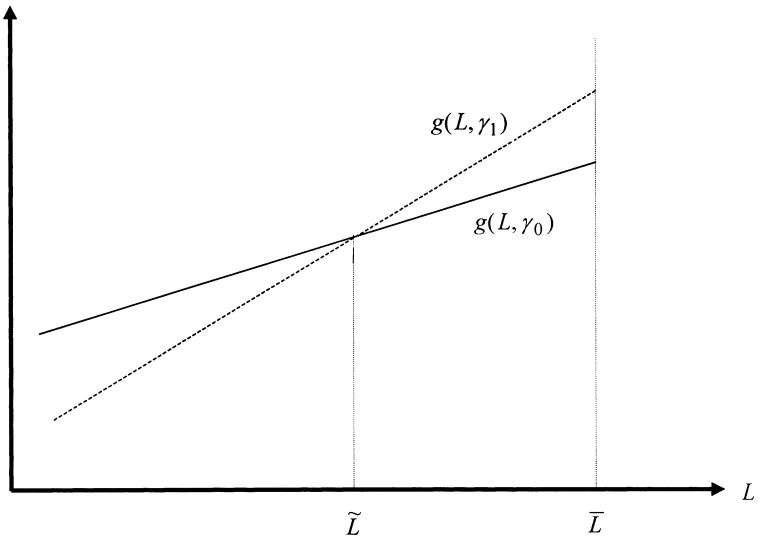

Figure 1.
Supervision requirement per low-skilled worker for different technologies $\gamma_0 < \gamma_1$

according to (3). In monopolistic competition at stage 2, each firm facing the demand function (2) maximizes its profit margin, i.e. solves the optimization problem

$$\max_{y_i,\ p_i} (p_i - c)y_i \quad \text{s.t.} \quad y_i \leq y_i^D = \left(\frac{p_i}{P}\right)^{-\sigma} \frac{Y}{nP} \tag{7}$$

(Dixit and Stiglitz, 1977). Thus, prices are set as constant mark-up on marginal production costs c, i.e.

$$p_i = p = mc = P, \tag{8}$$

where $m \equiv \sigma/(\sigma - 1) > 1$ is the degree of monopoly. Since $c_i = c$, also output $y_i = y_i^D = \frac{y}{nP}$ is identical in all firms. With $\kappa_i = \kappa$, this implies $l_i = l = L/n$, according to (3), and thus $h_i = h$.

We now turn to the analysis of the organization/supervision stage 1.

What is the optimal number of supervisors S_i chosen by firms perfectly foreseeing the outcome of stage 2? Firms take into account that given the installed number of work places $l_i = S_i/g(L, \gamma)$, production capacity becomes $S_i f(\kappa)/g(L, \gamma)$, according to (3) and (4). Thus, in stage 1, firms solve the optimization problem[5]:

$$\max_{y_i,\ S_i} (p - c)y_i - w_H S_i \quad \text{s.t.} \quad y_i \leq \frac{S_i f(\kappa)}{g(L,\ \gamma)}, \quad p = mc. \tag{9}$$

Since non-production costs, i.e. wage costs for the high-skilled supervisors, are sunk in the production stage 2, it cannot be optimal to produce below capacity, i.e. $y_i = S_i f(\kappa)/g(L, \gamma)$. Thus, (9) implies that profits π_i are linear in the number of supervisors S_i. We have

$$\begin{aligned} \pi_i &= (m-1)cy_i - w_H S_i \\ &\equiv [(m-1)cf(\kappa)/g(L,\ \gamma) - w_H]S_i. \end{aligned} \tag{10}$$

Hence, firms increase (decrease) S_i if the term in square brackets is positive (negative). Note that each firm chooses the same number of supervisors in equilibrium since the outcome of stage 2 is symmetric.

In an equilibrium with unemployment of low-skilled workers, the term in square brackets and thus profits are zero. To see this, suppose this were not the case. Then all firms would want to change their capacity. However, unless there is full employment, this cannot be an equilibrium situation. Only if the term in square brackets is positive and there is full employment, profits are positive in equilibrium since in this case each firm wants to expand production but does not find workers.

Regarding the skill intensity in equilibrium, two measures for skill intensity must be distinguished in this model. On the one hand, we have the ratio of total employment of high-skilled to low-skilled workers H/L. On the other hand, we have the skill intensity $\kappa = h/l$ in production. Using $S_i = S$, we have

$H = n(h + S)$ for the aggregate employment level of high-skilled workers. Thus, the skill intensity in production is given by[6]:

$$\kappa = \frac{h}{l} = \frac{H/n - S}{L/n} = \frac{H}{L} - g(L,\ \gamma). \tag{11}$$

It does not depend on the number of firms n.

3. Equilibrium employment

In this section, we first derive the equilibrium employment levels of high-skilled and low-skilled workers, respectively. For this purpose we develop a simple cost-benefit diagram for the decision of firms about the organization of work places at stage 1. Using this graphical tool, we then derive comparative static results with respect to the technology parameter γ and the supply of high-skilled workers $\overline{H}$.

For a better intuitive understanding of the cost-benefit considerations behind a firm's decision about the provision of work places for low-skilled workers it is convenient to consider real profits per low-skilled worker, given by $(\pi_i/p)l_i = [(1 - c/p)y_i - (w_h/p)S_i]/l_i$. Substituting (3), (4) and (8), we obtain

$$\frac{\pi_i/p}{l_i} = (1 - 1/m)f(\kappa) - \frac{w_H}{p}g(L,\ \gamma). \tag{12}$$

The first term on the right-hand side is the real profit margin per low-skilled worker, whereas the second term equals real supervision costs per low-skilled worker. Using (5), (6) and (8), the real wage of high-skilled labor can be written as[7]:

$$\frac{w_H}{p} = \frac{f'(\kappa)}{m}. \tag{13}$$

Note that, according to (11), the skill intensity in production κ is given by aggregate employment levels of high-skilled and low-skilled labor, respectively. Thus, aggregate employment levels determine the relative wage ω, according to (5)[8]. Thus, looking at (12) and (13), one sees that real profits (per low-skilled worker) do not depend on the nominal wage rate w_L of low-skilled workers. This is because low-skilled workers only work in production, and, for a given relative wage ω, prices are set proportionally to the nominal wage rate w_L, according to (6) and (8)[9]. Note further that the skill intensity in production κ is increasing in H and decreasing in L, according to (11). This and $f'' \leq 0$ imply that the real high-skilled wage w_H/p is non-increasing in H and non-decreasing in L. Moreover, since $(1 - 1/m)f(\kappa)$ and $m > 1/f' > 0$, the real profit margin per low-skilled worker $f' > 0$ increases with H and decreases with L. In sum, (real) profits in equilibrium are always increasing if additional high-skilled workers are available for employment: the (real) profit margin of production increases without forcing up the (real) supervision costs As a result, no high-skilled

workers will remain unemployed in equilibrium, i.e. $H = \overline{H}$. Flexible labor markets guarantee full employment of high-skilled labor[10].

The situation is considerably different for low-skilled labor. Since κ is decreasing in aggregate employment L of low-skilled workers, the real profit margin per low-skilled worker, i.e. the real average profit margin (APM), is decreasing and real average supervision costs (ASC) are non-decreasing in L. Note that this holds whether or not low-skilled workers are heterogeneous in social skills, i.e. for both $\partial g/\partial L > 0$ and $\partial g/\partial L = 0$. Using (11)-(13) and the fact that high-skilled workers are fully employed, zero profits imply that the equilibrium level of employment of low-skilled labor $L_0 \leq \overline{L}$ is defined by the equation

$$\underbrace{(1 - 1/m) f\left(\overline{H}/L_0 - g(L_0, \gamma)\right)}_{\text{Average profit margin } APM(L_0;\gamma,\, \overline{H})} = \underbrace{(1/m) f'\left(\overline{H}/L_0 - g(L_0, \gamma)\right) g(L_0, \gamma)}_{\text{Average supervision costs } ASC(L_0;\, \gamma,\, \overline{H})} \quad (14)$$

or we have full employment $L = \overline{L}$ and positive profits[11].

It is now easy to determine the equilibrium employment level of low-skilled workers by confronting the APM curve, representing the profit achieved per employed low-skilled worker, with the ASC curve, representing the supervision costs required per employed low-skilled worker. Both curves are functions of the aggregate level of employment L. Figure 2 shows a situation where the two curves intersect at an equilibrium level $L_0 < \overline{L}$[12].

The costs of organizing employment of low-skilled labor and the return on an employed low-skilled worker are equalized before full employment is reached. Expanding employment beyond the level L_0 would require shifting high-skilled labor from production to non-production. But this would depress the profits realized in production and raise supervision costs so that firms would make a loss. Note that there is unemployment despite full wage

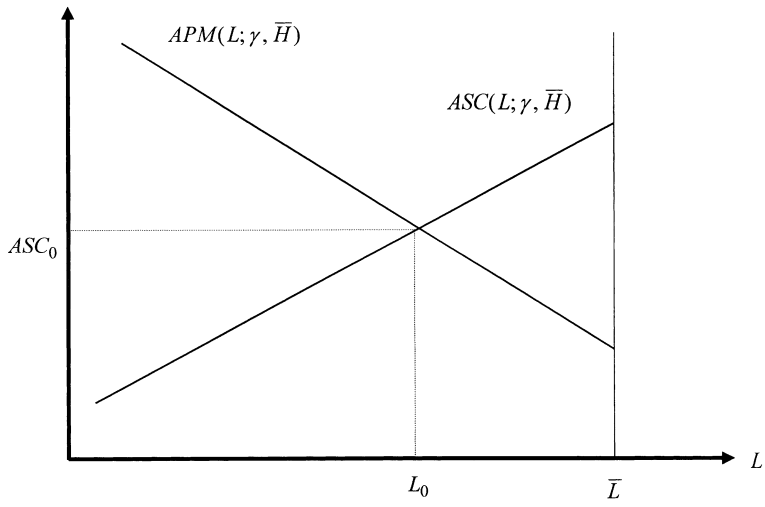

Figure 2.
Low-skilled equilibrium unemployment despite fully flexible wages

flexibility and independent of the number of firms. Equilibrium employment L_0 determines the average supervision costs $ASC_0 \equiv ASC(L_0; \gamma, \overline{H})$ in equilibrium.

If the average profit margin still exceeds average supervision costs at full employment $\overline{L}$, there will be positive profits and no unemployment, as shown in Figure 3.

In the following, we use these pictures for determining the impact on equilibrium employment of changes in the supervision requirements of the used technology and the supply of high-skilled labor, respectively.

3.1 Change in supervision requirements

Consider a change in supervision requirements as in Figure 1, i.e. from γ_0 to γ_1. Examining the left-hand side of condition (14), we see that such a change raises the average profit margin, APM, if $L < \tilde{L}$ and it depresses APM if $L > \tilde{L}$. With respect to average supervision costs, as given at the right-hand side of condition (14), a switch from γ_0 to γ_1 has the opposite effects. If $L < \tilde{L}$, ASC declines whereas ASC rises for $L > \tilde{L}$. As can be seen from Figure 4, if initial equilibrium employment is above $\tilde{L}$, equilibrium employment unambiguously falls due to a change in γ (although supervision requirements decrease for employment levels below $\tilde{L}$).

That is, if there is heterogeneity among the low-skilled, the least able workers become unemployed because, for all employment levels above $\tilde{L}$, the average profit margin declines and the average supervision costs rise. However, the impact on average supervision costs in equilibrium is ambiguous. This is because, first, the decline in equilibrium employment may have an external effect which reduces supervision requirements if $\partial g / \partial L > 0$, and second, real wages for high-skilled supervisors may decline. Thus, even a

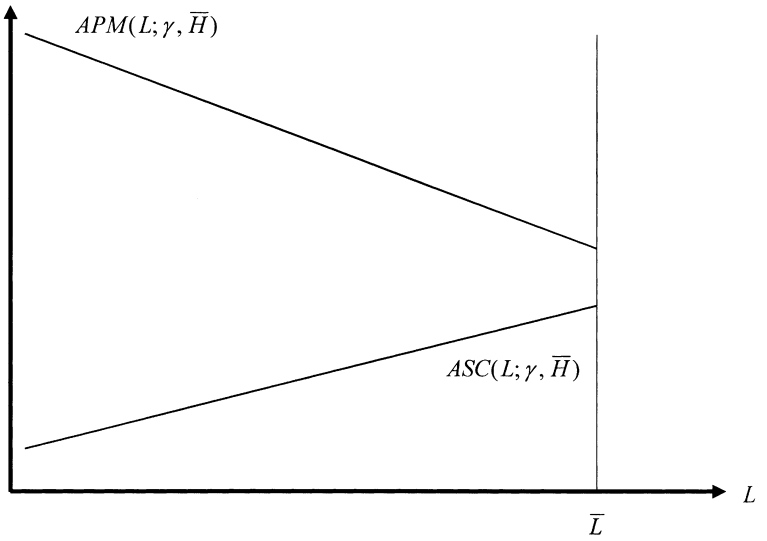

Figure 3.
A full employment equilibrium with positive profits

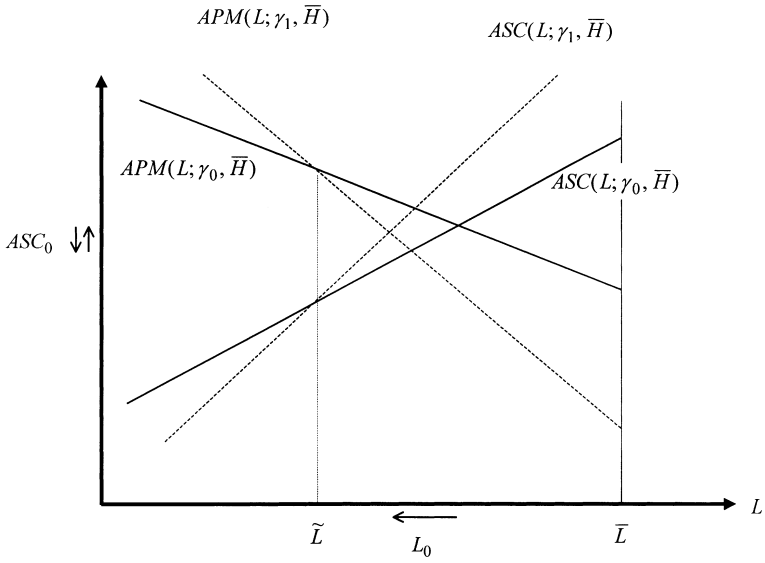

Figure 4.
The impact of a change in supervision requirements on low-skilled equilibrium employment of low-skilled labor and on average supervision costs. $\gamma_0 < \gamma_1$

decrease in equilibrium supervision costs per worker is consistent with a change in an employment equilibrium which has been due to a *ceteris paribus* increase in supervision costs. Moreover, also without a decrease in equilibrium supervision costs per worker a reduction in total supervision costs is possible due to declining employment.

3.2 Change in the supply of high-skilled labor

What are the effects of an increase in the supply of high-skilled labor? In particular, does it become more difficult or easier for low-skilled workers to find a job? As we have established in the beginning of this section, high-skilled workers are fully employed. Thus, an increase in the supply of high-skilled labor leads to an equal increase in high-skilled employment. For a given L the supervision requirements are fixed so that all additional high-skilled workers could be used in production. This increases the profit margin for any level of L, and may decrease the real wage of high-skilled supervisors[13], who are paid equally to the high-skilled production workers in a perfectly competitive labor market. Formally, the left-hand side of condition (14) increases with $\overline{H}$, whereas the right-hand side is non-increasing in $\overline{H}$. Thus, as depicted in Figure 5, the *APM* curve shifts upwards and, if $f''(\cdot) < 0$, the *ASC* curve shifts downwards. As a result, equilibrium employment L_0 rises unambiguously.

An increase in the supply of high-skilled labor has a positive impact on the employment of low-skilled workers. This result is in stark contrast to models in which an increasing availability of high-skilled labor leads to a substitution of low-skilled workers in production. (See, for example, the search model of Saint-Paul (1996)). Even though an increase in L implies that physical supervision requirements rise if $\partial g/\partial L > 0$, the impact on average supervision costs is

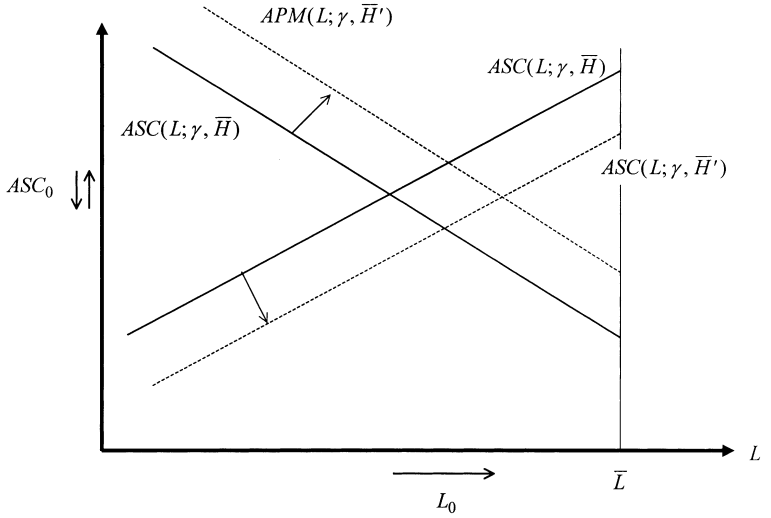

Figure 5.
The impact of an increase in the supply of high-skilled labor on equilibrium employment of low-skilled labor and average supervision costs. $\overline{H} < \overline{H}'$

generally ambiguous since the real wage of high-skilled workers may fall. If $\partial g/\partial L = 0$ (i.e. if the average supervision requirement does not depend on aggregate low-skilled employment) and $f''(\cdot) < 0$, average supervision costs would unambiguously decline with $\overline{H}$.

4. Conclusion

This paper presented a model with flexible wages in which unemployment of low-skilled labor is possible in equilibrium, whereas high-skilled workers are fully employed. Thus, the model can explain why even in countries with flexible labor markets and full employment of skilled labor an employment problem exists at the bottom of the skill spectrum.

The model was used to evaluate the impact of technological change and increased skill supply on the employment of low-skilled workers. Current trends in the reorganization of work require high abilities of workers. Workers who do not possess these abilities are either not employed or they must be guided and supervised by high-skilled workers. It was shown that a switch to technologies with higher skill requirements leads to an unambiguous rise in unemployment of low-skilled workers, whereas the effect on the average supervision costs per low-skilled worker is ambiguous. An increase in the supply of high-skilled labor has an unambiguous positive effect on the employment level of low-skilled labor. The reason is that it is profitable for firms to use at least part of the additional labor force in non-production which increases the capacity to supervise and integrate low-skilled workers. The impact on the average supervision costs per low-skilled worker is again ambiguous.

Regarding economic policy, the analysis of the paper points in two directions. One way to reduce unemployment of low-skilled workers is of course increasing the workers' abilities, where both the improvement of low-skilled education as

well as increasing the share of high-skilled labor are good for the employment of low-skilled labor. The second implication of the analysis is a warning rather than a positive policy instrument. If the supply of skills does not keep pace with the new abilities required by modern forms of organizing work, not only rising wage inequality but also increasing joblessness of low-skilled workers will be characteristics of future labor markets.

Notes

1. There is no effort incentive problem in the model as there is in efficiency wage theory. Rather, in our model coordination and supervision are necessary due to the complexity of work tasks in modern production.
2. As will be derived below, this fact, in addition to a linear technology, implies that the equilibrium employment levels are independent of the number of firms n.
3. This is similar to models with perfect labor and goods markets in which identical firms have a linear homogenous production technology and there are no fixed costs. However, in our model we can have unemployment despite flexible wages.
4. Note that $\partial\omega/\partial\kappa = ff''/(f - \kappa f')^2$, according to (5).
5. To be precise, in stage 1 firms also have to observe the restriction output y_i and cannot exceed expected demand $Y/(np)$ for each good. However, according to (6) and (8), p increases with w_L so that demand is always high enough to exhaust the capacity as long as the labor force is not fully employed and wages go down. Thus, the restriction can be neglected if flexible wages are assumed. Alternatively, one could assume that money supply and thus Y is sufficiently high such that the constraint is never binding. See Falkinger and Grossmann (1999) for both further discussion and a formal treatment regarding the demand constaint of stage 1.
6. Use $l = L/n = S/g(L, \gamma)$, according to (4).
7. Using $p = mc$, determined by (8), and c as given in (6), we have $\frac{w_h}{p} = \frac{\omega f(\kappa)}{m(\omega\kappa+1)}$. Substitution of ω from (5) into the latter expression gives (13).
8. Remember that according to (5), the skill intensity κ and the relative wage ω are negatively related.
8. Nominal variables are given by the aggregate money income Y and thus by money supply.
10. If relative wages are rigid so that ω and w_H/p cannot be fully adjusted, unemployment of high-skilled workers is possible. This is shown in Falkinger and Grossmann (1999) where the different employment situations in European and US labor markets are explained.
11. However, note that if $APM(0; \gamma, \overline{H}) < ASC(0; \gamma, \overline{H})$ the economy would not be variable in the sense that even for the first work place the organization costs cannot be covered by mark-up pricing in stage 2, such that no equilibrium with positive employment would exist. A sufficient condition to ensure positive equilibrium employment is $\lim_{\kappa \to 0} f(\kappa) > 0$ and $\lim_{\kappa \to 0} f'(\kappa) = 0$ which implies $APM(0; \gamma, \overline{H}) > ASC(0; \gamma, \overline{H})$, according to the definition of APM and ASC in (14).
12. Note that the ASC-curve in Figure 2 is positively sloped if $\partial g/\partial L > 0$ or $f''(\cdot) < 0$.
13. The real wage of the high-skilled unambiguously decreases after an increase in the supply of high-skilled labor if $f''(\cdot) < 0$.

References

Acemoglu, D. (1998), "Why do new technologies complement skills? Directed technical change and wage inequality", *Quarterly Journal of Economics*, Vol. 113, pp. 1055-90.

Berman, E., Bound, J. and Grichiles, Z. (1994), "Changes in the demand for skilled labor within US manufacturing: evidence from the annual survey of manufactures", *Quarterly Journal of Economics*, Vol. 109, pp. 367-97.

Berman, E., Bound, J. and Machin, S. (1998), "Implications of skill-biased technological change: international evidence", *Quarterly Journal of Economics*, Vol. 113, pp. 1245-80.

Dixit, A.K. and Stiglitz, J.E. (1979), "Monopolistic competition and optimum product diversity", *American Economic Review*, Vol. 67, pp. 297-308.

Falkinger, J. (2000), "Macroeconomic equilibrium and the organization of work: a new theory of employment", unpublished manuscript, University of Regensburg, Regensburg.

Falkinger, J. and Grossmann, V. (1999), "Skills, unemployment and the costs of organizing jobs", Discussion Paper No. 321, University of Regensburg, Regensburg.

Gregg, P. and Manning, A. (1997), "Skill-biased change, unemployment and wage inequality", *European Economic Review*, Vol. 41, pp. 1173-200.

Heckman, J.J., Lochner, L. and Taber, C. (1998), "Explaining rising wage inequality: exploration with a dynamic general equilibrium model of labor earnings with heterogenous agents", *Review of Economic Dynamics*, Vol. 1, pp. 1-58.

Krugman, P. (1994), "Past and prospective causes of high unemployment", in *Reducing Unemployment. Current Issues and Options*, Proceedings of a Symposium in Jackson Hole, Wyoming, Kansas City, Federal Reserve Bank of Kansas, KS, pp. 68-81.

Machin, S. and van Reenen, J. (1998), "Technology and changes in skill structure: evidence from seven OECD countries", *Quarterly Journal of Economics*, Vol. 113, pp. 1215-44.

Machin, S., Ryan, A. and van Reenen, J. (1996), "Technology and changes in skill structure: evidence from an international panel of industries", Discussion Paper No. 1434, Centre for Economic Policy Research.

Murphy, K.M. and Topel, R.H. (1997). "Unemployment and nonemployment", *American Economic Review Papers and Proceedings*, Vol. 87, pp. 295-300.

Nickell, S. and Bell, B. (1997), "Would cutting payroll taxes on the unskilled have a significant impact on unemployment?", in Snower, D.J. and de la Dehesa, G. (Eds), *Unemployment Policy: Government Options for the Labour Market*, Cambridge University Press, Cambridge, pp. 296-328.

Saint-Paul, G. (1996), "Are the unemployed unemployable?", *European Economic Review*, Vol. 40, pp. 1501-19.

Snower, D.J. (1999), "The organizational revolution and its labor market implications", keynote address to the European Association of Labour Economists (EALE), Regensburg.

Weitzman, M.L. (1982), "Increasing returns and the foundations of unemployment theory", *Economic Journal*, Vol. 92, pp. 787-804.