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A WORKER SCREENING DEVICE**

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ABSTRACT

We present a model of the labor market with asymmetric information in which the equilibrium of the market generates unemployment and job queues so that wages may serve as an effective screening device. This happens because more productive workers--within any group of individuals with a given set of observable characteristics--are more willing to accept the risk of being unemployed than less productive workers. The model is consistent with cyclical movements in average real wages as well as with differences in unemployment rates across different groups in the population. We also show that the market equilibrium is not, in general, constrained Pareto efficient. Moreover, we identify a new category of nonexistence problems, different in several essential ways from those earlier discussed by Rothschild-Stiglitz [1976] and Wilson [1977]. We also extend the analysis to incorporate the possibility of renegotiation, showing that a separating-renegotiation-proof-equilibrium exists for certain parameters and that a renegotiation-proof equilibrium is always constrained Pareto efficient. Finally, we present a version of the model in which firms enter sequentially, as in Guash and Weiss [1980]. But contrary to the main result in that paper, we show that there is no advantage of being late, provided workers have rational expectations.

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Equilibrium Unemployment as a Worker Screening Device

Introduction

One of the reasons that firms are reluctant to lower wages, even in the face of unemployment, is that they are afraid that doing so will lower the quality of their labor force. Their best workers will quit, and good workers will not apply. The fact that firms are concerned about the quality of their labor force has one immediate implication: firms must not believe that each worker is receiving his marginal product. There are several reasons why this may be so. Among the more important of these is that firms are imperfectly informed concerning the productivity of workers, at least at the time they are hired. The objective of this paper is to analyze equilibrium in markets in which prices (wages) convey information about quality (productivity). For wages to be an effective signal, it must be more expensive for lower productivity workers to ask for higher wages than for higher productivity workers. We argue that the market generates that cost differential through unemployment. Unemployment is a necessary part of a market screening device. If there were no unemployment (or at least no job queues), everyone would apply to, and get, the jobs with the highest wage. The equilibrium of the market generates unemployment and job queues so that wages may serve as an effective screening device.

In this context, unemployment means that among workers with the same observable characteristics to employers, some obtain jobs, while others do not. Those who do not must rely on their fall-back opportunity, which may be self-employment or leisure. (For simplicity, in what follows, we will simply refer to the fall-back opportunity as "self-employment.") Among workers with the same ability, those who succeed in getting a job have a higher income than those who fail to do so. Employment, for any given ability level, pays better than self-employment.

The existence of unemployment implies that some workers are forced to accept their fall-back opportunity. A critical, and we think

reasonable, assumption of the analysis is that the fall-back opportunity wage is positively correlated with workers' on the job productivity. Thus, more productive workers--within any group of individuals with a given set of observable characteristics--are more willing to accept the risk of being unemployed than less productive workers. The higher a worker's wage demands, the greater the chance of being unemployed. Hence, wages in conjunction with unemployment may be an effective signal of productivity.

The adverse selection-efficiency wage model, which, as we have just described it, holds that it pays firms to pay high wages--above those that clear markets--both to retain and attract high quality workers, has become one of the standard explanations of why wages do not fall in a recession to eliminate unemployment. The theory has intuitive appeal, and there is considerable anecdotal support for it. Yet, since its earliest formulation,¹ objections have been raised to the intellectual coherency of the theory.

1. The standard models used differences in reservation wages--in self-employment opportunities--as the basis of self-selection. But in modern economies, most workers who do not get hired do not go into self-employment. Can one nonetheless construct a relationship between quality of work-force and wage of the kind required by the efficiency wage theory?
2. Firms that first enter a labor market, unless they simply randomly choose among all workers, affect the quality mix of subsequent entrants, and in a way which gives them an advantage (Guasch and Weiss [1980]). But then, if firms recognize this, won't the early entrants postpone entering? How can there be an equilibrium with

¹The earliest formulation that we are aware of was contained in J. E. Stiglitz [1969]. Revised and expanded versions of the adverse selection part of that paper appeared as Stiglitz [1976, 1983, 1991] and Nalebuff and Stiglitz [1982]. For a survey with additional references, see Stiglitz [1987] and Weiss [1990].

different firms facing different labor costs?

3. Efficiency wage models frequently result in a "pooling" equilibrium, in which high and low productivity workers are hired together. Is there must be some way of inducing self-selection device which will break this pooling equilibrium? Are there existence problems, of the kind encountered by Rothschild and Stiglitz [1976]?
4. If unemployment is used as a self-selection device, the resulting equilibrium is inefficient. Wouldn't renegotiation eliminate these inefficiencies and restore Pareto optimality (or at least constrained Pareto optimality) to the market?

Developing a coherent theory of competitive equilibrium unemployment as a screening device turns out to be a complicated task for two reasons. First, the relationship between the quality of the labor force attracted by one firm, as a function of the wage it offers depends on the wage offers of other firms. Even if all firms are identical, *ex ante*, and even if, in terms of observable characteristics (other than the willingness to accept different wage offers), all individuals are identical, it may pay different firms to pay different wages. Equilibrium will be characterized by a wage distribution. Solving for an equilibrium wage distribution is obviously a more difficult task than solving for a single equilibrium wage.

Secondly, the precise nature of the equilibrium turns out to depend on a number of assumptions concerning how the labor market works: on the search/application technology (whether there is no cost to applying to jobs, or whether the number of applications is limited); and on the nature of commitments, on the part of firms, to the wages they have announced, and on the part of workers, to the jobs they have accepted. Yet, while the precise nature of the equilibrium (and indeed, even its very existence) is thus sensitive to these and other features of the market, the central results of efficiency wage theory, that there will be unemployment in equilibrium,

that it pays firms to pay wages higher than those it must pay to obtain labor, that some workers get "good" (i.e. high paying) jobs while other workers, equal in ability, either remain unemployed as they seek these good jobs, or must be content to accept lower paying jobs (possibly, self-employment), and that wages may not respond much to changes in the demand for labor (but employment will) appear to be robust.

We also conduct several comparative statics exercises with our model, showing that the behavior is consistent both with cyclical movements in average real wages as well as with differences in unemployment rates across different groups in the population.

While, from the macro-economic perspective, these are perhaps the major findings of our analysis, there are several other results which deserve attention. First, we are able to show that the resulting market equilibrium is not, in general, constrained Pareto efficient. Though Pareto efficient allocations may be characterized by unemployment and queues, the levels differ from those generated by the market. We identify the source of this market failure.

From an information-theory perspective, the theory we construct is of interest because it differs from previous adverse selection models, in which firms set both a price and a quantity variable (Rothschild-Stiglitz [1976], Spence [1974], etc.) or only the price is observable, and hence only the price is used as a screening device ("judging quality by price," as in Stiglitz [1976, 1987] and Weiss [1980]). In the models we construct, queue length—the ratio of the number of individuals being hired by a firm to the number of those applying—is a quantity variable, which, together with the entire wage distribution, acts as a self-selection device; but the queue length is set not by the firm, but is a consequence of the joint decisions of all the firms and workers in the market. Thus, like the earlier studies on the efficiency wage-adverse selection model, the firm only sets the wage, but like other models of self-selection, both a price (here the wage) and a

quantity variable (here the queue length) are relevant to choices. Here, it is the market, not firms, that effectively screens workers. Hence, the title of the paper: equilibrium unemployment acts as a worker screening device.

Still within the information-theoretic perspective, beyond extending the general framework in the manner described, two results are noteworthy. First we identify a new category of non-existence problems, different in several essential ways from those earlier discussed by Rothschild-Stiglitz [1976] and Wilson [1977]. Second, we extend the analysis to incorporate the possibility of renegotiation. The techniques of analysis may prove to be of more general interest.

We also present a version of the model in which firms enter sequentially, as in Guash and Weiss. But contrary to the main result in that paper, we show that there is no advantage of being late, provided workers have rational expectations. This version of the model allows individuals to apply to many firms but imposes the restriction that once a worker is hired, he is committed to stay with that firm that is, no recontracting is allowed. We show how the issue of whether recontracting is or is not allowed can be addressed within the model: under the assumptions employed in the analysis, there will not be restrictions on recontracting.

As we mentioned earlier, the nature of equilibrium depends crucially on the assumptions that are made about search and the sequence of events. The paper is divided into three parts according to the assumptions made on these issues. In the first part, we present the basic description of the economy and analyze equilibrium with costless search and unlimited applications. This is the standard adverse selection-single wage-efficiency wage model (Weiss [1980]). In the second part, we assume that workers can apply to only one job and that this application is costless. This results in unemployment as a market screening device. The third part extends the analysis of the second, by assuming that firms cannot commit themselves to a particular wage; hence there are possibilities for renegotiation. The fourth

section assumes that firms enter the market sequentially and that once hired, a worker commits to stay with his employer. We show there that the rational expectations equilibrium involves no advantage of being late.

I. ADVERSE SELECTION WITH UNLIMITED APPLICATIONS

The Basic Model - Description of the Players

We are interested in studying a labor market in which workers differ in their productivity in a simple multiplicative way: a worker with a productivity of "a" can do in an hour what it takes a worker of productivity "b" a/b hours to do. A firm measures its labor input by the sum of the productivity or efficiency units of its workforce.

There are two types of jobs: each individual can be self-employed or can work in "manufacturing." Type v workers have an effective productivity of $a(v)$ units in manufacturing and v in self-employment. There is a continuum of types in $V = [v_0, v_1]$. For simplicity, each worker supplies one unit of labor. The density of type v in the population is $g(v)$. There are constant returns to labor in self employment and units are such that v represents the wage which an individual of type v can earn in self-employment.

Workers with better fall-back opportunities are on average more productive: $a'(v) > 0$.² The assumed positive correlation between productivity and fall-back opportunities (including self-employment) arises naturally as productivity is typically positively correlated across different jobs; for most workers, fall-back opportunities lie in previous jobs or professions and the value of this option depends on past performance which is positively correlated with future performance. A firm has no information about any particular worker (other than that he is applying for a particular

²In the case of a discrete number of types, we rewrite this condition as saying that if $v_1 \geq v_2$, then $a(v_1) \geq a(v_2)$.

job). On the other hand, firms have perfect statistical information; the firm knows the probability distribution of productivity and fall-back opportunities for the applicant pool.³

Jobs are indexed by their wage, w . At wage w , the number of jobs available is $n(w)$. Workers decide which job to apply for and join the appropriate queue. Firms offering wage w then hire $n(w)$ applicants chosen at random from the worker queue. The fraction of workers hired from each queue determines the probability of employment at each wage.⁴

In a rational expectations equilibrium, workers correctly predict the length of each queue and the corresponding probability of employment, $h(w)$. Workers are optimizing; this leads to a function $w(v)$ mapping the worker's fall-back wage to his job choice. In equilibrium, workers expecting employment probability $h(w)$ act in a manner that actually generates $h(w)$.

Unemployment (or under-employment depending on fall-back opportunities) arises among workers who get no job offers. Over several variations of search technology and firm commitment, (the fear of) unemployment is used as the screening device to deter low-productivity workers from applying to high-salary jobs. Even when there exist additional instruments for screening workers, unemployment is still used

³This view of the labor market can be translated into a general bargaining model with incomplete information. Workers are the sellers; they value their product (labor) at v . Firms are the buyers; labor worth v to a worker is on average worth $a(v)$ efficiency units to the firm. Although v is unobservable, firms know the function $a(v)$ and the number or density of each type, $g(v)$.

⁴In the model presented in Part II, with workers applying to only one firm, if a worker is not hired at the firm to which he has applied, he is "unemployed." Here, the overall unemployment rate is not simply related to the probability of employment at each wage.

provided that when all other instruments are used, there remains a residual of imperfect information, which there almost surely will.

It is assumed that all firms have the same production function $F(e)$, where e is the number of efficiency units. Also for simplicity, there is a continuum of firms with mass 1 so that the marginal condition of one firm characterizes the marginal condition of the market.

Efficiency Wages with Unlimited Applications

In the simplest version of an efficiency wage model, firms simultaneously offer to hire a certain amount of workers at a particular wage. Workers are able to apply to all firms. If a firm has more applicants than jobs offered, it rations the jobs randomly among the applicants. Applicants who are not hired at any firm are self-employed.

Because individuals of different productivities have different reservation wages, the mix of individuals offering their services on the labor market will change as the wage increases. As the wage raises, workers with higher reservation wages offer their labor services, and since these workers are more productive, the average productivity is an increasing function of the wage, as shown in Figure 1.

If a firm offering wage w attracts all workers (or a representative sample) with fall-back opportunity no greater than w , then its efficiency units per wage will be

$$A(w) = \frac{1}{G(w)} \int_{v_0}^w a(v)g(v)dv.$$

where $G(w)$ is the probability distribution of v . $A(w)$ is plotted in Figure 1. It is upward sloping, but we can see little more about its shape than that. Define $w^*(E)$ as the wage which minimizes the cost of acquiring E efficiency units. It is the solution to:

Maximize $A(w)/w$

subject to $A(w)G(w) \geq E$.

Figure 1 shows that $w^*(E)$ is either in the interval $[w^*(0), w_1^*]$ or is higher than or equal to w_2^* , depending on E . w_1^* is defined implicitly by

$$\frac{A(w_1^*)}{w_1^*} = \frac{A(w_2^*)}{w_2^*}.$$

We can now characterize market equilibrium:

Proposition 1. If there are unlimited applications, competitive equilibrium is characterized either by full employment or unemployment. When equilibrium involves full employment, there is a single wage offered in the market. When it involves unemployment then there are two possibilities: a single wage $w^*(0)$ is offered and some workers with reservation wages below $w^*(0)$ are involuntarily unemployed or two wages, w_1^* and w_2^* , are offered and some workers with reservation wage between w_1^* and w_2^* are involuntarily unemployed.

Proof. Let $N^d(w)$ be aggregate demand for efficiency units at wage w and $N^s(w) = A(w)F(w)$ be the aggregate supply. If for any wage $\hat{w} \in [w^*(0), w_1^*] \cup [w_2^*, \infty]$ we have $N^d(\hat{w}) = N^s(\hat{w})$, then market equilibrium involves full employment at wage \hat{w} . If $N^d(w^*(0)) < N^s(w^*(0))$, then market equilibrium involves a single wage $w^*(0)$ offered, and $N^d(w^*(0))$ efficiency units hired and involuntary unemployment among workers with reservation wage $v < w^*(0)$ since they would be willing to work for a wage

lower than $w^*(0)$, but no firm is willing to lower the wage and hire them.

If $N^d(w^*_1) > N^s(w^*_1)$ but $N^d(w^*_2) < N^s(w^*_2)$, then two wages are offered, w^*_1 and w^*_2 and by definition, firms are indifferent as to which one to offer. All workers with $v \leq w^*_2$ apply for jobs with wage w^*_2 ; of the ones who fail to get employed at that wage, the ones with $v \leq w^*_1$ apply for jobs with wage w^*_1 . There is just enough firms offering wage w^*_2 so that all workers who apply for wage w^*_1 get employed. Therefore, no firm can gain by deviating to a lower wage than w^*_1 , because then it would not succeed in recruiting applicants. The same is true for firms offering w^*_2 because that would only increase the cost-per-efficiency unit.

To end the proof we only need to note that an equilibrium with more than two wages offered can occur only if the average-quality wage curve has two or more tangencies for the same ray from the origin. That is, there is a set

$$T = \left\{ x \mid \frac{A(x)}{x} = \kappa, \frac{d}{dx} \left[\frac{A(x)}{x} \right] = 0 \right\}$$

with more than one element. But such cases almost never happen and so are not interesting for this analysis. Q.E.D.

It is worth noting that this result differs somewhat from the standard result about efficiency wages for this case. For example, Weiss [1990] argues that if labor supply exceeds demand at $w^*(0)$, then the equilibrium wage will be $w^*(0)$ and jobs will be rationed. But if demand exceeds supply at $w^*(0)$ then wages will rise until supply equals demand. This

second part needs to be qualified. The cheapest way to increase the size of the applicant pool may be to raise wages a lot, to the point where once again supply exceeds demand, and once again ration jobs. But if jobs are rationed, then someone will want to hire the unemployed workers at lower wages and this leads to the equilibrium we have characterized.

This simple case illustrates some of the basic features of quality-efficiency wage models. There may be a wage dispersion, with workers with identical observable characteristics obtaining different wages; and wages do not respond to small changes in demand. (Though the wage rates do not change with aggregate demand, average wages increase, since all marginal hiring occurs at the high wage, w_2^* . Thus the model generates procyclical movements in average wages, in contrast with standard neoclassical models, as do most versions of the effort-efficiency wage theory.) If there is any unemployment in the equilibrium, then the response to a small shift in demand will be to vary the quantity of jobs rather than wages. It is only in the cases where there is single wage with full employment at that wage that firms respond to a change in demand with a change in the wage.

II. LIMITED APPLICATIONS

In the model of the preceding section, there is no opportunity cost to applying for a job. Thus, workers apply to all jobs paying wages in

excess of their fall-back wage. It is, however, more realistic to assume that there are costs to applying to a job, or at the very least, that workers can apply only to a limited number of jobs. This is the case we investigate here. We focus on the simple case where individuals can apply to only one firm, but that application is costless.⁵ To simplify the analysis, we also assume there are only two groups in the population. The more general case with a continuum of types is discussed in Appendix A. With two groups, we can simplify our notation as well.

The Basic Model

The two types of workers, type L and type H, are denoted by subscripts L and H. The proportion of type L in the population is μ . We assume that $v_H > v_L$ and $a_H > a_L$. If the wage is below v_H , only type Ls will offer labor services and efficiency units per worker are a_L . If the wage is above v_H then all workers supply labor and average efficiency units per worker are \bar{a} , where

$$\bar{a} = \mu a_L + (1-\mu)a_H$$

The efficiency wage is the wage at which the cost per efficiency unit is minimized. If type L workers have the comparative advantage in manufacturing, then v_L is the efficiency wage. If type H workers have the

⁵As we shall see, this is not a critical assumption. Another assumption that leads to very similar results is that there is a fixed cost per application.

comparative advantage in manufacturing, then depending on the proportion of workers who are type H, the efficiency wage may be v_L or v_H .⁶

This is true only if there is one single manufacturing firm and there are no costs to applying to a job. Otherwise the efficiency units per labor unit obtained by one firm may depend on the wages paid by other firms as will be shown below.

The idea underlying our analysis is that queues will screen workers because type H workers are willing to accept a higher probability of not obtaining a job since their fallback wage is higher.

The sequence of events is as follows. First all firms simultaneously offer to hire a certain amount of workers at a particular wage; then workers choose the firm to which they apply. If many firms offer the same wage, workers are divided equally among these firms. If a firm has more applicants than jobs offered, it rations the jobs randomly among the applicants. The unsuccessful applicants are self-employed.

It is assumed for the moment that there is full commitment on the part of the firms to the wages announced so that there is no renegotiation (this assumption is relaxed in Section 3).

⁶ v_H is the efficiency wage if $(a_L\mu + a_H(1-\mu))/v_H \geq a_L/v_L$, i.e. if

$$\mu \leq [a_H - (v_H a_L / v_L)] / (a_H - a_L).$$

Characterization of Equilibrium

We look for an equilibrium as follows. As we have said, the game is composed of two stages: in the first stage firms propose contracts and in the second stage workers choose where to apply. For every set of offers that the firms make in the first stage, there is a unique Nash equilibrium in the second stage. This implies that firms can calculate their payoffs from any set of contracts being offered. There is then a well-defined simultaneous move game between the firms in the first stage of the game. The equilibrium of the market is the Nash equilibrium of this first stage simultaneous move game.

Lemma 1. There cannot exist any "pooling" at the equilibrium; that is, in the equilibrium workers of both types cannot apply to the same kind of job.

Given a set of offers by the firms, each worker will apply to the job which maximizes his expected utility given what other workers are doing. If p is the probability of getting a job at a firm with wage w , then an individual of type i 's expected utility is

$$pU(w) + (1-p)U(v_i) = u_i(p;w)$$

where $U' > 0$, $U'' \leq 0$.

Figure 2 shows the indifference curves of types L and H through (w^*, p^*) where supposedly in equilibrium both types apply. The slope of the indifference curve for type i at this point is:

$$\frac{dp}{dw} = \frac{-p^*U'(w^*)}{U(w^*) - U(v_i)}$$

It is clear that the indifference curve of the more productive workers is always steeper (since they have a higher reservation wage v_i), as depicted in Figure 2. This means that if in the first stage of the game a firm raises its wage by a small amount, say to w' , it would find that its number of applicants increases until p reaches p' , where type H workers are indifferent between (w^*, p^*) and (w', p') while type L workers strictly prefer the former and hence in the equilibrium of the second stage of the game only type H individuals apply. Since there is a discrete change in quality mix with a marginal change in the wage, any firm deviating will have a discrete increase in its profits. Thus, an equilibrium has to entail complete separation: each type of worker applies to different kinds of jobs.

Separating Equilibria

If there exists a separating equilibrium, it must entail two wages, with queues at the high wage sufficiently long to discourage the low productivity workers from applying. Figure 2 illustrates such a situation with low wage w_L , high wage w_H and probability p of employment at the high wage job; type L apply to the low wage jobs.

A separating equilibrium must satisfy the following 6 conditions

$$(1) \quad \frac{a_H}{w_H} = \frac{a_L}{w_L} \text{ (equal profit condition)}$$

- (2) $U(w_L) \geq p_H U(w_H) + (1-p_H)U(v_L)$ (self selection condition)
- (3) $w_H \geq v_H$ (individual rationality constraint of type H)
- (4) $w_L \geq v_L$ (individual rationality constraint of type L)
- (5) $F'(a_L p_L \mu + a_H p_H (1-\mu)) = \frac{w_L}{a_L}$ (marginal condition)
- (6) In a two wage equilibrium $w_L > v_L$ and there are no queues at the low-wage firms.

The last condition requires some comment. If two wages are offered then if $w_L = v_L$, it is impossible to have self-selection (type L workers have nothing to lose by applying to a high wage firm). Then it must be that $w_L > v_L$. But then if $p_L < 1$, a low-wage firm could offer a wage lower than w_L and have any number of type L workers it wants (we are assuming firms are "small"). It would simply have a shorter queue. But its cost-per-efficiency unit would be lower than that of firms paying w_L .

We now specialize the model to risk neutrality, in which case (2) becomes (2').⁷

$$(2') \quad w_L \geq p_H w_H + (1-p_H)v_L \text{ (self selection with risk neutrality)}$$

When condition (2') holds with equality, conditions (1) and (2') can be summarized in:

$$(7) \quad w_L = \frac{(1-p_H)v_L}{1-(a_H/a_L)p_H}$$

Figure 3 shows all possible different equilibria using conditions (5)

⁷In the Appendix we explore the implications of risk aversion.

and (7) to obtain explicitly the low wage and p_H in equilibrium, denoted by p_H^*, w_L^* . If the solution entails $p_H < 0$, then $w_L^* = \max \{a_L F'(a_L \mu), v_L\}$, $p_H^* = 0$, i.e. there is a single, low wage offered, and there may be unemployment at that wage.

Proposition 2. The market equilibrium, if it exists, always involves $p_H < \frac{a_L}{a_H} < 1$ and is further characterized by one of the following three possibilities:

(i) $0 < p_H < 1$; the self-selection constraint satisfied with equality (binding)

(ii) $0 < p_H < 1$; the self-selection constraint satisfied with inequality (not binding)

(iii) $p_H = 0$: all firms pay a low wage ($< v_H$)

The fact that an equilibrium necessarily involves $p_H < \frac{a_L}{a_H}$ follows from Proposition 1 and because a separating equilibrium must satisfy the self selection (2) and the equal profit conditions which require $p_H < \frac{a_L}{a_H}$.

We now describe each of the cases in which equilibrium exists.

(i) Separating equilibrium with two wages offered and self selection condition satisfied with equality (see Figure 3(a)). Here the low wage is w_L^* and the probability of employment at high wage jobs is p_H^* . w_H^* is derived from condition 1.

(ii) Separating equilibrium with two wages offered and self selection condition satisfied with inequality (see Figure 3(b)). This happens

only if type L have the comparative advantage in manufacturing ($a_L/v_L > a_H/v_H$).⁸

(iii) Separating equilibrium with only type L workers hired. This happens if type L workers have the comparative advantage in manufacturing and $a_L F'(\mu a_L) \leq b$; or if type H workers have the comparative advantage, $a_L F'(\mu a_L) \leq v_L$ and v_L is the efficiency wage.

If type L workers have the comparative advantage there are two possibilities: if $v_L < a_L F'(\mu a_L) \leq b$ (see Figure 3(c)) the low wage is $w_L = a_L F'(\mu a_L)$ and all type L workers are hired; if $F'(\mu a_L) \leq v_L$ (see Figure 3(d)) the low wage is equal to v_L and the proportion of type L hired is given by condition (5).

If type H workers have the comparative advantage and v_L is the efficiency wage, then if $a_L F'(\mu a_L) \leq v_L$ the equilibrium low wage is v_L and the proportion of type L workers is again given by condition (5).

Interpretation: Queues

It is clear that in case (a) that the type H workers not hired in the

⁸ Formally, this case arises when the low wage at the intersection of the two curves is lower than $b = \frac{v_H a_L}{a_H}$. In this case $w_H = v_H$, $w_L = b$ and p_H is determined by condition (5). Intuitively, this situation arises when, given that all the type L workers have been hired, the demand for type H at $w_H = w_H$ is so low that, were they all to apply, queues would be so long as to deter all type L workers from applying.

manufacturing sector are involuntarily self employed: they would be willing to work for less than the current high wage. In this sense, considering self-employment as unemployment, this model has the same results as the other kinds of efficiency wage models. (And indeed, even if there were a period of time after failing to be hired in manufacturing before they could re-enter self employment--during which they were truly unemployed--our analysis would remain essentially unaffected.)

Proposition 3. There may exist no equilibrium.

This happens if v_H is the efficiency wage and $a_L F'(\mu a_L) \leq v_L$. In this case, if all firms are offering only to hire workers at a wage equal to v_L , any firm would find it profitable to deviate and offer v_H . Since the equilibrium can't involve pooling and the only possible separating equilibrium is not a subgame perfect equilibrium of the game above, there is no subgame perfect equilibrium in pure strategies.

Figure 4 illustrates the possible configurations in terms of the parameters μ and v_L .

Interpretation of Non-existence Result

There is a fundamental difference between the non-existence result of Proposition 3 and the non-existence result in the standard self-selection model. In that model, equilibrium does not exist when selection is "too costly" relative to the benefits, namely, whenever there are too few of the

"low" type or the low and high types are too close to each other. That is why there never exists an equilibrium when there is a continuum of types. By contrast, there may well exist an equilibrium here when there is a continuum of types, and it is the existence of large differences among the types--the high ability having a strong comparative advantage (making the high wage the efficiency wage) which leads to non-existence.

We can change the "game" to restore equilibrium: if (as in Riley [1979]) we assume that offers made by a firm can't be withdrawn and that offers can always lead to reactions by other firms, so that the game has no last move. The Reactive Equilibrium can be modeled as the outcome of a particular perfect Nash equilibrium of this game (Engers and Fernandez [1987]⁹). In the model considered in this paper, the non-existence result disappears with this new formulation because a deviation from the actual separating equilibrium always involves a pool at a higher wage and a new (profitable) offer by another firm can always make this deviation unprofitable.

Wilson [1977] changes the game so that there is a second stage after firms have proposed their offers when firms may withdraw unprofitable offers. In the Rothschild-Stiglitz insurance model, a pooling equilibrium can now be maintained since if a firm deviates from the pool and attracts

⁹Engers and Fernandez also give sufficient conditions for existence of a reactive equilibrium.

only the low-risk agents, the other firms are left only with high-risk individuals and incur losses so they withdraw their contracts and the deviating firm is left again with a pool but at a higher wage. In the present model, the same argument holds if there is free entry and hence in the pooling equilibrium each firm makes zero profits.

We believe that the particular formulation that best represents reality depends on the particular case at hand. In the labor market, it seems that the degree of competition among firms is sufficiently strong that the simple simultaneous move formulation of this paper is more accurate than these alternative formulations. The fact that for some cases, equilibrium fails to exist suggests that other changes to the formulation are appropriate. One such change is explored in Part IV below. More generally, we note that there are strong grounds for dropping the assumption of "perfect" competition; dealing with this properly would, however, take us beyond the scope of this paper.

Constrained Pareto Efficiency of Market Equilibrium

This section deals with the conditions that make it possible for the government to intervene in the market in such a way that every one is at least as well off as without intervention. Obviously this is only interesting if we assume (as is likely to be) that the government has the same information problems that firms have.

Intuitively, there appear to be three kinds of inefficiencies in the equilibrium of this model. First, when the high wage is above the reservation wage of type H workers, the marginal productivity of a type H worker is higher in manufacturing than in self-employment but still some of these workers are unemployed. This is the usual inefficiency of involuntary unemployment. Secondly (and related), firms hire workers up to the point where the value of their marginal product equals the wage, but the wage does not represent their opportunity cost. Thirdly, when the wage is below v_H and type H workers have comparative advantage in manufacturing, there is inefficiency in the allocation of labor since the workers in the self-employment sector are the ones with comparative disadvantage in that sector.

In the case in which the equilibrium entails hiring only type L workers, the efficiency properties depend on which type of worker has the comparative advantage in manufacturing. If type L workers have the comparative advantage in manufacturing, the equilibrium is the same as it would be with full information. If type H workers have the comparative advantage in manufacturing, the equilibrium is constrained Pareto Efficient (CPE). The reason is that since the equilibrium exists, v_L is the efficiency wage; this means they paying v_H would increase the cost per efficiency unit and hence profits would decrease. Even though in such an "equilibrium" efficiency is enhanced (labor is being allocated according to the principle of

comparative advantage) and type L workers are better off, there is no way to tax them to compensate the decrease in profits without at the same time making type H workers worse off.

The "slack separating equilibrium" is CPE since the self-selection constraint is not binding.¹⁰

If there is separation with two wages offered and the high wage is above the high reservation wage in equilibrium, the government can decrease the high wage and adjust the queue so that type H workers are not worse off. To maintain the self-selection constraint the low wage would have to increase. This is illustrated in Figure 5: the high wage decreases from w_H to w_H' and the probability of employment increases from p to p' . Type H workers remain on their original indifference curve. To maintain self selection, the low wage increases from w_L to w_L' and type L workers are strictly better off. But in order for this to be a Pareto improvement it must be that the combined profits of all firms do not decrease as a result of this policy. The details of the argument, including a proof that the reduction in high wage labor costs may exceed the increase in low wage labor costs, are provided in the appendix. Here we state the main results.

¹⁰If the government increases the proportion of type H's hired so that p increases then wages do not change (the self-selection condition is not binding). Using the marginal productivity condition one can check that the combined total profits of all firms would decrease.

Proposition 4.

(i) Whenever an equilibrium exists and v_H is the efficiency wage, it is not CPE.

(ii) If $F'[(v_H a_L - v_L a_H)/(v_H - v_L)] > v_H/a_H$, for any set of parameters $\{a_H, a_L, v_H, v_L\}$ there exists a level of μ, μ^* , such that for all $\mu < \mu^*$ the equilibrium involves two wages and is not CPE.

(iii) There are parameters $\{a_H, a_L, v_H, v_L, \mu\}$ for which type H has the comparative advantage in manufacturing and the two wage equilibrium exists and is CPE.

It is an interesting corollary of this proposition that the allocative inefficiency mentioned before is neither sufficient nor necessary for the equilibrium to be constrained pareto inefficient. That is, there are cases in which type H has the comparative advantage in manufacturing and the two wage equilibrium is CPE and there are cases in which type L has the comparative advantage in manufacturing and the two wage equilibrium is not CPE. Rather, the inefficiency occurs because of what (in the context of moral hazard) Arnott and Stiglitz call the "cross subsidization market failure." Standard competitive theory (with perfect information) entails decentralization, with each firm maximizing its own profits and no cross subsidies. Here, efficiency requires that the high-wage firms cross subsidize the low-wage firms. The cross subsidy shifts the self-selection constraint, enabling queues to be shortened.

We have restricted this discussion of Constrained Pareto efficiency to policy instruments directly related to the market in question. However, with a richer model in which there are other markets besides the labor market, it is possible that the government could do something in these other markets to induce a better outcome in the labor market. For instance, anything that affects the risk aversion of workers, or which, more generally, shifts the indifference curve of L-type workers, leads to changes in unemployment.¹¹

Comparative Statics

In this section we undertake two comparative statics exercises with the model developed in Section 1. First we consider the effects of changes in labor demand on employment and wages. Then we analyze how different parameter values imply different queues and unemployment in equilibrium. We take the equilibrium to be of the type in which two wages are offered in equilibrium. The equilibrium in that case was described in Figure 4 as the intersection of the demand for labor curve and the curve corresponding to equation (7), which we can think of as the wage setting curve, giving the wage which must be set (in equilibrium) for self-selection to occur, as a

¹¹In effect, anything which flattens the L-types indifference curve means that separation can occur with a lower level of unemployment. Commodity taxes may be able to do this. See Greenwald and Stiglitz [1986] or Arnott and Stiglitz [1985].

function of the level of employment.

Labor Demand Shocks

A negative shock to productivity (or any shock that affects the labor demand curve in a negative way) implies an increase in the size of the queue or the percentage of the high types who are unemployed. Wages, both high and low, decrease. How much they decrease depends on the type of the original equilibrium.

If the original equilibrium is a two wage equilibrium with the self-selection condition binding, then the slope of the wage setting curve determines how much wages decrease. This slope is

$$\frac{\partial w_L}{\partial p} = \frac{v_L(a_H/a_L - 1)}{\left(1 - \frac{a_H}{a_L} p\right)^2}.$$

If p is low, then this slope is small and wages would change relatively little with respect to changes in quantity; we would have a flat "wage setting curve" that fits the stylized facts. Note that the fact that p is small doesn't mean that unemployment is high because p is just the employment rate in the high productivity group. The unemployment rate u is

$$u = (1-\mu)(1-p).$$

If μ is sufficiently close to one, p may be small and still the unemployment

rate be small.

If the original equilibrium is a two wage equilibrium but with the self selection condition not binding, we saw before that the relevant "wage setting curve" is flat at the level b . In this case, for local shifts in the labor demand curve, wages do not change at all; only quantities adjust.

Cross Section Comparative Statics

We consider here what happens to the unemployment rate and wages when the productivity in the manufacturing sector of the different types of workers become more dispersed (when $a_H - a_L$ increases but $\bar{a} = \mu a_L + (1 - \mu)a_H$ remains constant). The idea is that this kind of parameter change gives us an idea as to how the dispersion of unobservable abilities in the population affects the unemployment level. We also consider how changes in the reservation wage parameters (v_L) affect the equilibrium unemployment rate.

a_L, a_H Comparative Statics. Assume that $a_H - a_L$ increases but the average productivity, \bar{a} , remains constant. In this case, both the labor demand curve and the wage setting curve shift up. Given our assumption of diminishing marginal productivity of labor, the labor demand curve shifts up because there are less efficiency units hired for each p (size effect). The wage setting curve shifts up because for each level of the low wage, w_L , the equal profit condition requires that w_H increase and hence the self selection

condition requires a lower p (selection effect). The selection effect is intuitive: as the difference in unobservable productivity—which is the source of the adverse selection problem—becomes more important, self-selection is more difficult to satisfy and unemployment is higher. These two effects go in the opposite direction.

We are interested in considering how different parameters imply different unemployment levels in equilibrium for groups which are observably different. As long as these groups are within the same sector of the economy (subject to the same labor demand), we can derive an unambiguous result about this. For this implies that the size effect is shared by both groups equally and hence for the comparison only the selection effect dominates. To understand this better, consider a subsector of an economy with two observably different groups of workers, both of which are composed of low and high productivity workers who are undistinguishable to the employer. Assume that both groups have the same average productivity but group 1 has a higher difference $a_H - a_L$ than group 2. Then group 1 will have a higher level of unemployment in equilibrium. To show this we reason by contradiction: if they both had the same p_H , by the selection effect, the wage for low productivity workers of group 1 would be higher than for low productivity workers of group 2; but then firms would prefer to hire from group 2 instead of from group 1.

This has the important implication that, if there are two groups in

the population with different observable characteristics (each constituting a different "labor market"), then unemployment in the group with greater dispersion in abilities may be larger. If dispersion (given observable characteristics) of abilities among unskilled workers is greater than among skilled workers, this theory could explain differences in unemployment rates across skills.

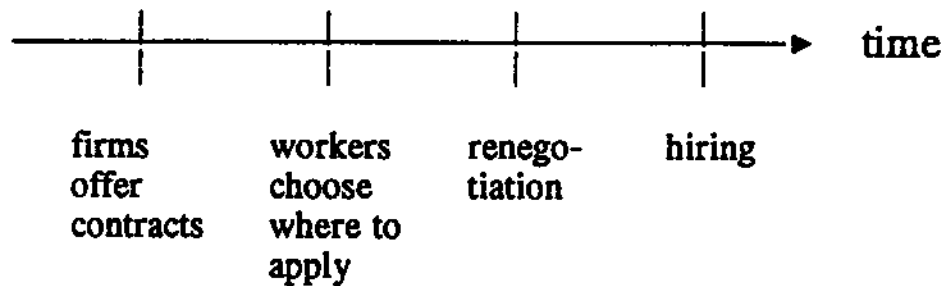
Reservation Wage Comparative Statics. Assume that v_L increases (v_H is irrelevant in the two wage-self selection binding-equilibrium). The only change is in the wage setting curve, which shifts up because now it is more difficult to satisfy the self-selection constraint. The result is an increase in unemployment. This result is similar to the result in Shapiro-Stiglitz (1984) where an increase in unemployment compensation leads to an increase in the unemployment level. The intuition is however different. Here what happens is that if outside opportunities reflect less the productivity of workers in the manufacturing sector, it is more difficult to get workers to self select, queues have to be longer and unemployment has to increase.

III. SEPARATING EQUILIBRIUM WITH RENEGOTIATION

Section 3 described the sequence of moves in the game. It was assumed there that there was no renegotiation of contracts at any point. We

relax that assumption in this section.¹²

In the separating equilibrium described in Proposition 2, high-ability workers are distributed equally among all firms paying high wages and each firm hires randomly from its queue. We assume now that, before telling each worker whether or not he has been hired, the firm can go to the applicants and offer a Pareto improvement: a higher probability of being employed, but at a lower wage. Notice that the firm can do this only after the workers have selected themselves, for if it did this before, it would get applications from the low ability workers. The time sequence of events is shown below:



In Figure 6, assume that the lottery the firm offers the workers is (w^*, p^*) . We have also drawn the isoprofit curve for the firm, given by

¹²Most models of asymmetric information involve inefficiencies in the mechanism of self-selection; this makes it likely that there are incentives for ex-post renegotiation (Compte [1991]). Hillas [1987] deals with this problem successfully in the model developed by Miyazaki [1977]: he shows that a renegotiation proof separating equilibrium exists in that model and it maintains all the qualitative properties of the original equilibrium concept.

$$\pi^* = F(a_H p_H^* N) - w^* p_H^* N \quad (15)$$

where N is the number of high ability applicants each high wage firm gets in the separating equilibrium derived in Section 1.

The isoprofit curve will first have negative slope and then bend backwards due to decreasing marginal productivity. Since the firm chooses how many workers to hire at w^* , at (w^*, p_H^*) the isoprofit curve must be tangent to the vertical line at w^* .

Notice that the indifference curve of type H workers and the isoprofit curve for the firm are not tangent at (w^*, p_H^*) . This leaves room for renegotiation. Assuming the firm has all the bargaining power, the new situation would be as in (w', p_H') where tangency occurs.

But the low ability type foresee that this renegotiation will occur and hence the equilibrium depicted in Proposition 2 would not "separate." For any proposed (w, p_H) in equilibrium, type L workers can see that after renegotiation the (w, p_H) pair will lay at the tangency between an isoprofit curve and the indifference curve of type H workers that crosses (w, p_H) . So we might as well have firms propose contracts that are not subject to renegotiation.

We assume that a firm can hire workers paying a uniform wage. At the low wage it is necessary for an equilibrium that the marginal product of labor be equal to the low wage. But at the high wage this is not the condition: for firms are, with respect to high skilled workers, not wage

takers but indifference (utility) takers. Once a firm has a number of workers asking for a job, it can renegotiate and increase its profits while not making any worker worse off in the ex-ante sense.

In equilibrium, a proportion m of firms will decide to pay low wages and a proportion $1-m$ will decide to pay high wages. The equal profit condition becomes more complicated because it is no longer a marginal condition as before. A two-wage equilibrium has, in addition to the individual rationality conditions, four other conditions:

$$a_L F'(a_L \mu/m) = w_L \text{ (marginal condition for low skilled workers)} \quad (16)$$

$$(w_H, p_H) \text{ solve } p_H w_H \max \{F(a_H \hat{p}_H(1-\mu)/(1-m)) - \hat{w}_H \hat{p}_H(1-\mu)/(1-m)\} \text{ s.t.}$$

$$\hat{p}_H \hat{w}_H + (1-\hat{p}_H)v_H = p_H w_H + (1-p_H)v_H \text{ (renegotiation-proof condition)} \quad (17)$$

$$w_L \geq p_H w_H + (1-p_H)v_L \text{ (self selection condition)} \quad (18)$$

$$F(a_L \mu/m) - w_L \mu/m = F(a_H p_H(1-\mu)/(1-m)) - w_H p_H(1-\mu)/(1-m) \text{ (equal profit condition)} \quad (19)$$

Condition (17) is equivalent to

$$F'(a_H p_H(1-\mu)/(1-m)) - v_H/a_H = 0 \quad (17')$$

The main results of this section are given in the following proposition.

Proposition 5. In the cases for which the equilibrium with binding contracts is characterized by (ii) or (iii) in Proposition 2, that equilibrium is renegotiation proof. If an equilibrium with binding contracts fails to

exist, then a renegotiation-proof equilibrium also fails to exist. There are parameters for which a renegotiation-proof equilibrium exists and involves the self selection condition satisfied with equality.

Proof. The first statement in the proposition follows from the fact that at an equilibrium in which there is only one wage or two wages with $w_H = v_H$ (which is the case when the equilibrium involves the self-selection condition satisfied with strict inequality), there is no incentive for renegotiation. Now we prove the last statement of the proposition. Fix all parameters except μ and let μ be equal to μ^* , where μ^* is such that the equilibrium is one in which there are two wages and the self selection condition is satisfied with equality but is not binding, that is, $w_L^* = b$, $w_H^* = v_H$, w^* given by (16), $p_L^* > 0$ and p_H^* given by (18) with equality. The proof will show that there is a neighborhood of μ lower than μ^* for which there exists a separating two-wage renegotiation-proof equilibrium for which the self selection condition is binding ($w_L^* > b$, $w_H^* > v_H$). Let

$$z(w_L, w_H, p, m, \mu) = F(a_L \mu / m) - w_L \mu / m - F(a_H (1 - \mu) p / (1 - m)) + w_H (1 - \mu) / (1 - m). \quad (20)$$

From equations (16), (17') and (18) one can obtain w_L , w_H and p as functions of m and μ when the self-selection condition is satisfied with equality. Substituting these functions for w_L , w_H and p in (20) we get

$$\pi(m, \mu) = z(w_L(m, \mu), w_H(m, \mu), p(m, \mu), m, \mu) = 0 \quad (21)$$

Note that equilibrium m is solved from $\pi(m, \mu) = 0$ and then one can obtain

the other variables from the other equations. Assuming $F()$ is twice continuously differentiable, the function $\pi(m, \mu)$ is continuously differentiable and hence, if we show that $\pi_m(m^*, \mu^*) \neq 0$, there is a continuously differentiable function $m(\mu)$ defined in an open neighborhood N of μ^* and such that $\pi(m(\mu), \mu) = 0$ for all $\mu \in N$. But in the space of fixed parameters and production functions, $\pi_m(m^*, \mu^*)$ is almost everywhere different than zero; hence we assume that $\pi_m(m, \mu) \neq 0$.

In order to show that $m(\mu)$ for $\mu \in N$ is a renegotiation proof equilibrium, we also need to show that $w_L \geq v_L$, $w_H \geq v_H$ and $0 \leq p \leq 1$. Since in the equilibrium with $\mu = \mu^*$, we have $w_L > v_L$ and $0 < p < 1$, then if we restrict to a neighborhood \tilde{N} of μ around μ^* , we need only worry about $w_H \geq v_H$ by continuity. (16) and (17') imply that $\pi_\mu(m^*, \mu^*) = 0$: Then $\frac{dm(0)}{d\mu} = 0$. This implies

$$\frac{dw_H(m^*, \mu^*)}{d\mu} = \frac{\partial w_H(m^*, \mu^*)}{\partial \mu}$$

and it is easily shown that the right hand term is negative; hence, if $\mu \in N$ ($N \cap \tilde{N}$) and $\mu < \mu^*$, then $w_H > v_H$ and a two-wage renegotiation-proof separating equilibrium exists. Q.E.D.

We have seen that in a two-wage renegotiation-proof equilibrium with $w_H > v_H$, profits of high wage firms are maximized along the indifference curve of the high-type worker. But this implies that such an

equilibrium is constrained pareto efficient: if the government decreases w_H and increases p so that type H workers remain on their indifference curve and also increases w_L to maintain self selection (the same policy unanalyzed in the previous section) then profits of both high- and low-wage firms decrease. This implies that the original equilibrium is CPE. This result is summarized in the following proposition.

Proposition 6. A renegotiation-proof equilibrium is CPE.

III. UNLIMITED APPLICATIONS IN A DYNAMIC MODEL

The Competitive Equilibrium with Multiple Applications

The previous sections have assumed that workers can apply to only one firm. Here, we make the more reasonable assumption that workers can apply repeatedly (and costlessly), but once they accept a job, they are committed. This means that the reservation wage is determined not just by the individual's fall back wage, but by the foregone opportunities that result from accepting a job.

As Guasch and Weiss [1980] point out, it would seem that in this market environment firms that enter late have an advantage over earlier entrants. Since an early entrant hires some of the lowest quality workers (those with reservation wages below that offered by the firm), the average quality of the applicant pool is improved for later entrants, at any wage greater than that offered by previous firms. The implications of this

advantage of being late are potentially serious: it would seem to deter firms from entering. We show, however, that if firms and workers have rational expectations, there exists an equilibrium where there is no advantage to being late.

The market equilibrium consists of firms offering sequentially higher wages. The quality of those applying at the higher wages is higher for two reasons: some of the lower quality workers have already been hired by lower wage firms, and higher ability workers enter the applicant pool at higher wages. We show that average ability increases (in equilibrium) just enough to offset the higher wage.

The formal structure of the problem is similar to that of our earlier model. If a worker with fall back wage v has a reservation wage of $w(v)$, he applies for all jobs with a higher wage. The higher the reservation wage, the higher the expected wage he gets, conditional on getting a job, but the lower the probability of getting a job. Thus, the choice of a reservation wage involves exactly the trade-off between wage and probability of getting a job described in Part I. There is one important difference: at any wage, there is not just one ability type applying but many, and the average ability of those applying is not related in a simple way to the $A(w)$ function derived in the first part of the paper. The analysis differs in one other fundamental respect: the non-existence problem, which played a prominent role in Part I, does not arise here.

The competitive equilibrium is characterized by the function $p(w)$ giving the probability of employment at the different wages. Acting competitively, no firm believes that it can change the distribution of employment probabilities. Worker optimization leads to a $w(v)$ function, giving the reservation wage of a worker with fall-back opportunity v . Firms then take $w(v)$ as given.

Profit maximization by firms implies that the efficiency units per wage must be both equal and maximal across all wage offers; no competitive firm would hire workers at any wage offering less than the highest ratio of efficiency units per wage. (All wages not offered must be associated with a lower ratio of efficiency units/wage). The wage-per-efficiency unit must equal the (value of the) marginal product of labor.

In general, equilibrium is described by a wage distribution. The first entrants offer a wage equal to the efficiency wage, which now must take account of the endogenous reservation wages of the workers. Subsequent entrants then work their way up the wage scale. Late entrants have both an advantage and a disadvantage of being late. The advantage is that some of the worst workers have already been hired so that the efficiency units-per-wage trade-off looks better at all wages above the first firm's offering. The disadvantage is that the first firm gets to offer the best efficiency wage. The first firm hires just enough labor at the first wage so that these two effects exactly cancel.

Proposition 7. In the case in which there are two types of labor,¹³ there are two possible patterns of equilibrium:¹⁴

1. **Single wage equilibrium.** This occurs when v_H is the efficiency wage. Then the first and all subsequent firms offer $w_H \geq v_H$; $w_H > v_H$ if there is full employment.
2. **Two wage wage-distribution.** Type-H workers have the comparative advantage in manufacturing, but the low wage is the efficiency wage. In this case, the high wage is v_H and the first firm will hire just enough workers at a wage w_L such that

- $$a_L/w_L = \left[\frac{(1-p_L)\mu a_L + (1-\mu)a_H}{(1-p_L)\mu + (1-\mu)} \right] / v_H$$
 (equality of efficiency units per wage)

- $w_L = p_H v_H + (1-p_H)v_L$ (reservation wage equation)

- $F'[p_L \mu a_L + p_H[(1-p_L)\mu a_L + (1-\mu)a_H]] = a_L/w_L$ (labor demand equation)

The reservation wage equation says that the lower-ability individuals are indifferent between applying to the low-wage job, and holding off for the high-wage job.

¹³In Appendix C we solve for the equilibrium of this model with a continuum of types and constant returns to scale.

¹⁴There are issues of subgame perfection that fall outside the scope of this paper. Here we characterize a Nash equilibrium of the model. The crucial element is that workers commit to a reservation wage at the start of the game.

Why is there always an equilibrium in this model where it may fail to exist in the one job application model? The critical difference is that application behavior here is determined by workers' beliefs about the market as a whole, beliefs which any single, competitive firm cannot alter. By contrast, with workers applying to one firm only, any single firm can affect his own applicant pool. Accordingly, in this model, firms can not break the high wage pooling equilibrium. If workers do not expect any subsequent wage offers to be forthcoming, then all workers will apply to the job at v_H ; but then no firm will find it in its interest to offer a job at any higher wage (so that the expectations are self-confirming).

A final remark is in order. We have assumed that workers commit to stay at the job at which they are first hired. One may wonder if this is a reasonable assumption. We explore this matter formally in Appendix D. Here we note that if it was up to the firms, they would choose to pay lower wages and allow their worker freedom to accept higher paying employment if they find any. The institutions that prohibit or impose costs on recontracting must arise from forces outside of our model.

Conclusions

In these concluding remarks, we draw out some of the more general methodological implications of our work, address some criticisms of the theory, and finally, try to place the theory within a more general

perspective.

Firms do worry about the effect of wage policies on the quality of their work force. This basic insight, and the observation that it can give rise to wage rigidities, and hence unemployment, seems incontrovertible. More problematic is the relative importance of this explanation of wage rigidities, as compared to other explanations which have been explored elsewhere.

We believe that these adverse selection effects play a role in cyclical movements: Greenwald and Stiglitz [1991] have emphasized that the uncertainty about the effect on quality associated with wage cuts provides a rationale for firms to reduce wages only slowly. Here, however, we have been concerned with constructing equilibrium models of unemployment.

Our paper has been able to address several of the important objections to earlier formulations of the adverse-selection efficiency wage model. First, and most importantly, we have shown how it can be formally modeled within the context of a competitive labor market, where each firm is small, and each firm takes the wage and hiring decisions of other firms as given.

The concern that there might not exist a competitive equilibrium, since later entrants are able to obtain workers at a lower cost per efficiency unit (the advantage to being late) has been addressed in Part IV; within a dynamic model with rational expectations, we have shown that the cost per

efficiency unit of all firms are identical.

The objection that, for most workers, self-employment is not the relevant fall-back opportunity, is again formally addressed in Part IV, where we show that what determines the individual's reservation wage is primarily foregone opportunities within the employment sector; yet the qualitative properties are the same as in the earlier analysis.

The concern about the "pooling" equilibrium which played a central role in earlier versions of adverse selection-efficiency wage models (Weiss [1980]) we showed was, in fact legitimate: with search costs, there cannot be a pooling equilibrium. The concern that, as a result, there might not be any equilibrium has also shown to be legitimate, though the non-existence problems, are rather different in nature than those explored earlier by Rothschild and Stiglitz [1976].

Finally, the concern that the standard description of the equilibrium could be "broken" through renegotiation has been shown to have some validity. Though there may exist a renegotiation-proof equilibrium, the conditions for existence are more stringent than in the absence of the possibility for renegotiation.

Methodological Remarks

There are two important lessons to be learned from the kind of modeling we have attempted here. First, we have seen how sensitive the

nature of the equilibrium (even its existence) is to certain institutional and technological assumptions. Secondly, our analysis suggests that great care needs to be taken in formulating appropriate equilibrium conditions in models with imperfect information. In the conventional model, market equilibrium is defined as having demand equal supply (full employment) and a single wage (for individuals who otherwise appear identical). But in a market equilibrium with imperfect information, we have shown that there may be a wage distribution and unemployment.

While we do not claim that the theory we have presented here provides the explanation of unemployment, we believe that it provides part of the explanation. Before commenting on the relationship between our theory and several alternatives, we briefly address several of the criticisms (beyond those which the models were designed specifically to address) that have been raised.

Some Criticisms

The first criticism concerns the seemingly peculiar prediction of the theory that the unemployment rate is highest among the most productive. Aren't unemployment rates in fact higher among the low skilled? This criticism reflects a misunderstanding of the model. The analysis provides a description of equilibrium within a well defined sub-labor market, among a group of workers who have otherwise identical characteristics. Skilled

workers and unskilled workers are not, in general, in the same labor market. Differences in the distribution of abilities, given the observed characteristics, as well as differences in search technologies can easily give rise to differences in unemployment rates between these different job groups which are consistent with the data, as the comparative statics analysis of our model showed.

A second criticism, raised equally against other efficiency wage theories, concerns the possibility of bonding—workers here are assumed to know their productivities, so why cannot they guarantee to their employer their abilities? There are by now a standard set of answers: for instance, the lack of capital to provide the bond, difficulties of ensuring that firms will not assert that the employee has failed to live up to his guarantee.¹⁵

A third criticism argues that if lack of information about individual

¹⁵For a discussion in the context of the effort-efficiency wage model, see the exchange between Carmichel and Shapiro-Stiglitz. Borrowing does not resolve this problem, so long as there is limited liability. This problem may be partly addressed by firm reputations. Having third parties be the beneficiaries leaves open the possibility of collusion between the two of the parties. Equally important, even if individuals are perfectly certain about their fall-back wage (an assumption we made not because of its realism, but because it simplified the analysis), they may be uncertain about their productivity on a particular job. (Our analysis did not assume that workers were better informed concerning their productivity in employment, only that they were better informed concerning their fall-back wage.) Moreover, if individuals have limited abilities to post bonds, then the maximum bond they can post defines one of the characteristics of individuals within a sub-labor market. If, given this and other observable characteristics, there remains some dispersion of productivities, then our analysis applies.

productivities were important, there are less expensive ways of remedying it. But if screening is imperfect and costly, it is surely inefficient to test everyone; the market should use what private information there is to induce some self-selection.¹⁶

Wage rigidities have played a central role in conventional theories of unemployment. Recent years have seen the development of implicit contract, efficiency wage, and insider-outsider theories, among others, to explain wage rigidities.

Each of these theories has its problems. For instance, though implicit contract theory does explain wage rigidities, the wage rigidities to which it gives rise do not necessarily cause unemployment (Newbery-Stiglitz [19]). This is not the occasion to provide a comprehensive review of these alternative theories. In our view, unemployment is a multi-faceted phenomena. No single theory provides a complete explanation. The theory which we have put forward here is, we suspect, an important element of a theory of unemployment in at least two contexts. First, it provides part of the explanation of the equilibrium level of search unemployment. Secondly, and perhaps more importantly, it provides part of the explanation of why, when the economy is shocked, firms are slow to adjust wages: they are uncertain about what other firms will do, and they know that if their wage

¹⁶See Rodriguez and Stiglitz [1992] for an exposition of a screening by test efficiency wage model.

becomes lower than that of other firms, it will have adverse effects on the quality of its labor force.

Appendix A

Generalizations of the Basic Adverse Selection Model

In this section, we consider three generalizations of the basic adverse selection model presented in section 2, to the case of risk aversion, multiple-period search, and a continuum of types.

A.1. Risk Aversion

With risk aversion, the equilibrium analysis is very similar to the one given above. In order to see the effects of different coefficients of relative risk aversion, we use the CRRA utility function:

$$U(x) = \frac{x^{1-\delta}}{1-\delta} \text{ where } \delta \text{ is coefficient of absolute risk aversion.}$$

Now conditions (1) and (2) give:

$$(8) \quad w_L \geq \left[\frac{(1-p)v_L^{1-\delta}}{1-p(a_H/a_L)^{1-\delta}} \right]^{1/(1-\delta)}$$

As δ increases, the size of the queue decreases and wages decrease. The result is intuitive because when workers are more risk averse, the certainty equivalent of a given lottery decreases and hence the self-selection constraint is less binding and wages can decrease.

A.2. A Multiperiod Version of the Model

Here we show that in a multiperiod version of the model presented above, in which a worker can apply only to one job per period the results are very similar.

Let the discount rate be β . Let V_H and V_L be the lifetime valuation of being employed at high and low wage jobs, respectively. At the

beginning of each period the low type worker can apply for a job. If he applies for a low wage job he gets V_L . If he applies for a high wage job and is hired he gets V_H ; if he is not hired he gets v_L for one period and the discount of the valuation next period, formally:

$$V = pV_H + (1-p)V_*$$

$$V_* = v_L + \beta \max(V, V_L)$$

From this we can derive that a condition for $V_L \geq V$ is:

$$V_L \geq C(p_H V_H + (1-p_H)v_L)$$

where $C = \frac{1}{1-(1-p_H)\beta}$

We see that the condition is very similar to Condition 2. With this formulation, the relation between the slopes of the indifference curves for the two types of workers is the same as in the analysis of the simple model above and hence the analysis of separation is very similar and the results the same.

A.3. Continuous Case: Generalization of the Non-Existence of Equilibrium Result

In this section the model in Section 3 is generalized in order to show that the non-existence problem is quite general.

There is a continuum of workers with mass 1 with reservation wages v in $V = [v_0, v_1]$. The density function in V is $g(v)$. $a(v)$ is the productivity of type v workers, and we normalize to that $a(v_0) = 1$. A crucial assumption for this analysis is that $a(v)$ is increasing. We also assume for simplicity that $a(v)$ is differentiable.

The equilibrium is characterized by a wage, queue schedule, or

$\{w(v), p(v)\}$ and a cut off level v_c such that workers with a reservation wage above v_c are all self-employed. This will in general be below v_1 ; the reason for the existence of this cut-off level will become clear below.

The equal profit condition implies for all wages paid:

$$\frac{w(v)}{a(v)} = \frac{w(v_0)}{a(v_0)} = w(v_0) \equiv w_0 \text{ for all } v, \text{ and hence}$$

$$w(v) = w_0 a(v) \text{ for all } v \quad (\text{A1})$$

The self selection constraint implies:

v^* maximizes $p(v)w(v) + (1-p(v))v^*$ with respect to v , for all v^* in

V . A sufficient condition for this to hold is

$$p'(v)(w(v)-v) + p(v)w'(v) = 0 \quad (\text{A2})$$

for all v and $p(v)$ decreasing (from the second order condition). Using (A1) this implies

$p'(v)(w_0 a(v)-v) + p(v)w_0 a'(v) = 0$ for all v (this is sufficient for $p(v)$ decreasing by $a'(v) > 0$).

Integrating (A2) and using $p(v_0) = 1$ (which follows from the same argument made in Section 1) as boundary condition we get

$$p(v; w_0) = \exp\left[-\int_{v_0}^v \phi(v; w_0) dv\right], \quad (\text{A3})$$

where $\phi(v; w_0) = \frac{w_0 a'(v)}{w_0 a(v) - v}$.

From (A1) and (A3) we see that w_0 determines completely the $\{w(v), p(v)\}$ schedule.

$$\text{Let } E(v_c; w_0) = \int_{v_0}^{v_c} p(s; w_0) a(s) g(s) ds; \text{ this is the}$$

total number of efficiency units hired by all firms given w_0 , wages are separating and only workers up to reservation wage v_c are hired. It is easy to check that $E(v_c; w_0)$ is increasing in both v_c and w_0 .

Since the cost of an efficiency unit is w_0 and the same for all possible wages, the marginal condition, analogous to condition (3) in Section 1, is

$$F'(E(v_c; w_0)) = w_0. \tag{A4}$$

We denote the solution of (A4) for a fixed v_c by $w_0(v_c)$. So long as $F'(E(v_0; v_0)) > v_0$, $w_0(v_c) > v_0$ for some v_c . Since $F'' \leq 0$, $w_0' \leq 0$.

v_c is defined by

$$w_0 a(v_c) = v_c \tag{A5}$$

$$w_0 a(v) \leq v \text{ for all } v > v_c.$$

The simultaneous solution to (A4) and (A5) is the market equilibrium--if it exists.

For this to be an equilibrium we need that no firm wants to deviate and offer wages higher than $w(v_c)$ to attract workers with reservation wages

higher than v_c .¹⁷ This requires that¹⁸

$$w_0 \leq \frac{v'}{a(v_c; v')} \text{ for all } v' \geq v_c, \text{ where} \quad (\text{A6})$$

$$a(v_c; v) = \left[\frac{1}{G(v) - G(v_c)} \right] \int_{v_c}^v a(s)g(s)ds$$

This condition guarantees that the cost per efficiency unit that a firm would have to pay if it deviates is not lower than the cost per efficiency unit in equilibrium.

If $v/a(v)$ is increasing, so that the efficiency wage is v_0 , the existence of the separating equilibrium is guaranteed. If $v/a(v)$ is not always increasing then it is quite possible that there is no competitive equilibrium. This may be the case if $v/a(v)$ is first increasing and then decreasing; the efficiency wage can be either at a low value of v or at a high value. In this case there may be no pair $\{w_0(v_c), v_c\}$ that satisfies (A4), (A5) and (A6). Another possibility is that $v/a(v)$ is u shaped so that the efficiency wage is at an intermediate value of v . In this case it may happen that no pair

¹⁷It is never profitable for a firm to deviate with a set of contracts. This would be beneficial only if by offering a set of wages a firm could induce some separation; but since firms are small (in the sense that no firm would ever want to hire more than the density of workers for any type) no firm can achieve this.

¹⁸Workers with reservation wages less than v_c will not deviate to this higher wage offer since the probability of employment there is almost zero since firms are small compared to the number of workers with reservation wage between v^c and the wage offered by the deviating firm.

$\{w_0(v_c), v_c\}$ satisfies conditions (A4) and (A5) together.

Intuitively, if the efficiency wage is for a high wage, say w^* , then all firms would prefer to offer that wage; but in order to offer that wage, all wages below must also be offered. With decreasing returns, it may be that the manufacturing sector is not large enough to employ all the labor that must be employed in order to offer all wages up to w^* and satisfy the self selection conditions. But then, some firm will find it profitable to deviate and offer w^* . What this implies is that there cannot exist a fully separating equilibrium. But by the usual arguments, there cannot exist an equilibrium in which some firms hire an interval of types. Hence, again, there cannot exist an equilibrium. For a more extensive discussion on the nature of this non-existence problem see Rodriguez [1991].

Appendix B

Proof of Proposition 3:

If there is separation and two wages offered in equilibrium, the government can decrease the high wage so that the queue decreases and low wages increase. But in order for this to be a pareto improvement it must be that the combined profits of all firms does not decrease as a result of this policy. The following is a condition that is necessary and sufficient for this:

$$\text{Condition (A): } p > b_1 + b_2\mu$$

where

$$b_1 = \frac{(v_H a_L - v_L a_H)}{a_H(v_H - v_L)} \text{ and } b_2 = \frac{v_L(a_H - a_L)}{a_H(v_H - v_L)}.$$

This condition is obtained as follows. w_H decreases and p_H increases so as to leave type H workers on the same indifference curve. One can easily check that this implies:

$$\frac{dp}{dw_H} = - \frac{p}{(w_H - v_H)} < 0.$$

Also, w_L increases to maintain the self selection condition. This implies that

$$\frac{dw_L}{dw_H} = p(1 + (w_H - v_H)) \frac{dp}{dw_H} < 0.$$

Denoting profits by π , we know that

$$\pi = F(a_L\mu + a_H(1-\mu)p) - w_H(1-\mu)p - w_L\mu.$$

If $d\pi/dw_H < 0$, then a decrease in w_H implies an increase in the low wage and an increase in profits; this would certainly be a pareto improvement. It just requires some algebra to show that when the self selection condition is satisfied with equality, the condition for $d\pi/dw_H < 0$ is precisely condition (A).

The equation describing p^* ,

$$a_L F'(a_L\mu + a_H(1-\mu)p^*) = v_L(1-p^*)/(1-(a_H/a_L)p^*)$$

and the condition

$$p^* \geq b_1 + b_2\mu = \zeta(\mu)$$

define a set of parameters for which the equilibrium is not CPE. The remainder of the Appendix characterizes this set. In terms of Figure 5, we show that all points in region A (the two wage separating equilibrium with v_H the efficiency wage) and the northern part of region B (the two wage separating equilibrium with v_L the efficiency wage) are not CPE, while in the rest of the diagram the equilibria are CPE.

First note that $\zeta(1) = \frac{a_L}{a_H}$. Let μ' be defined implicitly by

$$b_1 + b_2\mu' = 0.$$

It can be shown that $\mu' < 0$ if $\frac{a_L}{v_L} > \frac{a_H}{v_H}$.

It is easily checked that μ' is also the level of μ that solves:

$$\frac{a_L}{v_L} = \left[\frac{\mu' a_L + (1-\mu') a_H}{v_H} \right]$$

that is, for $\mu < \mu'$, the efficiency wage is v_H .

p also varies with μ ; denote $p(\mu)$ the equilibrium p as a function of μ . It is clear that $p(\mu)$ is increasing. When type L has the comparative advantage in manufacturing, p is zero (only type L workers hired) for an interval $\{\mu'', 1\}$, where μ'' is defined implicitly by

$$F'(a_L \mu'') = \frac{v_H a_L}{a_H}.$$

When type H workers have the comparative advantage in manufacturing an equilibrium doesn't exist for an interval $\{\mu''', \mu'\}$, where μ''' is defined implicitly by

$$F'(a_L \mu''') = \frac{v_L}{a_L}.$$

For μ such that $\mu \geq \mu'$ and $\mu \geq \mu'''$ then p is zero.

Note also that $p(1) < \eta(1) = \frac{a_L}{a_H}$.

With these definitions it is easy now to prove the proposition.

(i) If v_H is the efficiency wage then $\mu < \mu'$ and hence $b_1 + b_2 \mu < 0$. If a two wage equilibrium exists it has $p > 0$ and hence condition (A) is satisfied.

(ii) There are three possibilities in terms of the set of parameters

(a_H, a_L, v_H, v_L) :

a) $\frac{a_H}{v_H} \leq \frac{a_L}{v_L}$. Then equilibrium $p(\mu)$ exists for all μ .

If $p(\mu)$ tends to a point above $\eta(0) = b_1$ as μ goes

to zero, then there exists μ^* with $0 < \mu^* < 1$ such that for $\mu < \mu^*$, the equilibrium is not CPE. The condition for $p(\mu)$ to tend to a point above b_1 as μ goes to zero can be derived to give:

$$F' \left[\frac{v_H a_L - v_L a_H}{v_H - v_L} \right] > \frac{v_H}{a_H}.$$

- b) $\frac{a_H}{v_H} > \frac{a_L}{v_L}$ and $\mu''' \geq \mu'$. In this case an equilibrium always exists and there exists a level of μ , μ^* , such that $p(\mu^*) = \zeta(\mu^*)$. For $\mu < \mu^*$ the equilibrium is not CPE and for $\mu \geq \mu^*$ the equilibrium is CPE.
- c) $\frac{a_H}{v_H} > \frac{a_L}{v_L}$ and $\mu''' < \mu'$. An equilibrium exists if and only if μ is not in the interval $\{\mu''', \mu'\}$. If $\mu < \mu''' < \mu'$ an equilibrium exists and condition (A) holds, since $\zeta(\mu) < 0$ and $p(\mu) > 0$, so the equilibrium is not CPE.

Part (iii) of the proposition follows because for the set of parameters implied in (b) above with $\mu > \mu^*$, type H workers have the comparative advantage in manufacturing and the equilibrium is CPE.

Appendix C

Workers are forced to trade-off between losing the chance for high salaries by joining low wage queues and increasing the probability of getting no job at all by postponing joining low wage queues. We assume workers are risk neutral. At the lowest wage job that they apply for, workers will be indifferent between being hired and being turned away. Their lowest acceptable salary is their expected salary. To see this, let $r(v)$ reservation wage of type v worker $m(w,r)$ chance of employment at a wage between w and r for a worker who enters the job market at r .

The probability of getting a job at wage w is the probability of not having been hired until then, $1-m(w,r)$ times $h(w)$, the proportion of applicants at wage w who are hired.¹⁹ Thus $\partial m/\partial w = [1-m]h(w)$ and integration yields

$$m(w,r) = 1 - \exp \left[- \int_r^w h(v)dv \right] \quad (C1)$$

If $\rho(v,r)$ is the expected salary of a worker with self-employment v , and reservation wage r , then

$$\rho(v,r) = \int_r^\infty [1 - m(w,r)] h(w)w dw + v[1 - m(\infty,r)] \quad (C2)$$

¹⁹Mathematically, not being hired at wage w is like not observing any blips in a poisson process that has a density h .

A worker's expected salary is an average of the wages available, weighted by the probability of getting them.

The risk neutral individual sets r to maximize (C2):

$$\frac{\partial \rho}{\partial r} - h(r)r - \int_r^{\infty} \frac{dm(w,r)}{dr} h(w)dw - v \frac{dm(\infty,r)}{dr} = 0.$$

But from (C1)

$$\frac{\partial m}{\partial r} = -(1-m)h(r).$$

Hence

$$\begin{aligned} \frac{\partial \rho}{\partial r} &= h(r) \left\{ \int_r^{\infty} (1-m(w,r))h(w)dw + v[1-m(\infty,r)] - r \right\} \\ &= h(r) \{ \rho(v,r) - r \} = 0, \end{aligned} \tag{C3}$$

so finally:

$$r = \rho(v,r) \tag{C3'}$$

Without ambiguity, we shall denote the reservation wage of an individual with ability v (the solution to C3') as $\rho(v)$.

The optimal wage at which to enter is a worker's expected wage. At any lower wage he would rather not be hired, but starting at any higher wage implies that he forfeits acceptable opportunities.

The actual number of jobs of type w is $n(w)$. Thus, $n(w)/h(w)$, the number of workers seeking jobs of wage w , may be characterized by the sum of workers who are in the market but have not been hired by the time a firm offers wage w . Let $\psi(w)$ denote the reservation wage of the most able person applying at wage w . ψ is found by solving for the inverse of $\rho(v)$.

$$\frac{n(w)}{h(w)} = \int_0^{\psi(w)} [1 - m(w, \rho(v))] f(v) dv. \quad (C4)$$

Firms offering wage w are interested in the average productivity of their employees, $\bar{A}(w)$; where

$$\bar{A}(w) = \frac{H(w)}{n(w)} \int_0^{\psi(w)} a(v) [1 - m(w, \rho(v))] f(v) dv. \quad (C5)$$

The criterion determining the competitive equilibrium is

$$\bar{A}(w) = kw. \quad (C6)$$

The cost per efficiency unit of labor must be the same for all wages that are offered. Only if this condition is met will firms be indifferent between offering any of the wages in the distribution.²⁰ The marginal cost of

²⁰Because firms may offer a multiplicity of wages, they will not be constrained by an insufficient supply of labor (efficiency units). If a firm needs more than $N(w)$ then it will also hire employees as $w + \epsilon$, until the supply, $\int_w N(x) dx$, satisfies their demand.

offering higher wages is exactly offset by the higher quality.

Nalebuff and Stiglitz [1983] show how (C6) can be converted into a simple non-linear second order differential equation. Standard theorems on the existence of solutions to second order differential equations provide sufficient conditions to ensure the existence of a competitive equilibrium.

Appendix D

In this Appendix we show that recontracting arrangements indeed dominate no recontracting agreements. Firms would choose to pay lower wages and allow their workers freedom to accept higher paying employment if they find any. The institutions that prohibit or impose costs on recontracting must arise from forces outside of our model.²¹

The simplest model within which to investigate these questions entails a slight simplification of our earlier analysis. We assume there are two periods of search. We first present the no-recontracting solution. In order to keep productivity/wage constant a worker of type v must be induced to apply for the same salary job in both periods. That is, the higher fallback wage in the firms period must be counterbalanced by a lower probability of employment.

We start by considering the decision made in the second period where workers of type v (fallback self-employment wage) who have not found work choose w to maximize

$$\frac{v + \beta(w\tau(w) + v(1-\tau(w)))}{1 + \beta} \tag{D1}$$

²¹We have, for instance, ignored firm specific information and training costs.

where $\tau(w)$ is the probability of finding a job paying w in the second period and β is the discount rate. Let $w(v)$ be the wage that maximizes (D1) and $\zeta(v)$ the maximized value. We can solve for $\tau(w)$:

$$\frac{\tau'(w)}{\tau(w)} = \frac{-1}{w-v}. \quad (D2)$$

Let $v(w)$ be the reservation wage of a worker who applies to a job with wage w ; that is $v(w) = w^{-1}(w)$. The condition for a competitive equilibrium price distribution,

$A(w) = a(v(w)) = kw$, implies $v(w) = a^{-1}(kw)$. This defines $\tau(w)$:

$$\frac{\tau'(w)}{\tau(w)} = \frac{-1}{w-a^{-1}(kw)}. \quad (D3)$$

In the previous period, we replace v by the "expected" fallback, $\zeta(v)$. The distribution of employment probability in the first period is $h(w)$. The equilibrium condition below defines $h(w)$:

$$\frac{h'(w)}{h(w)} = \frac{-1}{w-\zeta(v)}. \quad (D4)$$

The equilibrium without binding contracts is similar but more difficult to characterize.²² Here we consider the stability of these

²²The interested reader is referred to Nalebuff and Stiglitz [1983].

contractual arrangements. Imagine all firms are in the no-recontracting equilibrium. We will show that a firm would like to enter and offer a recontracting option. In the no-recontracting equilibrium a worker with fallback wage v expects to earn $\hat{\rho}(v) = h(w_0)(1+\beta)w_0 + [1 - h(w_0)](1+\beta)\zeta(v)$ if he applies to a job with wage w_0 . In order to attract a worker of type v to the new firm which allows recontracting, the entrant would need to guarantee the same expected salary. With a $\mu(\bar{w}_0)$ chance of employment at the recontracting firm, expected salary is

$$\rho(v) = \mu(\bar{w}_0)[(1+\beta)\zeta(\bar{w}_0)] + (1 - \mu(\bar{w}_0))(1+\beta)\zeta(v).$$

Since $\zeta(x) > x$ for all x , there is thus a salary $\bar{w}_0 < w_0$ for which $\zeta(\bar{w}_0) = w_0$, which will induce the same length of queues and the same quality of applicants. A firm offering recontracting is able to use the second period's conditional expectations to raise its workers' expected salaries. Identical workers will be attracted to the lower wages at the recontracting firm. In particular a firm allowing recontracting could offer a wage below the minimum wage offered by a non-recontracting firm and obtain the same quality of labor. The converse is also true. If all firms offered recontracting contracts, a firm which announced it would not allow recontracting would find that at the same wages, it faced a shorter queue and obtained lower quality workers. Thus, the recontracting equilibrium is "stable."

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Figure 1

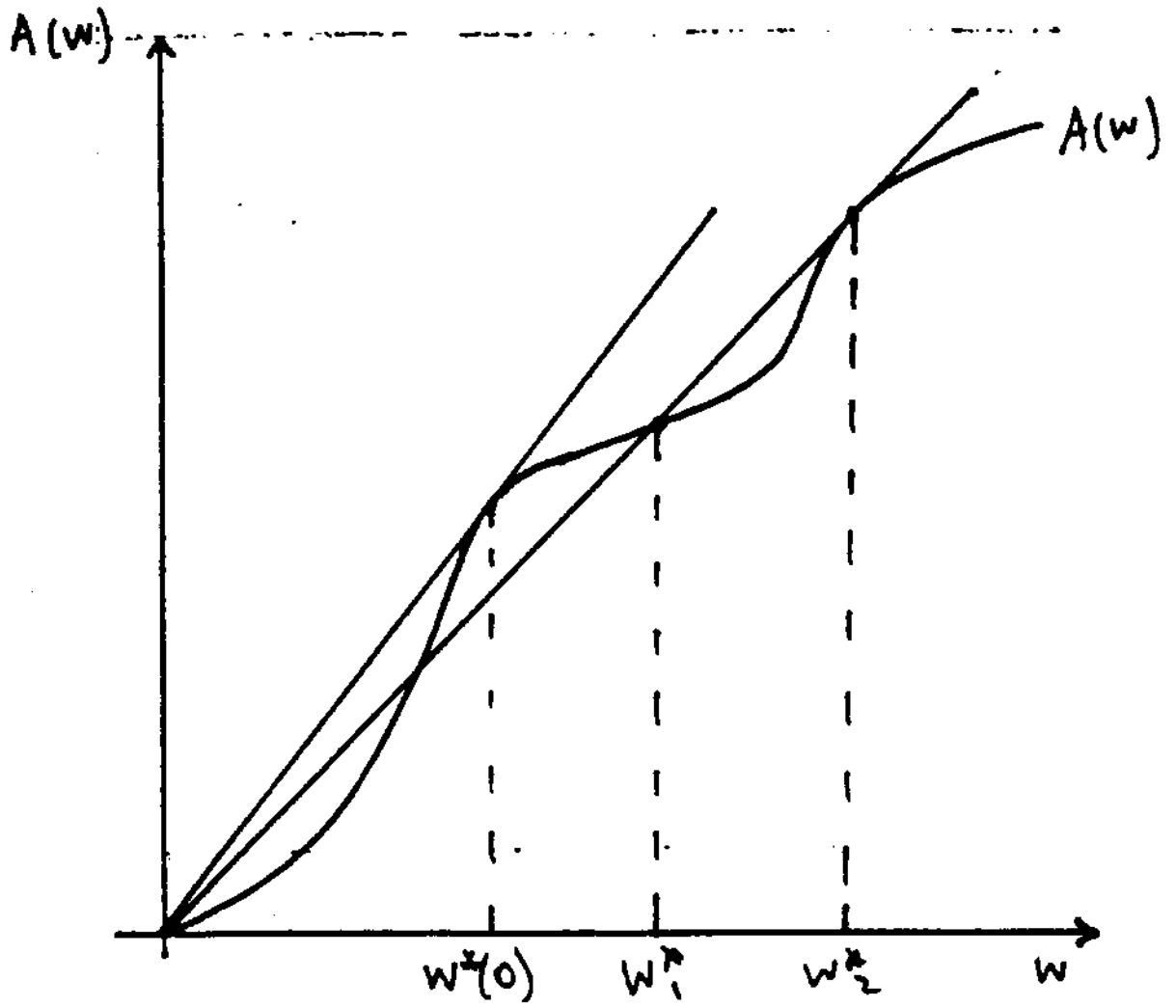


Figure 2

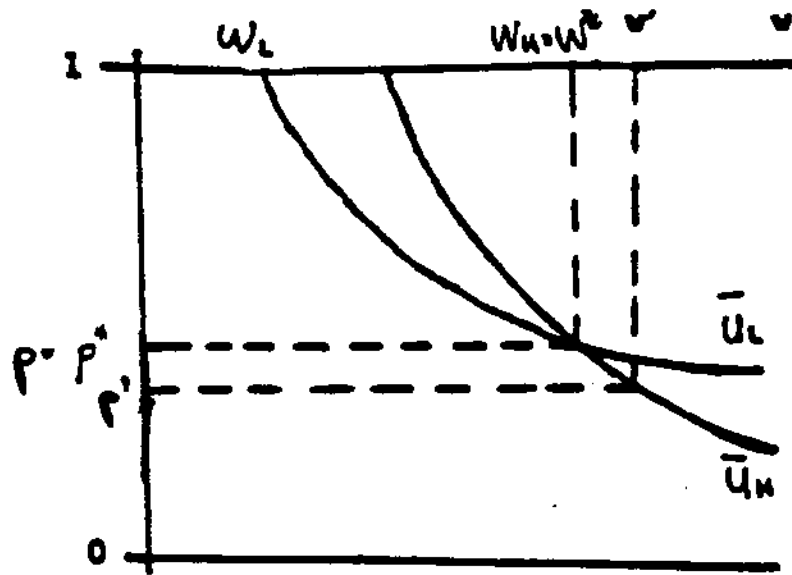
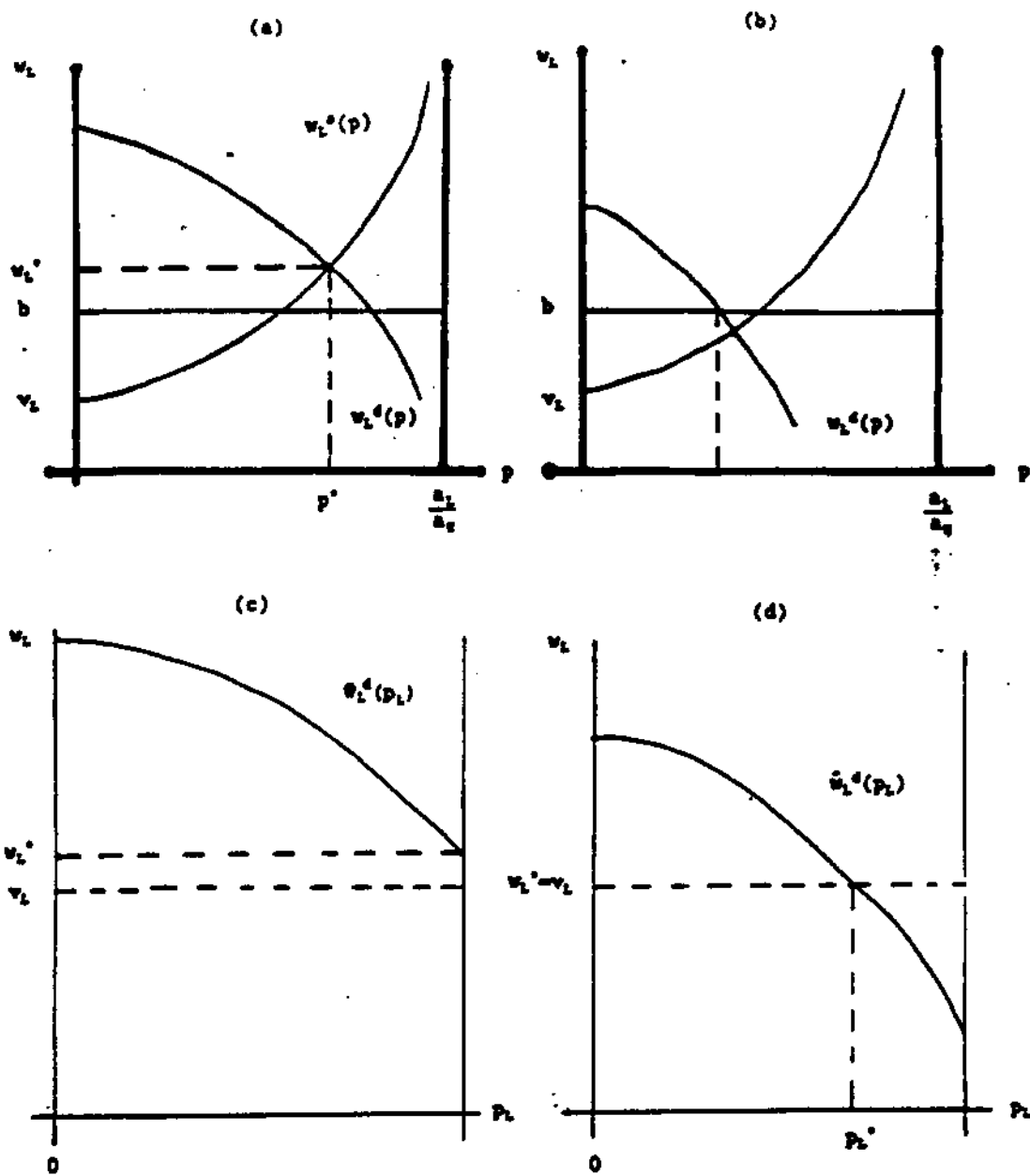


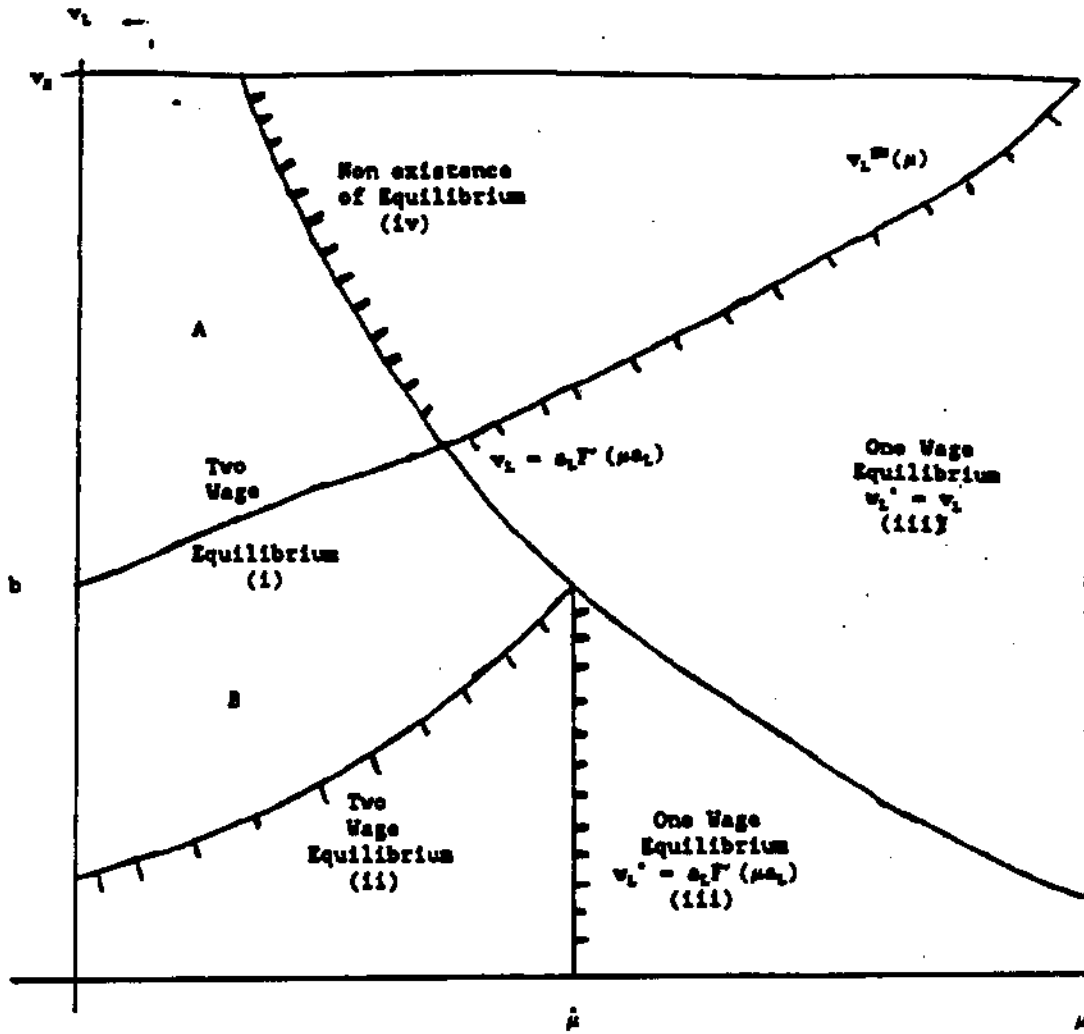
Figure 3



where $w_L^s = \frac{v_L(1-p)}{1-(a_1/a_2)p}$

$w_L^d(p) = a_2 F'(pa_L + (1-p)a_2)$ and $\theta_L^d(p_L) = a_2 F'(pa_L p_L)$

Figure 4



where $a_2F(\hat{\mu}_2) = b$

$v_1 \geq v_1^*(\mu) = v_2$ is off wage

Figure 5

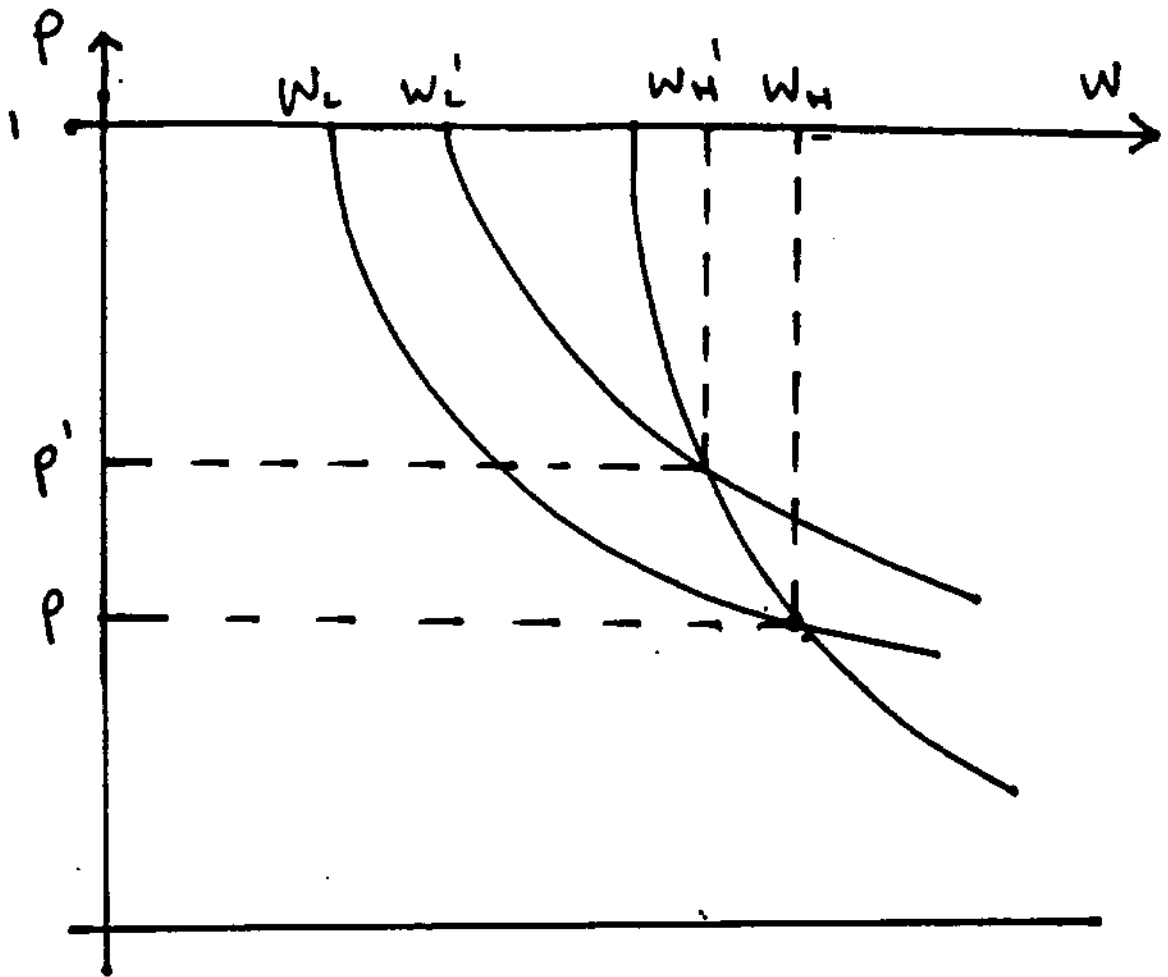


FIGURE 6

