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ASYMMETRIC INFORMATION AND INDIVIDUALLY RIGID WAGES

by

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Asymmetric Information and Individually Rigid Wages*

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0. Introduction

The cause of excessive unemployment is the major question in business cycle theory and macroeconomics. In recent years economists have become much more precise about what they mean by excessive unemployment and most would now phrase this question as, Why do we observe unemployed people whose opportunity cost of work is less than their real marginal revenue product? Obviously a necessary condition for one to be able to answer this question is to have an explanation of such apparent inefficiency at the level of the firm, though one should be careful not to fall into the reductionist trap of thinking that such an explanation at the microeconomic level necessarily constitutes the explanation of the macro phenomenon. Over the years many micro-explanations of this apparent inefficiency have been provided but most recently a series of explanations have been given that hinge on the existence of asymmetric information between workers and employers regarding some parameter relevant to trade. In general, the introduction of private information about such parameters imposes certain restraints on the available schemes for conducting market exchanges. It thereby limits the set of incentive-feasible trades. This shrinking of the set of feasible trades may well result in trades which would have been efficient under symmetric information becoming infeasible, as in the classic Akerlof (1970) "lemons" example. If this occurs, then asymmetric information in the labor market could give rise to trades that appear to be inefficient.[1]

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[1] See Myerson (1979). Throughout the paper allocations will be termed "inefficient" if they are not members of the set of full information, efficient allocations. Such "inefficient" allocations may be efficient relative to the information actually available to agents. On this see Harris and Townsend (1981).

Perhaps the most well-known asymmetric information explanations of inefficient unemployment at the micro level are those contained in the "second generation" implicit contract literature; see Grossman and Hart (1981), Hart (1983) and Holmstrom (1981, 1983). These papers follow the insight provided by the "first generation" implicit contract papers (Azariadis (1975), Baily (1974), Gordon (1974)), namely that incomplete insurance markets together with differing degrees of risk aversion on the part of firms and workers provide an incentive for workers to trade income risk with firms via a long-term labor contract. This insight by itself, however, is not sufficient to generate inefficiently high levels of unemployment as was shown by Akerlof and Miyazaki (1980) and Lowenstein (1983). However, this negative result may be reversed if the realizations of the random variable that shifts the firm's labor demand curve are observed only by the firm, that is, asymmetric information is introduced. This change makes state contingent labor contracts incentive incompatible and forces contracts to be either state independent or dependent on the observable level of employment. This restriction of the set of incentive-compatible mechanisms results in apparently inefficient trades which may involve insufficiently flexible wages and too large fluctuations in employment from the point of view of full information efficiency.[2]

Although the insights provided by this literature can hardly be overstated, there are some questions as to the empirical relevance of these models of the labor market. This is immediately apparent when we

[2]See Green and Kahn (1983) for the restrictions on preferences necessary to generate this particular type of inefficiency.

note that only a fraction of employees in the U.S. are covered by formal contracts. Indeed, the employment-at-will doctrine which covers the bulk of labor traded explicitly allows for instantaneous quits and fires without "just cause." The response to this lack of multi-period or even single period labor contracts was to claim that agents in the labor market, though not explicitly covered by a labor contract, act as if their trades were mediated by such contracts. Hence the term implicit contracts. However, as Hart has pointed out (1983, p. 23), if one uses this "as if" argument one must say how these implicit contracts are enforced, i.e., how they constrain, ex post, both parties' behaviors.

The standard assumption used in the literature to prevent workers or firms from reneging on the contract by trading through the spot labor market is that there are sufficiently high transactions costs that, having joined together in an implicit contract, subsequent trade via the spot market is prohibitively costly (see, e.g., Baily (1974), Akerlof and Miyazaki (1980)).[3] It is certainly conceivable that in some industries investment in firm-specific human capital, search costs and the like might be so high as to preclude subsequent spot market trades at least for a large set of realizations of the spot market price. However, even where this characterization of the post-hiring situation as a bilateral monopoly is correct there still remains the question of why the parties adhere to the terms of the contract? There seems to be little to stop the firm, ex post, from unilaterally declaring a different

[3]Alternatively one can appeal to reputation effects, see Holmstrom (1981). This analysis has yet to be carried out and there are, moreover, good reasons for thinking that reputation effects will be weak. See Bull (1983a).

wage-employment policy than that contained in the implicit contract.[4] Thus in order to make the existing implicit contract literature consistent with individual optimization one needs to say how ex post opportunism is prevented which is obviously a difficult game theoretic task.[5]

The purpose of this paper is to show that this "problem" of ex post opportunism is in fact an advantage if one's goal is to provide an explanation of inefficiently high levels of unemployment. If one adopts the implicit contract assumption of prohibitively high costs of trading ex post through the spot labor market, then the workers and the firm will face each other in a post-hiring, repeated trading game. The prospect of this, as several other authors, most notably Hashimoto and Yu (1980) and Hall and Lazear (1982), have stressed, provides a strong incentive for both parties to precommit at the time of hiring by signing a long-term labor contract. However, implicit labor contracts are unenforceable under the employment-at-will doctrine and so the post-hiring, trading game must be played without the benefits of precommitment which makes it very unlikely that the trade in risk which is the core of the implicit contract literature will be incentive compatible. Thus the unenforceability of implicit labor contracts deprives us of the implicit contract explanation of inefficiently high layoffs.

What is shown in this paper, however, is that workers might choose, for strategic reasons, not to work in some states of the world even when the alternative is employment at a wage exceeding their marginal value of

[4] This is, again, a point made by Hart (1981).

[5] See Bull (1983b) for an attempt in this direction.

leisure. The rationale for rejecting such an apparently favorable offer is that by accepting the job the worker is signalling his or her value of leisure. In other words, he or she is indicating a willingness to work at this wage. To the extent that his future earnings depend on his wage-history (the "record" effect) it might well be to his advantage to refuse a current job offer. A sensible employment decision strategy for the worker should balance the immediate and future gains from accepting a current offer. When the value of leisure is private information, this is accomplished by establishing a minimum acceptable wage and rejecting all offers the employer might make below it. This strategy, in turn, produces excessive unemployment from the point of view of a full-information economy. Thus from the strategic aspects of the "post-hiring" game alone and without appeals to implicit contracts and risk trading, one can generate inefficiently high levels of unemployment and layoffs. Moreover, inasmuch as a Nash equilibrium is, by definition, self-enforcing, this strategic explanation is immune to the ex post enforceability criticism.

As well as providing an alternative game-theoretic rationale for the results of the implicit contract literature, this paper also sheds some light on the role of worker heterogeneity in generating layoffs and interpreting the time series behavior of aggregate wage variables. A major drawback of existing micro theories of inefficient unemployment is that workers are assumed to be homogeneous both in terms of their marginal products and their opportunity costs of work. This severely limits the range of empirical implications that the models can generate, for example whose wages are inflexible and who is chosen to be laid off. The reason why this is a major drawback is that the incidence of cyclical unemployment differs substantially across age, sex and race divisions. Thus it is unlikely that an homogeneous labor theory can provide a basis for the analysis of cyclical unemployment. In this paper workers are homogeneous with respect to their productivity but heterogeneous with respect to their opportunity costs of work.[6] This gives rise to predictions as to who will be laid off in each state and, more importantly, enables a distinction to be drawn between individual and aggregate real wage behavior. More specifically, in the Nash equilibrium studied although each worker's employment is state dependent his wage when employed is not. In this sense, individuals' wages are rigid. However, workers' wages and layoff probabilities differ with their opportunity costs of work; thus observable variables such as the level of employment and the average wage paid by the firm will be state dependent. In particular, the level of employment, output and the average real wage paid will increase

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[6]Weiss (1980) is the only other example of an asymmetric information model in which the workers are heterogeneous.

with the underlying state of the economy, thus these series will move procyclically. However, despite the procyclical movement in the average real wage, there will remain inefficiently high levels of unemployment. Thus, in this model, there is a sharp distinction between the rigidity of every individual's wage and the simultaneous flexibility of aggregate wages. This raises an important empirical issue. Implications about individual behavior are often drawn from aggregate wage-employment studies by a tacit use of the representative individual assumption and an homogeneous worker model of the employment relationship (see, among others, Ashenfelter and Card (1982)). However, this paper provides an example of an optimizing model of the employment relationship in which such a method of inference would lead the analyst seriously astray.[7]

The paper is organized as follows. In the next section the model and its properties are described and the existence of an individually rigid wage Nash equilibrium to the post-hiring game is proved. Section 2 provides an explicit example. As well as making the forces at work in the model clearer it also allows the efficiency loss caused by the informational asymmetries to be calculated. In the third section we look at an alternative Stackelberg equilibrium to the game in which the firm acts as leader and the workers as followers and see how the firm might manipulate its layoff policy to capture even more of the gains from trade than it did in the Nash case. The final section contains some concluding remarks.

[7] This is particularly important when comparing wage-employment relationships across countries (Gordon (1982)) and doubly so if one is going to draw policy implications from them (Branson and Rotemberg (1980), Sachs (1979)).

1. The Model and the Existence of an Individually Rigid Wage Nash Equilibrium

Following the implicit contract literature it is assumed that after a worker is hired the firm and the worker are locked into a bilateral monopoly situation because of the high costs of trading ex post through the spot labor market. Apart from pure lump sum transactions costs, firm-specific human capital acquired by the worker and the worker's monopoly of knowledge of efficient ways of carrying out production may generate such post-hiring bilateral monopolies. On this see Hall (1980), Hall and Lazear (1982), Williamson et al. (1975) and Mayers and Thaler (1979). Empirical support for the importance of such bilateral monopolies is provided by job tenure data. Hall (1982) has found that in 1978 43% of all U.S. workers were in jobs that had lasted or were expected to last ten or more years, while fully 28% were in jobs expected to last twenty years or more. For men tenure is even more common, with approximately half the male workers aged thirty-five or over in jobs that are expected to last twenty years or more. As several authors have pointed out, notably Hall and Lazear (1982) and Hashimoto and Yu (1980), this prospect of a post-hiring bilateral monopoly, and so trading game, gives rise to a desire for precommitment on parts of the firm and the worker. Practically, such precommitments require explicit contracts which are enforceable by third parties. However, such explicit contracts are largely confined to the unionized sector of the labor market and so cover a relatively small proportion of the trades in the U.S. labor market. In the non-unionized sector of the labor market the post-hiring trading game must be played out under employment-at-will and so without the benefit of precommitment. The rest of this section deals with this game and the existence of an individually rigid wage Nash equilibrium to it.[8]

Workers, who will for simplicity be assumed to be infinitely long lived, are perfect substitutes in production for each other but differ in their post-hiring opportunity costs of working for the firm. Apart from differing tastes the difference in opportunity costs could arise for many reasons such as differing unemployment benefits[9] and differing productivities in home production, the latter being especially important for women with children. Denote the opportunity cost of working for the firm by v which lies in the interval $[0,\bar{v}]$, $\bar{v} < \infty$. In order to keep the mathematics tractable it is assumed that the workers hired by the firm form a continuum with the total labor force being assigned measure one. The labor force is, therefore, parameterized by $v \in [0,\bar{v}]$. In line with the preceeding discussion, the worker-specific v is unobservable private information to the worker. The cumulative distribution and probability density functions of v are denoted by G(v) and g(v) respectively. Both functions are assumed to be continuous with support $[0,\bar{v}]$, while g is assumed, in addition, to be bounded away from zero.

The firm's revenue function is given by f(L,x) where $L \in [0,1]$ is the proportion of the firm's labor force employed and x is a stochastic state variable, e.g., output price, which is distributed independently over time with a continuous cumulative probability distribution function

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[8] This situation may be changing as the courts appear to be starting to circumscribe the employment-at-will doctrine, e.g., Toussaint (1980).

[9] Given an initial distribution of wages, earnings related unemployment benefits will result in a distribution of opportunity costs which might in turn, in this model, support the initial distribution of wages.

$H(x)$ and density function $h(x)$ having support $[0,\bar{x}]$, $0 < \bar{x} < \infty$. Denote, for future reference, the hazard rate, $\frac{1 - H(x)}{h(x)}$, by $z(x)$.

The function $f(L,x)$ is non-negative, increasing and concave in L with $f_{Lx} > \varepsilon > -\varepsilon > f_{LL}$, for some positive ε. Increases in x are unambiguously good for the firm; thus both revenues, $f(L,x)$ and the marginal revenue product of labor, $f_L(L,x)$, are increasing in x for all levels of L. Finally, as is usual in this literature, the realizations of x are assumed to be known only to the firm.

To establish a standard with which to compare the results of this section, let us look first at the welfare maximizing allocation under complete information. Maximizing the sum of the firm's and workers' surpluses requires the firm in each state to employ workers, starting with those with the lowest opportunity cost of work, up to the point at which the opportunity cost of work of the marginal worker equals marginal revenue product.[10] The remainder of the labor force is laid off. Remembering that workers are hired in ascending order of their opportunity costs of work, v, welfare maximization involves finding the function $v^* = v^*(x)$ which solves the following equation for all x:

$$f_L[G(v),x] = v$$

where $f_L[\cdot,\cdot]$ denotes the marginal revenue product of labor. Given the assumptions above, it is straightforward to show that $v^*(x)$ exists, is unique, and is locally non-decreasing and globally increasing in x.

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[10] This is the case if all parties are either risk neutral or have access to actuarily fair insurance markets. It is precisely this assumption which is broken in the usual implicit contract literature.

welfare maximizing layoffs as a function of the state of the world are given by $(1 - G[v^*(x)])$. One way of implementing this optimal allocation would be for the planner to set a wage in each period equal to $v^*(x)$ and employ all those who wished to work at that wage. However, it is more interesting to ask if the optimal allocations are incentive-compatible for the monopsonist firm. If the firm cannot perfectly price discriminate then obviously these allocations would not be chosen for the usual textbook reasons. Conversely, a perfectly discriminating monopsonist would set the wage of the marginal worker equal to $v^*(x)$ and so, under full information, would achieve a welfare maximizing allocation. In order to bring out as clearly as possible the role of imperfect information in generating inefficient layoffs, it is assumed that the firm is able to perfectly discriminate with respect to wages and so none of the inefficiency results in the paper are due to the existence of monopsony per se.

Now consider the post-hiring trading game. The first thing to note about the game is that the inability of the workers and the firm to trade on the spot labor market makes it a repeated game thereby widening the set of strategies available to the firm and its workers. In particular, this allows them to choose strategies that make use of information revealed in past plays of the game. The second aspect of the game to note is that it is one of imperfect information. In each period, nature "moves" by choosing a realization of x for the firm. However, this move is only revealed to the firm though the distribution of x is assumed to be common knowledge. This form of asymmetric information is the one typically used in the implicit and explicit contract literatures, e.g., Grossman and Hart (1981), Hall and Lilien (1979), Holmstrom (1981) and Hart (1983). Nature can also be thought of as making another set of moves at the start of the repeated game by assigning to each worker an opportunity cost of work. Although the distribution of these moves is assumed to be common knowledge each specific move is assumed to be revealed only to the worker concerned. This second asymmetryin information, though empirically reasonable, has seldom been used in the literature either by itself or in conjunction with the use of firm-specific information. Notable exceptions to this are Hall and Lilien (1979), Hall and Lazear (1982a) and Hashimoto and Yu (1980). However, all of these papers dealt with explicit, legally enforceable labor contracts which do not give rise to a post-hiring game.

The purpose of this section is to show that there exists a Nash equilibrium to the trading game that involves both individually rigid wages and inefficiently high levels of layoffs or unemployment. Consider first the strategy of the firm. Its post-hiring discounted profits would be maximized by acting like the full information, perfectly discriminating monopsonist, that is, by paying each worker employed his opportunity cost of work and employing up to the point where the wage of the marginal worker equalled marginal revenue product. This strategy is, however, informationally infeasible as the opportunity costs of work are private information to the workers. But the firm does have some information about the worker's v. In past plays of the game, the worker will have been employed for a sequence of wages and the firm can infer that the worker's v is equal to or less than the minimum wage in the sequence. In view of this, a favorable strategy for the firm to follow would appear to be to pay a worker no more than the minimum wage which the worker has accepted in the past. Let us assume then that at the beginning of each period, the firm asks each worker what wage he is willing to work at that period. The firm then assigns a supply wage to the worker which is equal to the lesser of the worker's stated supply wage and the minimum wage that the worker has worked for in the past. A state of the world is then realized and the firm chooses a cut-off wage $w' = \alpha(x)$ and employs at their supply wages all workers with a supply wage less than or equal to w'. We now ask what an individual worker's optimal response to this strategy would be.

Assume that all workers are wealth maximizers and have discount factors strictly less than unity. In determining the worker's optimal strategy, it is important to realize that the problem faced by the worker is stationary. Consider the problem the worker is faced with in the first period after hiring. His choice of a reservation wage for that period is unconstrained by any employment history with the firm. Let the worker choose a reservation wage $\hat{w}$. After this decision he is either employed or laid off. If he was not employed, then his choice of reservation wage for the next period is also unconstrained by any employment history, thus he will again pick the reservation wage $\hat{w}$. If he was employed, then he is constrained in the second period to choose a reservation wage no greater than $\hat{w}$. But as the solution to his original unconstrained problem was $\hat{w}$, the constraint that he must not choose a reservation wage above $\hat{w}$ will not be binding and so he will again choose $\hat{w}$. Thus we can conclude that the worker's optimal strategy will involve a time-invariant reservation wage.

In choosing the reservation wage, $\hat{w}$, to announce at the beginning of each period, the worker faces the following trade-off. The firm's

cut-off wage $w' = \alpha(x)$, which is taken as given by the worker, is assumed to be monotonically increasing in x.
Define $\beta(w) = \alpha^{-1}(w)$. Thus for any w, $\beta(w)$ gives the x for which the firm would choose a cut-off wage $w' = w$. Now choosing a high reservation wage raises the wage the worker will receive _if_ he is employed but it also reduces the probability of employment because the probability of layoff, $H[\beta(w)]$ is increasing in w. His problem then is to maximize his per period income which is assumed to be concave in w,

$$\max_{w \in [0,\infty]} \; vH[\beta(w)] + w(1 - H[\beta(w)]) \tag{1}$$

The first order condition for this maximization is

$$v \cdot h[\beta(w)] \cdot \beta'(w) + 1 - H[\beta(w)] - w \cdot h[\beta(w)] \cdot \beta'(w) = 0$$

$$\therefore \quad \hat{w} = v + \frac{1 - H[\beta(\hat{w})]}{h[\beta(\hat{w})]\beta'(\hat{w})} \tag{2}$$

Equation (2) defines a function $\phi(v)$ which is the optimal reservation wage rule, i.e., a worker with a value of leisure v "announces" a reservation wage $\hat{w} = \phi(v)$. Assume that $\phi(v)$ is monotonically increasing in v and let the function ψ be the inverse of ϕ. Thus

$$\psi(w) = w - \frac{1 - H[\beta(w)]}{h[\beta(w)]\beta'(w)} \tag{3}$$

Equation (2) immediately implies the existence of too many layoffs from an efficiency point of view. (2) implies $\hat{w} \geq v$ for all workers and $\hat{w} = v$ only for those workers on permanent layoff, i.e., for whom $H[\beta(\hat{w})] = 1$. All workers with layoff probability less than one capture at least some of the surplus from trade. However, this implies that the firm will employ up until the point at which marginal revenue product equals marginal factor cost which will be greater than the marginal opportunity cost of work. Thus too many workers will be on layoff at least in some states of the world. Equation (2) also indicates the wage behavior of both individual workers and the marginal worker. At the level of the individual the choice of reservation wage is state independent for the simple reason that the worker does not observe this period's realization of the state nor does he observe the employment it generates before choosing his reservation wage. Consequently the individual's wage will be completely rigid. If one interprets this rigidity as strong positive autocorrelation of wages after systematic time-related components such as age and tenure are removed, then this is supported empirically by McCurdy's (1982) analysis of longitudinal data for married, prime age, white males. In sharp contrast, the wage of the marginal worker, and so the average wage of employed workers, will be state dependent. A better state of the world shifts up the marginal revenue product curve which, as $\phi(v)$ is assumed to be monotonically increasing,[11] will raise the number of workers employed and the wage of the marginal worker. Thus the "aggregate" data for the firm would indicate flexible, i.e., state dependent, average wages which would move "procyclically" and "countercyclical" movements in layoffs or unemployment. Notice how easy it would be to interpret this aggregate data as indicating the responsiveness of individual wages to the state of the world or unemployment and to infer from this that the layoffs

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[11]This will be the case of the hazard rate $\frac{1 - H(\cdot)}{h(\cdot)}$ is non-decreasing in x.

observed were efficient whereas in fact individual wages are perfectly rigid and too many layoffs are occurring relative to the full information efficiency level.

All these results assume, of course, that a Nash equilibrium to the trading game of the type assumed above exists. This is shown below. The first step is to find what decision rule, $\alpha(x)$, the firm would choose if it took the workers' strategies as given. In Section 3, we will allow the firm to realize that it can manipulate $\phi(v)$ and find the Stackelberg leader strategy of the firm. At a fixed x, all workers with $\hat{w} \leq \alpha(x)$ will be employed. In terms of ψ, we see that the number employed is $G[\psi(\alpha(x))]$. Thus $L = G[\psi(\alpha(x))]$ and so the wage bill in state x given $\alpha(x)$ is

$$\int_0^{\psi(\alpha(x))} \phi(v)g(v)dv = \int_{\underline{\hat{w}}}^{\alpha(x)} \hat{w}g(\psi(\hat{w}))\psi'(\hat{w})d\hat{w}, \text{ where } \underline{\hat{w}} \equiv \phi(0). \qquad (4)$$

The firm's profits in state x are therefore

$$f(G[\psi(\alpha(x))],x) - \int_{\underline{\hat{w}}}^{\alpha(x)} wg[\psi(w)]\psi'(w)dw.$$

So the firm's problem is to maximize its expected profits over states by choosing $\alpha(x)$ appropriately, that is,

$$\underset{\alpha(x)}{\text{Max}} \int_0^{\bar{x}} \{f(G[\psi(\alpha(x))],x) - \int_{\underline{\hat{w}}}^{\alpha(x)} wg[\psi(w)]\psi'(w)dw\}h(x)dx \qquad (5)$$

Pointwise maximization yields the following condition which must hold at each x,

$$\{f_L(G[\psi(\alpha(x))],x) - \alpha(x)\}g[\psi(\alpha(x))]\psi'(\alpha(x)) = 0$$

and so

$$f_L(G[\psi(\alpha(x)],x) = \alpha(x) \quad (6)$$

This is, of course, the rule one would expect, namely, set marginal revenue product equal to marginal factor cost in each state.

It remains to be established, of course, whether a pair of strategies $\alpha(x)$ and $\phi(v)$ can be found which are simultaneously the best responses to each other? This existence issue can be settled simply along the following lines. Given our assumptions, "inverting" (6) yields the following equivalent functional equation in $\alpha(x)$:

$$\psi(\alpha(x)) = \gamma(\alpha(x)).$$

From (3), however, we see that $\psi(\alpha(x)) = \alpha(x) - z(x)\alpha'(x)$ and so (6) can be written as

$$\alpha'(x) = \frac{1}{z(x)}[\alpha(x) - \gamma(\alpha(x))] \quad (7)$$

The standard theory of differential equations tells us that (7) has a solution if the right-hand side satisfies a Lipschitz condition (see Coddington and Levinson (1955)). The latter, however, holds if, as we have assumed, $g(\cdot), f_{Lx}(\cdot) > \varepsilon > 0 > -\varepsilon > f_{LL}$. It should be noted also that these are only sufficient conditions for a Nash equilibrium to exist. The example below indicates that such an equilibrium can exist even when some of these requirements are violated.

2. The Welfare Loss: An Example

The previous section has demonstrated that informational asymmetries can result in individually sticky wages and inefficiently large numbers of layoffs. Given this result, a natural question to ask is how large this inefficiency might be. As this depends on the functional forms involved, little of generality can be said about this. However, in this section a linear example is provided that will allow numerical comparisons of the welfare loss caused by the lack of full information and this in turn can be compared with the traditional loss that would result from preventing the monopsonist from price discriminating in a full information setting. This example also allows comparisons of wage and layoff behaviors in these three situations.

Assume that $x \epsilon [0,1]$, $v \epsilon [0,1]$ and $H(x)$ and $G(v)$ are both uniform so that $h(x) = g(v) \equiv 1$. Further assume that the firm's revenue function $f(L,x) = L \cdot x$. Now consider the full information, perfect price discrimination case. Noting that $L = v$, surplus maximization for a given x requires

$$\underset{L \epsilon [0,1]}{\text{Max}} \quad xL - \int_0^L v \, dv$$

from which we derive the efficient employment rule $L^*(x) = x$. Thus expected welfare is given by

$$\int_0^1 [xL^*(x) - \int_0^{L^*(x)} v \, dv]dx = \int_0^1 (x^2 - \frac{x^2}{2}) \, dx = \frac{1}{6}$$

Notice that the efficient layoff level is $1 - x$, and the efficient level of the average wage of the employed is just $\frac{x}{2}$ and so layoffs will have the same distribution as x while average wages will have the distribution of $\frac{x}{2}$.

In the case of the full information, non-discriminating monopsonist, the profit maximizing employment rule is to set marginal revenue product, x, equal to marginal factor cost, 2L, so that $L^*(x) = \frac{x}{2}$. The expected surplus generated is given by

$$\int_0^1 [xL^* - \int_0^{L^*(x)} v\, dv]dx = \int_0^1 [\frac{x^2}{2} - \frac{x^2}{8}]\, dx = \frac{1}{8}$$

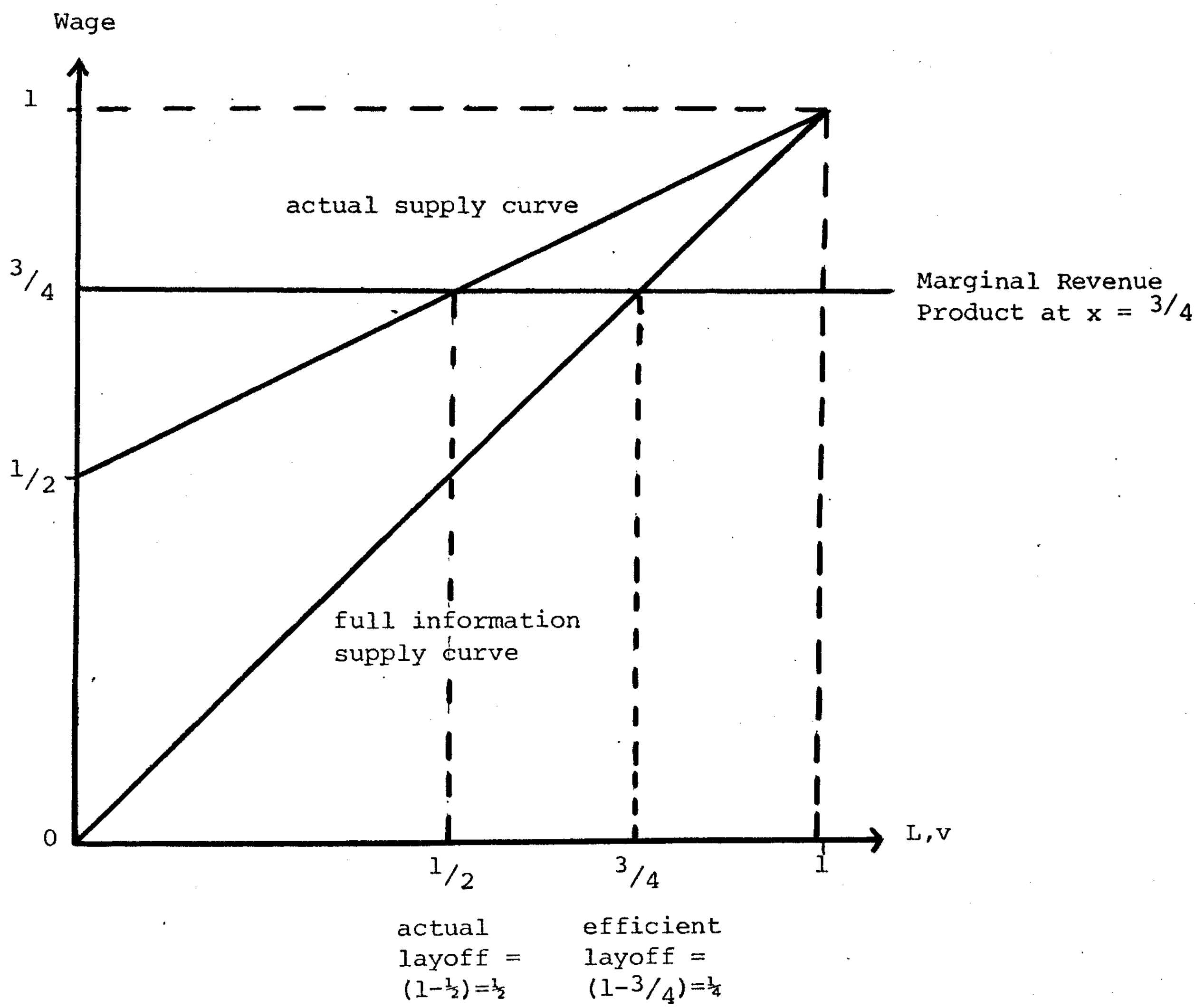
So the move to a non-discriminating monopsonist results in a 25% reduction in welfare. It also affects the behavior of layoffs but not average wages. Layoffs are now equal to $1 - \frac{x}{2}$; thus half of the work force is on permanent layoff, while the average wage of the employed, which here is equal to the wage of each individual employed, is $\frac{x}{2}$. Notice that the average wage as a function of the state is the same as in the welfare maximizing allocation.

Consider now the asymmetric information case analyzed in the previous section. We postulate that the firm's strategy will involve a cut-off wage function, $w' = \alpha(x) = x$ and so $\beta(w) = w$. The worker's optimal choice of reservation wage in response to this is given by (2), which in this example reduces to

$$\hat{w} = \phi(v) = \frac{v+1}{2} \geq \frac{1}{2}$$

This supply curve is shown in Figure 1. Note that $\underline{\hat{w}} = \frac{1}{2}$. The firm's maximization is

Figure 1



Wage
1
3/4
1/2
0
actual supply curve
Marginal Revenue
Product at x = 3/4
full information
supply curve
L,v
1/2
3/4
1
actual
layoff =
(1-½)=½
efficient
layoff =
(1-3/4)=¼

$$\max_{L\in[0,1]} \; xL - \int_0^L \phi(v)dv$$

which gives at interior solutions $L^*(x) = 2x - 1$ with $L^* = 0$ if $[x - \phi(0)] < 0$ and $L^* = 1$ if $[x - \phi(1)] > 0$. So if $x \leq \frac{1}{2}$, $L^* = 0$ and the entire work force is laid off. Notice that layoffs as a function of x are given by $2(1 - x)$, $x > \frac{1}{2}$ and 1 for $x \leq \frac{1}{2}$ so that except at $x = 0$ and $x = 1$ asymmetric information results in excessive layoffs, the excess reaching its peak at $x = \frac{1}{2}$, at which point it is equal to half the work force. A comparison of this layoff function with that in the two full information cases is provided in Figure 2.

To check that $\alpha(x) = x$ is the firm's optimal strategy, we check that $\phi(v) = \alpha(x)$ is satisfied at $v = L^*(x)$, which it is. Turning to the average wage of the employed as a function of x, we see that it is $\frac{x}{2}$, $x > \frac{1}{2}$, which is the same as the full information cases in this range of states. For $x \leq \frac{1}{2}$ no one is employed and so the average wage per employee cannot be calculated.

Finally, we consider the expected welfare in the asymmetric information case. As for $x \leq \frac{1}{2}$ there is no surplus generated, expected welfare is given by

$$\int_{\frac{1}{2}}^{1} [x(2x - 1) - \int_0^{2x-1} v \, dv]dx$$

which can be integrated by parts to give $\frac{1}{8}$. Thus the loss in welfare from moving to asymmetric information, 25%, is precisely the same as that from preventing the monopsonist from discriminating, which indicates both that the welfare losses can be large and that they can be of the same order of magnitude as the more common textbook "wedges."

In section 1, the firm and its employees were treated symmetrically in that each was constrained to take the other's strategy as given. However, in many situations it is natural to suppose that while workers are competing for jobs, the firm enjoys some form of market power. Similarly, in much of the implicit contract literature, the tradition has been to deal with the Stackelberg leader-follower equilibrium in which the firm is the leader. Thus, typically, the firm's problem is to choose the feasible contract that maximizes its expected profits given that the workers receive a minimum level of expected utility, i.e., all the gains from trade accrue to the firm. It would be interesting, therefore, to look not only at the Nash equilibrium to the post-hiring trading game, but also at this Stackelberg equilibrium especially as it is reasonable to assume that the firm will realize that it has monopsony power and would try to exploit it in all the ways open to it.

One obvious way for the firm to exploit its market power is to first recognize, and then exploit the fact, that the workers' reservation wage strategy, $\phi(v)$, depends on its own choice of cutoff wage policy, $\alpha(x)$, as given in (2). We see, in particular, that the lower is $\alpha'(x)$, the lower will be the workers' reservation wage. The firm can therefore induce workers to ask for lower wages by lowering $\alpha'(x)$. In economic terms, by choosing a highly inelastic wage policy, the firm is threatening workers who demand high wages with frequent layoffs and rewarding those who choose low reservation wages with a lower probability of layoff. The extreme form of this maneuver would be to select a state independent wage policy, i.e., lower $\alpha'(x)$ to zero. In this case, the firm is effectively making a "take it or leave it" offer which, in turn, severely restricts the workers' choice of strategies.

The problem with this policy of course is that setting $\alpha(x)$ equal to some positive constant k will require the firm to employ $G(k)$ workers in every state of the world and so except for the one state, x_k, in which $f_L[G(k),x] = k$, the firm will be hiring to a point at which marginal revenue product does not equal the marginal wage. For states far away from x_k, these productive inefficiencies and so foregone marginal profits will be very large. Thus while the firm is able to influence its workforce's behavior, its manipulation is constrained by productive considerations. The firm has to trade off the lowering of the labor supply curve effect of flattening and lowering $\alpha(x)$ with the foregone productive efficiency that such manipulation of $\alpha(x)$ causes along any given $\phi(v)$. The necessity for such a trade-off means that the firm will not be able to achieve its first best result, namely, manipulating $\phi(v)$ such that $\phi(v) = v$ for all v. So even in the Stackelberg case there will be too little employment compared with the full information case. This is demonstrated formally below.

Consider first the wage bill for the firm in state x given by equation (4). This can be rewritten as

$$\int_{\underline{\hat{w}}}^{\alpha(x)} w\,d[G\circ\psi(w)]$$

which, noting that $G\circ\psi(\underline{\hat{w}}) = 0$, can be integrated by parts to give

$$\alpha(x)G\circ\psi(\alpha(x)) - \int_{\underline{\hat{w}}}^{\alpha(x)} G\circ\psi(w)\,dw \qquad (8)$$

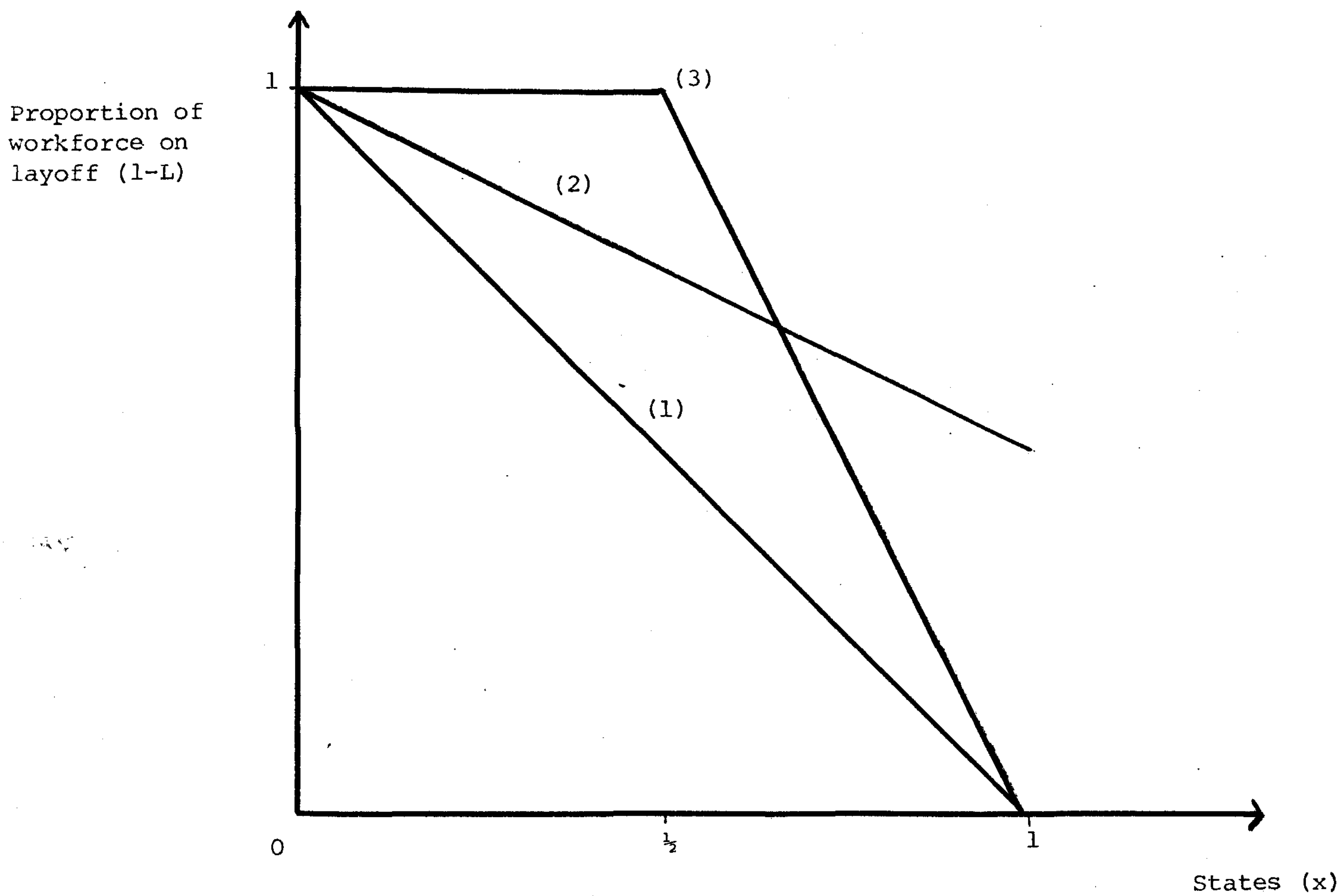
Note that the first term in (8) would be the wage bill if the firm had to pay each worker $\alpha(x)$ and the second term simply corrects this for the fact that the firm can and does discriminate in the wages it pays.

Now, from (3), $\psi(\alpha(x))$ can be written as $\alpha(x) - z(x)\alpha'(x)$. The first term of (8) can be rewritten as

$$\alpha(x)G[\alpha(x) - z(x)\alpha'(x)]. \qquad (9)$$

Defining $\bar{w} = \alpha(\bar{x})$, the <u>total</u> wage bill (average across states) can be expressed as:

Figure 2



(1) Full information, perfect wage discrimination

(2) Full information, no wage discrimination.

(3) Asymmetric information.

$$\int_0^{\bar{x}} \{\alpha(x)G[\alpha(x) - z(x)\alpha'(x)] - \int_{\underline{w}}^{\alpha(x)} G o\psi(w)dw\} h(x)dx$$

$$= \int_0^{\bar{x}} \alpha(x)G[\alpha(x) - z(x)\alpha'(x)] h(x)dx - \int_{\underline{w}}^{\bar{w}} [1 - H(\beta(w))] G o\psi(w)dw$$

$$= \int_0^{\bar{x}} \alpha(x)G[\alpha(x) - z(x)\alpha'(x)] h(x)dx - \int_0^{\bar{x}} z(x) G[\alpha(x)-z(x)\alpha'(x)]\alpha'(x)h(x)dx \tag{10}$$

using the substitution $\beta(w) = x$.

The firm's task, finally, given the stationarity of the problem, is to choose the function $\alpha(x)$ so as to maximize

$$\int_0^{\bar{x}} F(\alpha,\alpha',x)dx$$

where

$$F \equiv \{f(G[\alpha(x) - z(x)\alpha'(x)],x) - \alpha(x)G[\alpha(x) - z(x)\alpha'(x)]$$
$$+ z(x)\alpha'(x)G[\alpha(x) - z(x)\alpha'(x)]\}h(x)$$

This is a straightforward variational problem and so if a solution exists $\alpha(x)$ must fulfill the Euler equation, which here is[12]

$$[1 - H(x)] \frac{d}{dx}\{-G[\alpha(x) - z(x)\alpha'(x)]$$
$$+ g(\cdot)[f_L(\cdot,\cdot) - (\alpha(x) - z(x)\alpha'(x))]\} = 0 \tag{11}$$

Thus, except at $\bar{x}$, $\alpha(x)$ must be such that

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[12]The derivation of (11) is provided in the Appendix.

Figure 3

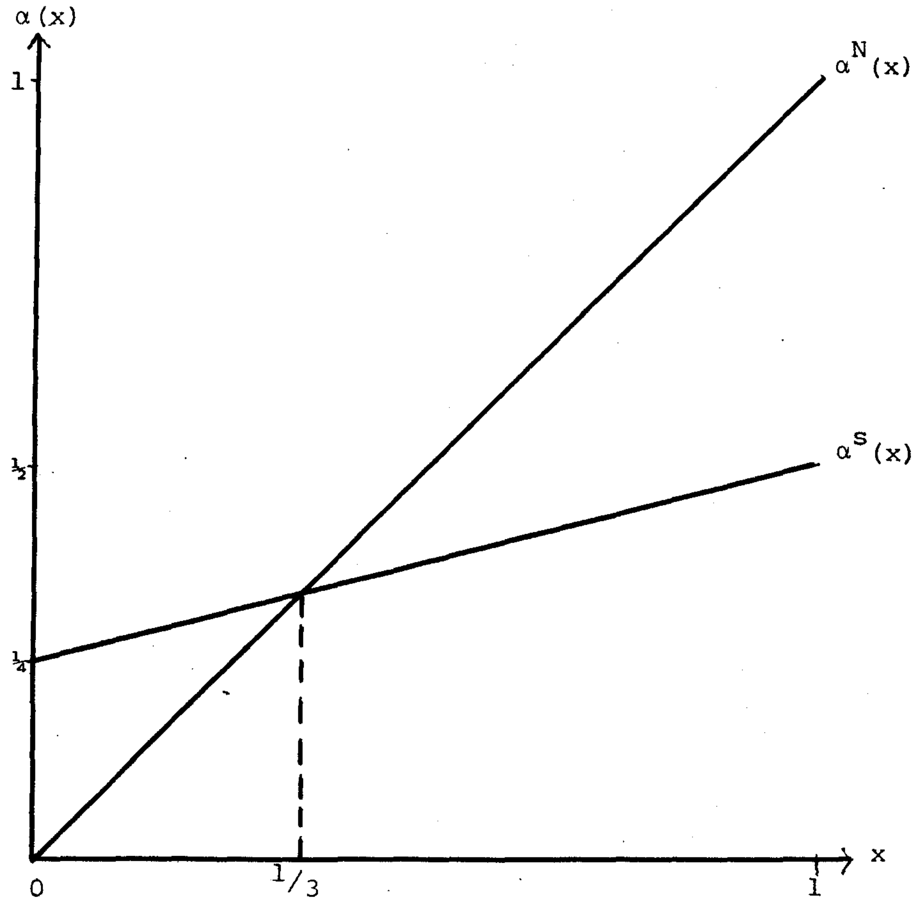
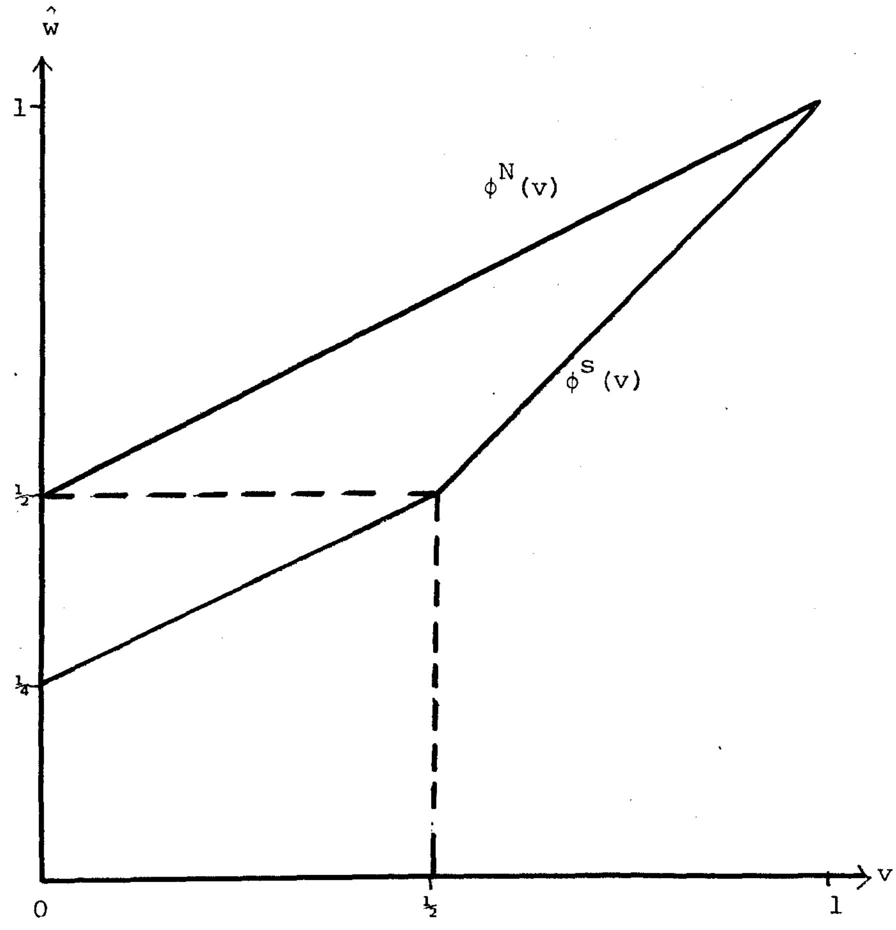


Figure 4



$$- G[\alpha(x) - z(x)\alpha'(x)] + g(\cdot)[f_L(\cdot,\cdot) - (\alpha(x) - z(x)\alpha'(x))]$$

$$= \text{constant} \qquad (12)$$

Moreover, the transversality condition requires that this constant equal zero.

Equation (12) shows that even in the Stackelberg case there will be an inefficiently large number of layoffs in most states of the world. Note that $(\alpha(x) - z(x)\alpha'(x))$ is the value of leisure of the marginal worker employed in state x. Using this we can see that for (12) to hold for all $x < \bar{x}$, $f_L(\cdot,\cdot) > v$ for the marginal worker in contrast to the equality required for efficiency in the full information case.

Unfortunately, (12) is a rather complex condition and it is difficult to derive further insight or intuition from it. To remedy this partially, let us consider the example of section 2 in the Stackelberg case. Noting that in the case of the example $z(x) = (1 - x)$, (12) reduces to $2[\alpha(x) - \alpha'(x)(1 - x)] = x$, the solution to which is $\alpha(x) = \frac{1}{4}x + \frac{1}{4}$. Denote the Nash $\alpha(x)$ and $\phi(v)$ by $\alpha^N(x)$ and $\phi^N(v)$ and similarly those in the Stackelberg case by $\alpha^S(x)$ and $\phi^S(v)$. $\alpha^N(x)$ and $\alpha^S(x)$ are displayed in Figure 3. As economic reasoning suggested, $\alpha^S(x)$ is indeed flatter than $\alpha^N(x)$ and over the range of states in which any labor was hired in the Nash equilibrium, $x \in (\frac{1}{2},1]$, $\alpha^N(x) > \alpha^S(x)$. We see, moreover, that the difference between α^N and α^S increases with x. Intuitively, a layoff threat strategy by the firm is most effective if it raises the probability that "demanding" workers will be laid off more frequently while lowering the probability that less demanding workers will be laid off. This can be carried out by raising the cutoff wage for bad states and lowering it for good states.

The effect of this on the labor supply schedule which the firm faces is shown in Figure 4, which shows that the firm has successfully lowered the supply curve at all points other than v = 1. Moreover, it has lowered the reservation wages most for those workers it in fact employs, i.e., $v \leq \frac{1}{2}$. Notice that contrary to the Nash case, in the Stackelberg equilibrium some workers are employed in all states of the world but some workers, $v > \frac{1}{2}$, are never employed. Finally, we note that the firm's manipulation of $\phi(v)$ through its choice of $\alpha(x)$ was not costless in terms of productive efficiency. In Figure 3, marginal value product equals x, which is given by the curve $\alpha^N(x)$. Comparing this with $\alpha^S(x)$ we see that for $x < \frac{1}{3}$ workers are employed beyond the point where marginal revenue product equals the marginal worker's wage while for $x > \frac{1}{3}$ the reverse is true.

4: Conclusion

Implicit contracts, by definition almost, are unenforceable by third parties. Given that this is so, a necessary condition for such "contracts" to constrain the traders' behaviors ex post is that none of the parties be able to trade ex post on the spot market and indeed, this assumption of the existence of a persistant, bilateral monopoly after the initial hiring has been made in almost all of the major implicit contract papers. However, this assumption gives rise to a repeated, post-hiring, trading game in which the surplus is divided up between the parties. Moreover, because of the unenforceability of the implicit contract, the parties to it cannot credibly pre-commit themselves to strategies for the trading game at the time of hiring. This paper has shown that under bilateral asymmetric information, the strategic problems that the workers and firm are faced with can result in a Nash equilibrium in which each individual's wage will be rigid in the sense of being independent of the state of the firm's demand for labor. As a consequence, workers will be laid off too often from a full information efficiency point of view. Thus the principal result in the implicit contract literature can be obtained and rationalized simply from strategic considerations ra than by an appeal to insurance contracts. This is particularly fortunate as the unenforceability of implicit contracts makes the trade of risk problematic.

Finally, despite the existence of individually rigid wages in this model, the heterogeneity of wages across workers together with the firm's layoff policy results in "pro-cyclical" movements in the average wage paid to employed workers. As a result, the typical empirical wage equations, e.g., average wage as a function of unemployment or layoffs, would indicate, possibly great, sensitivity of wages to "labor market conditions" despite the fact that all wages are state independent. This suggests that far greater attention should be paid to compositional changes within the set of employed workers as the level of employment changes if we are to draw correct inferences concerning the behavior of individual's wages from aggregate wage data.

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Appendix

$$F = \{f(G[\alpha(x) - z(x)\alpha'(x)],x) - \alpha(x)G[\alpha(x) - z(x)\alpha'(x)]$$

$$+ z(x)G[\alpha(x) - z(x)\alpha'(x)]\alpha'(x)\}h(x)$$

$$\frac{\partial F}{\partial \alpha} = [f_L \cdot g - g \cdot \alpha - G + z \cdot \alpha' \cdot g]h = h[g[f_L - (\alpha - \alpha' \cdot z)] - G]$$

$$\frac{\partial F}{\partial \alpha'} = [-z \cdot f_L \cdot g + \alpha \cdot z \cdot g + z \cdot G - z^2 \cdot \alpha' \cdot g]h = - zh[g[f_L - (\alpha - \alpha' \cdot z)] - G]$$

But $z \cdot h = \frac{1 - H(x)}{h(x)} \cdot h(x) = 1 - H(x)$

$$\therefore \frac{\partial F}{\partial \alpha'} = - [1 - H(x)][g[f_L - (\alpha - \alpha' \cdot z)] - G]$$

$$\therefore \frac{d}{dx}\frac{\partial F}{\partial \alpha'} = h(x)[g[f_L - (\alpha - \alpha' \cdot z)] - G]$$

$$- [1 - H(x)] \frac{d}{dx} [g[f_L - (\alpha - \alpha' \cdot z)] - G]$$

$$= \frac{\partial F}{\partial \alpha} - [1 - H(x)] \frac{d}{dx}]g[f_L - (\alpha - \alpha' \cdot z)] - G]$$

The Euler equation is $\frac{\partial F}{\partial \alpha} - \frac{d}{dx}(\frac{\partial F}{\partial \alpha'}) = 0$ and so (11) is derived.

The relevant transversality condition is in this case

$$\frac{\partial F}{\partial \alpha'}\Big|_{\bar{x}} = 0 .$$