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Imperfect information, wage formation, and the employability of the unemployed

Stefan Eriksson

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Imperfect information, wage formation, and the employability of the unemployed[*]

by

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Abstract

This paper considers the optimal hiring strategy of a firm that is unable to observe the productive abilities of all its applicants. Whom the firm considers as hireable, will depend crucially on the extent to which the firm can use its wage setting to mirror productivity differences. However, when setting its wages the firm has to consider other factors as well, e.g. turnover, that may make it optimal not to set wages that fully reflect productivity differences. Instead, it may be optimal to avoid hiring workers that have certain characteristics; i.e. to use a discriminatory hiring strategy. In the paper it is shown that discrimination based on employment status is an equilibrium hiring strategy even when the firm is free to set different wages for workers with different expected productivities. It is also shown that if all firms use such hiring procedures this will have strong implications for the aggregate economy and welfare.

Keywords: Hiring, Imperfect information, Discrimination, Employed job seekers, Efficiency wages, Turnover, Unemployment, Welfare, Policy.

JEL classification: E24, J64, J71.

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1 Introduction

A firm posting a vacancy typically receives a number of job applications from job seekers. This means that the firm has to make a decision whom to hire. Obviously, it wants to choose an applicant that can perform the tasks of the job satisfactorily. This might sound easy but the abilities of the applicants are often uncertain. A firm that chooses the wrong applicant will waste money on training the worker and incur costs to hire a replacement.[1]

In a situation with imperfect information, the employer is often unable to distinguish undesirable applicants from other applicants. One characteristic of the applicants that is easy to observe is their employment status. If employers believe that those workers that are unproductive are concentrated to the pool of unemployed workers, they may use the employment status of the applicant as a sorting criterion. An important issue is whether this will imply discrimination against fully able unemployed workers who cannot credibly show that they are indeed fully productive.

Whom the firm considers as hirable will depend crucially on the extent to which wages reflect productivity differences among workers. Assume, for example, that the firm can divide its applicants into two distinct groups each with a different expected productivity, net of hiring costs etc. If the firm can set two different wages, each corresponding to the expected productivity of one of the two groups, a risk neutral firm should be indifferent between hiring from the two groups. But if the firm, for some reason, cannot differentiate wages sufficiently, it will instead be optimal to avoid hiring from one of the groups; thus discrimination will be an optimal hiring strategy.

This paper analyzes the hiring decisions of firms in a situation characterized by imperfect information. The purpose is to show that even in a situation where the firms are allowed to set their wages freely it can still be optimal for them to choose a hiring strategy that excludes some groups of workers; thus showing that discrimination is an equilibrium strategy. In addition, the aggregate and welfare properties of this equilibrium are examined.

The model is inspired by the following four key observations about the functioning of labor markets. First, a firm posting a vacancy typically receives a number of job

[1] The following newspaper quote illustrates an extreme example of this: "US Open threatened by sabotage: employee poured acid on the greens. Estimated damage $ 3 million." (Aftonbladet June 12, 2001).

applications from both unemployed and employed applicants. While the number of job seekers applying for a particular job varies with the cycle and the characteristics of the job, it is reasonable to assume that employers often have more than one applicant to choose from. For the U.S., Barron et al (1997) report that the average firm posting a vacancy receives between 10 and 23 applications per job offered. Behrentz (2001) reports similar figures for Sweden. Also there is ample evidence that many of these job seekers are employed. For the UK, Pissarides and Wadsworth (1994) report that around five percent of all employed workers do search for another job and Boeri (1999) shows that around fifty percent of all workers hired are job-to-job switchers.

Second, firms make significant investments in the workers they hire and, therefore, they are very concerned about keeping worker-initiated turnover low. Firms spend considerable time and money on the recruitment process. For the U.S., Barron and Bishop (1985) show that the employers in their sample spent more than two hours on average evaluating each of the applicants. In addition, substantial amounts of time and money are spent helping the newly hired worker acquire the firm-specific skills needed to do the job. In the paper mentioned above, this amounted to approximately 150 hours on average. There is also ample evidence that employers care about turnover. Survey studies indicate that managers are genuinely concerned about keeping worker-initiated turnover low; see Bewley (1999) for the U.S. and Agell and Lundborg (1999) for Sweden.

Third, it is difficult to determine the productive abilities of applicants before hiring. The productivity of a worker in a particular job depends on a lot of factors. Some of these, such as education, are relatively easy to observe whereas others, such as motivation, are almost impossible to observe prior to hiring. Instead, employers might use easily observable factors, such as employment status, as indicators of unobservable productive abilities, to sort the applicants. It seems that in many real-world situations, the important thing for the employer is to locate a worker who has sufficient skills to perform given tasks satisfactorily. This is especially relevant for jobs that are neither very low skill, so that everyone can perform them satisfactorily, or very high skill, so that it really is crucial to find an applicant with rare talents. For such jobs, the main concern for employers is to look out for those workers who are inferior, for example by having very low skill levels or by having personal characteristics that might disturb production.

Fourth, it is more likely that the pool of unemployed applicants contains workers with undesirable characteristics than that they are in the pool of employed applicants. There are, at least, two reasons for believing this; employers will be more likely to fire bad workers and workers may lose skills during unemployment.[2] The implication of this is that we would expect employers to be more wary of hiring from the pool of unemployed workers than from the pool of employed job seekers.

It might however be argued that, if the wage is sufficiently flexible, it should be possible to adjust the wage in such a way as to compensate for expected productivity differences between applicants. If a worker cannot show that he has the necessary ability, a risk neutral firm should calculate the expected productivity of such a worker by taking the expectation of the distribution of productivities and then pay him the corresponding wage. Moreover, it may be argued that the worker himself could be forced to pay all hiring and training costs in the form of a very low first period wage, or even pay a fee, or post a bond, to get the job. However, there are several arguments against this line of reasoning. First, a worker that knows he is fully able but cannot credibly show this to his present employer has very strong incentives to start looking for a new job if the employer pays him a very low wage. Second, in most countries the wage level is not totally flexible downwards because of factors such as minimum wage legislation, unions, fairness considerations etc. These factors may prevent wages from falling sufficiently. Third, the use of entrance fees/bonds is problematic on theoretical grounds since they would create strong incentives for the firm to cheat on the worker.[3]

In this paper, a model is formulated where workers decide whether or not to search on the job based both on wages and a stochastic job dissatisfaction factor. Firms make their hiring decisions in a situation characterized by imperfect information. The applicant pool consists of both on-the-job searchers and unemployed searchers. All workers are identical, except for a small number of unproductive workers that no firm wants to employ. These unproductive workers are found in the unemployment pool.

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[2] See Gibbons and Katz (1991). For a model based on skill loss as a result of unemployment see Eriksson (2001).

[3] The issue of bonding has been discussed extensively elsewhere. See for example Dickens et al (1989) and McLeod and Malcolmson (1989).

Firms cannot always separate these unemployed workers from other applicants but firms can identify some of the unemployed applicants as being productive. Thus, firms sort their applicants into two pools: one pool of workers that the firm is certain are productive (the certain pool) and one pool of workers that the firm is uncertain about (the uncertain pool). The productivity of workers in the uncertain pool are revealed several periods after hiring. Firms set all wages unilaterally considering that worker-initiated turnover is costly since they must pay a hiring and/or training cost for every hired worker.

The paper starts by showing that it is an equilibrium hiring strategy to "discriminate", i.e. only hire workers from the certain pool. This is done by construction of an equilibrium where all firms discriminate and showing that no individual firm has an incentive to deviate by instead hiring from the uncertain pool. While it is optimal to pay a lower wage to a worker with uncertain productivity, if he is hired, the wage will not be sufficiently low to compensate the firm for the extra costs associated with hiring such a worker. The reason for this is that the wage must simultaneously discourage search among productive workers in the uncertain pool, cover the costs for replacing unproductive workers and compensate for the low net productivity of unproductive workers until they are discovered. It is impossible to find a wage that does all this. Hence, it is rational for employers to follow a discriminatory hiring strategy, i.e. to avoid hiring workers with uncertain productivity.

The paper then analyzes the properties of this discriminatory equilibrium by deriving the steady state solution if all firms follow their discriminatory hiring strategy. It is shown that unemployed job seekers will face a lower expected probability to find a job than employed job seekers. Given the efficiency wage mechanism, this will obviously raise wages and lead to higher equilibrium unemployment.

Finally, the paper analyzes the welfare properties of the discriminatory equilibrium. The social planner maximizes the total sum of utility in the economy given that the information constraint cannot be eliminated. It is shown that the market participants do not consider all socially relevant effects. The analysis also indicates that the market solution yields an employment level that is too low. Different policy interventions to improve welfare are also discussed.

The main point of this paper is that, even though firms are allowed to set their wages freely, it is not possible to differentiate wages so that firms become indifferent in their hiring decisions among different groups of applicants. Instead, it is optimal to discriminate in hiring. Two related papers are Gibbons and Katz (1991) and Sattinger (1998).[4] The paper by Gibbons and Katz is based on the idea that the present employer knows more about the productivity of his workers than prospective employers do. Other firms, therefore, try to infer the quality of workers from their employment history; i.e. whether workers are laid of after a plant closing or for other reasons. Obviously there is an analogy between the certain vs. uncertain pool distinction in my paper and laid off workers vs. other workers in their paper. However, a key difference is that they assume that laid off workers suffer by having to accept a lower wage rather than by not getting a job. Thus, in their paper firms do use the wage to make them indifferent among different groups of job applicants, and there is no unemployment. In my model, unemployed workers find it hard to get a job. Sattinger analyzes a situation where it is optimal for the firm to use different employment criteria for different groups. However, Sattinger assumes that the wage cannot be differentiated between the groups, thus avoiding the issue of why the wage cannot be used to make up for the differences in productivity. My paper thus complements Sattinger's analysis by showing that discrimination may arise without this exogenously imposed wage inflexibility.

Another related paper is Tranæs (2001). He studies the effects of raiding in labor markets in which worker's abilities differ. A firm with a vacancy can choose between hiring an unemployed worker and trying to induce an employee of another firm to switch jobs by offering a higher wage. My paper shares the idea that employers are more certain about the abilities of employed than unemployed workers, as well as the policy implication that search among the unproductive workers creates an externality affecting all other unemployed workers. However, my model differs in a number of

[4] This paper is obviously related to the huge literature on discrimination and information imperfections. For a survey of the discrimination literature see Cain (1986). The literature on information imperfections and signaling is surveyed in Riley (2001). A related paper is Kugler and Saint-Paul (2000). In their model, firms lay off their most unproductive workers, as in Gibbons and Katz (1991), and thus firms find it more profitable to hire employed rather than unemployed workers. However, their model differs from mine in several important ways. First, they assume that the same wage must be set for all workers, making it obvious that it is more profitable to hire employed workers rather than unemployed workers. Second, while I focus on a situation where a firm needs to fill a fixed number of jobs and must choose whom to hire from a pile of applications, they consider a situation where firms always hire the workers they meet if they find it profitable to do so.

fundamental ways. Most importantly, in my model firms worry about the incentives of their employees to look for other jobs (as in most traditional efficiency wage models) whereas firms in Tranæs' model worry about the incentives of other firms to raid their workers.

The rest of the paper is organized as follows. Section 2 presents the model and shows that it is an equilibrium hiring strategy to only hire from the certain pool. Section 3 analyzes the aggregate properties of this equilibrium. Section 4 discusses welfare and policy issues. Section 5 concludes.

2 Discrimination as an optimal hiring strategy

There are many identical firms producing one good with labor as the only input, and many workers who can be either employed or unemployed. The size of the workforce is fixed and normalized to one.

Employed workers get utility from both wages and a non-pecuniary factor measuring their job satisfaction. Every period workers compare the utility they get if they remain with the firm with the utility they would get if they switch jobs. Workers that find that it is beneficial to find a new job, start on-the-job search by submitting an application to a randomly chosen firm. Some of these workers get the jobs they apply for and therefore quit from their present employers. In addition, an exogenous fraction of the employed workers quit into unemployment and all unemployed workers submit one application to a randomly chosen firm.

The firms' set wages unilaterally taking into account that turnover is costly. The firms are free to set different wages for different workers but to prevent arrangements like bonding all firms have to pay all workers an amount at least equal to a minimum wage. Every newly hired worker has to be trained to be able to perform the tasks of the job and firms incur all these costs.

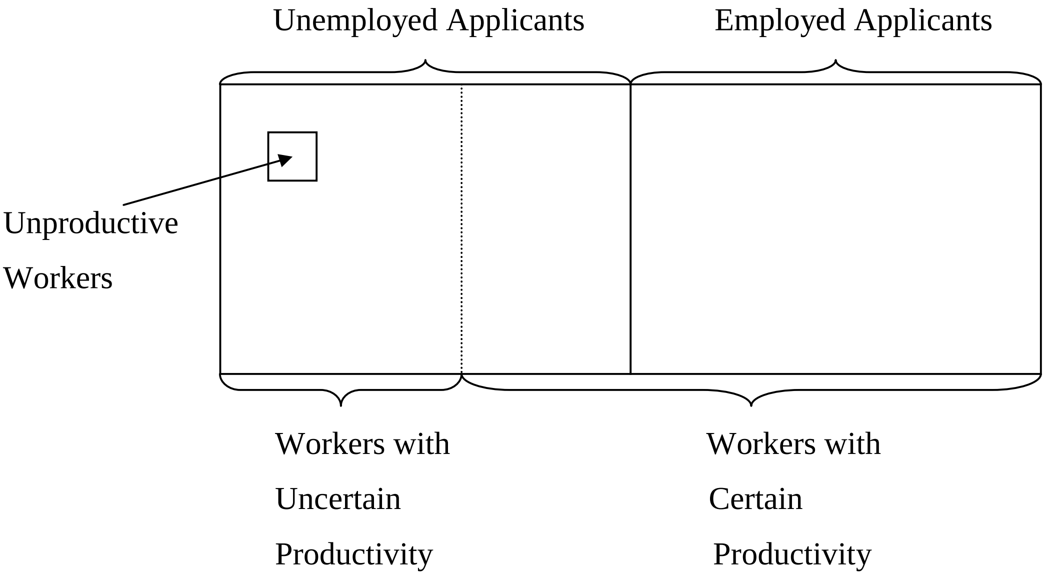
2.1 Firms' information about job applicants

All workers are equally productive in all jobs except for a small number of really unattractive workers, Ω, which we call "unproductive". These workers produce zero output; possibly net of the costs they impose on the firms if they are hired. Firms receive the applications and can choose to hire on-the-job searchers or unemployed searchers. When choosing whom to hire, firms are not able to determine the abilities of all the applicants with certainty and thus are careful about whom they hire. Firms have access to the following information. First, they know the structure of the model and all its parameters, especially the fraction of unproductive workers in the economy. Second, they know whether or not the applicant is employed or unemployed. As we will see, no firm hires an unproductive worker in equilibrium so firms know that all employed applicants are productive. Third, firms can use other information (references etc.) to classify some of the unemployed applicants as productive. But different employers may reach different conclusions about the same worker, because different employers have access to different information.[5] For example, if an applicant includes a reference in his application, we would expect different employers to assess the value of such a reference differently. Formally, let as assume that the probability that an employer considers an unemployed worker as productive with certainty is given by ψ if he is productive and zero if he is unproductive.

Based on their information about the applicants, firms divide their applicants into two pools; those they are certain are productive (the certain pool) and those they are uncertain about (the uncertain pool). The first group consists of all employed applicants and those unemployed applicants the firm knows are productive. The second group consists of all other unemployed applicants including the unproductive workers. Figure 1 illustrates the applicant pool of an individual firm.

[5] The reason for this assumption is that we otherwise would have a large group of productive workers that never has any chance of getting a job since employers cannot verify them as productive workers. This would be unreasonable. However, we might expect that some productive unemployed workers always are unable to credibly demonstrate their abilities.

Figure 1: The applicant pool of an individual firm.



A firm in this economy can choose to hire either from both the certain pool and the uncertain pool or to just hire from the certain pool. Thus, there are two possible hiring strategies, which we call non-discrimination and discrimination. In this section, it is shown that there exists an equilibrium where firms discriminate; i.e. where firms hire only workers with certain productivity. This is done by constructing a discriminatory equilibrium and showing that it is not profitable for a firm to deviate by hiring in a non-discriminatory way.

2.2 The sequence of events

The model takes place in discrete time and there are an infinite number of periods. The sequence of events is the same in all periods and consists of three stages. First, firms decide which wages to offer its present employees as well as those newly hired. Second, all employed workers remaining employed after exogenous quits into unemployment decide whether to seek a new job or not given the wage offers, and firms choose whom to hire from the pile of applications. Third, production takes place.

We analyze these decisions starting with the search decision made by the employed workers and then consider the wage and employment decisions made by the firms.

2.3 The workers' on-the-job search decision[6]

The workers' utility function is given by the wage divided by a job dissatisfaction factor. The dissatisfaction factor, μ, is drawn from a random distribution with cdf function $G(\mu)$, which has mean equal to one. Workers make new independent draws from this distribution every period.[7]

An employed productive worker decides whether or not to search on the job by comparing the utility from staying in the present job with the utility from changing jobs. Only the present period outcome matters, because the worker is back in the same position in the next period whether or not he gets a new job. The current-period utility from staying in the present job is equal to $w_t^i / \hat{\mu}_t$, where w_t^i is the wage offered by the firm in period t and $\hat{\mu}_t$ is the job dissatisfaction from staying in the present job in period t. The current period utility from changing jobs is equal to $\lambda \underline{w} E(1/\mu)$, where $\lambda < 1$ is what remains of the utility from the new job after moving costs and $\underline{w}$ is the first period wage offered by other firms. There are no costs of search so workers search if the expected gain from changing jobs is positive. This means that the worker will search if $\lambda \underline{w} E(1/\mu) > w_t^i / \hat{\mu}_t$. Using the distribution of the job dissatisfaction factor, the fraction of all employed workers that search on the job can be written as:

$$S(\frac{w_t^i}{\kappa \underline{w}}) = 1 - G(\frac{w_t^i}{\kappa \underline{w}}), \tag{1}$$

satisfying $S' < 0$ and $S'' \geq 0$ and where $\kappa = \lambda E(1/\mu)$.

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[6] It should be noted, that what is important is that the decision whether or not to search on the job is a function of the relative wage. This section tries to sketch a highly simplified micro-foundation for this assumption.

[7] This is obviously a simplification of real world behavior but a convenient way of introducing the important fact that non-pecuniary factors seem to be as important as wages in the decision of whether or not to search for a new job (see Akerlof et al (1988)). It should be possible to introduce serial correlation in the job satisfaction component without changing the basic results. However, this would severely complicate the analysis.

2.4 Discriminating firms' wage and employment decisions

This section considers the wage setting and employment decisions of a firm, which hires only workers who are productive with certainty. The firm's objective is to maximize the present value of all future profits by choosing the optimal wage and employment levels. The firm is free to set different wages for different groups of workers but is constrained by the fact that it has to pay a minimum wage to all its workers.[8] Formally, we assume that firms have to pay all their workers a wage that is at least equal to $\underline{w}$. Firms incur hiring and training costs, h, for every newly hired worker.[9] Then discriminating firms have to set two different wages; the wage for the first period of employment and the wage for all remaining periods of employment.

Let us start by considering the optimal wage to offer the first period.[10] Since workers are unable to apply for new jobs during the first period, firms do not have an incentive to offer a high wage to keep turnover down. The only factor placing a constraint on this wage is that the firms must ensure that there exist workers who are willing to work at this wage. Here, we simply assume that the firms can get away with setting a wage equal to the minimum wage, $\underline{w}$, during this period.

Now let us consider the optimal wage for all other periods maintaining the assumption that the firm hires only productive workers. To solve for this wage, we must set up the firm's profit maximization problem. However, first we must introduce some additional notation. Let the employment level in firm i be given by n_t^i, the production function be $f(n_t^i)$ satisfying $f'>0, f''<0$, the discount factor be β, the fraction quitting for exogenous reasons be s and the probability to get a job for an employed job

[8] This assumption can be justified by arguing that there exists a minimum wage stated in law or that some other factor places a constraint on the wage. In reality, there are a number of factors that might create a wage floor. One is obviously the existence of unions. Another is an insider-outsider argument were workers already with the firm would feel that their jobs are threatened if the hiring wage gets to low (such factors are analyzed in depth in Gottfries and Sjöström (2000)).

[9] It should be noted that it would be easy to incorporate an additional cost for worker-initiated quits. Such a cost could be justified by arguing that such quits disturb production etc.

[10] The wage the first period is not really that important because the existence of such a period is clearly an artifact of the discrete time assumption. In real world labor markets, we would expect a worker who is dissatisfied to start searching for a new job immediately after hiring implying that the optimal wage the first period would be equal to the optimal wage the second period.

seeker be a_t. Let w_t^i be the wage all subsequent periods. Hiring in period t is given by $n_t^i - (1-s)(1-S(w_t^i)a_t)n_{t-1}^i$.[11] Then the profit maximization problem can be stated as:[12]

$$\max_{w_t^i, n_t^i} \sum_{\tau=t}^{\infty} \beta^{\tau-t}[f(n_\tau^i) - (\underline{w}+h)(n_\tau^i - (1-s)(1-S(w_\tau^i)a_\tau)n_{\tau-1}^i) - w_\tau^i(1-s)(1-S(w_\tau^i)a_\tau)n_{\tau-1}^i] \qquad (2)$$

i.e. the profit every period equals production minus wage and hiring costs for newly hired workers minus wage costs for workers remaining employed from the previous period.

This problem looks like a dynamic optimization problem that requires standard dynamic programming techniques to solve. However, a closer inspection shows that the only dynamic part of the problem is the fact that if the firm hires one more worker period t this will affect the number of workers it needs to hire period t+1. Since we are primarily interested in an equation for the optimal wage, we can solve the problem quite easily by simply using the first order conditions for period t. These are:

$$-(\underline{w}+h-w_t^i)S'(w_t^i)\frac{1}{\kappa\underline{w}}a_t - (1-S(w_t^i)a_t) = 0, \qquad (3)$$

$$f'(n_t^i) - (\underline{w}+h) + \beta(1-s)(1-S(w_{t+1}^i)a_{t+1})(\underline{w}+h-w_{t+1}^i) = 0. \qquad (4)$$

Equation (3) implicitly defines the optimal wage as a function of variables which are given for the individual firm while equation (4) defines the employment level given the optimal wage. The optimal wage can be written as:

$$w^i = h_1(a, \underline{w}, h). \qquad (5)$$

[11] Note, that we have simplified the notation for the S-function slightly.
[12] It is implicitly assumed that the parameter values are such that this profit level is non-negative.

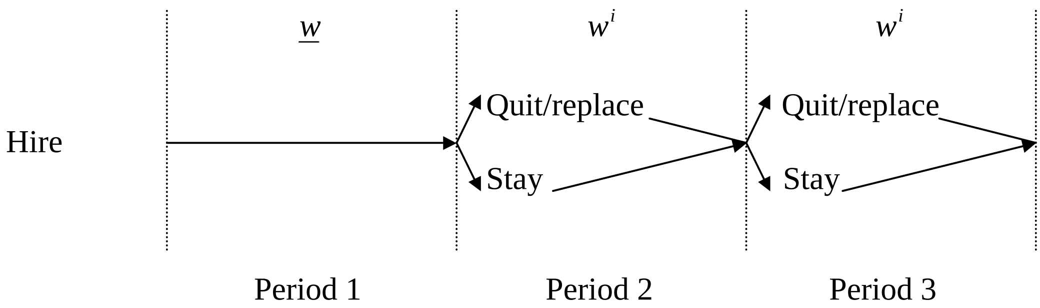
It is straightforward to show that the wage is an increasing function of a and h.[13] Note that equation (3) implies that the optimal wage will satisfy $\underline{w} + h - w^i > 0$.

Equation (5) determines the optimal wage when the firm hires only workers from the certain pool. We are now ready to begin the analysis of the whether it is more profitable to deviate by hiring from the uncertain pool, possibly at a lower wage. We do this by studying the consequences of hiring just one marginal worker from the uncertain pool given that the firm itself, and all other firms, otherwise only hires from the certain pool. However, to facilitate a comparison with the discriminatory case we first look at the consequences of always filling a job with workers from the certain pool. To keep the analysis simple, we treat the employment level of the firm as fixed in the rest of this section and focus on the optimal wages.

2.5 The profit from one job if the firm discriminates

In order to compare between the hiring of a worker from the certain pool and the uncertain pool, we consider the profit from recruiting just one worker with marginal product θ.[14] If the firm hires a worker with certain productivity, it faces the events illustrated in Figure 2.

Figure 2: The hiring of a worker with certain productivity.



Let V be the discounted value of having the job filled with productive workers from period four onwards when the wage is set optimally for those periods. Then we can write the total discounted profit from hiring such a worker as:

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[13] For reasonable parameter values it is also an increasing function of $\underline{w}$.

[14] We can interpret θ as the marginal product of the marginal worker given that all other n-1 workers are fully productive.

$$\pi^H = (\theta - \underline{w} - h) + \beta[(1-s)(1-S(w^i)a)(\theta - w^i) + (s + (1-s)S(w^i)a)(\theta - \underline{w} - h)] +$$

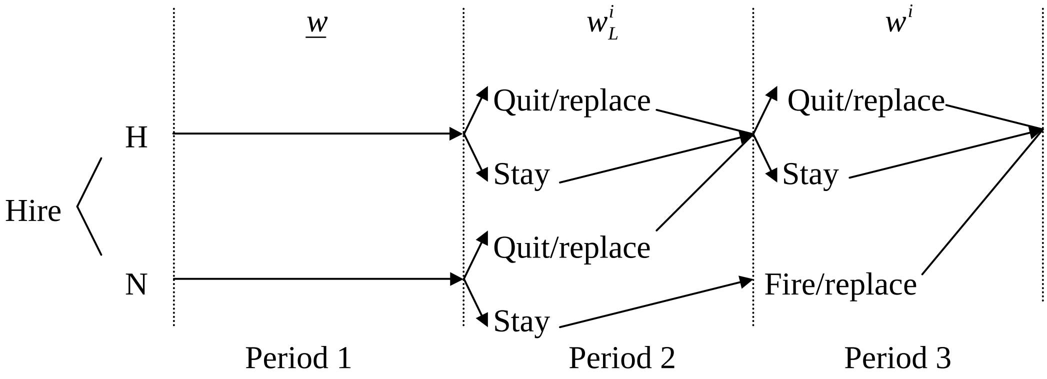
$$\beta^2[(1-s)(1-S(w^i)a)(\theta - w^i) + (s + (1-s)S(w^i)a)(\theta - \underline{w} - h)] + \beta^3 V. \quad (6)$$

For convenience, all time subscripts have been omitted since every period is identical. We see that the profit from hiring a worker with certain productivity is the sum of several terms; the profit the first period, the profit the second period if the worker remains employed with the firm, the profit from hiring a new worker if the worker quits from the firm, the corresponding terms the third period and the sum of future profits. Equation (6), therefore, gives us an expression for all future profits, if the firm hires a worker with certain productivity today *and* continues in the future with a strategy of only hiring workers with certain productivity.

2.6 The profit from one job if the firm deviates

Now let us consider the case when the firm deviates from the strategy presented above and instead hires a worker from the uncertain pool today, while maintaining the discrimination strategy in the future; i.e. if the worker quits he is replaced by a worker with certain productivity. We assume that the firm discovers whether the worker is a productive after two full periods of employment.[15] The sequence of events is illustrated in Figure 3.

Figure 3: The hiring of a worker with uncertain productivity.



[15] What is crucial is not that the worker's type is discovered after exactly two periods, but rather that it is not discovered before the firm has a chance to use the wage to compensate itself for the fact that the expected productivity is lower for a worker from the uncertain pool; i.e. discovery cannot be before the end of period two.

The firm has to pay that worker the same minimum wage the first period, but has the possibility to pay a lower wage the second period to compensate for the risk that the worker is unproductive. Let w_L^i denote the wage offered to such a worker the second period. At the beginning of period three, the type of the worker is revealed and, henceforth, it is obviously optimal to fire unproductive workers and pay the remaining workers the wage w^i derived above.

Now consider the worker's decision whether or not to search on the job. First, consider a worker in the uncertain pool that knows he is productive but cannot demonstrate this to a firm. The fraction of such workers that will search for a new job in period two is given by equation (1) if we replace w^i with w_L^i. Second, consider a worker in the uncertain pool that knows he is unproductive. Such a worker realizes that he will be fired directly after period two. Therefore, he will have very strong incentives to apply for a new job irrespective of his level of job satisfaction. Under reasonable conditions, and this is what we assume, all such workers always use the opportunity to look for a new job.[16]

We can now write an equation for the profit from filling the job with a worker from the uncertain pool, denoted by π^L. Letting φ be the fraction of unproductive workers in the group of workers with uncertain productivity[17], this is given by:

$$\begin{aligned}
\pi^L &= (1-\varphi)(\theta - \underline{w} - h) + \varphi(0 - \underline{w} - h) + \beta(1-\varphi)[(1-s)(1-S(w_L^i)a)(\theta - w_L^i) + \\
&(s + (1-s)S(w_L^i)a)(\theta - \underline{w} - h)] + \beta\varphi[(1-s)(1-a)(0 - w_L^i) + (s + (1-s)a)(\theta - \underline{w} - h)] + \\
&\beta^2\varphi(1-s)(1-a)(\theta - \underline{w} - h) + \beta^2(1-\varphi(1-s)(1-a))[(1-s)(1-S(w^i)a)(\theta - w^i) + \\
&(s + (1-s)S(w^i)a)(\theta - \underline{w} - h)] + \beta^3 V. \qquad (7)
\end{aligned}$$

The terms in equation (7) are in principle equivalent to the terms in equation (6), but are more complicated because we now have to keep track of two types of workers whom

[16] That is, we assume that it is not optimal to stay with the firm until the end of the period and then be fired into unemployment. Essentially, what is needed is that it is not too nice to be unemployed.
[17] I.e. the number of unproductive workers divided by the number of workers with uncertain productivity.

the employer cannot separate until the beginning of period three; those who are productive (denoted H in Figure 3) and those who are unproductive (denoted N in Figure 3). The terms are the following; the profit the first period if the worker is a H-worker, the profit the first period if the worker is a N-worker, the profit the second period if the worker is a H-worker and remains with the firm or is replaced by a H-worker, the profit the second period if the worker is a N-worker and remains with the firm or is replaced by a H-worker, the profit the third period if the worker is a N-worker, remains with the firm at the beginning of period 3 and thus is replaced by a H-worker, the profit the third period if the N-worker does not remain with the firm and finally all future profits from a H-worker.

Maximization of equation (7) with respect to the second period wage, w_L^i, yields the following first order condition, if we assume that the constraint $w_L^i \geq \underline{w}$ does not bind:[18]

$$(1-\varphi)[-(1-S(w_L^i)a)-S'(w_L^i)\frac{1}{\kappa\underline{w}}a(\underline{w}+h-w_L^i)]-\varphi(1-a)=0\,. \tag{8}$$

The similarity between equations (3) and (8) is striking. The difference is just the last term and the fraction $(1-\varphi)$ in the first term. Equation (8) implicitly defines the second period wage for a worker with uncertain productivity as a function of what the firm perceives as parameters. This can be written as:

$$w_L^i = h_2(\varphi, a, \underline{w}, h)\,. \tag{9}$$

2.7 Comparison of the wage levels

Intuitively, it is natural to believe that the wage defined in (9) is lower than the wage defined in (5) since the existence of unproductive workers in the case where firms hire from the uncertain pool means that the firm might waste money. If the worker turns out to be unproductive, the firm will have wasted money on him in the form of costs for

[18] It is reasonable to assume that φ is quite small and, therefore, that w_L^i is only a bit smaller than w^i so that the constraint does not bind.

hiring/training and wages as well as costs to replace him. This intuition turns out to be true and the results are summarized in Proposition 1.

Proposition 1

Let the second period wage for a worker with certain productivity, w^i*, be given by equation (5) and the second period wage for a worker with uncertain productivity,* w_L^i*, be given by equation (9). Then it can be shown that* $w_L^i < w^i \quad \forall \varphi \in (0,1)$.

Proof: see the Appendix.

2.8 Comparison of the profit levels

We have seen that if there exist unproductive workers in the economy it is optimal to pay workers with uncertain productivity a wage that is lower than the one paid to other workers during the second period. The more important question, though, is if this wage is sufficiently low to compensate the firm for all the costs associated with the risk that the worker is unproductive. This question can be rephrased as asking whether the profit from filling a job with a worker with certain productivity is bigger or smaller than the profit from filling the same job with a worker with uncertain productivity. We can easily get an expression for this by subtracting equation (7) from equation (6), if we evaluate all wages at their optimal values. This after some manipulation yields the equation:

$$\pi^{Diff} = \pi^H - \pi^L = \varphi\theta + \beta(1-s)[\varphi(1-a)\theta - (w^i - w_L^i) + \varphi a(\underline{w} + h - w_L^i) -$$

$$S(w^i)a(\underline{w} + h - w^i) + (1-\varphi)S(w_L^i)a(\underline{w} + h - w_L^i)] + \qquad (10)$$

$$\beta^2\varphi(1-s)^2(1-a)(1-S(w^i)a)(\underline{w} + h - w^i).$$

The profit-difference expression in (10) essentially compares the pros and cons of deviating from the main strategy. If the firm deviates, the optimal second period wage is lower but the firms' costs for expected turnover increases and there is a risk that the worker hired is unproductive, thus producing zero output and making it necessary to replace him at the beginning of the third period.

Intuitively, we might expect that it is not optimal to deviate from the main strategy because it is unlikely that there exists a wage that, at the same time, can compensate for all the differences between workers in the certain pool and workers in the uncertain pool. This intuition is confirmed in Proposition 2.

Proposition 2

Let the second period wage for a worker with certain productivity, w^i*, be given by equation (5) and the second period wage for a worker with uncertain productivity,* w_L^i*, be given by equation (9). Then it can be shown that* $\pi^{Diff}(w_L^i, w^i) > 0 \quad \forall \varphi \in (0,1)$.

Proof: see the Appendix.

We can get some intuition for the results in Proposition 2 by considering the derivative of π^L with respect to φ (note that it is only π^L in equation (10) that is a function of φ). Applying the envelope theorem, we obtain:

$$\frac{\partial \pi^L}{\partial \varphi} = -\theta - \beta(1-s)(1-a)\theta - \beta(1-s)(1-S(w_L^i))a(\underline{w} + h - w_L^i) - \beta^2(1-s)^2(1-a)(1-S(w^i)a)(\underline{w} + h - w^i) < 0. \tag{11}$$

The first two terms in equation (11) can be interpreted as the expected loss of production from hiring a worker with uncertain productivity (unproductive workers produce zero output). The third term can be interpreted as the increase in expected costs of replacing workers quitting (productive workers will get increased incentives to search at the lower wage). The fourth term can be interpreted as costs arising from the fact that the expected cost for firing and replacing unproductive workers increase (such workers will be fired at the beginning of the third period).

To summarize the results in this section, we have shown that it is an optimal hiring strategy for an individual firm to hire only workers with certain productivity. It is never profitable to deviate from this strategy by hiring workers with uncertain productivity even though the firm can use the wage to compensate for the risk that such a worker is unproductive. The reason for this is that even though the optimal second period wage for a worker with uncertain productivity is lower than the corresponding wage for other workers, it is not sufficiently low to compensate the firm for costs associated with the risk that the worker hired is unproductive (wages and replacement costs) and to make sure that those workers who are productive do not get too eager to apply for new jobs. The first consideration tends to push the wage downwards, while the second tends to keep it high. Thus, the existence of the turnover component prevents the optimal wage from being low enough to make employers indifferent between applicants. Instead, the wage will always be so high that it is profitable to abstain from hiring workers with uncertain productivity.

It is important to note, that none of these results hinge on the assumption that there exists a first period of employment when the minimum wage is paid. Even if we let the length of that period approach zero the results would still hold. Also, the result will hold if we assume that the first period is a training period where workers only train and do not produce anything.[19] What is important, however, is that workers cannot pay up front for the job or post bonds.

2.9 Numerical illustration

To gain some further intuition for the results, it is illuminating to consider a numerical example. To do that, we need to make some assumptions about the distribution of the job satisfaction factor as well as about various parameters.

To keep the simulation as simple as possible, let us assume that the job satisfaction component is drawn from a uniform distribution on the interval zero to two.[20] This means that the fraction searching on-the-job, defined in equation (1), can be written as:

$$S\left(\frac{w^i}{\kappa \underline{w}}\right) = 1 - \frac{w^i}{2\kappa \underline{w}}, \tag{12}$$

[19] In other words, it is not the fact that unproductive workers produce zero output the first period that drives the results.

[20] It should be noted, that these effects probably would become even more striking if we assume a distribution for the job satisfaction component that is strictly convex. In that case, the fraction of employed workers seeking new employment would increase much more rapidly if the wage were decreased, making it even more difficult to use the wage to compensate for differences among workers.

$$S\left(\frac{w_L^i}{\kappa \underline{w}}\right) = 1 - \frac{w_L^i}{2\kappa \underline{w}}, \tag{13}$$

for workers with certain and uncertain productivity respectively. Using equations (12) and (13) in the first-order conditions in equations (3) and (8), we obtain the following expressions for the optimal wage levels:

$$w^i = \frac{2\kappa(a-1)+a}{2a}\underline{w} + \frac{h}{2}, \tag{14}$$

$$w_L^i = \frac{2\kappa(a-1)+a}{2a}\underline{w} + \frac{h}{2} - \frac{\varphi}{(1-\varphi)}\frac{\kappa(1-a)}{a}\underline{w}. \tag{15}$$

Note the similarity between equations (14) and (15), the only difference is the last term in (15) which as expected is a function of φ.

We consider a symmetric equilibrium and choose the following values for the parameters: $a = 0.4$, $h = 3$ times the wage, $\underline{w} = 0.6$ times the wage, $\beta = 0.9975$ and $s = 0.015$.[21] Moreover, the value of κ is chosen so that 5 percent of the workers perceived by the firm as belonging to the certain pool search.[22] Let us also set $\theta = 2$.[23] Figure 4 shows the optimal wage as a function of φ.

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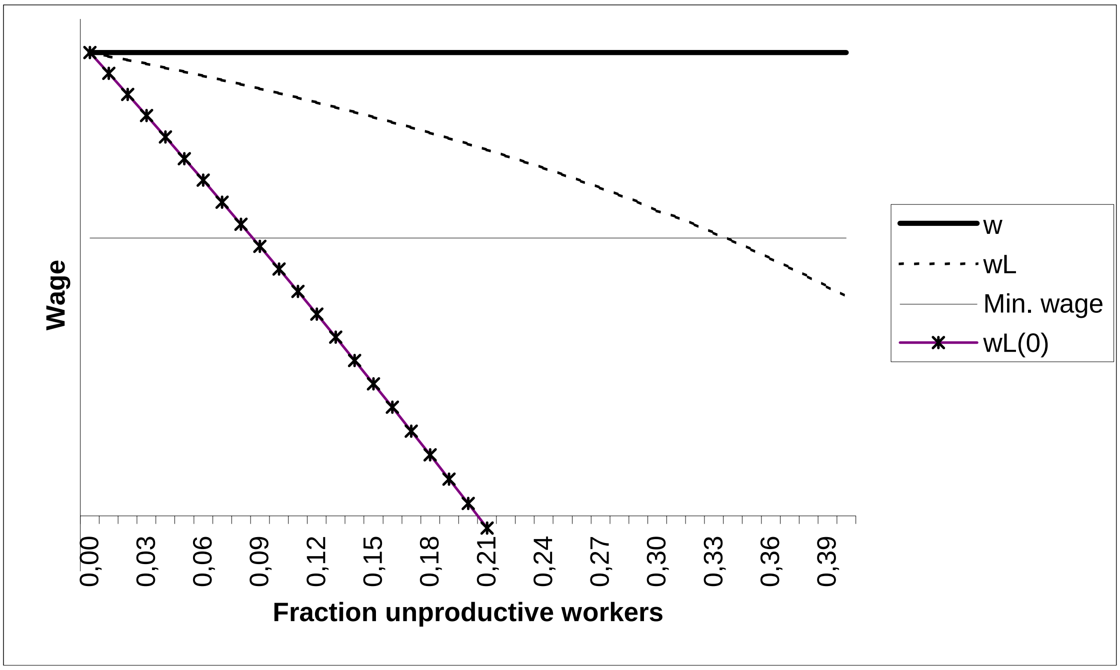
[21] Blau and Robins (1990), find that that employed job seekers change jobs at a rate of 0.13 per week implying a value of approximately 0,4 per month, the flow from employment to unemployment is 1,5 percent per month for the U.S. (Blanchard and Diamond (1990)), the minimum wage is set at a low 60 percent of the wage, the discount rate is set to 3 percent per year, hiring/training is set to three monthly wages.

[22] As was mentioned in the introduction around 5 percent of all employed workers search in the U.K.

[23] This value of θ is chosen so that the firm makes a small profit every period except the first. This is reasonable since it must recover the investment it has made in hiring/training costs. This value is only used to calculate the curve $w_L^i(0)$ in Figure 4.

Figure 4: The optimal wage level as a function of φ.



There are several things worth noting in Figure 4. First, we see that the optimal second period wage for a worker with uncertain productivity, w_L^i, is a declining function of φ, as we would expect from Proposition 1. Second, we see that it takes a quite extreme fraction of unproductive workers in the pool of applicants before the constraint given by the minimum wage starts to bind. This is true even if we set a higher value for the minimum wage than 60 percent of the wage. Third, if we assume the fraction of employed workers seeking a new job is constant at five percent (irrespective of the wage), we can calculate the wage that makes the profit-difference expression in (10) equal to zero. This wage, $w_L^i(0)$, falls quite rapidly with φ. The firm is not willing to set a wage given by $w_L^i(0)$ since that would mean that turnover would increase rapidly, thus generating substantial costs. Instead, it is optimal to keep the wage higher and this implies that the profit-difference expression is always positive.

3 Labor market equilibrium

We have seen that it is an equilibrium strategy to discriminate and thus only hire from the certain pool. When all firms follow such a hiring strategy, this will obviously have strong implications for the aggregate labor market equilibrium. This section analyzes the aggregate properties of our discriminatory equilibrium focusing on the steady state effects on unemployed workers.

3.1 The probability to get a job

It is important to keep in mind how firms perceive employed and unemployed workers in a discriminatory equilibrium. A rational firm knows that what is rational for the firm itself is also rational for all other firms. Since no firm will ever employ a worker with uncertain productivity, all unproductive workers will be in the pool of unemployed workers, and all employed applicants will be productive. Hence, firms will perceive employed job seekers as highly attractive to hire compared with unemployed job seekers.

Consider first the probability to get a job for an *employed* job seeker. This probability is defined as the number of vacant jobs divided by the number of workers considered as worth hiring by the firms to which they have applied in the period under consideration. Let n_t denote aggregate employment and u_t denote aggregate unemployment. Noting that the number of unemployed workers that are considered as hirable by discriminating firms is given by $\psi(u_{t-1} + sn_{t-1} - \Omega)$ we can write this probability as:[24]

$$a_t = \frac{n_t - (1-s)(1-Sa_t)n_{t-1}}{\psi(u_{t-1} + sn_{t-1} - \Omega) + (1-s)Sn_{t-1}} . \tag{16}$$

Solving equation (16) for a_t we get:

$$a_t = \frac{n_t - (1-s)n_{t-1}}{\psi(1-(1-s)n_{t-1} - \Omega)} . \tag{17}$$

[24] The number of firms in the economy is assumed to be fixed. Aggregate employment, therefore, is just equal to the sum of the employees in those firms.

An unemployed, but productive worker, has a lower chance to get a job. With probability $1-\psi$ the firm will be uncertain about his productivity and then he will not be hired. With probability ψ the firm will realize that he is productive and then he will compete with employed job applicants on equal terms. Then his chance to get a job is ψa_t which is obviously lower than a_t.

3.2 Aggregate employment: the general case

The aggregate economy consists of a large number of identical firms. The number of firms is fixed.[25] Since all firms are identical, they solve the same optimization problem and choose the same wage level. Then it must also be true that the first order conditions derived above for the individual firms also hold in equilibrium. This means that we can use those relations to find the aggregate employment level. To simplify the analysis, let us assume that the minimum wage is linked to the average wage. Formally, $\underline{w} = bw$ where $b < 1$. This assumption is reasonable since in reality we would expect the minimum wage to rise over time with the wage level.

In equilibrium, the aggregate employment level is then given by the following equations (where the discount factor is set equal to 1 and where the notation for the S-function is simplified to $S = S(1/\kappa b) = S(w/\kappa bw)$):

$$f'(n) - h(1-(1-s)(1-Sa)) - bw - (1-s)(1-Sa)(1-b)w = 0, \tag{18}$$

$$-(h-(1-b)w)S'\frac{1}{\kappa bw}a - (1-Sa) = 0, \tag{19}$$

where in a steady state the probability to get a new job for an employed searcher (equation (17)) can be written as:[26]

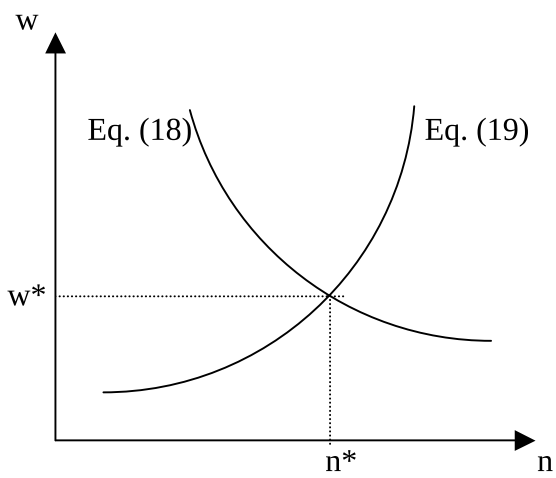
[25] This can for example be due to the fact that entry into the market requires a fixed set-up cost that is so high that no new firms enter the market.

[26] It should be noted that equation (20) can be derived from the requirement that the outflow from employment to unemployment must equal the corresponding inflow; i.e. $sn = a\psi(1-(1-s)n-\Omega)$.

$$a = \frac{sn}{\psi(1-(1-s)n-\Omega)}. \quad (20)$$

Figure 5 illustrates how equations (18) and (19) determine equilibrium employment and wages.

Figure 5: The market equilibrium.[27]



The wage setting curve (equation (19)) is upward sloping because higher employment is associated with a higher probability to get a job for an employed searcher and this makes it optimal for firms to set a higher wage. The labor demand curve (equation (18)) is downward sloping.

In principle, it is possible to perform a comparative statics analysis using equations (18) and (19). However, this is analytically difficult and the same intuition can be grasped by looking at the special case where the training cost is linked to the wage.

3.3 Aggregate employment: a special case

If we assume that $h = kw$, where $k > 1$, the equation system in equations (18) and (19) becomes recursive. Equation (19) determines equilibrium employment while equation (19) determines the equilibrium wage. This special case implies that the wage-setting curve in Figure 5 becomes vertical, while the labor demand curve remains downward sloping. We can then solve for steady state employment explicitly and get:

[27] It can be shown that the expression in (19) defines an increasing and convex function while the expression in (18) defines a decreasing function that is concave for some parameter values.

$$n^{SS} = \frac{\psi(1-\Omega)}{s\left(S(\frac{1}{\kappa b}) - \frac{1}{\kappa b}(k+b-1)S'(\frac{1}{\kappa b}) \right) + (1-s)\psi}. \quad (21)$$

The comparative statics of the aggregate employment level is summarized in Proposition 3.

Proposition 3

If the aggregate employment level in steady state is given by equation (21) it can be shown that:

$$\frac{\partial n^{SS}}{\partial \Omega} < 0, \; \frac{\partial n^{SS}}{\partial \psi} > 0, \; \frac{\partial n^{ss}}{\partial k} < 0, \; \frac{\partial n^{ss}}{\partial S} < 0, \; \frac{\partial n^{ss}}{\partial(-S')} < 0.$$

Proof: see the Appendix.

Let us consider these results briefly. First, if more of the unemployed workers are unproductive this makes it easier for employed job seekers to get jobs, wages increase and employment falls. Second, if the probability that an unemployed worker can convince an employer that he is a productive worker increases this obviously has the opposite effect. Third, if hiring/training costs increase firms become anxious to reduce turnover, wages rise and employment falls. Fourth, if the fraction of employed workers looking for a new job increases (for given values of b and κ) firms respond by setting a higher wage, thereby, causing equilibrium employment to fall. Finally, if the sensitiveness of the S-function with respect to wages (for given values of b and κ) increases this leads to higher wages and lower employment.

4 Welfare and policy issues

From the analysis so far we have seen that a combination of efficiency wage considerations and information imperfections causes unemployment, and that it is an equilibrium hiring strategy for firms to sort workers according to their employment status. This means that unemployed workers will have a hard time finding a job.

A natural question to ask is whether the market solution is efficient or not. This question is important because it is only meaningful to discuss policy if we can show that there are efficiency gains to be made by changing the market outcome.[28] To answer this question, this section focuses on three issues. First, we clarify exactly who is unemployed in this model. Second, we ask whether the market solution yields too low employment by comparing it to the socially optimal solution, given that the information constraints cannot be eliminated. Third, we ask how policy can be used to improve welfare.

4.1 The composition of unemployment

The reason why we have unemployment is clearly that wages are higher than what is consistent with market clearing. The efficiency wage constraint makes it optimal for firms to keep wages high and this obviously makes it impossible for an unemployed worker to offer to work at a lower wage. No firm would be willing to accept such an offer.[29] In addition, we have the minimum wage that prevents firms from forcing their employees to accept a very low wage the first period of employment. This means that all unemployment in the model must be considered as involuntarily.

Now consider the composition of unemployment. We can divide all workers remaining unemployed *after* hiring has taken place in a given period into three distinct groups. First, we have a group of unemployed workers who are truly unproductive. Second, we have a group of fully productive workers that have been rejected by a firm because they could not be distinguished from the unproductive workers. Third, we have a group of fully productive workers who were recognized by a firm as productive but, since there were more applicants than jobs, could not find work. One difference between these three groups is that, after all job searchers have submitted their applications, only those unemployed workers whom an employer considered as belonging to the certain pool had a chance to get a job. This means that unemployed workers belonging to the first two groups really did not have any chance of finding a job during the period, while the last group had the same chance as employed applicants.

[28] Obviously, it can still be interesting to discuss distributional issues. However, such issues are not discussed in this paper.

[29] This assumes that it is not possible for workers to commit to some kind of contract that prevents the worker from switching jobs. However, such contracts are hardly feasible in reality.

4.2 The social vs. the market solution

Consider a social planner who maximizes the sum of all individual utilities. One important issue that faces the social planner is to determine which employment level that is socially optimal.[30] To formulate the welfare function, we need to use the utility functions of workers derived in Section 2. We can divide the workers into four distinct groups and derive a measure of utility for each of these groups.[31]

- First, we have a group of workers whose job satisfaction is so high that they do not find it worthwhile to search for new jobs. The number of such workers is equal to $(1-s)(1-S)n$ and their average utility level is equal to $\int_{m}^{1/\kappa b}(w/\mu^i)dG(\mu^i) = w\int_{m}^{1/\kappa b}(1/\mu^i)dG(\mu^i) = w\Delta_1$,

  where $\Delta_1 \equiv \int_{m}^{1/\kappa b}(1/\mu^i)dG(\mu^i) > 1$.

- Second, we have a group of workers whose job dissatisfaction factor is high enough to make it worthwhile to search for jobs but that do not get any jobs. The number of such workers is equal to $(1-s)S(1-a)n$ and they each get a utility level equal to $\int_{1/\kappa b}^{M}(w/\mu^i)dG(\mu^i) = w\int_{1/\kappa b}^{M}(1/\mu^i)dG(\mu^i) = w\Delta_2$,

  where $\Delta_2 \equiv \int_{1/\kappa b}^{M}(1/\mu^i)dG(\mu^i) < 1$.

- Third, we have a group of workers that either search on the job or are unemployed, and that do get a new job. The number of such workers is equal to

[30] Another issue that might face the planner is to determine the optimal wage. In this paper, we focus on employment. This can be justified by arguing that the most important function of the wage is to distribute the surplus between workers and firms. To avoid discussing distributional issues, we therefore assume that the wage is given by what the market generates.

[31] Assume that the job dissatisfaction factor can take on all values between m and M , where 0<m<M.

$(1-s)San + sn$ and they each get a utility level equal to[32]

$$\int_m^M (\lambda \underline{w} / \mu^i) dG(\mu^i) = \lambda \underline{w} \int_m^M (1/\mu^i) dG(\mu^i) = \lambda bwE(\frac{1}{\mu^i}) = b\kappa w,$$

where $\kappa = \lambda E(\frac{1}{\mu^i})$.

- Fourth, we have a group of workers that are unemployed and do not get a new job. For simplicity, we let these workers get a utility level of zero.[33]

Let us assume that the economy, in addition to the workers, includes a group of risk neutral capitalists who do not work but that receive all profits.[34] Their utility is set equal to their income. The total welfare, W, in the economy is then given by:[35]

$$\mathrm{W} = (1-s)(1-S)nw\Delta_1 + (1-s)S(1-a)nw\Delta_2 + [(1-(1-s)(1-Sa)]n\kappa bw +$$

$$f(n) - (1-s)(1-Sa)nw - (1-(1-s)(1-Sa))n(bw+h), \tag{22}$$

where $a(n;s,\psi) = \dfrac{sn}{\psi(1-(1-s)n-\Omega)}$.

Let us briefly consider each of the components of the welfare function. The first three terms consist of the utility of workers belonging to each of the groups identified above. The next three terms consist of the utility received by capitalists; i.e. profits. Given that the information constraint cannot be eliminated, the probability to get a job for an on-the-job searcher is given by equation (20).

There are two things worth noting about the way we have formulated the welfare function that will help us understand the results later. First, the non-pecuniary gains from switching jobs have an important impact on the way total welfare is calculated. If job switching did not imply a gain in the non-pecuniary component of utility, all terms

[32] For simplicity, it is assumed that unemployed workers who do find a job also incur the moving cost.
[33] Nothing changes if we assume that unemployed workers receive positive utility.
[34] Remember that firms in this economy can yield positive profits. The assumption that there exist capitalists that do not work are similar to what is used in Fredriksson and Holmlund (2001).
[35] We assume that the parameters/functions are chosen so that W has a well-defined unique maximum.

involving wages would cancel out in the welfare function and only two terms would remain; production minus hiring/training costs.[36] Second, the average value of the non-pecuniary factor *after* job switching has taken place will differ from the average of the distribution of the non-pecuniary factor. Only workers with a bad draw will search and since everyone who receives a new job gets the average value, all such workers will gain in utility. Thus, the average job dissatisfaction *after* job switching will be lower than the average of the distribution of the non-pecuniary factor.

The issue we are interested in is whether the employment level generated by the market is too low or not. One way to answer this question is to look at the derivative $\partial W / \partial n$ evaluated at the market solution. Given that W is single-peaked, the socially optimal employment level is higher than the market solution if this derivative is positive. The derivative evaluated at the market solution is given by:

$$\frac{\partial W}{\partial n} = (1-s)(1-S)w\Delta_1 + (1-s)S(1-a)w\Delta_2 + (1-(1-s)(1-Sa))\kappa bw +$$
$$(1-s)Swn(1-\Delta_2-(1-\kappa)b)\frac{\partial a}{\partial n} - (1-s)Shn\frac{\partial a}{\partial n}, \tag{23}$$

where a is defined by equation (20), where $\partial a / \partial n$ is the partial derivative of a with respect to n, which is always positive, and where the wage and employment levels are evaluated at the values from the market solution.

Let us consider the terms in equation (23). The first three terms reflect the fact that workers who are employed receive higher utility (in terms of wages and job satisfaction) than unemployed workers. These terms imply that a higher employment level is desirable. The last two terms reflect the fact that higher employment results in more turnover. If employment increases, this will increase the probability that on-the-job searchers get the jobs they apply for, since a is an increasing function of n, and this increase in turnover will have two effects.[37] It will increase the utility of the workers

[36] This would correspond to the case often analyzed in the matching literature, e.g. Pissarides (2000), where the sole function of wages is to divide the surplus between workers and firms. Thus, in that case wages would not enter the welfare analysis.

[37] It can be shown that $(1-\Delta_2-(1-\kappa)b)>0$. The effects of a marginal increase in turnover can be interpreted as follows. On-the-job searchers that find a new job, on average, get a utility gain of $\kappa bw - w\Delta_2$, which is

since more job switching creates utility gains for workers; i.e. higher job satisfaction. This implies that higher employment is desirable. However, it will also divert more resources towards covering hiring/training costs. This term implies that lower employment is desirable.

From this discussion it is apparent that it is impossible to determine the sign of equation (23) analytically. However, it is intuitively reasonable to expect higher employment to be optimal, since the utility gains unemployed workers get if they find employment should outweigh the negative effects of an increase in turnover, unless the hiring cost is very high and the difference in utility between being employed and unemployed is very small. One way to test this intuition is to perform numerical simulations. This means that we must choose a distribution for the job dissatisfaction factor and set values for the parameters. It is natural to use similar assumptions as we used in the simulation in Section 2; i.e. a uniform distribution on the interval zero to two for the dissatisfaction component, a Cobb-Douglas production function, h =3, $\underline{w}$ =0.6 times the wage, $s = 0.015$, $S = 0.05$, ψ =0.5 and $\Omega = 0.01$. Using these assumptions it can be shown that the expression in equation (23) is positive and that the socially optimal employment level is significantly higher than what the market generates. For these figures, the market yields an unemployment rate of around 13 percent while the socially optimal unemployment rate is around 5 percent.

4.3 Can welfare be improved with policy interventions?

Given that the socially optimal employment level is higher than what the market generates, the social planner should order all firms in the economy to increase employment.[38] However, in a real world economy there exists no social planner that can force firms to hire more workers. Instead, what is needed is some kind of scheme that persuades firms that it is in their best interest to increase employment. The key to achieving higher em-

always positive because otherwise they would not search. Capitalists that lose an employee meanwhile face a profit decrease of $h+bw-w$.

[38] It should be noted that the welfare analysis has been performed under the assumption that it is possible to increase employment without having to force firms to employ workers from the uncertain pool. Formally, this can be achieved as long as $n^{Planner} - n^{SS} < \psi(u^{SS} + sn^{SS} - \Omega) - sn^{SS}$; i.e. if the difference between the socially optimal employment level and the market equilibrium is not too big. If the socially optimal employment level requires hiring from the uncertain pool, the best policy option is to try to lessen the information constraint.

ployment is to induce firms to view turnover a bit less unfavorably. One way of achieving this is a subsidy that covers some part of the hiring/training cost. Such a policy would induce firms to set a lower wage, thus in equilibrium, generating higher employment. To succeed with such a policy, the planner should calculate the optimal size of this subsidy using equations (18) and (23). A policy involving subsidies would probably increase employment but it is important to keep in mind that it also might create incentives for firms to try to cheat the system and that the financing of the subsidies might create other distortions.

Another way to increase welfare is to find ways to lessen the information constraints. In the model, all unemployed workers seek employment by submitting job applications to a randomly chosen firm. This means that even those workers who know they are unproductive apply for jobs. Employers respond to this fact by avoiding hiring all unemployed workers whom they are not sure are productive. Therefore, those workers who are unproductive impose an externality on all other unemployed workers who risk being rejected by employers because they cannot credibly be distinguished from unproductive workers. The severity of the problem depends on how difficult it is for employers to identify a worker as productive. There are two methods that can be used to mitigate this externality; to remove unproductive workers from active search (to decrease Ω), or to enable fully productive unemployed workers to credibly demonstrate their abilities (to increase ψ).

Starting with the first alternative, it should be noted that the economy does not lose anything in terms of welfare from removing the unproductive workers from active search. In the model, the only reason these workers do apply for jobs is that they are forced to do so. In reality, we expect unproductive workers to search because they are required to search to receive unemployment benefits. However, given the potentially strong negative externalities these workers create, it can be argued that it would be welfare improving if such workers were identified, removed from active job search and, if possible, rehabilitated in some way. The success of this method depends crucially on the ability of public agencies to identify unproductive workers. An important implication of this discussion is that it is beneficial for society to remove some job searchers from the applicant pool. This contradicts the conventional wisdom that it is always beneficial to keep up the search intensity of all unemployed workers.

The second alternative might be a more feasible way to improve welfare. If society in some way can help unemployed workers to showcase their abilities, this would improve welfare. The key is to provide employers with credible information about the people who apply for jobs. This can be achieved either by enabling employers to share information about their previous employees more effectively or by devising some scheme where public agencies certify the skills of workers. The usefulness of this approach hinges on the requirement that employers must perceive the information as credible. One way to achieve this would be if the agency could give the firm some kind of guarantee that it would pay all costs incurred by a firm if a worker turns out to be unproductive; i.e. use some sort of trial employment scheme.

5 Conclusions

This paper has considered hiring in a situation characterized by imperfect information. Firms make significant investment in their employees at the time of hiring and this makes them very concerned with keeping worker-initiated turnover low. There exist a small number of unproductive workers in the economy that firms cannot detect. Instead, firms use all information they have available prior to hiring to sort their applicants into two groups; one group consisting of workers the firm is certain are productive and one group the firm is uncertain about.

It is shown that it is an equilibrium hiring strategy to only hire from the certain pool even though wages can be used to compensate the firm for the differences between the groups. The optimal wage is lower for workers in the uncertain pool than for workers in the certain pool but not low enough to make firms indifferent in their hiring decisions. This is because the wage at the same time must prevent search among those workers who really are productive and compensate the firm for the possibility that the searcher is unproductive.

If all firms follow their equilibrium strategies, all unproductive workers will end up in the unemployment pool and firms will treat all employed applicants as fully productive. This means that firms will consider employment status as an important signal for productivity. As a consequence, the expected probability to find a job is higher for employed job seekers than for unemployed job seekers. Due to the efficiency wage considerations in wage setting this gives rise to higher unemployment.[39]

The welfare analysis shows that the firms in the economy do not consider all socially relevant effects in their wage setting decisions. Thus, the private solution seems to yield a too low employment level leaving room for policy to improve welfare.

The main contribution of this paper is that it shows that flexible wages do not necessarily prevent discrimination against groups of workers. This means that we cannot simply assume that flexible wages always will make a firm indifferent between different groups of applicants unless we are willing to allow for implausible arrangements like job fees etc. Instead, it is possible that the wage that the firm considers as optimal for a particular group, taking into account factors like turnover consequences, is so high that it is less profitable to hire from that group than from some other group of applicants.

[39] This result is similar to the results in Eriksson and Gottfries (2000).

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Appendix: Proofs of propositions 1-3

Proof of proposition 1

We divide this proof into two parts. First, we show that $w_L^i = w^i$ when $\varphi = 0$. Second, we show that $\partial w_L^i / \partial\varphi < 0 \;\; \forall \varphi \in (0, \overline{\varphi})$ where $\overline{\varphi}$ is the value where the constraint starts to bind.

First, consider the case when $\varphi = 0$. Then the first order conditions in equations (3) and (8) become identical and this obviously implies that $w^i = w_L^i$.

$\because \;\; w_L^i = w^i$ if $\varphi = 0$.

Second, let us consider the case when φ>0. Implicit differentiation of (8) with respect to φ yields us:

$$(1 - S(w_L^i)a) + S'(w_L^i)\frac{1}{\kappa \underline{w}}a(\underline{w} + h - w_L^i) - (1-a) + (1-\varphi)S'(w_L^i)\frac{1}{\kappa \underline{w}}a\frac{\partial w_L^i}{\partial \varphi} - \\ (1-\varphi)S''(w_L^i)\frac{1}{(\kappa \underline{w})^2}a(\underline{w} + h - w_L^i)\frac{\partial w_L^i}{\partial \varphi} + (1-\varphi)S'(w_L^i)\frac{1}{\kappa \underline{w}}a\frac{\partial w_L^i}{\partial \varphi} = 0. \tag{A1}$$

Equation (A1) can be rewritten as:

$$\frac{\partial w_L^i}{\partial \varphi} = \frac{(1 - S(w_L^i)a) + S'(w_L^i)\frac{1}{\kappa \underline{w}}a(\underline{w} + h - w_L^i) - (1-a)}{-(1-\varphi)S'(w_L^i)\frac{1}{\kappa \underline{w}}a + (1-\varphi)S''(w_L^i)\frac{1}{(\kappa \underline{w})^2}a(\underline{w} + h - w_L^i) - (1-\varphi)S'(w_L^i)\frac{1}{\kappa \underline{w}}a}. \tag{A2}$$

Now consider the numerator in (A2). This expression is negative if:

$$(1 - S(w_L^i)a) + S'(w_L^i)\frac{1}{\kappa \underline{w}}a(\underline{w} + h - w_L^i) - (1-a) < 0. \tag{A3}$$

If we multiply with $-(1-\varphi)$, (A3) can be rewritten as:

$$(1-\varphi)[-(1-S(w_L^i)a)-S'(w_L^i)\frac{1}{\kappa \underline{w}}a(\underline{w}+h-w_L^i)]-\varphi(1-a)+(1-a)>0\,. \qquad \text{(A4)}$$

But from equation (8) we now that:

$$(1-\varphi)[-(1-S(w_L^i)a)-S'(w_L^i)\frac{1}{\kappa \underline{w}}a(\underline{w}+h-w_L^i)]-\varphi(1-a)=0\,. \qquad \text{(A5)}$$

Then since $(1-a)$ is clearly positive we can conclude that equation (A4) is satisfied. Now consider the denominator in (A2). Since we have assumed that the S-function is decreasing and convex this expression is clearly positive.

$$\because \ \frac{\partial w_L^i}{\partial \varphi}<0\,.$$

Now consider the case when the minimum wage constraint does bind. Then it must be that $w_L^i=\underline{w}$ irrespectively of the value of φ. The result still holds as long as the constraint does not bind when $\varphi=0$, but that case is hardly relevant since the constraint would then bind for all workers.

Combining these two results we see that $w_L^i<w^i \quad \forall \varphi \in (0,1)$.
QED.

Proof of proposition 2

We divide this proof into two parts. First, we show that $\pi^{Diff}=0$ when $\varphi=0$. Second, we show that $\partial \pi^{Diff}/\partial \varphi>0 \quad \forall \varphi \in (0,1)$.

First consider the case when $\varphi = 0$. From the proof of Proposition 1 it follows that $w_L^i = w^i$. Using these two facts in equation (10) we immediately see that $\pi^{Diff} = 0$.

$\because\ \pi^{\text{Diff}} = 0$ if $\varphi = 0$.

Second, consider the case when $\varphi > 0$. Implicit differentiation of equation (10) with respect to φ yields:

$$\frac{\partial \pi^{Diff}}{\partial \varphi} = (1+\beta(1-s)(1-a))\theta + \beta(1-s)(1-S(w_L^i))a(\underline{w}+h-w_L^i) +$$

$$\beta^2(1-s)^2(1-a)(1-S(w^i)a)(\underline{w}+h-w^i) + \tag{A6}$$

$$\beta(1-s)\left[1-\varphi a+(1-\varphi)S'(w_L^i)\frac{1}{\kappa \underline{w}}a(\underline{w}+h-w_L^i)-(1-\varphi)S(w_L^i)a\right]\frac{\partial w_L^i}{\partial \varphi}.$$

If we compare the terms within the brackets in A6 with the first order condition in (8), we see that they are identical (the envelope theorem). This means that it must be that:

$$\frac{\partial \pi^{Diff}}{\partial \varphi} = (1+\beta(1-s)(1-a))\theta + \beta(1-s)(1-S(w_L^i))a(\underline{w}+h-w_L^i) +$$

$$\beta^2(1-s)^2(1-a)(1-S(w^i)a)\,(\underline{w}+h-w^i). \tag{A7}$$

Looking at (A7) we see that it clearly is positive since it follows from the first order conditions in (3) and (8) that $\underline{w}+h-w^i > 0$ and $\underline{w}+h-w_L^i > 0$.

Now consider the unlikely case when the wage constraint does bind. Then we have that $w_L^i = \underline{w}$. The result above hold since the derivative then would be given by:

$$\frac{\partial \pi^{Diff}}{\partial \varphi} = (1+\beta(1-s)(1-a))\theta + \beta(1-s)(1-S(\underline{w}))ah +$$

$$\beta^2(1-s)^2(1-a)(1-S(w^i)a)(\underline{w}+h-w^i), \qquad \text{(A8)}$$

which is also clearly positive.

$$\because \ \frac{\partial \pi^{Diff}}{\partial \varphi} > 0 \quad \forall \varphi \in (0,1).$$

Combining these two results we see that $\pi^{Diff} > 0 \quad \forall \varphi \in (0,1)$.

QED.

Proof of proposition 3

Differentiation of equation (21) with respect to the parameters yields:

$$\frac{\partial n^{SS}}{\partial \Omega} = \frac{-\psi\left\{s\left(S(\frac{1}{\kappa b}) - \frac{1}{\kappa b}(k+b-1)S'(\frac{1}{\kappa b})\right) + (1-s)\psi\right\}}{\left(s\left(S(\frac{1}{\kappa b}) - \frac{1}{\kappa b}(k+b-1)S'(\frac{1}{\kappa b})\right) + (1-s)\psi\right)^2} < 0, \qquad \text{(A9)}$$

$$\frac{\partial n^{SS}}{\partial \psi} = \frac{(1-\Omega)s\left(S(\frac{1}{\kappa b}) - \frac{1}{\kappa b}(k+b-1)S'(\frac{1}{\kappa b})\right)}{\left(s\left(S(\frac{1}{\kappa b}) - \frac{1}{\kappa b}(k+b-1)S'(\frac{1}{\kappa b})\right) + (1-s)\psi\right)^2} > 0, \qquad \text{(A10)}$$

$$\frac{\partial n^{SS}}{\partial k} = \frac{s\frac{1}{\kappa b}S'(\frac{1}{\kappa b})\psi(1-\Omega)}{\left(s\left(S(\frac{1}{\kappa b}) - \frac{1}{\kappa b}(k+b-1)S'(\frac{1}{\kappa b})\right) + (1-s)\psi\right)^2} < 0, \qquad \text{(A11)}$$

$$\frac{\partial n^{SS}}{\partial S} = \frac{-s\psi(1-\Omega)}{\left(s\left(S(\frac{1}{\kappa b}) - \frac{1}{\kappa b}(k+b-1)S'(\frac{1}{\kappa b})\right) + (1-s)\psi\right)^2} < 0, \tag{A12}$$

$$\frac{\partial n^{SS}}{\partial(-S')} = \frac{-s\frac{1}{\kappa b}(k+b-1)\psi(1-\Omega)}{\left(s\left(S(\frac{1}{\kappa b}) - \frac{1}{\kappa b}(k+b-1)S'(\frac{1}{\kappa b})\right) + (1-s)\psi\right)^2} < 0. \tag{A13}$$

QED.

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