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INCENTIVE CONTRACTS

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ABSTRACT

Labor relations involve incentive problems. The market solves these problems by developing a variety of institutions. This paper describes and assesses the various forms of incentive contracts.

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Incentives are the essence of economics. The most basic concept, demand, considers how to induce a consumer to buy more of a particular good, i.e., how to give him an incentive to purchase. Similarly, supply relationships are descriptions of how agents respond with more output or labor to additional compensation.

Incentive contracts arise because individual love leisure. In order to induce them to forgo some leisure, or put alternatively, to put forth effort, some form of compensation must be offered. The theme of the essay is that different forms of incentive contracts deal with some aspects of the problems better than others. The strength of one type of contract is the weakness of another. The labor market trades off these strengths and weaknesses and thereby selects a set of institutions. In what follows, the development of the literature on incentive contracts is briefly discussed. The emphasis is on concepts, rather than specific papers or authors, so the bibliography is far from exhaustive.

To discuss incentive contracts, the most general concepts must be narrowed. This essay does that in two ways: First, attention here is restricted to the labor market. At a more general level, incentive contracts can relate to other areas as well. For example, the government may want to have a space satellite built at the lowest possible cost. To do so, incentives must be set appropriately or the producer may charge too much or fail to meet desired quality standards. This problem is analogous to those that arise in the labor context, but for the most part, they are ignored, except when isomorphic with the labor market paradigm. Similarly, the law and economics literature is another area where incentive problems are studied, usually in the context of accident liability. (See, for example, Green (1976), Shavell (1980), Polinsky (1981).) These specific questions are

ignored as well, except as they border on the labor market context. Second, the focus is on observability problems. Standard labor supply functions, where hours of work can be observed and paid, are incentive contracts. However, standard labor supply issues are eliminated from consideration since they are dealt with in other essays in the New Palgrave.

I. General Framework

An employer in a competitive environment must induce a worker to perform at the efficient level of effort or face extinction. The reason is simple: If one employer can, through clever use of an incentive contract, get a worker to perform at a more efficient level, that firm's cost will be lower. Lower costs imply that higher wages can be paid to workers and all workers will be stolen from inefficient firms. As a result, the objective function that is taken as standard for the firm is:

$$\underset{F}{\text{Max}}\ F(Q; E) - C(E)\ , \tag{1}$$

where Q is output and E is worker effort. Thus, $F(Q; E)$ is the compensation schedule that the firm announces to the worker; $C(E)$ is the worker's cost of effort function, to be thought of as the dollar cost associated with supplying effort level E.

The competitive nature of the firm in factor and product markets implies that the firm must maximize worker net wealth as in (1) subject to the zero profit constraint:

$$Q = F(Q; E)\ . \tag{2}$$

Output is defined so that each unit sells for one dollar (the numeraire). Thus, (2) merely says that output, Q, must be paid entirely to the worker otherwise another firm could steal the worker away by paying more.

The incentive problem arises because the worker takes the compensation scheme $F(Q; E)$ as given and chooses effort to maximize expected utility. Once the worker has accepted the job, his problem is:

$$\underset{E}{\text{Max}}\ F(Q; E) - C(E) . \tag{3}$$

The worker's effort supply function comes from solving the first-order condition associated with (3) or

$$C'(E) = \frac{\partial F}{\partial Q} \cdot \frac{\partial Q}{\partial E} + \frac{\partial F}{\partial E} , \tag{4}$$

which says that the worker sets the marginal cost of effort equal to its marginal return to him. The transformation of output into effort, i.e., $\partial Q/\partial E$, depends on the production function. A convenient specification is

$$Q = E + \nu , \tag{5}$$

so that output is the sum of effort, E, and luck, ν.

An incentive contract selects $F(Q; E)$ subject to the zero profit constraint, (2), taking into account that the worker behaves according to (4). There are an infinite variety of incentive contracts that are subsumed by $F(Q; E)$. To make things clear, we consider two polar extremes--the salary and the piece rate.[1]

Let us define a salary as compensation that depends only on input so that $F(Q; E)$ takes the form $S(E)$. An hourly wage is an example. Irrespective of the amount that is produced during the hour, the worker receives a fixed amount that depends only on the fact that he supplies E of effort for the hour. (Of course, difficulty in measuring E may be a compelling reason to

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[1]An elaboration of some of the points contained herein can be found in Lazear (1986a).

avoid this form of incentive contract.) At the other extreme is a piece rate where compensation depends only on output so that $F(Q; E)$ takes the form of $R(Q)$. There, no matter how much or how little effort the worker exerts, his compensation depends only on the number of units produced. Both salaries and piece rates are incentive contracts; the first provides incentives by paying workers on the basis of input. The second provides incentives by paying on the basis of output. More sophisticated incentive contracts, which blend the two or use multiperiod approaches are discussed later.

II. The Principal-Agent Problem

At the center of the incentive contract literature is the "principal-agent" problem. The principal, say, an employer, wants to induce its agent, say, a worker, to behave in a way that is beneficial to the employer. The problem is that the principal's knowledge is imperfect; either he cannot see what the agent does (as in the case of a taxi driver who can sleep on the job) or he cannot interpret the actions (as in the case of an auto mechanic who replaces a number of parts to correct a perhaps simple malfunction). The incentive contracts that can be used to address the problem were discussed early by Ross (1972), Mirrlees (1976), Calvo and Wellisz (1978), and by Becker and Stigler (1974). The last in particular, uses a sampling approach. For example, a politician can be required to post a large bond on taking office. If he is caught engaging in some malfeasant behavior, he forfeits the bond. This contract is based on output, which is observed infrequently or imperfectly. Other kinds of incentive contracts are discussed in the following sections.

III. Payment by Output

A. Sharecropping

One of the earliest examples of incentive contracts that is based on output is sharecropping. In sharecropping, the owner contracts to split the output of the land in some proportion with the individual who farms and lives on it. It was also one of the first incentive schemes that was clearly analyzed (see Johnson, 1950 and later Cheung, 1968 and Stiglitz, 1974). The original problem as formulated in sharecropping can be seen as follows:

Payment is conditional only on Q and by some fixed proportion so that the worker receives γQ. Using (4) and (5), compensation of this sort implies that the worker's first-order condition is

$$C'(E) = \gamma ,$$

so that the worker sets the marginal cost of effort equal to γ. But (5) implies that the marginal value of effort is \$1, which exceeds γ so that the worker puts forth too little effort. This is inefficient. Additionally, if the farmer can obtain land without limit, he pushes his sharecropping acreage to the point where the next unit of land has zero marginal product. This is clearly inefficient, but can be remedied if landowners can select sharecroppers and terms according to the amount of land each works. Both the owner and worker could be made better off if the worker could be induced, by another incentive contract, to produce where $C'(E) = 1$.

Renting the land to the farmer and allowing the farmer to keep all of the output accomplishes this. Under rental, the worker's compensation is [Q - Rent]. By (4) and (5), the worker is induced to set $C'(E) = 1$; the marginal cost and marginal value of output are equated. Of course, rental does not solve all of the problems. Absent in the production function in (5)

is that maintenance may be required. For example, if the farmer does not fertilize the land, it may not produce as well in the future. A renter, who can move on to the next plot after the soil is drained of minerals, has little incentive to put resources into the land. Thus, the solution is to sell the land to the farmer. Then the individual who works the land has the correct incentives, either because he will continue to use it in the future or because the sale price will reflect the quality of the land. But sale of the land begs most of the questions. The sale may not come about because of the farmer's capital constraints, because of his lack of entrepreneurial skill, or because of his distaste for risk.[2]

The sharecropping paradigm applies to industrial production as well. Profit sharing arrangements are, in many respects, like sharecropping. This is especially true when there is only one worker. Partnerships are similar. The same incentive problems arise. A worker who can quit and move on to another firm without penalty does not have the same desire to maintain the equipment as the firm's owner. Again the solution is to sell the capital to the worker, but this simply redefines the owner. Then there is no principal-agent problem because there is no agent. This can be considered in more detail in the next section.

B. Piece Rates

Piece rate compensation is not much different from sharecropping, the latter being a special case of the former (see Stiglitz, 1975). The owner allows the worker (or farmer) to use his capital (or land) and pays the worker according to some function of output. In the simplest scheme, a linear piece

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[2]Note that risk is shifted from owners to farmers even in sharecropping and renting. Only labor contracts based exclusively on effort shift the risk entirely to the owner.

rate is used and the worker is paid rate R per unit Q so that compensation is RQ. The worker's maximization problem (3) and (4) implies that the worker sets $C'(E) = R$. The firm's zero profit constraint in (2) implies that $Q = RQ$ or that $R = 1$. Thus, the piece rate is efficient because the worker sets the marginal cost of effort equal to its marginal social value, \$1.

The issue is only slightly more complicated if capital is involved. A linear piece rate with an intercept, i.e., compensation equal to $A + RQ$, will do the job. This incentive contract achieves first-best efficiency. The worker's first-order condition, (4), still guarantees that he sets $C'(E) = R$. The intercept drops out. But the zero profit constraint now becomes:

$$Q - \text{rental cost of capital} = A + RQ \ .$$

The firm must "charge" the worker for the cost of using the capital, but how should this be done? R can be reduced below 1 or A can be set to a negative number. The answer is that $A = -(\text{Rental cost of capital})$ and $R = 1$. Since (4) does not contain A, the worker does not respond to changes in A. However, reducing R below 1 causes the worker to reduce effort. Thus, the efficient incentive contract, which also maximizes worker wealth subject to the firm's zero profit constraint, requires that $R = 1$. Zero profit requires that $A = -(\text{Rental cost of capital})$.

A major advantage to the use of piece rates as an incentive contract is that it tolerates heterogeneity of worker ability. More able, i.e., lower effort cost workers choose higher levels of effort, but are paid more. There is no inefficiency involved in having workers of both types in the firm. Of course, if capital is important so that the worker is "charged" A for the right to work on a machine, only workers above some threshold ability level will choose to work. But workers self-sort. There is no need for the firm to

do anything other than pay the efficient piece rate, in this case $R = 1$.

Linear piece rates are no longer appropriate incentive contracts if workers are risk averse. In general, a nonlinear scheme will do better, but will fail to achieve first-best solutions. As long as asymmetric information exists, so that individual actions cannot be observed and contracted upon, Pareto optimal risk sharing is precluded. (See Holmstrom, 1979 and Harris and Raviv, 1979.)

C. Payment by Relative Output

The study of relative compensation has become increasingly important. There are two approaches in this literature. The first, from Lazear and Rosen (1981), characterizes the labor market as a tournament, where one worker is pitted against another. The one with the highest level of output receives the winning prize, i.e., the high-wage job, while the other gets the losing prize, i.e., the low-wage job. By increasing the spread between the winning and losing prizes, incentives are provided to work hard. The optimum spread induces workers to move to the point where the marginal cost of effort exactly equals the marginal (social) return to it. The major advantages to payment by tournament method are two: First, tournaments require only that relative comparisons be made. It may be cheaper to observe that one worker produces more than another than to determine the actual amount that each produces. Second, compensation by rank "differences out" common noise. For example, sales may be low because the economy is in a slump, which has nothing to do with worker effort. Risk aversion operates against penalizing or rewarding workers for factors over which they have no control. But since the slump affects both workers equally, relative comparisons are unaffected. The best worker still produces more, even though both produce small amounts.

Tournament-type incentive contracts induce workers to behave efficiently if they are risk neutral. They are easy to use, but carry one major disadvantage. Workers increase the probability of winning, not only by doing well themselves, but also by causing the opponent to do poorly. Thus, tournaments discourage cooperation. This results in wage compression, which works to discourage the aggressive behavior of workers who are competing for the same job (see Lazear, 1986). Other work in the area of tournament-type incentive contracts includes Nalebuff and Stiglitz (1983), Green and Stokey (1983), and Carmichael (1983).

The second approach, from Holmstrom (1982), suggests that if levels of output can be observed, then payments can be based, at least in part, on a team average. As Holmstrom points out, a tournament is not a sufficient statistic so that using a team average allows the firm to better address risk aversion. This incentive device also takes out common noise. A peer average picks up disturbances that are common to the industry and allows the firm to cater to the tastes of risk-averse workers.

IV. Payment by Input

A. Observability of Effort

It is commonly alleged that payment of a salary or hourly wage does not provide workers with the appropriate incentives. Whether or not this is true depends on the connection between the measurement of time and measurement of effort. To see this, suppose that effort can be observed perfectly, but that output cannot be observed at all. For example, suppose that it is easy to measure the number of calories burned up by a worker during his work day, but it is impossible to separate his output from that of his peers. Payment by effort is a first-best incentive contract. The compensation scheme that pays

the worker $1 per unit of effort exerted induces him to set $C'(E) = 1$, which as we have seen, is first best. Note further that this is first best even for risk-averse workers since compensation does not vary with random productivity shocks, v (see Hall and Lilien, 1979).

The allegation that effort pay does not provide incentives is based on the difference between hours of work and effort. If hours were a perfect proxy for effort, then payment of an hourly wage would be an optimal incentive contract. But because workers can vary work per hour, the connection breaks down. Payment per hour provides appropriate incentives for choice of the number of hours, but does not deal with what is done within the hour.

B. Payment by Effort and Worker Sorting

Piece rates induce workers to sort appropriately. Above, it was argued that workers who cannot produce a sufficiently high level of output will not come to a firm that "charges" for use of capital. Salaries (or hourly wages) that pay on the basis of an imperfect measure of effort encourage the lower-quality workers to come to the firm. Lazear (1986a) demonstrates that a separating equilibrium (see, e.g., Rothschild and Stiglitz, 1976 and Salop and Salop, 1976) exists where high-quality workers choose to work at firms that pay piece rates and low-quality ones choose salaries. The difference in quality across firms might lead one to conclude that movement to output-based incentive contracts increases total output. In fact, the reverse may well be true. In the same sense that screening in Spence (1973) is socially unproductive, forcing salary firms to adopt piece rate incentive contracts wastes resources on a potentially useless signal.

C. Incentive Contracts and Product Quality

Sometimes quantity is easier to observe than quality. The problem with

incentive contracts that are based on output quantity is that they induce the worker to go for speed and to ignore quality. If quality can be observed, then the worker can be compensated appropriately for quantity and quality. The appropriate compensation function is essentially the consumer's demand for the product as it varies with quality and quantity. But if quality cannot be observed, payment by input "solves" the quantity/quality problem. If the worker is paid, say, by hour, and merely instructed to produce goods of a given quality, he has no incentive to deviate from that instruction. Compensation is based only on input so there is no desire to rush the job. Of course, this requires a method of monitoring effort cheaply. (See Lazear, 1986a for a full discussion of the tradeoffs.)

V. Other Issues in Incentive Contracting

A. Efficient Separation and Long-Term Investments

A properly structured incentive contract must induce the correct amount of long-term investment. The problem is most clearly seen in the context of specific human capital as in Becker (1962, 1975). Specific human capital is only valuable when the worker is employed at the current firm. As such, workers are reluctant to invest in specific capital because the firm may capriciously fire the worker, in which case the investment is lost. Similarly, firms are reluctant to invest because the worker may capriciously quit. The incentive contract that Becker suggests is a sharing of investment costs and returns by both workers and firms. (Hashimoto and Yu, 1980 model this more precisely.) Kennan (1979) points out that a particular kind of severance pay solves the investment problem. It is akin to the liability rules that are efficient in auto accident problems. But as Hall and Lazear (1984) argue, these rules may actually induce too much investment. Since a

worker is compensated for the full investment whether work occurs or not, he has no incentive to account for situations that make a separation optimal. E.g., if it were optimal to sever the work relationship 25% of the time, the worker should behave as if a specific investment that yields $1 return only yields $.75. A full-reimbursement severance pay arrangement ensures a full $1, irrespective of the status of work, and induces too much investment.

More general issues of efficient separation arise in the labor market context and incentive contracts must be structured to deal with these problems. Hall and Lazear (1984) consider a variety of different incentive contracts and conclude that none generally achieves first best. One that come close to doing so are is Vickrey (1961) bilateral auction approach. There, compensation and work are separated so that the worker and firm have incentives to reveal the true relevant values. Another scheme is coordinated severance pay, suggested by d'Aspremont and Gerard-Varet (1979). Sufficiently high penalties on the firm associated with a worker's refusal to work induces the firm to behave in a manner that is apparently first best.

B. Intertemporal Incentive Contracts

Sometimes, the fact that workers live for more than one period allows contracts to be structured in a way that solves incentive problems. This is the subject of Lazear (1979, 1981). The problem is that as a worker approaches the end of his career, he has an incentive to shirk because the costs, even of being fired, are reduced as his retirement date draws near. A way to discourage shirking is to tilt the age-earnings profile and couple it with a contingent pension. Young workers are paid less than their marginal products; old workers are paid more. In equilibrium, shirking is discouraged and workers receive exactly their lifetime marginal products. The distortion in the timing of the payments implies that workers do not voluntarily choose

to work the correct number of hours. Thus, hours constraints are required, an extreme form of which is mandatory retirement. Other work that has refined or provided empirical support for that concept is Kuhn (1986) and Hutchens (1986a, b).

There are other papers that focus on the intertemporal aspects of incentive contracts. The first, Fama (1980) argues that the market provides a discipline on workers. In a spot market, the wage that another firm is willing to offer a worker next period depends on how well he did last period. Fama shows that this can act as a perfect incentive device. Of course, no end-game problems are addressed by this mechanism, but it does demonstrate the possibility of incentive provision even without explicit or implicit contracts. The second idea is attributable to Rogerson (1985). The emphasis here is on risk sharing, but the work has some features in common with Fama (1980). In particular, memory plays a strong role in these incentive contracts, so that an outcome that affects the current wage also affects the future wage.

C. Intertemporal Strategic Behavior by Firms

Once intertemporal contracts are considered, it is necessary to examine the issue of opportunistic behavior by firms. It may be that a firm does not know a worker's cost of effort function, C(E). Actions that the worker takes may reveal information about that function. The firm can use that information in subsequent periods against the worker. As a result, the worker attempts to disguise C(E), leading to inefficiencies. Such is the case for salesmen, whose next period quota depends on this period's performance. In Lazear (1986a) it is shown that a properly structured contract in a competitive labor market can undo the effects of this kind of strategic behavior. This is a specific example of the general theorem on revelation presented in Harris and

Townsend (1981). It is also related to the literature on planned economies, since bureaucrats tend to make things look worse than they are to lessen next period's requirements or to increase next period's budget allocation (see, e.g., Weitzman, 1976, 1980, and Fan, 1975).

D. Insurance

Finally, there is a closely related literature that examines insurance contracts. That literature focuses, for the most part, on the tradeoff between insurance and efficiency in the labor market. Some of the more important papers in that literature include Harris and Holmstrom (1982), Grossman and Hart (1983), and Green and Kahn (1983).

VI. Conclusion

Although incentive problems are pervasive, the market has found a number of solutions. These involve payment by output of the piece rate or share-cropping variety, payment by relative output exemplified by labor market tournaments, payment by measured input, such as hours of work, and multi-period incentive contracts. The contracts do not always achieve the first best, especially when risk aversion is an issue. Still, the rich variety of institutions that addresses incentive problems and the large amount of literature devoted to study attests to the problem's importance in the labor market context.

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