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SEARCH AND EFFICIENCY WAGE MODELS

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ABSTRACT

This paper shows that market economies with search and in which wages are affected by efficiency wage considerations are not constrained Pareto efficient. Wages are not set at Pareto efficient levels, nor is the level of employment (unemployment) Pareto efficient. We identify the nature of the biases and the welfare improving government interventions.

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Pareto Inefficiency of Market Economies:

Search and Efficiency Wage Models

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Serious macro-economists have long been faced with a dilemma: how can one reconcile the seeming inefficiencies associated with the periodic episodes of unemployment and under utilization of capital with those rational, competitive forces which, in our traditional micro-economic paradigm, at least, we argue ruthlessly seek out profitable opportunities, eliminating waste and weed out incompetent producers. In their quest for a resolution to this dilemma, economists have identified a number of ways in which our economy differs from the idealization of the Arrow-Debreu model, ways which can explain the existence and persistence of unemployment, among the most important of which are the presence of search costs and the dependence of productivity on wages (the efficiency wage hypothesis.) Once we recognize the importance of these, then the existence of unemployment need not be evidence of market inefficiency: economic efficiency requires the movement of labor from one job

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to another, as disturbances change the marginal productivity of workers in different industries; search takes time and resources; even if it were always feasible always to move labor instantaneously from its low productivity use, with no interim period of unemployment, it may--for some individuals, under some circumstances--be inefficient to devote the resources to search required for such transitions; it may be more efficient to spend a period unemployed. Indeed, the very words we use to describe the resulting unemployment rate, "the natural rate" suggests that there is nothing particular perverse, or inefficient, about this unemployment.

By the same token, if productivity is increased by increasing wages, it is quite plausible that efficiency entails wages at above market clearing levels.

More broadly, the approach taken by modern macro-economists, in which the terms of the contracts between workers and employers takes into account not only the absence of income insurance for workers, but also search/mobility costs and efficiency wage considerations, seems to preclude the possibility that any resulting unemployment is inefficient: for the contracts are designed to be "locally efficient," that is, to maximize the firms' profits, given the reservation utility levels of workers.

The line of reasoning that we have presented in the preceding paragraph, as persuasive as it may seem, is simply wrong. The fundamental question in which we are interested is,

is a decentralized market economy--characterized by search costs, efficiency wages, incomplete insurance markets, by a variety of other informational imperfections, or by other deviations from the standard specification of the competitive model which seemingly enhance its realism--is such an economy Pareto efficient? In judging the efficiency of the resulting market allocations, we need to take explicitly into account the costs of search or information acquisition; of the factors which make productivity dependent on wages; of the absence of a complete set of insurance markets. We ask, are there feasible government interventions, which respect to these aspects of actual market economies, which can make everyone better off. (We do not ask, is it reasonable to assume that governments which actually intervene do so in such a way as to effect a Pareto improvement?) In deference to common usage, when there exist such interventions, we say that the economy is constrained Pareto inefficient; in adopting this language, we emphasize that we do not believe that the considerations under examination here, such as information costs, are any less "real" than production costs.

We show here that (for rather different reasons) market economies with search and efficiency wages are, in general, not constrained Pareto efficient. In earlier work (Greenwald and Stiglitz, 1986), we proved a general theorem establishing that markets with imperfect information and incomplete markets were constrained Pareto inefficient. An explicit assumption of that

analysis, however, was that markets cleared, whereas here we are concerned with situations where markets may not. Though efficiency may indeed entail the presence of some unemployment, with wages set above market clearing levels, there is a presumption that neither the level of unemployment or wages is Pareto efficient.<sup>2</sup>

### Efficiency Wage Models

The basic hypothesis of the efficiency wage model is that workers' productivity depends on the wage paid; here we generalize the standard formulation by allowing productivity (per hour) to depend also on the number of hours worked. Assume that there are  $L$  identical workers, we assume. The  $i$ th firm's output is simply a function of its effective labor supply,  $L_i h_i \Gamma_i(v_i, h_i)$  where  $v_i$  is the wage its workers receive (which may differ from the wage the firm pays,  $w_i$ , because of taxes) and  $h_i$  is the number of hours each of its  $L_i$  workers works:

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<sup>2</sup> Other studies have called attention to the Pareto inefficiency of implicit contract equilibria (Newbery and Stiglitz, 1987), of search equilibria ((Hosios (1984), Mortenson (1982), Pissarides (1984), Arnott and Stiglitz (1985), Stiglitz (1985)), and of implicit contracts which are explicitly designed to take into account the search which they induce (Arnott, Hosios, Stiglitz, 1980). The objective of this paper is to formulate a more general model than those previously employed, which can embrace both efficiency wage and search considerations; this general formulation is, in fact, a simple extension of our general approach to the analysis of the efficiency of economies with incomplete markets and imperfect information (Greenwald and Stiglitz, 1986). This general approach has the further advantage of being able to identify potential Pareto improving government interventions.

$$Q_i = F(L_i h_i E_i(w_i, h_i)) , F'_1 > 0. \quad (1)$$

$$\Gamma_1 > 0 , \text{ and } \Gamma_{11} << 0 \text{ as } w \in \hat{w}$$

The firm maximizes its profits,  $-p_i Q_i - w_i h_i L_i$ , subject to the constraint that it must offer a contract that exceeds workers' reservation utility:

$$U(w_i, h_i; p) \geq \bar{U} \quad (2)$$

where utility is a function of wages and hours, as well as the consumer price vector,  $q$ . It is by now well known that the solution may entail the constraint (2) not being binding. We focus on this regime here. The maximized level of profits will be a function of prices and the relationship between wages paid and wages received; with an ad valorem wage tax,  $v = w(1-r)$ , and we write  $\pi_i^* = \pi_i^*(p, r)$ , with the standard result that the derivative of profits with respect to price is equal to the firm's output.<sup>3</sup> (Because wages are set by the firm, they do not appear explicitly in the profit function.)

The fact that wages may exceed market clearing levels in equilibrium implies that we will need to divide consumers into two groups, the employed and the unemployed. Given consumer prices,  $q$ , the level of income (in excess of wage income, if any) required by an individual to attain a level of utility  $U^*$  is given by the modified expenditure functions:

$$E^j U = E^j(p, 0, 0, U^*) \text{ for an unemployed household}$$

and

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<sup>3</sup> With the caveat that if productivity depends on consumer prices, then there is an additional term reflecting the effect of the change in producer prices on consumer prices, and the effect of that on productivity, at any given level of wages and hours.

$E_j^e = E_j(p, h, v, U^*)$  for an employed household working  $h_j$  hours and receiving a wage of  $v_j$  per hour.

The  $j$ th household owns a fraction  $a_{ij}$  of the  $i$ th firm. If the government imposes a set of taxes which changes  $p$ ,  $q$ ,  $h$ , or  $v$ , then for the  $j$ th household to attain utility level  $U^*$  requires a compensatory payment of  $\Delta E_j - \sum a_{ij} \Delta \pi_i^*$ , where  $\Delta \pi_i$  is the change in the  $i$ th firm's profits. We denote these compensations by  $I_j^c$ .

Assume the government imposes a set of commodity taxes, so the  $k$ th consumer price is now  $q_k = p_k + t_k$ ; an ad valorem wage tax at the rate  $r$  and a tax per employed worker at the rate  $\mu$

The profit function can be modified in a straightforward way to reflect the per-employee tax, to read  $\pi_i^* - \pi_i^*(p, \mu, r)$ . Now, if the government can impose a set of taxes which raises revenue, after paying all individuals compensation which allows them to remain at the same level of utility they had attained in the market equilibrium, raises revenue, then the market equilibrium cannot have been (constrained) pareto efficient. Government revenue is

$$R = \sum t_k Q_k + r \sum w_j h_j + \mu L - \sum I_j^c \quad (3)$$

where  $L$  is aggregate employment,  $Q_k$  is aggregate consumption of the  $k$ th commodity, and where prices are determined at the market clearing levels (with firms choosing their profit maximizing levels of inputs and outputs, and households choosing their utility maximizing consumption bundles, constrained, of course,

by the availability of jobs). Wages and hours are set at profit maximizing levels. For the remainder of the paper, we assume the profit maximizing value of  $h$  is unaffected by taxes, and focus on wages.

Straightforward differentiation, making use of the standard properties of expenditure and profit functions, establishes that at  $\tau_i = 0$ ,<sup>4</sup>  $\mu = 0$ ,  $r = 0$

$$dR/dt = (EJ^u - EJ^e)dL/dt - L(dEJ^e/dw)(dw/dt) \quad (4)$$

$EJ^u - EJ^e$  is the amount an unemployed worker would be willing to pay to obtain a job. Similar expressions hold for changes in  $r$  and  $\mu$ . We decompose the total effects of the tax into four elements:

(i) A direct effect in raising consumer prices and government revenue. These are simply transfer effects--when the government compensates the individual for the increased prices, the two effects (for small taxes) cancel.

(ii) A general equilibrium effect on prices; an increase in prices raises profits, and lowers consumers' utility; again this is a transfer effect, and so long as the goods' market clears these effects cancel (recalling that every firm must be owned by

<sup>4</sup> This expression holds if all firms are identical and all individuals (ex ante) are well. More generally we write, for small taxes

$$\Delta R \approx \sum [\delta^j (\Delta E) - (dEJ^e/dw) \Delta w_j]$$

where  $\delta^j = 1$  for a worker who was unemployed before the imposition of the tax and is employed after;  $-1$  for a worker who was employed before the tax and is unemployed after; and  $0$  otherwise.

someone, i.e.  $\sum_{ij} \epsilon_{ij} = 1$ ). (If productivity depends on consumer prices, then there is an additional, non-transfer, effect, from any change in consumer prices, equal to  $\sum_p F' L_h \Gamma_q \cdot (dq/dt)$ .)

(iii) An indirect effect on the profit maximizing level of employment; by the envelope theorem, the effect on profits is zero, but the effect on consumers--since there is job rationing--is positive; the dollar value of this is equal to the difference between the compensation, net of wages received, required for the unemployed to be at the same level of utility as the employed. Because private firms ignore this term, market equilibrium entails too little employment.

(iv) An indirect effect on the wage level. Again, by the envelope theorem, the effect on profits is zero, but the effect on consumers is positive (if wages increase). Thus, there is a presumption that market wages are too low, even though they are set at above market clearing levels.

Notice that this formulation not only establishes that there are welfare enhancing government interventions, but also tells us precisely what kinds of interventions are desirable: those that increase employment and wages. Thus, a small ad valorem wage subsidy, which, at least in the simplest versions of the efficiency wage model, will leave consumer wages unchanged, will increase employment and hence increase welfare. Assume productivity is positively effected by food consumption and negatively affected by alcohol consumption, in such a way that the firm responds to a food subsidy and an alcohol tax by

increasing employment, but leaving wages unchanged or increased; in these circumstances a food subsidy and an alcohol tax may be desirable.

### Search

It has long been recognized that search can give rise to unemployment, particularly if (at least for some individuals) off-the-job search is more efficient than on-the-job search. Although some search unemployment will then clearly characterize market equilibrium, it is again by no means clear that the level of unemployment will be Pareto efficient. We show that it is not, using a framework similar to that employed in our discussion of efficiency wages. Again, there will be employed and unemployed workers, now depending upon which workers successfully obtain jobs. Firms' decisions concerning hiring, lay-offs, and search and workers' decisions concerning quits and search intensities all generate "search" externalities, affecting the likelihood of a firm finding a well-matched worker and a worker finding a well-matched job.

To see the parallel with the earlier section as clearly as possible, we focus on a special case where all individuals and firms are (ex ante) identical, and where, in equilibrium, all firms pay the same wage. The probability of a match is  $\Phi(x,y)$ , where  $x$  is the vector of workers' search intensities (here, for simplicity, assumed to be dollars spent on search), and  $y$  is

the vector of firms' "hiring" intensities. Employment,  $L$ , is just equal to  $N\Phi$ , where  $N$  is the number of potential workers. For simplicity, we partition the vector  $x = (x_j; x^*)$  where  $x^*$  is the search intensity of all other workers. Firm  $i$  chooses wages and hiring intensities to maximize expected profits (taking into account the effect of those decisions on the likelihood of a match); and its maximized value of profits can be represented by  $\pi^*_i(p; r, \mu; z_i)$ , where  $z_i$  is a description of the relevant market environment, here, the wages and hiring intensities of all other firms and the search intensities of all individuals (which are, of course, endogenous). As before we can write the expenditure function of those who are successful in obtaining a job and those who are not by  $Ej^e$  and  $Ej^u$ , respectively, noting now the dependence on the market environment,  $z_j$ , which now includes the search intensities of others as well as all firms' hiring intensities and wage levels. These variables together determine the individual's expenditures on search.

An identical argument to that employed before shows that if the government can impose taxes which raises revenue, after compensating individuals, then the market equilibrium is not constrained pareto efficient. Again, straightforward differentiation yields

$$dR/dt \approx \Delta E [dL/dt - N\Phi_x(dx/dt)] - L(dEj^e/dw)(dw/dt) + \Sigma(\partial\pi_i/\partial z^*)(dz^*/dt) \quad (5)$$

where the subscript  $z$  denotes a derivative with respect to  $z$  and where  $\Delta E = Ej^u - Ej^e$ .

The first term is slightly modified from its earlier form, to reflect the fact that the individual, deciding on her search intensity, takes into account the expected gain in utility from the increased likelihood of employment from additional search; the individual does not take into account the effect of those search decisions on the employment prospects of others, and firms do not take into account the gain in utility of those who do obtain jobs as a result of their increased recruitment activities.

There are two additional terms besides those discussed in the previous section, arising from the "external" effects on profits: An increase in hiring intensity by one firm reduces the likelihood of a match by another firm and hence has a negative effect on their profits. (These are, however, total general equilibrium derivatives, and the indirect effect of these perturbations on workers' search intensity, and of that on profits, needs to be taken into account.)

The market failure we have identified here can be given a "missing markets" interpretation. Suppose there is a notional employment agency that pays  $q_x$  for search intensity  $x$  and  $q_y$  for hiring intensity  $y$ , and in turn receives payments of  $q_0$  for matches. The expected number of matches is a function of the vector  $(x^j, y^i)$ . Then the employment agency maximizes  $q_0 \sum \phi_j(x, y) - q_x x - q_y y$ .  $\sum \phi$  looks like the production function of the employment agency. Since this formulation eliminates the externality, the solution to this problem in

conjunction with the maximization problems of households and firms yields the Pareto optimal set of outcomes. Looking at the resulting equilibrium prices paid to the notional employment agency, we obtain the optimal taxes and subsidies that a government would have to impose on search related activities in the absence of such an agency. And the degree to which the pseudo-production function  $\Sigma\Phi$  exhibits decreasing, increasing, or constant returns to scale determines whether these payments will leave a net surplus or deficit.<sup>5</sup>

A Generalization. It is easy to generalize the results of this model, for instance to implicit contract models, where firms sign contracts with workers to maximize their profits, for a given (reservation) expected utility of workers. The contract will specify firms' retention (lay-off) hiring and wage decisions as a function of the state of nature; expanding the "z" variable to include these as well as the equilibrium search intensities of others,  $x^*$ , state contingent profit and expenditure functions can again be presented as function of the market vector  $z$ ; and a state content tax on some commodity  $i$  is desirable if

$$dR/dt_i = (\Sigma\pi^*_z - \Sigma E_z) \cdot dz/dt_i \neq 0 .$$

A tax which discourages an individual from searching (say because it increases the opportunity cost of searching) has positive externalities on other individuals, since, at any fixed level of

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<sup>5</sup> It is clear that if, upon each transaction, any surplus is divided among the participants, there is no division rule which will result in a pareto efficient outcome unless the pseudo-production function exhibits constant returns to scale.

search intensities on their part, it increases the likelihood that they will find a good (better) job. A tax which encourages firms to search more for employees in any state  $\theta$  (by subsidizing new employees) or discourages lay-offs has positive externalities on workers, since at any fixed level of search intensities on the part of worker, the likelihood that they find a (better) match is increased, but negative externalities on other firms (because of the reduced likelihood of a match). We conjecture, but have not proved, that normally the first effect dominates the second: there is too little hiring.

Notice that firms, in setting their lay-off rates, take into account the effect of changes in the lay-off rate on the expected utility of its own workers, but not the external effect of the search efforts of its workers on the likelihood of others' obtaining employment.

Such a tax may have a second set of effects, on the wages offered by a different firms; if firms change their wages for new hires, in response to the changed search intensity, there is a second order effect on profits, which can be ignored, but a first order effect on workers' expected utility.

#### Concluding Remarks

In our earlier work, we showed that market equilibrium with competitive firms, in contexts in which all markets clear, but in which there was imperfect information or incomplete markets would not, in general, be Pareto efficient.

Here we have extended those results to incorporate equilibria in which firms are wage setters rather than wage takers, where they set their wage to take into account efficiency wage considerations (including the effect on the cost of recruiting workers and on labor turnover), and where they may set the wage at a level where markets do not clear. We believe that this provides a more accurate characterization of labor markets than is provided by the standard perfect information, market clearing model.

It should be clear that similar results obtain in other contexts--in labor, product, and capital markets--in which wages, prices, and interest rates affect market behavior, for instance by conveying information. Through efficiency may indeed entail unemployment, credit rationing, or prices exceeding marginal costs of production, there is no presumption that the extent of rationing, and the level of wages, prices, and interest rates in the market equilibrium are efficient. The precise nature of the distortions depends on the exact specification of the model: in the efficiency wage model, there was too little employment, as firms failed to take into account the potentially large discrepancy in utility of the employed and the unemployed.

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