A NOTE ABOUT EFFORT, WAGES, AND UNEMPLOYMENT*

María Dolores Alepuz, María Angeles Diaz, and Rosario Sánchez**

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ABSTRACT

The purpose of this paper is to observe that in a principal agent-model with performance contracts, may exist involuntary unemployment as a consequence of the incentive wage system used by the firm. We show that, in a context of identical firms, the firm that pays more gets a higher level of profits per worker. Also, the reward received for identical workers are different depending on the wage contract stipulated for alternative firms.

KEY WORDS: Incentives, efficiency-wages and principal agent.
JEL: J33, J41

RESUMEN

El propósito de este trabajo es demostrar que en un modelo de principal-agente, con contratos salariales endógenos, el desempleo involuntario aparece como consecuencia del sistema de incentivación salarial utilizado por la empresa. Se demuestra que, para empresas idénticas, la empresa que paga un salario mayor obtiene un nivel de beneficios por trabajador más elevado. Igualmente se comprueba que trabajadores idénticos consiguen ingresos diferentes dependiendo del tipo de contrato estipulado por la empresa.

PALABRAS CLAVE: Incentivos, salarios de eficiencia, principal-agente.
JEL: J33, J41

1. INTRODUCCIÓN

Much attention has been focused on the notion that worker productivity is not independent of the compensation scheme. A recurring theme of the agency literature is that a divergence of interest between a principal and an agent causes output to depend upon the contingent nature of compensation. More specifically, this paper discusses the way in which worker effort varies with contractual arrangements. Here, we obtain involuntary unemployment as a consequence of the incentive payment used for the firm and independently of the characteristics of the labour supply. To this end, we use a linear and non-linear[1] wage scheme to compare the differences between them in output per worker and wage. In a linear wage system the worker can choose the desired level of effort. However, when we move to a non-linear system we can regard the worker's choice variable will be his status-specific output level instead of his effort level. The firm is assumed to know the worker's utility function and the underlying distribution of his status. The expected profit of a firm is the excess of outputs over rewards, averaged over all possible status and summed over all its workers.

The most influential wage incentive models, such as Lazear(1979,1981), Shapiro and Stiglitz (1984), and Bulow and Summers (1986), stress that when wages are chosen to deter shirking, the rigor of supervision as well as the standards imposed by the firm for a worker to keep his job is the critical choice variable of the firm. In an effort model the cost of supervision affects both the wage and the equilibrium unemployment rate. If perfect monitoring were sufficiently cheap, firms could pay wages that were arbitrarily close to the reservation wage of their workers and still deter shirking. The traditional Shirking[2]model is based on the firms' imperfect information concerning the effort of their employees. Monitoring individual performance is assumed to be difficult or costly. As an incentive for workers to work instead of shirking, firms may find it profitable to rise wages because this attitude increases the cost of job loss. In general, by paying higher wages, firms obtain a higher quality[3] labour force. In our work, to deter shirking is not necessary since the firm will pay according to the observed output.

Theories that emphasize the importance of unemployment due to the friction of the search process, have frequently found it difficult to explain the reasons for a distribution of wage offers in the market. The efficiency wage hypothesis also provides a simple explanation for the existence of wage differentials. If the relationship between wages and effort differs among firms, each firm's efficiency wage will differ and, in equilibrium, there will emerge a distribution of wage offers for workers of identical characteristics. Here it is proof that, with the same composition of the labour force, identical firms could adopt different strategies

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[1] The non-linear scheme used here is similar to that used for Foster and Wan (1984).

[2]For a more extensive explanation. see Shapiro and Stiglitz (1984).

[3]In Stiglitz (1976) and Weiss (1980.1990), there are a good explanation of the improvement in the job quality of the applicants.

equally profitable[4] but with differences in the amount of labour needed for producing a single good.

2. THE MODEL

The basic framework of a standard principal agent equilibrium model starts by assuming a conflict between the principal and the agent, where the principal cannot control all the actions made by the agent. To solve it, the principal proposes a contract that ensure the agent will take the action the principal wants. The principal (the firm) is in charge to make the contract, hire the workers (agent) and decide the level of production. The output of a worker depends on the worker's effort level and the worker's status. The firm cannot observe the worker's effort, but it knows his individual output. Each worker has an utility function that depends positively on his reward and negatively on the effort expended. The problem facing a firm is to make a contract consistent with output responses that maximize its profits.

To make our exposition as transparent as possible, we shall consider a simple example with specific functional forms to analyze the behaviour of workers and firms. The workers possess identical utility function of the type U = U(w,e); where w is the wage and e the effort. The worker's utility function is of the form:

$$U = w - e^2 \qquad [1]$$

The firm produces a single good with two types of workers with low and high productivity respectively. Inside each group all the workers expend the same level of effort and consequently they obtain an equal amount of product. The common production technology for each worker is represented by:

$$y_1 = a_1 e_1^{\alpha} \qquad [2]$$

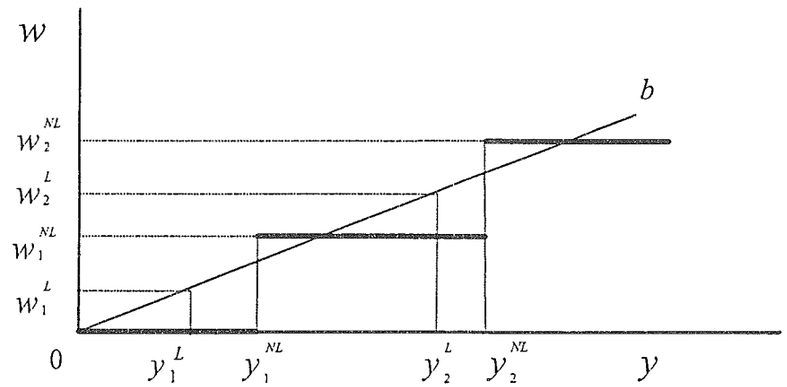
$$y_2 = a_2 e_2^{\alpha} \qquad [3]$$

[4] As it was suggested for Stiglitz (1984), we have used the condition that two identical firms could adopt alternatives strategies of high wages and low employment or low wages and high employment, and to obtain an equal level of total profits. In the first case the rotation of the labor force has to be smaller than in the second case.

Each worker has two possible status of productivity, a_1 and a_2, with corresponding probabilities $P_1 > 0$ and $P_2 > 0$. Without loss of generality, we take $a_1 < a_2$; i.e, status 2 is the more productive status.

The firm is unable to observe a worker's status or monitor his effort level, then it offers a performance contract w(y) which promises a non-negative reward depending on the observed output "y". A simple linear or "piece-rate wage" as well as a non linear contract is depicted in figure 1. The firm is assumed to choose an employment program, which specifies a level of employment and a performance contract for each worker hired by the firm.

figure 1



As a theoretical objection to these schemes , employers would be subject to moral hazard in evaluating worker's effort. In Lazear's model, the firm pays a wage in excess of marginal product to senior workers. There is an incentive for the firm to fire such workers, replacing them with young workers who are paid less than their productivity level. The seriousness of this moral hazard problem depends on the ability of workers to enforce honesty on the firms part. If effort is observable both by the firm and by the worker, and it can be verified by outside auditors, the firm will be unable to cheat workers. Even without outside verification, Lazear (1981) has shown how a firm, that is concerned for its reputation, can overcome the moral hazard problem. In our example the firm commits itself to a fixed-wage plan in which a high wage is paid to a fraction of workers and a low wage to the remaining fraction according to an ex-post ranking of their output levels. By precommitting itself to such a plan with a fixed wage bill, the firm's moral hazard problem disappears.

3. THE PIECE RATE WAGE CONTRACT

The firm offers a performance contract , w = w(y), which promises a non-negative reward depending on the observed output "y". The status of each worker is assumed to be identically and independently distributed. The firm can observe a worker's output, but neither his effort, nor his status. This contract takes the form:

$$w_1 = by_1 \qquad [4]$$

$$w_2 = by_2 \qquad [5]$$

The firm will never offer a wage which violates individual rationality. Thus, the utility of reward must at least cover the negative utility of effort, and therefor it imply:

$$w_i - e_i^2 \geq 0 \qquad [6]$$

Now the worker assumes, as given, the wage scheme and they will choose the level of effort which maximizes his utility, so:

$$\underset{e_i}{Max}\, U = (w_i - e_i^2) \qquad [7]$$

St. w_ig by

Thus, from the first order condition we obtain the optimal level of effort for worker of type "1" and "2"

$$e_1^L = \left(\frac{ba_1\alpha}{2}\right)^{\frac{1}{2-\alpha}} \qquad [8]$$

$$e_2^L = \left(\frac{ba_2\alpha}{2}\right)^{\frac{1}{2-\alpha}} \qquad [9]$$

The expected profits per worker can be expressed as:

$$\pi^L = P_1\left(y_1^L - by_1^L\right) + P_2\left(y_2^L - by_2^L\right) \qquad [10]$$

Assuming that the workers are induced to apply the level of effort reported in (8) and (9) and by rearranging them, we obtain the new profit function:

$$\pi^L = P_1\left[a_1\left(\frac{ba_1\alpha}{2}\right)^{\frac{\alpha}{2-\alpha}}\right](1-b) + P_2\left[a_2\left(\frac{ba_2\alpha}{2}\right)^{\frac{\alpha}{2-\alpha}}\right](1-b) \qquad [11]$$

Now, the optimal scheme can be found by solving the maximization problem with respect to "b":

$$b = \frac{\alpha}{2} \qquad [12]$$

In (12) it is obtained the optimal value of "b" to induce the workers to choose the desired level of effort. Thus, the optimal level of effort will be:

$$e_1^L = \left(\frac{\alpha^2 a_1}{4}\right)^{\frac{1}{2-\alpha}} \qquad [13]$$

$$e_2^L = \left(\frac{\alpha^2 a_2}{4}\right)^{\frac{1}{2-\alpha}} \qquad [14]$$

The level of production per worker of type "1" and "2" could be obtained substituting the expression (13) and (14) in (2) and (3) respectively:

$$y_1^L = a_1\left(\frac{\alpha^2 a_1}{4}\right)^{\frac{\alpha}{2-\alpha}} \qquad [15]$$

$$y_2^L = a_2\left(\frac{\alpha^2 a_2}{4}\right)^{\frac{\alpha}{2-\alpha}} \qquad [16]$$

The wage earned by each kind of worker depends on the production observed by the principal, thus:

$$w_1^L = \frac{\alpha a_1}{2}\left(\frac{\alpha^2 a_1}{4}\right)^{\frac{\alpha}{2-\alpha}} \qquad [17]$$

$$w_2^L = \frac{\alpha a_2}{2}\left(\frac{\alpha^2 a_2}{4}\right)^{\frac{\alpha}{2-\alpha}} \qquad [18]$$

As it was expected, the workers with a high productivity will get a higher wage as a result of the direct proportion over his level of production. In a piece rate wage model, the worker can decides the optimal level of effort, and it will depend on the amount of the fix proportion "b". Now, our main goal is to compare this results with that obtained when the firm adopts a non-linear contract.

4. THE NON LINEAR WAGE CONTRACT

As in the linear case, the firm hire workers to produce a single good. The status of each worker is assumed to be identically and independently distributed. The firm can observe a worker's output, but neither his effort, nor his status. Being unable to observe a worker's status or monitor his effort level, the firm offers a performance contract "w(y)", which promises a non-negative reward of "w" depending on the observed output:

$$\begin{cases} 0 & if \quad 0 \le y < y_1 \\ w_1 & if \quad y_1 \le y < y_2 \\ w_2 & if \quad y_2 \le y \end{cases} \qquad [19]$$

The worker's optimal response is "y_1" and "y_2"; any level of production above y_2 does not induce an additional wage, thus "y_2" will be the highest amount of output produced. For any quantity smaller than "y_2" the worker will receive a wage of w_1 so, the optimal replay is to produce y_1 to obtain a wage w_1, and y_2 for a reward of w_2.

The firm never will offer a wage concession which violate individual rationality, then the utility of reward has, at least, to cover the negative utility of effort. To be sure that each contract gives a non-negative reward for every level of output, the firm has to offer, to worker 2, a wage that cover, at least, the increment in effort made with respect to a worker of type "1", and then[5]:

$$w_2^{NL} = \Delta e^2 + w_1^{NL} \qquad [20]$$

Given the amount of output, we can regard the worker's choice variables as his status specific output levels instead of his effort levels:

$$e_1^{NL} = \left(\frac{y_1}{a_1}\right)^{\frac{1}{\alpha}} \qquad [21]$$

$$e_2^{NL} = \left(\frac{y_2}{a_2}\right)^{\frac{1}{\alpha}} \qquad [22]$$

The value of the wage in terms of production becomes for each type:

$$w_1^{NL} = \left(\frac{y_1^{NL}}{a_1}\right)^{\frac{2}{\alpha}} \qquad [23]$$

$$w_2^{NL} = \left(\frac{y_2^{NL}}{a_2}\right)^{\frac{2}{\alpha}} - \left(\frac{y_1^{NL}}{a_2}\right)^{\frac{2}{\alpha}} + \left(\frac{y_1^{NL}}{a_1}\right)^{\frac{2}{\alpha}} \qquad [24]$$

[5] This was firstly used for Foster and Wan (1984).

The status-dependent output responses of worker leads to a level of expected profits per worker of:

$$\pi^{NL} = P_1\left[y_1^{NL} - w_1^{NL}\right] + P_2\left[y_2^{NL} - w_2^{NL}\right] \qquad [25]$$

Substituting (23) and (24) in (25) we have:

$$\pi^{NL} = P_1\left[y_1^{NL} - \left(\frac{y_1^{NL}}{a_1}\right)^{2/\alpha}\right] + P_2\left[y_2^{NL} - \left(\frac{y_2^{NL}}{a_2}\right)^{2/\alpha} + \left(\frac{y_1^{NL}}{a_2}\right)^{2/\alpha} - \left(\frac{y_1^{NL}}{a_1}\right)^{2/\alpha}\right] \qquad [26]$$

We can obtain total expected profit by maximizing the expected profit of each worker independently, because the contracts or outputs of worker's co-workers have no effect on the contract or output of that worker. From the first order condition, we can achieve the optimal value of "y_1" and "y_2":

$$y_1^{NL} = \left[\frac{P_1\alpha a_1^{\frac{2}{\alpha}} a_2^{\frac{2}{\alpha}}}{2\left(a_2^{\frac{2}{\alpha}} - P_2 a_1^{\frac{2}{\alpha}}\right)}\right]^{\frac{\alpha}{2-\alpha}} \qquad [27]$$

$$y_2^{NL} = \left(\frac{\alpha a_2^{2/\alpha}}{2}\right)^{\frac{\alpha}{2-\alpha}} \qquad [28]$$

Under this scheme, the value of output for both, high and low quality workers, are higher than in the linear contract as well as wages and effort. An important difference with respect to the piece rate wage scheme is that here, the worker cannot decide the level of effort. In this case the effort level depends on the output ranking. In next section we will examine the level of employment for each contract.

5. THE LINKAGE BETWEEN UNEMPLOYMENT AND WAGE PROFITS

Now, we can assume the firm could obtain the same level of total profits[6] with both schemes and then:

$$\pi^{L} N^{L} = \pi^{NL} N^{NL} \qquad [29]$$

Since w(y) yields the highest profit, of a given worker, independently of the contracts of all other workers at the firm. It is clear that a program in which all contracts are w(y) must be profit maximizing for that N. Assuming the probability to be of type one or two is "1/2" and the value of α =1, the total profits of the linear and non linear contract are:

$$\pi_T^{L} = \frac{1}{16}\left(a_1^2 + a_2^2\right)N^{L} \qquad [30]$$

$$\pi_T^{NL} = \frac{a_2^4 N^{NL}}{4\left(2a_2^2 - a_1^2\right)} \qquad [31]$$

The proportion of employment in the firm which adopt a linear wage incentive r, with respect to the case where the program is non-linear one, can be expressed as:

$$\frac{N^{L}}{N^{NL}} = \frac{4a_2^4}{\left(2a_2^2 - a_1^2\right)\left(a_1^2 + a_2^2\right)} > 1 \qquad [32]$$

The equation (32) is clearly bigger than one, and it implies that the level of employment, when the firm chooses the linear wage incentive, has to be higher than in the second assumption, where the firm induces effort through a non linear scheme. These results are obtained for an equal level of profits, and it means that the firm could be indifferent between these two programs. Here it is clear the idea that wage increases can pay for

[6] We have make this assumption because our main interest is to proof that with the same profitability the firm can choose between different strategies and this election affects the employment's level.

themselves[7], in the sense that if the firm pay more it can obtain more in terms of production, with the same technology and composition of the labour force.

Now, we can also assume an industry with "m" identical firms, producing the same good and having the same composition of the labour force. Furthermore, we can suppose that the maximum level of employment in the industry, "N*, could be acquired when all the firms take the linear contract as a program. So we can assume that it is the full-employment level of the industry:

$$mN^{L} = N^{*} \qquad [33]$$

But if total profits are equal in both cases, we can observe some firms interested in the second scheme. Assuming the same probability for both types of firm we have:

$$N^{I} = \frac{m}{2}\left(N^{L} + N^{NL}\right) \qquad [34]$$

Where N^{I} is the total employment of the industry. This applies, when half of the firms choose the linear incentive and the other half choose the non-linear one. Obviously $N^{*}>N^{I}$ and it can be easily shown, dividing both sides of (35) by N^{NL} and then, rearranging them:

$$\frac{N^{I}2}{N^{NL}m} = \frac{N^{L}}{N^{NL}} + \frac{N^{NL}}{N^{NL}} \qquad [35]$$

Substituting (32) in (35) and rearranging them we have:

$$\frac{N^{I}}{N^{*}} = \frac{6a_2^4 + a_2^2a_1^2 - a_1^4}{8a_2^4} < 1 \qquad [36]$$

With this simple example we have proved that unemployment, at the level of the industry, can arise as a consequence of a strategy of the firm conducted to increase the level of observed output by worker. Even if the level of total profits are equal for these two

[7]David I. Levine (1992), has checked this idea through an empirical test of the efficiency wage hypothesis.

schemes, the results in terms of employment are different, by taking into account the whole industry.

6. INVOLUNTARY UNEMPLOYMENT

The involuntary unemployment arise when the worker's utility on the job are higher than that obtained for identical workers unemployed. An unemployed worker receives the utility level associated with the pair (w,e) = (0,0) and an employed worker, by contrast, enjoys a different level of utility depending of the program of the firm.

The utility of workers, that belong to firms that pay a piece rate wage contract, is:

$$U_1^{L} = \frac{a_1^2}{16} \qquad [37]$$

$$U_2^{L} = \frac{a_2^2}{16} \qquad [38]$$

Since a_1 is smaller than a_2 it follows that U_2^{L} is strictly higher than U_1^{L}, and U_1^{L} is strictly higher than zero. This implies that the expected utility of an employed worker is strictly greater than that of an unemployed worker in the piece rate wage contract case.

Now for the non linear contract case we have:

$$U_1^{NL} = \left(\frac{a_1a_2^2}{2\left(2a_2^2 - a_1^2\right)}\right)^2 - \left(\frac{a_1a_2^2}{2\left(2a_2^2 - a_1^2\right)}\right)^2 = 0 \qquad [39]$$

$$U_2^{NL} = \left(\frac{a_2^2a_1^2(a_2^2 - a_1^2)}{4(2a_2^2 - a_1^2)}\right) > 0 \qquad [40]$$

When we move to a non-linear contract the level of utility of worker's type "2" is higher than zero as it happens in the piece rate wage scheme. However, the level of utility of

worker of type "1" is equal to that obtained for an unemployed worker. What it means is that when this type of workers realize that they are better in a firm with a linear wage contract they will quit firms with non-linear wage scheme. To be unemployed is not a real problem for them since they obtain the same level of utility working in a firm that offers a non-linear contract than been unemployed.

In labour markets in which informational asymmetries are important there may be too little (or no) trade because of the adverse selection effect of wages. A rigorous analysis of markets with important informational asymmetries in which unobserved characteristics are correlated with the reservation wage, shows that the walrasian market-clearing price may not be consistent with optimizing behaviour by agents. Adverse selection yields further reasons for a relation between productivity and wages.

If ability and workers' reservation wage are positively correlated, firms with higher wages will attract more able job candidates. In such a model, each firm pays an efficiency wage and optimally turns away applicants offering to work for less than that wage. The willingness of an individual to work for less than the going wage places an upper bound on his ability, raising the firm's estimate that he is a "lemon". However, for the adverse selection model to provide a convincing account of involuntary unemployment, firm must be unable either to measure effort and pay piece rates after workers are hired or to fire workers whose output is too low.

In our example the firm can overcome this problem because it is clearly stipulated the output and reward and thus each worker can be clearly differentiated ex-post. Here is the worker of type "1" who has a strong incentive to leave the firm that pay through a non-linear wage contract. Now, we can assume that firms that pay a non-linear scheme cannot attract any worker of type "1", then we will suppose $P_1 = 0$ and $P_2 = 1$. Under this assumption the new value of the profits per worker would be:

$$\pi_{\bullet}^{NL} = \frac{a_2^2}{4} \qquad [41]$$

In a perfect informed world the firms which adopt the non-linear scheme will attract only the high quality workers and will obtain a higher level of profits per worker than in the case where both types of workers are evolved in the production of a single good. In this case the level of involuntary unemployment is still greater than when the firm has a $P_1 = 1/2$; it can be easily showed:

$$\pi^{NL} N^{NL} = \pi_{\bullet}^{NL} N_{\bullet}^{Nl} \quad if \quad \pi^{NL} < \pi_{\bullet}^{NL} \Rightarrow N^{NL} > N_{\bullet}^{NL} \qquad [42]$$

Where $\pi_{\bullet}^{NL}$ *and* $N_{\bullet}^{NL}$ are the level of profits and employment respectively when the probability of hiring workers of type "1" is zero. In this case a better distribution of workers between firms worsen the unemployment solution. The above example illustrates a situation in which exists persistent unemployment that is neither voluntary not frictional. By "not voluntary" we mean that there are two identical individuals, one employed and the other jobless, where the former is better off than the latter in expected utility terms.

7. CONCLUDING REMARKS

We have shown that inter-firm wage differentials could arise as a consequence of the program of incentive payment used for the firm. Also, it is proved that two alternatives strategies of payment can generate different levels of employment, in firms with the same technology and composition of the labour force. Through a simple example it is obtained that identical persons enjoy different expected utility with "on the job" being favoured. Our model looks explicitly how worker's allocation improve the profits per worker obtained for firms with a non-linear system of wage payment. Also it is shown how low productivity workers are better off when they move to firms that pay piece rate wages. However, even if this new allocation improve utility and profits per worker of both, employed workers and firms, it worsen the level of employment of the whole industry.

Furthermore our findings are on line with the existence of wage differentials, for identical workers, depending on the wage policy of the firm. Comparing wage dispersions from different countries casts some light on the importance of wage setting institutions and wage policies in shaping the wage structure. The results obtained in this paper are on line with the efficiency wage framework, in the sense that is the wage offered by the firm which produces involuntary unemployment.

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