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A signaling theory of unemployment*

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This paper presents a signaling explanation for unemployment. Employment at an unskilled job may be regarded as a bad signal. Therefore good workers who are more likely to qualify for employment at a skilled job in the future may be better off being unemployed than accepting an unskilled job. We present conditions under which all equilibria satisfying the Cho–Kreps intuitive criterion involve unemployment. However, there always exist balanced-budget wage tax and subsidy schedules that eliminate unemployment and increase the expected incomes of all workers. Moreover, unemployment can be eliminated with tax schedules that do not raise any revenue, and that place very weak informational demands on policy makers; however these tax schedules do not always increase the expected income of every worker.

1. Introduction

Several information theoretic (or efficiency wage) models have recently been proposed to explain persistent involuntary unemployment. They explain downward wage rigidities by the productivity enhancing effects of high wages. In these models wage cuts lower the quality of the firm's workers (the adverse selection effect), decrease their output, increase their quit rate (the incentive effect), or in other ways cause workers to act against the firm's interest.[1]

We offer a different information theoretic explanation of unemployment. In our model employment at an unskilled job serves as a bad signal to firms hiring workers for skilled jobs. Workers may therefore refuse unskilled jobs to avoid the associated bad label.[2]

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[1]See Weiss (1991) for a survey of efficiency wage models of unemployment.

[2]Although this unemployment is 'voluntary', it may nonetheless be socially devastating. Even among members of groups that have the worst labor market experience, a significant proportion of total unemployment appears to be voluntary. For instance 54% of black males aged 16–19 in poverty neighborhoods report that 'The people [they] know who are unemployed could find work if they really wanted.' See Daitcher-Loury and Loury (1986), We are not, however, arguing that our model explains the high unemployment rates of black youth. Rather we claim that our model provides insight into some aspects of unemployment.

In previous efficiency wage models, workers never refuse jobs. Those models can only be extended to encompass voluntary unemployment if one of the following auxiliary assumptions is made: Either the cost of finding a new job is higher for the employed than for the unemployed, or the jobs that are being rejected are offering wages below the reservation wage of the unemployed.

There are difficulties with each of these assumptions. First, our reading of the evidence on the cost and efficacy of search suggests that search costs are no higher for employed than for unemployed workers. For instance, surveys of workers indicate that the best source for information about jobs is contacts at work.[3] Second, the argument that unemployed workers have reservation wages that are higher than offered wages is not an explanation of unemployment. The relevant question is *why* the unemployed have reservation wages above current wages.

In our model there are equilibria in which taking an unskilled job is sufficiently damaging to the future employment prospects of a (skilled) worker that he will choose unemployment even if there is no disutility from work. This is because taking an unskilled job may be a worse signal than unemployment. Our model explains unemployment which may arise from these signaling effects.[4]

The following stories may be helpful. In August a Ph.D. student has her grant unexpectedly terminated for reasons independent of her performance. Suppose she has already completed the research for her Ph.D. Should she take a temporary job at a junior college immediately or remain in graduate school for another year and apply for faculty positions in major universities later in the year? The consensus response among those economists we have asked has been that the student should remain in graduate school. The reason given has been that taking a 'lousy job' is a very bad signal. Another thought experiment: Workers are laid off due to an unexpected plant closure.

[3]Corcoran et al. (1980) report that roughly half of all workers know someone who worked for their current employers before they got their first job there. Rosenfeld (1977) found that roughly the same number of employed people were actively searching for (other) jobs as were unemployed workers.

[4]McCormick (1990) also obtains the result that least able workers choose low-skilled jobs and more able workers choose unemployment. While our paper is about the interaction between signaling and testing, in the McCormick model there is no testing, and signaling plays an insignificant role. McCormick (1990) uses a standard search model, with a worker's productivity in the skilled sector entering directly into the worker's utility function (independently of the wage). This causes the opportunity cost of search to be correlated with worker productivity. Consequently the most productive workers pay search costs to immediately re-enter the high wage sector; medium productivity workers incur some unemployment to facilitate their job search; and low productivity workers take low wage jobs and re-enter most slowly. This result is due solely to the utility function chosen, and not to imperfect information or signaling. Signaling in that model merely changes the partitions between workers choosing high wage jobs, unemployment, and low wage jobs. The McCormick paper also ignores game-theoretic issues such as multiple equilibria, and classification of equilibria into pooling or separating ones.

The plant will reopen in three months under new management. Suppose all the able workers spend the three months fixing up their houses, while some other workers take jobs at McDonalds. We would argue that the new management will construe employment at McDonalds as a bad signal, and workers who have worked in McDonalds will be offered worse jobs upon being rehired. Workers who think they will satisfy the hiring standards of the new management can avoid the bad label by refusing jobs at McDonalds.

The key assumption in our model is that workers possess private information about their own abilities which is correlated with employers' evaluations. There is a potential gain to employers from using this private information (along with their own evaluations) to select among job applicants who are observationally indistinguishable. Therefore workers with favorable private information wish to signal this to employers. One way of signaling favorable information is for a worker to take a costly action for which the expected benefit is positively correlated with his private information.

Unemployment can be a useful signal if the signaling benefit from unemployment is greater for workers with good messages. Suppose employers screen applicants,[5] and the probability of passing this screening is positively correlated with workers' private information. Then unemployment would be an effective signal: The benefit from unemployment only accrues to workers who pass the hiring exam, and passing is more likely for workers with good messages. Because this signaling property raises the cost of taking a low wage (unskilled) job for all workers, it can lead to equilibria in which workers choose to be unemployed rather than taking unskilled jobs.

Even if the probability of passing the hiring test is uncorrelated with workers' private information, unemployment can still serve as an effective signal. This would be the case if the cost of unemployment were negatively correlated with the productivities of workers. For example, the productivity in home production may be positively correlated with productivity in the workplace and with workers' messages. As a second alternative, we could have allowed for risk averse workers and assumed that more productive workers either have more wealth, better access to credit, or higher earning spouses. We have ignored these effects. Including them would broaden the range of parameter values at which socially inefficient unemployment can occur.

Depending on the parameter values of the model, sequential equilibria exist in which all workers choose unemployment, all workers accept unskilled jobs, or some workers choose unemployment while others choose unskilled jobs. Perhaps surprisingly, for some parameter values of the model, sequen-

[5]Barron et al. (1987) report that for the 2,336 firms in the EOPP survey the mean number of screened applicants per accepted applicant is 9.

tial equilibria that satisfy the Cho–Kreps intuitive criterion must entail (some) unemployment.[6]

The main policy implication of our model is that there always exist balanced-budget taxes and subsidies that increase the expected income of all workers. Under these tax schedules full employment is the *unique* sequential equilibrium. These tax schedules do not require taxing unemployment or basing taxes or subsidies on workers' employment history; nor do they require that the government have information that is not known by firms. Furthermore if all that is demanded is the elimination of unemployment, it can be achieved by tax schemes that do not collect any taxes in equilibrium. The reason is that sufficiently progressive taxes at high wages destroy the incentive for workers with good (private) messages to separate themselves by choosing unemployment. These policies can be implemented even if government planners have significantly less information than do firms.

2. A signaling model

There are three stages or periods in the model. In period 1, each worker receives a 'good' message, G, or a 'bad' message, B. We label a worker that receives a t message as being of type t, $t = \mathrm{B}, \mathrm{G}$. Not all workers of the same type are identical. The message is only known by the worker. One may think of this message as the worker's own (possibly inaccurate) assessment of his ability.

In the second period workers enter the labor market due to an exogenous event, such as a plant closing or graduation from school, that does not discriminate among workers with different abilities. In this period workers choose either to get an unskilled job, L, or to become unemployed, U. (Section 6 discusses a model where skilled jobs are also offered in this period.) We normalize the current income of an unemployed worker at zero. The productivity of a worker at an unskilled job is $M > 0$ and is independent of his type and of the number of workers choosing unskilled jobs. Firms that offer unskilled jobs act competitively, paying a wage M for these jobs.

In the third period, workers are evaluated by firms that have minimum hiring standards. We refer to these firms as being in the skilled sector. These evaluations are known by at least two firms. Evaluations are zero–one (or pass–fail): workers are determined to be either qualified or unqualified.[7] Workers with a good message are more likely to be qualified than are

[6] In the context of our model, the intuitive criterion goes as follows. Starting from a full employment equilibrium a worker choosing unemployment is implicitly making the following statement: 'I must have received a good message because persons receiving the bad message have such low probabilities of passing the hiring exam that they would not choose unemployment, even if employers believed that only workers with good messages choose unemployment.'

[7] Firms in the skilled sector are assumed to use the same qualification test.

workers with a bad message. Specifically, a type t worker will be evaluated as qualified with probability p_t, $t = \mathrm{B}, \mathrm{G}$, and $0 < p_{\mathrm{B}} < p_{\mathrm{G}} < 1$.

The (expected) productivity of a qualified type G (resp. B) worker is denoted by G (resp. B). We asume that $0 < M < B < G$.[8] The (expected) productivity at a skilled job of an unqualified worker of either type is less than M.[9]

Workers are risk neutral and have time separable utility functions. For notational simplicity we assume that workers have no disutility from work and do not discount future wage payments. We further assume that there is a continuum of workers of each type. The cumulative distribution of all workers is normalized to 1 and the proportion of workers who receive 'good' messages (type G workers) is α, where $0 < \alpha < 1$. Firms are profit maximizers with constant returns to scale in production.

Firms know the population parameters: B, G, p_{G}, p_{B}, α and M. They do not know whether a particular worker is type B or G. In period 3, firms observe the (period 2) employment histories of job applicants.[10] After evaluating workers, firms in the skilled sector may make wage offers based on employment histories and their evaluations of workers.[11] Firms in the unskilled sector continue to offer M. Workers accept the highest wage offered. If two or more firms make the same wage offer to a worker, he accepts each offer with equal probabilities. Firms hire all workers that accept their wage offers.

A sequential equilibrium in this model is a strategy combination of workers and firms and a belief structure of firms such that a worker cannot increase his total expected life-time income by changing his second period choice of U or L given the wage schedules being offered, and a firm cannot increase its expected profit by offering a different contingency wage schedule given workers' strategies and its beliefs. [See Kreps and Wilson (1982) for a formal definition of sequential equilibrium.] Without loss of generality, we need only consider pure strategy sequential equilibria.[12] In the context of

[8]In an earlier version [Ma and Weiss (1990)], we included the case of $M > B$.

[9]One can think of the expected productivity of a worker as being the product of two attributes, one of which takes the values G or B and the other takes the values 0 or 1. Workers know the first attribute, firms can test for the second. The conditional probability that the test is correct is p_t.

[10]A worker usually finds it difficult to hide his employment history. Reference soliciting is so common that a worker cannot falsely claim that he is working at a certain firm. A working applicant may also find it difficult to claim that he is unemployed: he will not be able to go for lengthy interviews. In any case, few workers falsify their job applications. These lies violate social conventions that have particularly great force in employee–firm relationships.

[11]We could allow firms to condition wages on the distribution of workers choosing U and M. However, this would not change any of our results. Because there is a continuum of workers, no single worker can affect the distribution of employed and unemployed workers observed by firms.

[12]Since there is a continuum of workers of each type, and we allow for equilibria in which workers of the same type choose different strategies, this restriction has no force.

our model the restrictions imposed by sequentiality are weak. They simply preclude bizarre responses to out-of-equilibrium moves such as firms offering wages less than B or more than G to workers who pass the screening test. We analyze both symmetric equilibria in which workers with the same private information choose identical strategies, and asymmetric equilibria in which workers with the same private information choose different actions.

3. Characterization of equilibria

Recall that a worker's productivity in the skilled sector exceeds M only if the worker passes the evaluation test. We can simplify firms' strategies by assuming that in period 3 they offer zero wages to workers who do not pass their tests, regardless of their belief about the worker's type. Workers who fail the test are unqualified, and are employed in the unskilled sector. A firm's wage offers to a successful worker who has an employment history of L and U are denoted by $W(\mathrm{L})$ and $W(\mathrm{U})$, respectively. Let

$$\omega=\frac{\alpha p_{\mathrm{G}}G+(1-\alpha)p_{\mathrm{B}}B}{\alpha p_{\mathrm{G}}+(1-\alpha)p_{\mathrm{B}}},$$

where ω is the average productivity of a worker who passes the evaluation test. For $\beta,\gamma\in[0,1]$, let

$$\hat{\omega}(\beta)=\frac{\alpha p_{\mathrm{G}}G+\beta(1-\alpha)p_{\mathrm{B}}B}{\alpha p_{\mathrm{G}}+\beta(1-\alpha)p_{\mathrm{B}}}, \tag{1}$$

$$\tilde{\omega}(\gamma)=\frac{\gamma\alpha p_{\mathrm{G}}G+(1-\alpha)p_{\mathrm{B}}B}{\gamma\alpha p_{\mathrm{G}}+(1-\alpha)p_{\mathrm{B}}}, \tag{2}$$

where $\hat{\omega}(\beta)$ is the expected productivity of a randomly selected successful worker from the sub-population of all type G workers and a proportion β of type B workers; $\tilde{\omega}(\gamma)$ is the expected productivity of a randomly selected successful worker from the sub-population of all type B workers and a proportion γ of type G workers. Notice that as β increases from 0 to 1, $\hat{\omega}(\beta)$ decreases from G to ω, and as γ increases from 0 to 1, $\tilde{\omega}(\gamma)$ increases from B to ω.

These first theorem characterizes all equilibria in which some or all workers choose unemployment in the second period.

Theorem 1. The necessary and sufficient condition for a sequential equilibrium in which some workers choose unemployment is

$$\frac{M}{G-B} \leqq p_G. \tag{3}$$

It is not difficult to see that (3) is necessary for equilibria with unemployment. Notice that G and B are, respectively, the maximum and minimum wages that firms in the skilled sector would offer. Therefore $(G-B)p_t$ is the maximum expected gain from signaling for a type t worker. A worker loses M by refusing an unskilled job. Hence when (3) does not hold, the cost of signaling by choosing unemployment will be higher than the maximum potential expected benefit. To establish sufficiency, in Lemmas 1–3, we characterize three classes of unemployment equilibria; one, and only one, of these exists when (3) holds. These sequential equilibria are: all workers choose unemployment (Lemma 1); all type G and some type B workers choose unemployment (Lemma 2); and only type G workers choose unemployment (Lemma 3). These are, respectively pooling, semi-separating and fully separating sequential equilibria. Remark 1 shows that there is a fourth class of sequential equilibria: some type G workers choose unemployment. These are the only possible equilibria with unemployment; that is, it is never an equilibrium for type B workers to choose unemployment while type G workers choose unskilled jobs. The equilibria in Remark 1 are listed separately because they are somewhat questionable and are not necessary for the proof of Theorem 1.

Proof. We first show that (3) is necessary. Suppose that there is an equilibrium in which some worker prefers unemployment to unskilled jobs in period 2. Then

$$p_t W(\mathrm{U})+(1-p_t)M \geqq M+p_t W(\mathrm{L})+(1-p_t)M, \quad t=\mathrm{B} \text{ or } \mathrm{G}. \tag{4}$$

Consistency requires $W(\mathrm{U}) \leqq G$ and $W(\mathrm{L}) \geqq B$. These restrictions and (4) yield

$$p_t G \geqq p_t W(\mathrm{U}) \geqq M+p_t W(\mathrm{L}) \geqq M+p_t B,$$

and hence

$$\frac{M}{G-B} \leqq p_t.$$

Since $p_G > p_B$, inequality (3) follows. □

The following three lemmas establish sufficiency. First note that

$$M/(\omega - B) \leqq p_t \quad \text{implies} \quad M/(G-B) \leqq p_t, \quad t = \mathrm{B}, \mathrm{G}.$$

Lemma 1. There is a sequential equilibrium in which all workers choose unemployment when

$$\frac{M}{\omega - B} \leqq p_{\mathrm{B}}. \tag{5}$$

Proof. Because $\omega > B$, (5) can be written as

$$p_{\mathrm{B}}\omega + (1 - p_{\mathrm{B}})M \geqq M + p_{\mathrm{B}}B + (1 - p_{\mathrm{B}})M. \tag{6}$$

Inequality (6) and $p_{\mathrm{G}} > p_{\mathrm{B}}$ imply

$$p_{\mathrm{G}}\omega + (1 - p_{\mathrm{G}})M \geqq M + p_{\mathrm{G}}B + (1 - p_{\mathrm{G}})M. \tag{7}$$

Suppose firms offer $W(\mathrm{U}) = \omega$ and $W(\mathrm{L}) = B$. Inequalities (6) and (7) say that both types of workers would choose unemployment in the second period. Suppose all workers choose unemployment in the second period, $W(\mathrm{U}) = \omega$, and observing an out-of-equilibrium employment history of L from a worker, it is possible that firms would believe that they were observing a type B worker. Those beliefs would lead firms to offer $W(\mathrm{L}) = B$. □

Lemma 2. There is a sequential equilibrium in which all type G workers choose unemployment and a proportion, $\hat{\beta}$, of type B workers choose unemployment while all other type B workers choose unskilled jobs when

$$\frac{M}{G - B} \leqq p_{\mathrm{B}} \leqq \frac{M}{\omega - B}, \tag{8}$$

and $\hat{\beta}$ is given by the (unique) solution to the following equation:

$$\frac{M}{\hat{\omega}(\hat{\beta}) - B} = p_{\mathrm{B}}. \tag{9}$$

Proof. Suppose (8) is true. Since, from (1), $\hat{\omega}(\beta)$ has a range $[\omega, G]$ and is continuous, there must exist $\hat{\beta} \in [0, 1]$ that satisfies (9). Since $p_{\mathrm{G}} > p_{\mathrm{B}}$, we have

$$\frac{M}{\hat{\omega}(\hat{\beta}) - B} < p_{\mathrm{G}}. \tag{10}$$

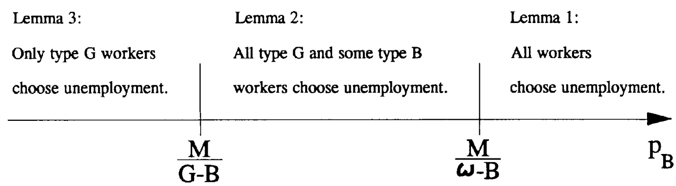

Fig. 1

Eq. (9) and inequality (10) can be written as

$$p_B\hat{\omega}(\hat{\beta})+(1-p_B)M=M+p_BB+(1-p_B)M, \tag{11}$$

and

$$p_G\hat{\omega}(\hat{\beta})+(1-p_G)M>M+p_GB+(1-p_G)M. \tag{12}$$

Expressions (11) and (12) say that if firms offer $W(\mathrm{U})=\hat{\omega}(\hat{\beta})$ and $W(\mathrm{L})=B$, type B workers will be indifferent between unemployment and taking unskilled jobs, while type G workers will strictly prefer unemployment. Suppose all type G workers and a proportion, $\hat{\beta}$, of type B workers choose unemployment while all other type B workers choose unskilled jobs, then firms offer $W(\mathrm{U})=\hat{\omega}(\hat{\beta})$ and $W(\mathrm{L})=B$. Therefore the strategies described in the lemma are equilibrium strategies. □

Lemma 3. There is a sequential equilibrium in which all type G workers choose unemployment and all type B workers accept jobs in the unskilled sector when

$$p_B\leqq\frac{M}{G-B}\leqq p_G. \tag{13}$$

Proof. Given workers' choices in the second period, firms offer $W(\mathrm{U})=G$ and $W(\mathrm{L})=B$ in equilibrium: they infer workers' private information from their strategies. Furthermore, (13) can be written as

$$p_GG+(1-p_G)M\geqq M+p_GB+(1-p_G)M,$$

and

$$M+p_BB+(1-p_B)M\geqq p_BG+(1-p_B)M,$$

which imply workers' strategies described in the lemma are optimal. □

This completes the proof of Theorem 1.

Fig. 1 illustrates the equilibrium in Lemmas 1–3. Under (3), we can also construct another class of semi-separating or asymmetric equilibria.

Remark 1. There is a sequential equilibrium in which all type B workers accept unskilled jobs and a proportion, $\tilde{\gamma}$, of type G workers choose unskilled jobs while all other type G workers choose unemployment when

$$\frac{M}{G-B} \leqq p_{\mathrm{G}} \leqq \frac{M}{G-\omega}, \tag{14}$$

and $\tilde{\gamma}$ is given by the (unique) solution to the following equation:

$$\frac{M}{G-\tilde{\omega}(\tilde{\gamma})} = p_{\mathrm{G}}.$$

The proof of Remark 1 is similar to that of Lemma 2 and is omitted.

It is straightforward to verify that the conditions in the above lemmas are not only sufficient but necessary for the respective classes of equilibria in the lemmas. Furthermore, the conditions in Lemmas 1–3 are mutually exclusive. Therefore at most two outcomes generating unemployment are feasible at the same time. ('Outcomes' refer to the proportion of each type choosing unemployment or unskilled jobs.) If two unemployment outcomes are feasible, one must be an outcome generated by an asymmetric equilibrium described in Remark 1.

We find the equilibria described in Remark 1 unsatisfactory. They do not fit our intuitive understanding of the dynamic processes that our simple static model is supposed to represent. In these equilibria, type G workers are indifferent between unemployment and employment at the unskilled sector. However, if in the past fewer than $\tilde{\gamma}$ of type G workers chose unemployment, the average productivity of qualified workers with history L would exceed $\tilde{\omega}(\tilde{\gamma})$. If this were reflected in an increase in $W(\mathrm{L})$, more type G workers would choose unskilled jobs and the equilibrium would not be sustained. Conversely, if more than $\tilde{\gamma}$ of type G workers chose unemployment, the average productivity of workers with history L would be less than $\tilde{\omega}(\tilde{\gamma})$. If this were reflected in a fall in $W(\mathrm{L})$, more type G workers would choose unemployment. Thus it seems unlikely that an economy would ever converge to an equilibrium described in Remark 1.[13] If one rejects the equilibria in Remark 1, there are at most two equilibrium outcomes: one in which some

[13]The asymmetric equilibria in Lemma 2 seem reasonable. If the (indifferent) type B workers were to choose unemployment and unskilled jobs in a different ratio than that described in Lemma 2, plausible responses by firms would lead them back to the postulated distribution of actions.

(or all) workers are unemployed, and full employment. Full employment is always an equilibrium outcome.

Theorem 2. *There is always a full employment sequential equilibrium.*

Proof. Since $M>0$, we have

$$M+p_{\mathrm{G}}\omega+(1-p_{\mathrm{G}})M \geqq p_{\mathrm{G}}\omega+(1-p_{\mathrm{G}})M, \tag{15}$$

and

$$M+p_{\mathrm{B}}\omega+(1-p_{\mathrm{B}})M \geqq p_{\mathrm{B}}\omega+(1-p_{\mathrm{B}})M. \tag{16}$$

Inequalities (15) and (16) imply that type G and B workers prefer unskilled jobs to unemployment when $W(\mathrm{L})=W(\mathrm{U})=\omega$. Since all workers choose to work in the unskilled sector, firms will offer $W(\mathrm{L})=\omega$. Firms can have consistent beliefs that if the out-of-equilibrium action U were to be observed, it would have been taken by a randomly selected worker. Therefore they can set $W(\mathrm{U})=\omega$. $\square$

Although there is always a full employment equilibrium, it is possible that only equilibria with unemployment satisfy the Cho–Kreps intuitive criterion. We next study equilibria that satisfy this refinement.

4. Equilibria refinements

In this section, we apply the Cho–Kreps (1987) intuitive criterion to our model. (Footnote 6 showed informally how the criterion operates in the model.)

The intuitive criterion. Suppose that on observing an employment history, $h\in\{\mathrm{L},\mathrm{U}\}$, from a worker, firms believe with probability μ that this is a type G worker. Let $W(\mu,h)$ denote firms' best response; $W(\mu,h)$ is a wage offer equal to the expected productivity of a randomly selected successful worker from a population consisting of a proportion μ of type G and a proportion $(1-\mu)$ of type B workers. Furthermore, let $\mathrm{BR}(\tau,h)$ be the set of best responses when firms' probability assessments concentrate on the set $\tau\subset T\equiv\{\mathrm{G},\mathrm{B}\}$, or

$$\mathrm{BR}(\tau,h)=\bigcup_{\{\mu:\,\mu(\tau)=1\}}\{W(\mu,h)\}.$$

Let $u(t,h,w)$ be the expected life-time income of a type $t\,\varepsilon\{\mathrm{B},\mathrm{G}\}$ worker with an employment history h when firms offer a wage w (conditional on a worker being successful in the test). Consider an equilibrium and let $u^*(t)$ be the equilibrium expected utility of a type t worker. For each out-of-equilibrium employment history h, denote by $S(h)$ the set of all types t such that

$$u^*(t) > \max_{w \in \mathrm{BR}(T,h)} u(t,h,w).$$

If for any history h, there is some type t' ($\notin S(h)$) such that

$$u^*(t') < \min_{w \in \mathrm{BR}(T \backslash S(h),h)} u(t',h,w),$$

then the equilibrium outcome is said to *fail* the intuitive criterion.

We proceed to show that the full-employment equilibrium in Theorem 2 may fail to satisfy the intuitive criterion. We then prove that all the unemployment equilibria satisfy the intuitive criterion. Furthermore we present a condition under which there is a unique outcome that satisfies the intuitive criterion. This outcome is generated by one of the equilibria described in Lemmas 1–3.

Theorem 3. The full-employment sequential equilibrium in Theorem 2 fails to satisfy the intuitive criterion if and only if

$$p_B < \frac{M}{G-\omega} < p_G. \tag{17}$$

Proof. We first show that (17) is sufficient. Inequalities (17) can be written as

$$p_B G + (1-p_B)M < M + p_B\omega + (1-p_B)M, \tag{18}$$

and

$$p_G G + (1-p_G)M > M + p_G\omega + (1-p_G)M. \tag{19}$$

Inequality (18) implies that $B \in S(U)$, while inequality (19) implies that $G \notin S(U)$. Therefore $T \backslash S(U) = \{G\}$. Inequality (19) consequently implies that the full employment equilibrium fails to satisfy the intuitive criterion.

To show that (17) is necessary, first note that $p_G > p_B$. If $p_B \geqq M/(G-\omega)$, then $S(U)$ would be empty and $B \in \mathrm{BR}(T \backslash S(U), U)$, which would deter a worker from deviating to L. If $p_G \leqq M/(G-\omega)$, then a type G worker would not benefit from choosing unemployment even when correctly identified. □

When (17) is true, irrespective of firms' beliefs when they observe U, a type B worker is worse off choosing U than he was in the full employment equilibrium. However, if by choosing unemployment a type G worker can convince firms that he is indeed type G, he will obtain strictly more than the equilibrium utility. Hence when (17) is true, the full employment equilibrium fails to satisfy the intuitive criterion.

Theorem 4. All equilibria with unemployment satisfy the intuitive criterion.

Proof. Since the equilibria described in Lemmas 2 and 3, and Remark 1 do not involve an unreached information set, they satisfy the intuitive criterion. For equilibria in Lemma 1, $S(\mathrm{L})$ is empty because $M>0$. Therefore $\min_{w\in \mathrm{BR}(T,\mathrm{L})} u(t,\mathrm{L},w)=M+p_tB+(1-p_t)M$, which is smaller than the (equilibrium) expected utility for either type B or type G when the condition for Lemma 1 [see (5)] is satisfied. Hence, the equilibria in Lemma 1 satisfy the intuitive criterion. □

In other words, in an equilibrium where all workers choose unemployment, choosing an unskilled job would be profitable for a type B worker if employers were to believe that only a type G worker would choose an unskilled job. Consequently the intuitive criterion does not restrict firms' beliefs when they observe the out-of-equilibrium employment history L. Thus, firms upon observing employment history L could believe that the worker with that history is of type B. This would dissuade workers from choosing L.

Corollary 1. If (17) holds, the outcome of equilibria that satisfy the intuitive criterion is unique and must be one with unemployment.

Proof. Inequality (17) contradicts the (necessary and sufficient) condition for equilibria described in Remark 1. Therefore, together with Theorems 3 and 4, we know that an equilibrium that satisfies the intuitive criterion must be the one described in Lemmas 1–3. Since these are mutually exclusive, the conclusion follows. □

5. Taxes and subsidies

We now show that there are tax–subsidy schemes that eliminate all equilibria with unemployment and induce full employment as the unique sequential equilibrium.

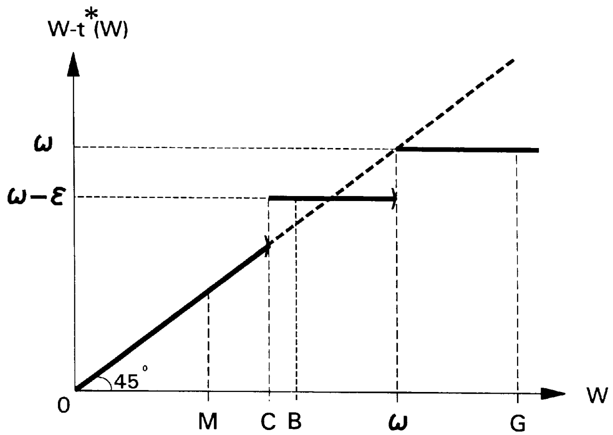

Fig. 2. Workers' net income under tax scheme in Theorem 5.

Let $t(W)$ be a tax (or subsidy) paid by a worker who receives a wage W from employment. We only consider tax schedules that are functions of current wages and that make after-tax income a non-decreasing function of wages.[14]

Theorem 5. Let the government choose tax schedule

$$t^*(W)=\begin{cases} 0, & W<C, \\ W-(\omega-\varepsilon), & C\leqq W<\omega, \\ W-\omega, & \omega\leqq W, \end{cases}$$

where $M/\varepsilon>p_G$, and $M\leqq C\leqq B<\omega-\varepsilon$, then full employment is the unique sequential equilibrium outcome. This satisfies the intuitive criterion, and no taxes are collected or subsidies paid.

(See fig. 2 for an illustration of a worker's after-tax income.)

Proof. The tax–subsidy scheme is obviously balanced-budget if all workers

[14]We do not allow schemes in which taxes depend on a worker's employment history or on time. Moreover, we do not allow taxes on unemployment.

choose L in period 1 and firms choose $W(\mathrm{L})=\omega$ in period 2. In that case no taxes are collected or subsidies paid.

We now show that t^* generates full employment as the unique sequential equilibrium. Given scheme t^*, suppose a type t worker chooses U in period 1. The highest possible (after-tax) life-time income for this worker is $p_t\omega+(1-p_t)M$. However, if this worker chooses the unskilled job L in period 1, his lowest possible total income is $M+p_t\,(\omega-\varepsilon)+(1-p_t)M$. Because ε is chosen to ensure that $M/\varepsilon>p_{\mathrm{G}}$ $(>p_{\mathrm{B}})$, all workers are strictly better off choosing L in period 2. Given that all workers choose L in period 2, employers in the skilled sector offer a wage of ω conditional on a worker with an employment history L passing the test. The equilibrium satisfies the intuitive criterion. Regardless of the wage offer from a firm in the skilled sector, a worker can never benefit from deviating from L to U. □

The intuition for Theorem 5 is simple. To induce full employment, it is sufficient to eliminate the gain from unemployment (the high wage G). The tax scheme t^* does this. A worker's maximal expected period 3 gain from taking a costly period 2 action (unemployment) is εp_t, which has been chosen so that it is always less than the benefit M from accepting employment in the unskilled sector in period 2. Without the gain from signaling his private information, a worker does not want to become unemployed. One interesting feature of this result is that equilibrium taxes and subsidies are zero.[15] Furthermore to implement the scheme t^* the government only need to know ω, and have a rough idea of M. These are surprisingly weak informational requirements.

While tax schedule t^* in Theorem 5 eliminates all unemployment equilibria, it does not guarantee that type G workers will (ex ante) benefit from the change. Suppose the economy has initially settled down in one of the equilibria that involves (some) unemployment. Type G workers may become worse off after the government has imposed the tax scheme described in Theorem 5. This is because some type G workers may initially be earning a high wage G in period 3 (see Lemma 3 for example). After the tax scheme has been imposed, they only obtain ω. The gain in income M in period 2 may not be sufficient to offset this decrease. We now investigate tax schemes that induce a Pareto improvement for each type of worker.[16]

Theorem 6. For any initial equilibrium with unemployment, there exist

[15]This result is sensitive to the assumption of $M<B$. In the case where $M>B$, the tax schedule needed to achieve full employment could entail nonzero taxes and subsidies in equilibrium. See Ma and Weiss (1990).

[16]It is too much to hope for tax–subsidy schemes that would make every worker better off, *ex post*. In particular our criterion for a 'Pareto improvement' only requires that the *expected* income of each type of worker be increased; *not* that workers who later pass the test – but who only knew their probability of passing at the time the taxes were levied – be made better off.

balanced-budget tax schedules under which full employment is the unique equilibrium, and all workers have higher expected incomes. The full employment equilibrium satisfies the intuitive criterion.

The next two lemmas provide the proof of this theorem. The tax schedules that are used in the lemmas may depend on the initial equilibrium. Also, if $M < p_G(G-\omega)$ equilibrium taxes may have to be nonzero. Nevertheless, Lemma 4 and Corollary 2 describe conditions under which the tax schedule that increases workers' expected income would result in zero equilibrium taxes.

Lemma 4. Suppose the initial equilibrium is described by either Lemma 1 or Remark 1. If tax schedule t^* in Theorem 5 is imposed, then all workers have higher expected equilibrium incomes.

Proof. First, suppose that the initial equilibrium of the economy is described by Lemma 1, i.e., all workers choose U in period 2. In this equilibrium, a worker of type t receives expected income $p_t\omega + (1-p_t)M$. After t^* is imposed, a type t workers' equilibrium expected income is $M + p_t\omega + (1-p_t)M$. Hence every type of worker becomes strictly better off.

Second, suppose that the initial equilibrium of the economy is described by Remark 1, i.e., all type B workers choose L, $\tilde{\gamma}$ of type G workers choose L and $(1-\tilde{\gamma})$ of type G workers choose U in period 2. In this equilibrium, because type G workers are indifferent between L and U, each type t has expected income $M + p_t\tilde{\omega}(\tilde{\gamma}) + (1-p_t)M$. Since $\tilde{\omega}(\tilde{\gamma}) < \omega$, every type of worker becomes strictly better off when tax scheme t^* is imposed. □

Lemma 5. Suppose the initial equilibrium is described by either Lemma 2 or Lemma 3. In each case there exists a balanced-budget tax schedule under which the unique sequential equilibrium is the full employment equilibrium, and all workers have higher expected equilibrium incomes. Moreover the equilibrium satisfies the intuitive criterion.

Proof. See appendix. □

Lemma 5 seems to us a surprising result since a type G worker could benefit greatly by being separated from type B workers. However, consider the following extreme example in which inducing a Pareto improvement seems especially difficult. There is one type G worker, and one million type B workers, $p_B = 0.01$, $p_G = 0.99$, $B = 12$, $G = 100$, and $M = 11$. Clearly t^* is not sufficient to induce a Pareto improvement when in an initial equilibrium the type G worker separates by choosing unemployment. In this example, the type G is made better off by an increasing function that maps all before-tax wages between 12 and 100 into 89 and $89+\varepsilon$, and taxes wages below 12 enough to pay for the required transfers.

Under some conditions equilibrium taxes can be zero even if the initial equilibrium is one described by Lemma 2 or Lemma 3.

Corollary 2. Suppose: (i) the initial equilibrium is described by Lemma 2 and $M \geqq p_G(\hat{\omega}(\hat{\beta})-\omega)$*; or (ii) the initial equilibrium is described by Lemma 3 and* $M \geqq p_G(G-\omega)$*. Then if tax schedule* t^* *in Theorem 5 is imposed, all workers will have higher (expected) equilibrium incomes.*

Proof. Consider case (i). In this equilibrium, type G workers prefer U, while type B workers are indifferent between U and L. Their equilibrium incomes are given by $p_G\hat{\omega}(\hat{\beta})+(1-p_G)M$ and $M+p_BB+(1-p_B)M$, respectively. Under t^*, the equilibrium taxes and subsidies are zero. Clearly, type B workers are better off; they gain by $p_B(\omega-B)>0$. The change in the equilibrium expected incomes for type G workers from imposing t^* is $M-p_G(\hat{\omega}(\hat{\beta})-\omega)$, which is positive under the hypothesis of the corollary. The proof of case (ii) is omitted since it is similar. □

From Lemma 4 and Corollary 2, and the observation that $G>\hat{\omega}(\hat{\beta})$, if $M \geqq p_G(G-\omega)$, unemployment can be eliminated, and the expected income of all workers increased, with a tax schedule which, in equilibrium, does not actually collect taxes or pay subsidies.

6. Conclusion

We have presented a model in which the combination of worker heterogeneity and imperfect testing by firms may generate unemployment. For a reasonable range of parameter values, unemployment equilibria are the only ones satisfying the Cho–Kreps intuitive criterion. If the market equilibrium is characterized by unemployment, Pareto improving taxes and subsidies always exist and they also eliminate unemployment.

One drawback of the model in section 2 is that workers in the second period are either unemployed or employed in the unskilled sector. This unrealistic assumption leads to the counter-factual prediction that workers with unemployment experience would have higher wages than workers with no such experience. In a previous version of this paper [Ma and Weiss (1990)] we also analyzed the case where workers can apply for skilled and unskilled jobs in each period after layoff. We assumed there that quitting a skilled job is sufficiently costly that a worker never quits from the skilled sector.

This richer model generates unemployment equilibria in which the average wage of a worker with some unemployment experience is always lower than that of a worker without such an experience. For instance, if all workers who are denied the highly skilled jobs in the second period choose unemployment, then the average productivity and average wage of workers with a history of unemployment will be lower than that of workers with no history of unemployment. The same pattern of wages being negatively correlated with previous unemployment will hold among skilled workers. The reason is that workers who get a job on their first try are likely to be more able than workers who satisfy hiring standards after their second or third attempts. Thus the anomalous result obtained in section 2, that the people who experience some unemployment have higher than average life-time wages, is due to the special simplifying assumptions of this model and is not a generic feature of signaling models of unemployment.[17]

One must be very cautious in using models of the sort discussed in the paper to guide public policy. In both the simple model presented in this paper, and the more complex model in Ma and Weiss (1990), confiscatory taxes on high incomes lead to full employment by eliminating workers' signaling incentives. However, important factors which could reverse this conclusion have been left out. For instance, in a richer model high marginal tax rates will generally reduce effort or hours worked. This disincentive effect could outweigh the positive effect of removing the signaling incentives. Other difficulties arise when Pareto improvements are affected by taxing low wage jobs and subsidizing high wage ones. (Such schemes may be required if the initial equilibrium is one in Lemmas 2 and 3). These tax schedules increase the variance of incomes of (low ability) workers. We have avoided this problem by assuming that workers are risk neutral.

The main messages of this paper are that signaling problems can give rise to unemployment, and that the inefficiencies generated by asymmetric information can be eliminated by properly designed taxes and subsidies. The government requires very little information to implement these tax schedules. Nevertheless, tax schedules that eliminate unemployment may generate or accentuate inefficiencies in the allocation of work incentives, human capital accumulation, and risk sharing. While the signaling problems we have discussed are likely to be present in many markets, their empirical importance is as yet unknown. Until we have a better understanding of the relative magnitudes of the various market inefficiencies, policy makers should be extremely cautious about implementing particular policies.

Appendix: Proof of Lemma 5

We will show that there are tax schedules under which full employment is the unique equilibrium outcome, and each type of worker has a higher

[17]On the other hand, the richer model can also generate equilibria in which the unemployed get higher wages than workers who never experienced unemployment.

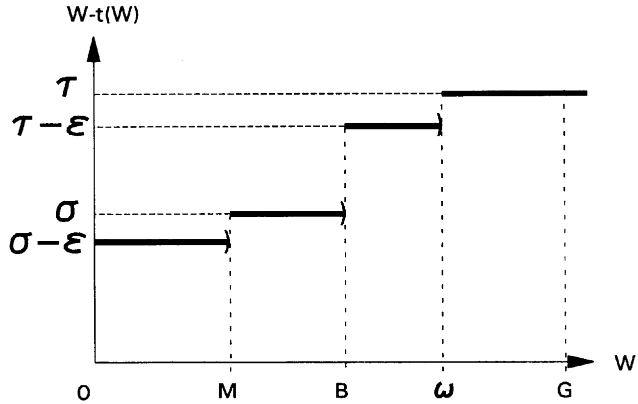

Fig. 3. Workers' net income under tax scheme in Lemma 5.

expected equilibrium life-time income than in the equilibrium where type G workers prefer U and type B workers are indifferent between choosing U and L in period 2 [i.e., case (i), the equilibrium in Lemma 2].

Consider the following tax schedule:

$$t(W)=\begin{cases} W-(\sigma-\varepsilon), & W<M, \\ W-\sigma, & M\leqq W<B, \\ W-(\tau-\varepsilon), & B\leqq W<\omega, \\ W-\tau, & \omega\leqq W, \end{cases}$$

where

$$0<\sigma<\tau, \tag{A.1}$$

and

$$\varepsilon p_{\mathrm{G}}<\sigma. \tag{A.2}$$

(See fig. 3 for the after tax income schedule.) Condition (A.1) guarantees that a worker prefers an unskilled job to unemployment, and that a worker who has passed the evaluation test prefers the skilled job to an unskilled job. We shall prove that there are suitable choices for σ, τ, and ε such that the part (i) of the lemma is true.

Any tax schedule satisfying (A.1) and (A.2) generates full employment as the unique sequential equilibrium. The argument is identical to the one used in Theorem 5. It is also obvious that the full employment equilibrium satisfies the intuitive criterion.

Second, if expected taxes are zero, then we must have

$$A(\omega-\tau)=(2-A)(\sigma-M), \quad \text{with} \quad A\equiv\alpha p_{\mathrm{G}}+(1-\alpha)p_{\mathrm{B}}. \tag{A.3}$$

To see this, note that the total taxes in the second period is $M-\sigma$. In the third period, a fraction A of all workers are employed by firms in the skilled sector. Hence, their total tax is $A(\omega-\tau)$. The remaining workers are then hired by firms in the unskilled sector, and their taxes are $(1-A)(M-\sigma)$. (A.3) then says total expected taxes are zero.

Under the proposed tax schedule, in the full employment equilibrium, a type t worker has an expected life-time income of $\sigma+p_t\tau+(1-p_t)\sigma$. From Lemma 2, $p_{\mathrm{G}}\hat{\omega}+(1-p_{\mathrm{G}})M$ and $M+p_{\mathrm{B}}B+(1-p_{\mathrm{B}})M$ are the expected incomes of type G and type B workers, respectively, where $\hat{\omega}\equiv\hat{\omega}(\hat{\beta})$ is the wage that a type G gets if hired by a firm in the skilled sector [see (12)]. For the tax scheme to induce a Pareto improvement, the differences between expected incomes for the two types of workers in the full employment equilibrium under the tax scheme and expected incomes in the equilibrium in Lemma 2 must be positive:

$$\sigma+p_{\mathrm{G}}\tau+(1-p_{\mathrm{G}})\sigma-p_{\mathrm{G}}\hat{\omega}-(1-p_{\mathrm{G}})M\geqq 0, \tag{A.4}$$

$$\sigma+p_{\mathrm{B}}\tau+(1-p_{\mathrm{B}})\sigma-M-p_{\mathrm{B}}B-(1-p_{\mathrm{B}})M\geqq 0. \tag{A.5}$$

Part (i) of the lemma is proved if we can find σ, τ and ε to satisfy (A.1)–(A.5). However, ε only appears in (A.2), therefore, for any σ, one can always find ε such that (A.2) is true. So our task reduces to finding σ and τ to satisfy (A.1) and (A.3)–(A.5).

Since (A.3) is a linear equation, any choice of σ also determines the value of τ. Hence, we only need to consider appropriate choices of σ. In σ, τ space, (A.3) is a downward sloping straight line intersecting the positive quadrant. It is easily verified that (A.3) intersects the 45° line (in σ, τ space) at $\sigma^*=[A\omega+(2-A)M]/2$. Therefore the choice of σ that satisfies (A.1) and (A.3) must lie in the interval $[0,\sigma^*]$. See fig. 4.

From (A.3) we obtain

$$\tau=\frac{A\omega+(2-A)M}{A}-\frac{2-A}{A}\sigma. \tag{A.6}$$

Substituting (A.6) to (A.4) and (A.5) and defining the LHS's of (A.4) and (A.5) by $G(\sigma)$ and $B(\sigma)$ respectively, we get (after simplification)

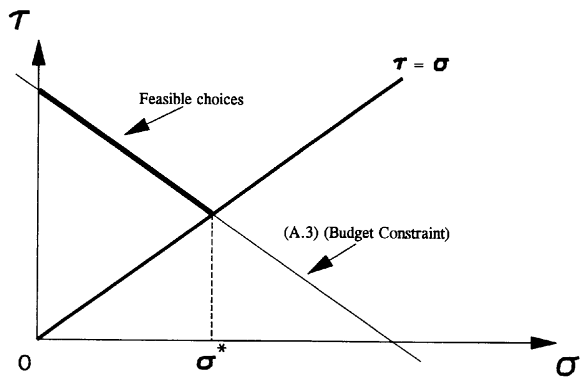

Fig. 4

$$G(\sigma)=\frac{2\sigma(1-\alpha)(p_B-p_G)}{A}+p_G(\omega-\hat{\omega})+\frac{M}{A}[p_G+(1-\alpha)(p_G-p_B)], \quad (A.7)$$

$$B(\sigma)=\frac{2\sigma\alpha(p_G-p_B)}{A}+p_B(\omega-B)-\frac{2M\alpha(p_G-p_B)}{A}. \quad (A.8)$$

Notice that $G(\sigma)$ is decreasing in σ and $B(\sigma)$ is increasing in σ. We next find σ^G and σ^B such that $G(\sigma^G)=0$ and $B(\sigma^B)=0$. That is, we put (A.7) and (A.8) to zero and solve for the values of σ:

$$\sigma^G=\frac{p_G(\omega-\hat{\omega})A+Mp_G}{2(1-\alpha)(p_G-p_B)}+\frac{M}{2}. \qquad \sigma^B=M-\frac{p_B(\omega-B)A}{2\alpha(p_G-p_B)}.$$

Since G is a decreasing function, from the definition of σ^G, it follows that $G(\sigma)>0$ if and only if $\sigma<\sigma^G$. Similarly, since B is an increasing function, from the definition of σ^B, it follows that $B(\sigma)>0$ if and only if $\sigma>\sigma^B$. We now want to show that $\sigma^B<\sigma^*$, $\sigma^B<\sigma^G$, and $0<\sigma^G$, which say that the intervals $[0,\sigma^*]$ and $[\sigma^B,\sigma^G]$ overlap. Since any σ in $[\sigma^B,\sigma^G]$ makes each type of workers better off, and any σ in $[0,\sigma^*]$ is sufficient to induce full employment as the unique equilibrium, any element common to both intervals will achieve the desired result.

We compute the difference between σ^* and σ^B. Using their definitions and after simplification, we get

$$\sigma^*-\sigma^B=\frac{A}{2}(\omega-M)+\frac{p_B(\omega-B)A}{2\alpha(p_G-p_B)}>0.$$

Next then we compute $2\alpha(1-\alpha)(p_G-p_B)(\sigma^G-\sigma^B)$, which obviously has the same sign as $\sigma^G-\sigma^B$:

$$\begin{aligned}
&2\alpha(1-\alpha)(p_G-p_B)(\sigma^G-\sigma^B)\\
&\quad=\alpha p_G(\omega-\hat{\omega})A+\alpha M p_G-M\alpha(1-\alpha)(p_G-p_B)+p_B(1-\alpha)(\omega-B)A\\
&\quad=A[\omega[\alpha p_G+(1-\alpha)p_B]-\alpha p_G\hat{\omega}-(1-\alpha)p_B B]\\
&\qquad+\alpha M[p_G-(1-\alpha)(p_G-p_B)]\\
&\quad>A[\omega[\alpha p_G+(1-\alpha)p_B]-\alpha p_G G-(1-\alpha)p_B B]+\alpha MA=\alpha MA>0,
\end{aligned}$$

where the last equality follows from the definition of ω. Finally, we show that σ^G is positive. It is somewhat more convenient to consider

$$\frac{\sigma^G(1-\alpha)(p_G-p_B)^2}{p_G MA}\equiv K.$$

Obviously K has the same sign as σ^G. From the definition of σ^G, we obtain

$$K=\frac{\omega-\hat{\omega}}{M}+\frac{1}{A}+\frac{(1-\alpha)(p_G-p_B)}{p_G A}.$$

Simplifying the last two terms of the above, we have

$$K=-\frac{\hat{\omega}-\omega}{M}+\frac{2}{A}-\frac{1}{p_G}.$$

Therefore α^G is positive if and only if the above expression is positive. Using the definitions of $\hat{\omega}$ and A, we have

$$K=\frac{\omega-B}{M}+\frac{2}{\alpha p_G+(1-\alpha)p_B}-\frac{1}{p_G}-\frac{1}{p_B}.$$

From the definition of ω, we can simplify K to

$$K=\frac{\alpha p_G(G-B)}{M(\alpha p_G+(1-\alpha)p_B)}+\frac{2p_G p_B-(p_G+p_B)(\alpha p_G+(1-\alpha)p_B)}{p_G p_B(\alpha p_G+(1-\alpha)p_B)}$$

$$= \left\{ \frac{G-B}{M} p_B \right\} \frac{\alpha p_G}{p_B(\alpha p_G + (1-\alpha) p_B)} + \frac{2 p_G p_B - (p_G + p_B)(\alpha p_G + (1-\alpha) p_B)}{p_G p_B(\alpha p_G + (1-\alpha) p_B)}.$$

From the condition of Lemma 2 [see (8)], we know that $M/(G-B) \leqq p_B$. Hence, the term inside the curly brackets in the above expression is greater than one. Therefore we derive

$$K \geqq \frac{\alpha p_G}{p_B(\alpha p_G + (1-\alpha) p_B)} + \frac{2 p_G p_B - (p_G + p_B)(\alpha p_G + (1-\alpha) p_B)}{p_G p_B(\alpha p_G + (1-\alpha) p_B)}$$

$$= \frac{p_B[p_G - (1-\alpha) p_B]}{p_G p_B(\alpha p_G + (1-\alpha) p_B)} > 0.$$

We conclude that σ^G is strictly positive. In sum we have proved that if the initial equilibrium is described by Lemma 2, there exists balanced-budget tax schedules that eliminate unemployment and increase the expected incomes of all types of workers.

The proof of case (ii), when the initial equilibrium is described by Lemma 3, follows the exact lines, and is therefore omitted.[18] □

[18] A proof of case (ii) is also available in our working paper version, Ma and Weiss (1990).

References

Barron, John, Dan Black and Mark Loewenstein, 1987, Employer size: The implications for search, training, capital investment, starting wages and wage growth, Journal of Labor Economics 5, Jan., 76–89.

Cho, In-koo and David M. Kreps, 1987, Signaling games and stable equilibria, Quarterly Journal of Economics 102, 179–221.

Corcoran, Mary, Linda Daitcher and Greg Duncan, 1980, Most workers find jobs through word of mouth, Monthly Labor Review, Aug., 33–35.

Daitcher-Loury, Linda and Glenn Loury, 1986, The effects of attitudes and aspirations on labor supply, in Freeman and Holtzer, eds., The black youth employment crisis (NBER, Cambridge, MA) 377–399.

Kreps, David M. and Robert Wilson, 1982, Sequential equilibria, Econometrica 50, 863–894.

Ma, Ching-to A. and Andrew Weiss, 1990, A signaling theory of unemployment, Working paper no. 3565 (NBER, Cambridge, MA).

McCormick, Barry, 1990, A theory of signalling during job search, employment efficiency, and 'stigmatised' jobs, Review of Economic Studies 57, 299–313.

Rosenfeld, Carl, 1977, The extent of job search by employed workers, Monthly Labor Review, Mar., 58–62.

Weiss, Andrew M., 1991, Efficiency wages: Models of unemployment, layoffs, and wage dispersion (Princeton University Press, Princeton, NJ).