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SUPERVISION, INCENTIVES, AND THE OPTIMUM SIZE

OF A LABOR-MANAGED FIRM

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ABSTRACT

This paper analyzes the impacts of income-sharing on the incentives to work and on the supply of labor in a labor-managed firm. Monitoring is explicitly incorporated in the measurement of labor input. The incentive structure in a labor-managed firm is distorted. Perfect monitoring is not Pareto-efficient. However, an income-sharing scheme does not change the argument that the incentives to work are positively correlated with the degree of accuracy in monitoring effort. The supply of effort in a labor-managed firm also depends on peer pressure which is a substitute for monitoring. The existence of peer pressure reduces the distortion in incentive structure and thus improves the efficiency of time allocation. In addition, the supervisibility of effort in the production process imposes a constraint on the optimum size of a labor-managed firm.

I. INTRODUCTION

The impacts of income-sharing characteristic on the incentives to work and the supply of labor in a labor-managed firm (LMF)[1] raise many theoretical disputes. On the one hand, Ward (1958), Domar (1966), Vanek (1969, 1970), Meade (1972), and others argue that a worker in a LMF has higher incentives to work than a wage worker in a conventional firm because he gets some direct benefits from the additional profits from his extra effort. Furthermore, Sen (1966), Israelsen (1980), Putterman (1980), and so forth argue that, if the income is distributed according to work, workers in a LMF tend to over-work instead of shirking. On the other hand, Jensen and Meckling (1979), and Williamson (1980), among other economists, argue that a LMF is subject to free-rider abuses because of its income-sharing nature; therefore, the incentives to work shall be low in a LMF. The empirical observations do not unequivocally support either view. Some authors find that the income-sharing has positive effects on the incentives to work in a LMF (e. g., Bradley and Gelb 1980; and Jones and Svejnar 1985). Others attribute the failure of some LMFs to the low incentives (e.g., Bradley and Clark 1972, Perkins and Yusuf 1984, chap. 5).

The income-sharing scheme itself does not necessarily invite over-working or free-rider abuses. Central to this controversy is how costly it is to monitor effort in a LMF (Alchian and Demsetz 1972). The pros implicitly assume that effort can be perfectly monitored without any

cost. Their opponents, conversely, imply that it is too costly to monitor in a LMF. In this paper I try to show that the incentives to work in a LMF depend on the nature of the production process, namely, how costly it is to monitor each worker's effort in production. The income-sharing characteristic of a LMF distorts the structure of incentives in a LMF. However, it does not change the fact that the incentives to work are positively correlated with the degree of accuracy of vertical supervision or monitoring exerted by the management. As in any other form of firm, a higher degree of accuracy of monitoring requires higher costs to perform. The management of a LMF thus has to balance the benefit of higher incentives and the additional costs arising from a higher degree of monitoring. Therefore, the optimum degree of monitoring in a LMF depends on how costly the monitoring of effort is in the production process, which is determined by the nature of production. If monitoring is easy, the incentives to work shall be high in a LMF, ceteris paribus. On the other hand, the free-rider abuse shall be severe if monitoring is difficult. But because the income-sharing characteristic alters the structure of incentives in a LMF, from the welfare point of view perfect monitoring is Pareto-inefficient.

The income-sharing characteristic in a LMF also affects effort supply from the other way. In a LMF, the income of each worker depends not only on his own effort but also on the effort of other workers. Therefore, there exists a horizontal supervision or peer pressure as defined by Chinn (1979). This paper throws additional light on the interactions between vertical and horizontal supervision. It is found that horizontal supervision is a substitute for vertical supervision. An

increase in the degree of monitoring by the management in a LMF induces a decrease of peer pressure between member workers. The existence of peer pressure reduces the distortion in incentive structure and thus improves the efficiency of time allocation.

The choice of optimum size of a LMF with considerations of monitoring costs is also discussed in this paper. Monitoring costs increase with the size of a LMF. Therefore, for an increasing size to be desirable, the gain in productivity should be able to compensate for the additional costs. Because of the income-sharing characteristic, the optimum size of a LMF is smaller than that of a conventional firm, ceteris paribus. Furthermore, the supervisibility of effort is found to be a constraint on the choice of size.

This paper is organized as follows. In section II, several key concepts are defined, and basic assumptions of this paper are presented. Section III analyzes the economic meanings of the incentives to work and of peer pressure and studies the effects of a change in monitoring on the incentives and peer pressure in a partial context. Section IV discusses the optimum choices of effort contribution by individual workers and of degree of monitoring by the management in an equilibrium framework. In Sections III and IV, the number of workers in a LMF is assumed to be exogenously given. Section V treats the number of workers in a LMF as an endogenous variable and turns attentions to the choice of optimum size of a LMF. Finally, some concluding remarks are presented in Section VI.

II. EFFORT, MONITORING, PEER PRESSURE, AND WORK POINTS

This section describes the basic model of a LMF in which income is

distributed according to work. The novelty of this model is its formal inclusion of monitoring as an argument in the determination of work points.

To simplify the matter, a LMF is assumed to have N identical workers, which will be taken as given in Sections III and IV. Every worker has the same ability and preference.[2] It is assumed that the utility index, U_i, of worker i depends on his income, y_i, effort, e_i, and the absolute value of peer pressure, $|p_i|$. A worker is assumed to choose his effort contribution to maximize his utility. More concretely, it is assumed that:

$$\underset{0 \leq e_i \leq 1}{\text{Max}} \quad U_i = U_i(y_i, e_i, |p_i|). \tag{1}$$

$U_i(.)$ is assumed to be twice differentiable and concave in all its arguments. $0 \leq e_i \leq 1$. Zero means that no effort is supplied. One stands for fully effective work.[3] Income is distributed from the LMF according to the ith worker's work point share, s_i, and the net income, Y, of the firm, that is,

$$y_i = s_i Y. \tag{2}$$

The work point share is a ratio between the work points accumulated by the ith worker, h_i, and the total work points in the LMF, H.

$$H = \sum_{i=1}^{N} h_i . \tag{3}$$

The work point represents the ith worker's effort contribution that is perceived and credited by the management.[4] It is, therefore, a function of his effort supply, e_i, and the degree of monitoring exerted by the

management in the LMF, π.

$$h_i = h(\pi, e_i), \quad \text{with} \quad \pi, e_i \in [0,1]. \tag{4}$$

π is defined as the degree of accuracy in metering workers' effort contributions. It is also a variable ranging from zero to one. When monitoring is perfect, $\pi = 1$. In this case, $h_i = h(1, e_i) = e_i$. When monitoring does not exist, $\pi = 0$. Under this condition, $h_i = h(0, e_i) = a$ for all i, where $0 < a \leq 1$; that is, if workers are not monitored, they are assumed to have worked equally intensively.[5] The work point function also has the following properties:

$$\frac{\partial h_i}{\partial e_i} \geq 0, \qquad \text{equality holds when } \pi = 0;$$

$$\frac{\partial h_i}{\partial \pi} \leq 0, \qquad \text{equality holds when } e_i = 1; \tag{5}$$

$$\frac{\partial^2 h_i}{\partial \pi \partial e_i} > 0 \;.^{[6]}$$

As each worker is assumed to be identical, it is important to mention here that in equilibrium each worker will offer the same amount of effort and, as a consequence, $h_i = h$, $s_i = 1/N$ for every worker.

The peer pressure on the ith worker is denoted as p_i. In a LMF, the income of each worker depends not only on his own effort but also on the effort of the other workers. If all the other workers can benefit from the additional effort contributed by an individual worker, there will be pressure on him from the other workers to contribute more effort. In this case, p_i is assumed to be positive. Conversely, if all the other workers benefit from the reduced effort by an individual worker, there will be

pressure on him from the other members to reduce his effort supply. In this situation, p_i is assumed to be negative. An operational definition of peer pressure will not be given until Section III, where we discuss the interactions between monitoring and peer pressure. The reasons that peer pressure is positive in the former case and negative in the latter case become obvious in that definition. However, we assume here that positive peer pressure and negative peer pressure have a symmetrical disutility effect on each worker's preference. Thus, what enters the utility function is the absolute value of peer pressure. It is shown in Section IV that when peer pressure is positive, an individual worker will increase his effort supply and he will reduce it when peer pressure is negative.[7]

To concentrate on incentive aspects of a LMF, the simplest technology for a firm is adopted. Production requires only the total effort that is contributed by the members. So,

$$X = F(E) \qquad \text{with } F_E > 0 \qquad F_{EE} < 0 \ . \tag{6}$$

X is output, E is the total effort offered by the N individual workers, and F is the production function. E is a function of the degree of monitoring.

$$E = E(\pi). \tag{7}$$

The rationale for this assumption will be discussed later.

The net income for the LMF is

$$Y = F[E(\pi)] - C(\pi; \ N, \ \Gamma),$$
$$\text{with } C_i > 0, \ C_{ii} > 0. \quad i = \pi, \ N, \ \Gamma, \tag{8}$$

where C, the costs of monitoring, is a function of the degree of monitoring, π, the size of the membership of the LMF, N, and the degree of difficulty in monitoring labor effort, Γ. Γ is itself a function of a vector of exogenous variables, such as sequential and spatial dimensions of the production process that affect the supervisibility of labor effort. An increased value of Γ implies that the difficulty of monitoring effort is raised. In addition to all the usual assumptions of a cost function with respect to its first and second derivatives, the monitoring cost function has the following properties:

$$C(0; \ N, \ \Gamma) = 0, \tag{9a}$$

$$C(\pi; \ 1, \ \Gamma) = 0, \tag{9b}$$

$$C(\pi; \ N, \ 0) = 0. \tag{9c}$$

Equation (9a) stipulates that monitoring costs are zero when no monitoring activities are engaged in. Equation (9b) says that monitoring costs are zero when a person works for himself. Since he knows exactly how he works, there is no need to divert any resources for the purpose of metering his own effort. Equation (9c) postulates that monitoring costs are zero when labor effort is transparent and thus can be metered perfectly at no cost.

The management of a LMF is assumed to have perfect knowledge of the monitoring cost function, $C(\pi; \ N, \ \Gamma)$; the production function, $F(E)$; and the effort supply function, $E(\pi)$. Following the tradition of Ward, Domar, and Vanek, the objective of the management is assumed to be that of maximizing the average net income per worker.[8] To be precise, the objective function is

$$\max_{\pi} \frac{1}{N} \{F[E(\pi)] - C(\pi; \ N, \ \Gamma)\}. \tag{10}$$

III. MONITORING, INCENTIVES, AND PEER PRESSURE

Economically, as in any other form of firm, a worker's incentives to work are the marginal income accrued to him for his contribution of an additional unit of effort. Nevertheless, due to the income-sharing characteristic, the return to an additional unit of effort has two components in a LMF. First, he will get a share of the increase in total output. Second, his share of total income becomes larger as now his contribution of effort in total effort increases. Whether the incentives are distorted upward or downward, however, depends on the degree of monitoring. Taking other workers' effort supplies and monitoring as given, we find from the partial derivative of expression (2) that the incentives to work for worker i can be expressed as

$$\frac{\partial y_i}{\partial e_i} = s_i F_E + (1 - s_i) \cdot A_i \cdot \left(\frac{F - C}{E}\right), \tag{11}$$

where $A_i = (E/H) \cdot (\partial h_i/\partial e_i)$.

The first term on the RHS is the gain from the increase in the production of the LMF, and the second term is the gain from the increase in the work point share. Notice that A_i has the following properties: when $\pi = 0$, $A_i = 0$; when $\pi = 1$, $A_i = 1$. Also notice that because each worker is assumed to be identical, in equilibrium s_i in expression (11) can be substituted for by $1/N$.

The confusion over the incentive structure in a LMF can be easily understood in the context of expression (11). When monitoring is perfect and costless, which is implicitly assumed by Sen (1966), Israelsen

(1980), and most theoretical models of LMF, expression (11) in equilibrium is reduced to

$$\frac{\partial y_i}{\partial e_i} = 1/N \cdot F_E + (1 - 1/N)\frac{F}{E} . \tag{11a}$$

The RHS of expression (11a) is a simple weighted average between the marginal product and the average product of effort. As the normal production range is located at where the average product is greater than the marginal product, Sen and others thus conclude that the incentives to work in a LMF are distorted upward from the optimum incentives, F_E. Perfect monitoring makes a worker over-work to compete for a larger share of the existing income. Therefore, perfect monitoring is Pareto-inefficient in a LMF. If monitoring does not exist, expression (11) becomes

$$\frac{\partial y_i}{\partial e_i} = \frac{1}{N} F_E . \tag{11b}$$

In this case, a worker only gets 1/N of the marginal product of his effort, so the incentives are distorted downward which is what has been implicitly assumed by some authors on Soviet and China's collective farms (Bradley and Clark 1972; Perkins and Yusuf, 1984, p.79).

The above discussions are summarized as following:

PROPOSITION 1: Whether the incentives to work in a LMF are distorted upward or downward from the optimum incentives depends on the degree of monitoring. In the normal production range (average product falling), perfect monitoring results in an over-contribution of effort in a LMF; therefore, perfect monitoring is

Pareto-inefficient.

A. Monitoring and Incentives

Raising the degree of monitoring will be accompanied by an increase in the costs of monitoring.[9] Before we study the combined effects, however, it is instructive to look at the separate effects that the degree of monitoring and the costs of monitoring have on the incentives to work in a LMF. Intuitively, an increase in the degree of monitoring itself shall improve the incentives, as reward is related more closely to effort; meanwhile, an increase in the costs of monitoring shall dilute the incentives as each share of income becomes smaller. These intuitions are confirmed in our model.

From expression (11) and applying the assumption that each worker is identical, we can see that an increase in the degree of monitoring affects a worker's incentives to work only through the change in A_i, the average net product's adjusting factor. Mathematically, this partial derivative is

$$\frac{\partial^2 y_i}{\partial \pi \partial e_i} = (1 - 1/N) \cdot \left(\frac{F - C}{E} \right) \cdot \frac{\partial A_i}{\partial \pi} \cdot \qquad (12)$$

Given each worker's effort contribution and the costs of monitoring, $\partial A_i / \partial \pi > 0$. Consequently, expression (12) is positive; that is, the increase in the degree of monitoring itself improves the incentives to work in a LMF.

The effect of monitoring costs on the incentives can be analyzed in the same way. Taking the partial derivative of expression (11) with respect to C and applying the assumption that workers are identical, we

get

$$\frac{\partial^2 y_i}{\partial C \partial e_i} = - (1 - 1/N) \cdot A_i/E. \tag{13}$$

Expression (13) is negative. Therefore, a rise in the monitoring costs itself lowers the incentives to work in a LMF.

PROPOSITION 2. In a LMF, an increase in the degree of monitoring itself improves the incentives to work and the accompanying rise of the costs of monitoring deteriorates the incentives to work; however, in the management's choice range of monitoring, the total effect on incentives of an increase in the degree of monitoring shall be positive.

The second part of this proposition holds because the objective of the management is to maximize the net output per worker. In choosing a degree of monitoring, the LMF management thus needs to consider these two opposite effects simultaneously. If the total effect on the incentives is negative, then the costs of monitoring can be reduced, and the output of the LMF can be increased by the decrease in the degree of monitoring. Such a point will necessarily be excluded from its choice set.

B. Monitoring and Peer Pressure

Due to the income-sharing characteristic in a LMF, a worker's income depends not only on his own effort but also on the other members' efforts. Taking the LMF as a whole, any increase in effort by any member is definitely desirable. The total and net outputs increase in consequence. Nonetheless, whether all the other workers encourage an individual worker to take such an action depends on how all the others'

incomes are affected. Chinn (1979) defines peer pressure as the incremental income gains that are accrued to all other members in a LMF and are derived from the increase in effort by an individual worker.[10] Although Chinn has studied the effects of different distribution schemes and different degrees of team cohesion on peer pressure, I would like to examine the sensitivity of peer pressure to changes in the degree of monitoring.

Mathematically, peer pressure on the ith worker, p_i, can be expressed as

$$p_i = \frac{\partial(Y - y_i)}{\partial e_i} = (1 - 1/N)F_E - (1 - 1/N) \cdot A_i \cdot \left(\frac{F - C}{E}\right). \qquad (14a)$$

Here the assumption that workers are identical is applied. The first term on the RHS is the incremental income contributed to all the other members in the LMF by the increase in output induced by the ith worker's additional effort. The second term, which we have noticed in expression (11), is the incremental income that is accrued to the ith worker due to his increased share of work points. Hence, if what he contributes to the other members by his increased effort is larger than what he takes away by his added work point share, the other members will encourage him to increase effort. Otherwise, they will discourage him to increase effort. By examining expression (14a), we see that when the marginal product of effort, F_E, is greater than the adjusted average net product, $A_i \cdot [(F - C)/E]$, peer pressure is positive; peer pressure is negative when the opposite holds; and it is zero when the marginal product of effort equals the adjusted average net product of effort. Thus, peer pressure on a worker depends on which region of effort supply is relevant to him.

However, if monitoring does not exist, expression (14a) becomes

$$p_i = (1 - 1/N)\ F_E. \tag{14b}$$

It is definitely positive. Everyone is better-off by pressing each other to work harder.

Expression (14a) can also be rearranged as,

$$p_i = F_E - \frac{\partial y_i}{\partial e_i}\ . \tag{14c}$$

The first term on the RHS is the incremental income gain to the LMF as a whole by the ith worker's extra effort. The second term is the ith worker's incentives to work.

Knowing the meaning of peer pressure, we will now show that, in a LMF, peer pressure is a substitute for monitoring in terms of their effects on the supply of effort. From the partial derivative of expression (14c) with respect to π,

$$\frac{\partial p_i}{\partial \pi} = - \frac{\partial^2 y_i}{\partial e_i \partial \pi}\ . \tag{15}$$

The RHS of expression (15) is the negative of expression (12). Because expression (12) is a positive function of π, an increase in π reduces peer pressure.

Similarly, the effect of an increase in the costs of monitoring on peer pressure is just the opposite of expression (13). This can be seen from the partial derivatives of expression (14c) with respect to monitoring costs.

$$\frac{\partial p_i}{\partial C} = - \frac{\partial^2 y_i}{\partial e_i \partial C} . \qquad (16)$$

From expressions (15) and (16), we conclude that the influences of monitoring terms--the degree of monitoring and the costs of monitoring-- on the incentives and on peer pressure are opposite. The total effect of an increase in the degree of monitoring on the incentives should be positive in the relevant region of the management's decision making (recalling Proposition 2); hence, the total effect on peer pressure should be negative in the relevant region. Both monitoring and peer pressure affect the supply of effort in a LMF (see discussions in the next section); therefore,

PROPOSITION 3: Peer pressure is a substitute for monitoring in the

relevant region, in terms of its impacts on the supply of effort.

When monitoring increases (decreases), peer pressure decreases

(increases) relatively.

IV. MONITORING, EFFORT SUPPLY, AND SUPERVISIBILITY

In this section we seek to prove the central proposition of this paper, namely, that the incentives to work in a LMF depend on the supervisibility of effort in its production process. In other words, we will demonstrate that if it is easy to monitor each worker's effort, the incentives to work will be high; the opposite holds if effort is difficult to meter, ceteris paribus. The method proceeds in two steps. First, the choices of optimum effort supply by each worker and optimum degree of monitoring by the management are analyzed, given the supervisibility of effort in the production process. When a worker chooses his effort supply, he considers his own rate of substitution

between income and leisure, his incentives to work, and peer pressure. As the incentive structure is distorted in a LMF, the existence of peer pressure is shown to improve the efficiency of time allocation. The management's choice of optimum degree of monitoring has to balance the incentive effect and the cost effect. In the second step, comparative statics are applied to demonstrate the central proposition.

A. Choice and Equilibrium

To analyze how the management chooses the optimum degree of monitoring and how individual workers choose their effort supplies, we need to proceed in an equilibrium framework because monitoring and effort supplies are simultaneously determined.

Each worker in a LMF is assumed to choose his own effort supply to maximize his utility. From expression (1), with the degree of monitoring, the cost of monitoring, and all the other workers' effort supplies given, the necessary condition for worker i's utility maximization is

$$- \frac{U^i_{e_i}}{U^i_{y_i}} = \frac{\partial y_i}{\partial e_i} + \frac{U^i_{p_i}}{U^i_{y_i}} \cdot \frac{\partial p_i}{\partial e_i} \cdot \text{sgn}(p_i) \qquad (17)$$

$$\text{for } i = 1, 2, \ldots, N.$$

$U^i_{e_i}$ is the ith worker's marginal disutility of work; $-U^i_{e_i}$ can then be interpreted as the marginal utility of leisure. Therefore, the LHS is the marginal rate of substitution between income and leisure. Welfare optimality requires that this rate be equal to F_E, the marginal product of effort. The first term on the RHS is the marginal income of effort or the incentives to work, which may be distorted upward or downward from F_E. The second term on the RHS is an adjustment for the existence of peer

pressure. It assumes the same sign as peer pressure. Recalling expression (14a), the sign of peer pressure on the ith worker is positive when his effort supply is located in the region where $F_E - A_i . [(F-E)/E] < 0$. By expression (11), his incentives to work are distorted downward in this region. Therefore, the existence of positive peer pressure increases the incentives to work and thus alleviates the distortion. On the other hand, when his effort supply is located in the region where $F_E - A_i . [(F-E)/E] > 0$, his incentives to work are distorted upward; however, peer pressure assumes a negative value (see expression 14a) in this case and thus the existence of peer pressure reduces his incentives to work. Peer pressure once again reduces the distortion. Peer pressure is zero if his effort supply is located at the point where $F_E - A_i . [(F-E)/E] = 0$. At this point his incentives to work as well as time allocation are optimum. Therefore,

PROPOSITION 4: The existence of peer pressure in a LMF reduces the distortion of incentive structure and thus improves the efficiency of time allocation between work and leisure.

If the utility gain for worker i from the improvement in time allocation outweighs the disutility of peer pressure, the existence of peer pressure is a Pareto-improvement because, by definition, all the other workers also gain from the peer pressure on the ith worker.

The determination of the degree of monitoring is modeled by permitting the management to decide how much monitoring is optimum for maximizing the average net income per worker, with workers making marginal adjustments in their decisions about how much effort to contribute. The relationships between the management and the workers are

supposed to be of Stackelberg type. The management takes the reaction functions of the individual workers as given, while individual workers take the actions of the management as given. For the determination of the optimum degree of monitoring, therefore, it is essential to know the properties of workers' effort supply functions.

The relationships among the workers are assumed to be of Cournot-Nash type. Each worker takes all the other workers' efforts as given. As there are N workers in the LMF, we will have N first-order conditions from each worker's utility maximization. The N first-order conditions may be solved to provide N effort supply functions:

$$e_i = e_i(\pi, e_1, \ldots, e_{i-1}, e_{i+1}, \ldots, e_N)$$
$$\text{for } i = 1, 2, \ldots, N. \tag{18}$$

Then, for a given π, assuming the Nash equilibrium is unique, $e_i^* = e(\pi)$ for all i (as workers are identical). Thus the effort supply function for the LMF as a whole is

$$E = E(\pi) = Ne(\pi) . \tag{19}$$

The task now is to show that $E(\pi)$ is an increasing function of π in the relevant region of management's choice. Proposition 2 posits that the total effect on incentives of an increase in the degree of monitoring should be positive in the relevant region of management's choice. The incentives, being the marginal income of effort, can be treated as the shadow price of leisure. When the price of leisure increases, each worker will substitute leisure for work. Meanwhile, the simultaneous increase in the costs of monitoring reduces each worker's net income.

Therefore, the income effect on the effort supply is also positive.
Because both the substitution effect and the income effect are positive
in the relevant region, the effort supply for the LMF as a whole
increases as a result of an increase in the degree of monitoring.
Although the increase in monitoring will simultaneously be accompanied by
a decrease in peer pressure, which has a negative effect on the effort
supply, the monitoring effect will necessarily dominate the peer pressure
effect in the management's choice set.[11] Thus,

PROPOSITION 5: Within the management's choice set of monitoring, the
supply of total effort is a positive function of monitoring.

From expression (10), assuming an interior solution exists, the
first-order condition for the maximization of a LMF 's objective is

$$F_E E_\pi - C_\pi = 0 \qquad (20)$$

The first term on the LHS is the increase in output arising from the
increase in effort supply which can be called the incentive effect. The
second term is the increase in costs of monitoring which will be called
the cost effect.

PROPOSITION 6: If an interior solution exists, the management's choice
of optimum degree of monitoring will equate, at the margin, the
incentive effect to the cost effect.

B. Supervisibility, Degree of Monitoring, and Incentives

So far we have demonstrated that the income-sharing characteristic
in a LMF can distort the incentive structure upward or downward depending
on the degree of monitoring exercised by the management. However, in

choosing the optimum degree of monitoring, the management has to consider both the incentive effect and the cost effect. How costly an additional degree of monitoring is depends on how difficult it is to monitor effort in the production process. Therefore, the incentives to work, high or low, actually hinge on the supervisibility of effort in the production process. Although supervisibility of effort is exogenous to a LMF, at least in the short run and without changing the sizes of a LMF, different LMFs may have different degrees of difficulty in monitoring effort. The difference in supervisibility may explain why the performances of LMFs are so diverse. To investigate how supervisibility affects the incentives to work in a LMF, we first see how it affects the management's choice of optimum degree of monitoring. Differentiating expression (20) totally with respect to π and Γ and solving for $d\pi/d\Gamma$ gives

$$\frac{d\pi}{d\Gamma} = \frac{C_{\pi\Gamma}}{F_{EE}E_\pi^2 + F_E E_{\pi\pi} - C_{\pi\pi}} . \tag{21}$$

The denominator of expression (21) is just the second-order condition of management's maximization problem. It is negative by assumption. The numerator is positive because, as the difficulty of monitoring, Γ, increases, it becomes harder to monitor effort. Thus, the marginal cost of an additional degree of monitoring increases as a result. The sign of expression (21) is thus negative. The next two propositions follow immediately from expression (21).

PROPOSITION 7: If there are two LMFs identical in every aspect except in the supervisibility of effort in their production processes, the management in the LMF with higher supervisibility chooses a higher degree of monitoring than the management in the LMF with lower

supervisibility.

PROPOSITION 8: If there are two LMFs identical in every aspect except in the supervisibility of effort in their production processes, workers in the LMF with higher supervisibility have higher incentives to work than workers in the lower supervisibility LMF.

Proposition 8 holds because, as stated in Proposition 2, the incentives to work are positively correlated with the degree of monitoring.

V. SUPERVISION AND THE OPTIMUM SIZE OF A LMF

This section investigates the effect of the income-sharing characteristic on the optimum size of a LMF. This issue is especially relevant in socialist countries. Most collective farms (one specific form of LMF) in socialist economies are large with low productivity. As Schultz (1964, p. 113) points out, such gigantic farms are established out of certain political motivations backed by particular beliefs about "returns to scale." As the costs of monitoring increase with the size, the low incentives to work in collective farms may arise from the fact that they are too large. However, some analytical models, overlooking monitoring problems, suggest that the incentives to work increase with size (see Israelsen 1980). In the last two sections, we have avoided the problem of size by assuming that a LMF is bestowed with fixed members. In this section, that assumption is relaxed, and the problems of size and other related issues are addressed.

A.   the Choice of Optimum Size

Intuitively, two factors need to be considered in the choice of

size. First, there must be some productivity gain related to larger size. Second, the costs of monitoring increase as the size becomes larger. In a conventional firm the optimum choice of size is at the point where the increase in productivity just compensates for the rise in monitoring costs. However, the optimum choice of size will be smaller for a LMF because of its income-sharing characteristic. To illustrate this choice of size, let us assume that the management is bestowed with the authority to recruit new members if the size of the LMF is too small or not to replace the retired members if the size is too large.[12] We also assume, following the convention of Ward (1958), that every worker supplies a fixed amount of effort.[13] The problem for the management is

$$\max_{N} \quad y = \frac{1}{N}[F(N; e) - C(N; \pi, \Gamma)] \tag{22}$$
$$\text{subject to} \quad N \geq 1.$$

Assuming that an interior solution exists, the first-order condition for maximization is

$$F_N - C_N = \frac{F - C}{N} . \tag{23}$$

The optimum size for a conventional firm locates at the point where $F_N - C_N = 0$. This verifies the following proposition.

PROPOSITION 9: Due to the income-sharing characteristic, the optimum

　　　　size of a LMF is smaller than a conventional firm, ceteris

　　　　paribus.[14]

From expression (23), we see that if an interior solution exists, the optimum size of a LMF is determined at the point where the net marginal product of size equals the net average product of size. Other

things equal, if the returns to size are larger, the optimum size of a LMF will be larger.[15]

B.   Supervisibility and the Optimum Size

A moment's reflection on expression (23) suggests that the optimum size of a LMF should be smaller if it is more difficult to monitor effort in its production process. However, due to the income-sharing characteristic, this intuition holds only with some additional assumptions on the cost function. Ignoring the possibility of a binding constraint, differentiating equation (23) totally with respect to N and Γ and rearranging yields

$$\frac{dN}{d\Gamma} = \frac{-C_{N\Gamma} \cdot N + C_{\Gamma}}{(C_{NN} - F_{NN})N} . \tag{24}$$

The sign of the denominator is positive. So $dN/d\Gamma$ has the same sign as the numerator.   However, the sign of the numerator seems to be indeterminate.

$$-C_{N\Gamma} \cdot N + C_{\Gamma} \gtreqless 0 \quad \text{iff} \quad \frac{C_{N\Gamma} \cdot N}{C_{\Gamma}} \lesseqgtr 1 \tag{25}$$

This bewildering situation arises from the fact that two things happen at the same time when the difficulty of monitoring increases. First, the monitoring costs are something like a tax on a LMF. As Ward (1958) has demonstrated, in a LMF, when the tax increases, it is beneficial for the existing members of the LMF to recruit more workers in order to reduce the burden of tax on each member. Thus, the size of the LMF should increase. Second, as the marginal cost of monitoring increases, the net

marginal product of size decreases; therefore, the size of the LMF should

be reduced. The final result depends on which force dominates.

Fortunately, expression (25) depends on the relative magnitudes of $C_{N\Gamma}$

and C_Γ. Therefore, the key to the answer is the structure of monitoring

cost function. One possible functional form that meets all the

requirements of equations (8) and (9a)-(9c) is a general Cobb-Douglas

function:

$$C(\pi, N, \Gamma) = \pi^\alpha (N - 1)^\beta \cdot \Gamma^\gamma, \tag{26}$$

where α, β, and γ need not be constant. However, in the relevant region,

α and β are required to be greater than 1 in order to meet the condition

that $C_\pi > 0$, $C_{\pi\pi} > 0$, $C_N > 0$, $C_{NN} > 0$.

If this general Cobb-Douglas function form is assumed,

$$\frac{C_{N\Gamma} \cdot N}{C_\Gamma} = \frac{\beta \cdot N}{N - 1} > 1 . \tag{27}$$

Consequently, the sign of dN/dΓ is negative. To the extent that

any function can be locally approximated by a general Cobb-Douglas

function, this result should also hold, in the relevant region, for any

cost function with the properties stipulated by equations (8) and (9a),

(9b), (9c). We thus conclude,

PROPOSITION 10: The optimum size of a LMF is negatively correlated

with the difficulty of monitoring in its production process, ceteris

paribus.

If the effort in the production process is easy to monitor, the

optimum size of a LMF will be large; if monitoring is difficult to

implement, the optimum size will be small, other things equal.

VI. Concluding Remarks

In this paper, I have studied the impacts of the vertical and horizontal supervision in a LMF on the incentives to work, the supply of labor, and the optimum size of a LMF. I hope this paper has shed some light on the crucial issue of supervision in a LMF, which has long been neglected in the formal models of a LMF.

Monitoring and peer pressure are only two of many factors that affect the incentives, labor supply, as well as the optimum size of a LMF. Other factors, such as the proportion between distribution according to need and distribution according to work, relative price of output, fixed charges on a LMF, and so on, also have important impacts on these issues.[16] However, supervision may very well be one of the most important factors in the determination of individual incentives and thus the success or failure of a LMF. Successful examples of LMFs are often found in the manufacturing or processing sectors (see Jones and Svejnar 1982, 1985; Stephen 1982); however, the performances of LMFs in agricultural production are often dismal (See Bradley and Clark 1972; Johnson and Brooks 1983; Perkins and Clark 1984; and Carter 1984). I think that one of the main reasons is differences in the supervisibility of labor in production processes. Manufacturing and processing are highly specialized, are concentrated in small areas, and have standardized routines. It is much easier for the manager to monitor the workers' performances and to relate the rewards to their efforts. Therefore, the incentives to shirk are smaller in these sectors. In agriculture, however, production is widely dispersed and involves long

periods of production and diversified jobs. It is very costly to provide close monitoring in agriculture. Because of the high costs of monitoring, the optimum degree of monitoring in an agricultural cooperative must be low; the monetary differences between a job done poorly and one done competently are thus little (Johnson and Brooks 1983, p. 179). Therefore, the incentives to work as well as the productivity are both very low.[17]

The efficient mode of organization is the one which economizes on transaction costs (Williamson 1980). The costs of monitoring are a major component of transaction costs. Because of its income-sharing characteristic and the existence of peer pressure, a LMF can be a superior way to provide the incentives to work if (a) the returns to size are fairly large and at the same time it is too costly to provide any meaningful monitoring, or (b) monitoring is not very costly. If the returns to size are limited and the costs of monitoring are high, a LMF is not an efficient mode of organization. Agriculture belongs to the last category. The efficiency of American farms, compared with those of the Soviet Union, should be attributed to the fact that most farms in the United States are owner-operated farms, which have little problems of properly monitoring, metering, and rewarding labor effort.[18] Nevertheless, most socialist countries, including China in the past, established gigantic collective farms and thus exacerbate the difficulties of monitoring. China has made a series of major reforms since 1978. A new institution called "the household responsibility system" has replaced the production teams with the individual household as the unit of production. The difficulty of monitoring in the

production team system is identified empirically as the main reason for this institutional change (Lin 1987a) and the incentives to work are found to have been improved greatly after this institutional reform (Lin 1987b).

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FOOTNOTES

[1]The term "labor-managed firm" (LMF) is used in this paper to designate entities that are called "worker-managed firm", "self-managed firm", "producers' cooperative", "collective farm", or "production team" in the economic literature.

[2]For the case of heterogeneous workers, see an early, detailed version of this paper (Lin 1985). All the propositions in this paper are not altered, except wording, by the introduction of heterogeneity of preferences. However, the analyses become very complicate because workers need to be classified into three categories, namely, income-preferring, leisure-preferring, and average workers.

[3]The same specification is adopted in Calvo and Wellisz (1978).

[4]The management in a LMF refers to the managers who are hired by the workers' council in a competitive market to perform the monitoring function. The management monitors workers' effort instead of their marginal product because the principle of income distribution is "to each according to his work."

[5]$h(.)$ is assumed to be a nonstochastic function in this paper. At first glance, it might appear to be preferable to make it stochastic. However, s_i would become a ratio of two random variables. The expectations of s_i as well as y_i might fail to exist. Consequently, the problem became unsolvable without making other more strained assumptions (see Putterman 1985). $h(.)$ may be interpreted as a "certainty equivalence" of a stochastic work point function.

[6]One of the possible functional forms which have all the required properties is:

$$h_i = 1 - \pi + \pi e_i.$$

[7]Peer pressure on a worker is assumed to incur no cost on the other workers in the LMF. This is admittedly a somewhat strained assumption. I make it for two reasons. First, Binswanger and Rosenzweig (1986) have argued that supervision as a by-product of the production process has the lowest cost. Peer pressure is a by-product of the production process; therefore, this assumption may not be too unrealistic. Nevertheless, it greatly simplifies the expositions. Second, it can be verified that the propositions in this paper can be extended in a straight-forward fashion,

with some minor changes in the wording, to the case that cost of peer

pressure is included.

[8]When the members of a LMF are fixed, it makes no difference in

maximizing average net income or total net income. We can also make the

objective of the management to maximize both net average income and

other elements of individual satisfaction instead of average net income

alone. However, this would yield a structure that is identical for

analytical purposes, but at the cost of much added complexity.

[9]The workers' council either has to hire more managers or a more

competent manager with higher salary to perform it.

[10]To be precise, the incremental income gain is the incentives for

the other members to put peer pressure on the ith worker. Here the

implicit assumption is that peer pressure is a linear transformation of

the incentives for applying peer pressure with the slope equal to unity

and starting from the origin. I owe this point to Charles Kahn.

[11]If, at the management's choice set of monitoring, this claim does

not hold, then effort supply can be increased and cost of supervision can

be reduced by the decrease in the degree of monitoring. As management's

objective is maximizing the average net output, such a point will be

excluded from the management's choice set.

[12]The asymmetry between hiring and dismissing workers in a LMF

arises from the fact that the management in reality has difficulty to

decide who should be dismissed even if income for those that remain could

be increased by dismissing some, as Robinson (1967) pertinently argued in

her comments on Ward's and Domar's papers. However, the size of a LMF can be reduced by not replacing retired members although it may take longer period of time to reach the optimum level.

[13]This is a typical assumption made in the literature dealing with the size of a LMF (see Ward 1958, Maurice and Ferguson 1972, Miyazaki and Neary 1983). The problem becomes intractable if effort is a choice variable. Also, for the simplicity of exposition, the degree of monitoring is assumed given.

[14]Ward (1958), Vanek (1970), and others find that the income-sharing property also makes a LMF choose a smaller size than a conventional firm when profits are positive.

[15]In this model only effort is included in the production function so there is no difference between size and scale. If the production function includes several inputs, the same conclusion can be extended to scale in a straight-forward fashion.

[16]For an excellent overview of the effects of other factors, see Bonin and Putterman, 1986.

[17]Johnson and Brooks (1983) also identify bureaucratic interference in farm decision making, poor quality inputs, lack of a smoothly functioning supply system of non-farm inputs, distorted price incentives, and lack of efficient rural labor markets as reasons for the low factor productivity in Soviet agriculture.

[18]The average number of worker per farm in the Soviet Union was about 515 for collective farms and about 550 for state farms (Johnson and Brooks, 1983, p.4). In the U.S., it was 1.6 in 1979 (U.S. Department of Agriculture, 1980, p. 431). As pointed out by Bradley and Clark (1972), the emergence of American corporate farms does not invalidate this conclusion. American corporate farms are large in terms of total assets and scale, but they typically employ only small numbers of permanent workers. They are also most successful in production that is not spatially dispersed and in using capital-intensive techniques in which the problems of monitoring are minimal.