

**Incentive Complementarity: Investment-bonding, Profit-sharing and the Performance  
of Firms in Rural China**

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## Abstract

Complementarity between incentive instruments is regarded as one of the central themes of theoretical research in the economics of industrial organization in recent years. However, despite its importance, empirical evidence on the existence of complementarities is limited. In this paper we identify complementarities between incentive mechanisms used by firm-owners to motivate managers. Using a multi-task principal-agent framework we consider a problem in which the owner uses two incentive instruments, profit-sharing and investment-bonding, to motivate the manager in two tasks, production and asset-maintenance. Our theoretical model yields testable hypothesis regarding the complementary and individual effects of incentives on performance. We test the hypothesis of our theoretical model against a dataset on 56 rural firms in China, observed in 1988 and 1995. Our descriptive results clearly show that the two instruments are complements. Our econometric model using a panel regression framework confirms that significant complementarities exist in terms of the impact of the two instruments on performance. In order to evaluate the robustness of our results we account for unobserved differences in firm quality using fixed effects and instrumental variables regressions. Support for the complementarity hypothesis is also found after controlling for unobserved heterogeneity.

## **1.1 Introduction**

It has long been recognized that firms develop innovative organizational designs when faced with the challenges of intensifying competition in an environment in which information is costly and incomplete (McMillan, 1997; Prendergast, 1999). The innovations include a variety of managerial and worker compensation practices such as profit sharing (e.g., Weitzman and Kruse, 1990; Groves et al., 1995), bonding (e.g., McMillan, Naughton and Lin, 1996; McMillan, 1995), and other forms of incentive-based payment schemes (e.g., Gordon and Li, 1991; Pinto, Belka and Krajewski, 1993). Theorists describe the innovations as instruments for firm owners to motivate employees to work hard and increase firm performance when performance cannot be perfectly measured or monitored.

While the theoretical basis of the new institutional forms is well-established, researchers and practitioners still do not understand clearly how effective the different instruments are in raising performance in practice, either when firm owners use them in isolation or in combination with each other. Until recently many papers were mainly theoretical and typically relied on anecdotal evidence as a way to support their predictions (Chiappori and Salanie, 2000). The relatively small empirical literature has been unable to establish clearly the nature of the relationship between incentives and performance. In fact, a number of papers have failed to find a statistical connection between the presence of incentives and performance. Since economists believe in incentives, recent papers have attempted to explain the absence of a strong linkage. Some have shown it is a problem with measuring the true nature of incentives (Li and Rozelle, 2001). Others have shown it is an estimation problem and emphasized the necessity of controlling adequately for unobserved

heterogeneity (Akerberg and Botticini, 2003).

Alternatively, it is possible that in many previous studies scholars have focused on a single incentive instrument, but owners, because of the complicated nature of firm operations, in fact use multiple incentive instruments (Dewatriport et al., 2000). The empirical literature on firm organizational design contains studies of many different incentive mechanisms, but most consider only one mechanism at a time (e.g., Weitzman, 1980; Lazear and Rosen, 1981; Hsiao et al., 1998). Little attention has been paid to the fact that firm owners frequently employ more than one instrument to provide the incentives that motivate managers and workers, or to the fact that in such situations estimating the marginal effect of a single incentive instrument in isolation of others could produce misleading results (Holmstrom and Milgrom, 1994).

As a consequence, some researchers have suggested that in order to gain a better understanding of the effect of incentive mechanisms on firm performance, empirical studies need to consider multiple instruments simultaneously (Holmstrom and Milgrom, 1991). It is possible that a particular instrument may have a greater effect on firm performance when used in conjunction with other instruments than when used alone (Milgrom and Roberts, 1990). In other words, two or more incentive instruments may be complementary. Surprisingly, however, the literature contains little systematic evidence on either the existence of complementarities or the consequences of not controlling for complementarity effects when they are relevant. Only a few empirical studies, including Ichniowski, Shaw and Prennushi, (1997) and Brynjolfsson and Hitt (1998), have attempted to empirically study complementarities between organizational design practices of firms.

In light of these considerations, the overall goal of the paper is to identify and understand the nature of the complementarities between different incentive instruments that firm owners use to motivate firm managers. We consider a case in which the owner seeks to maximize the firm's performance by *both* managing the profitability of the firm's immediate production activities (its current profits) and maintaining the firm's fixed assets and capital equipment (which we assume will enhance long-term earnings). In order to induce the manager to put effort into increasing current profits, the owner can offer a *profit sharing* arrangement that links the manager's pay to current profits. However, with such a contract it is possible that the manager could myopically focus on current period profits to the detriment of profits in future periods. For example, in pursuit of high profit margins in the current period the manager could overuse an asset, say a piece of equipment, on which future production relies. To motivate the manager to maintain the firm's assets, and to not abuse the firm's long-term earning prospects, the owner also can require the manager to invest in the firm. Such investments serve as implicit bonds, providing the manager with incentives to put effort into asset maintenance, since he owns part of the asset and shares in its value were it to be liquidated or used in future periods. In the rest of the paper we call such a contractual requirement by the owner for the manager *investment bonding*. Under investment bonding, an individual manager should be less willing to exploit a firm's assets excessively for current production and the profits that it could generate. We examine this problem in the context of firms in rural China, an economy in which both profit sharing and investment bonding are observed.

To achieve the above goal, we have two objectives. First, we use a principal-agent

framework based on the work of Holmstrom and Milgrom (1991) to demonstrate the necessity of multiple incentive instruments when the principal has multiple objectives. The theoretical model provides us with testable hypotheses on the individual effects of the two incentive instruments on firm performance and on the existence of complementarities between the instruments. Given the hypotheses, the second objective of the study is to empirically test the individual and joint effects of the two incentive instruments on firm performance. We do so by building an empirical model that separates the different effects of short-term and long-term incentives using a data set of 56 rural firms in China that were observed in 1988 and 1995. The empirical approach follows the work of Athey and Stern, (1998). Specifically, the complementarity test evaluates whether the sum of the performance increase from implementing profit sharing in isolation and the performance increase from implementing investment bonding in isolation is less than the performance increase from jointly implementing both.

Our choice of rural China to conduct this study is appropriate because innovations in organizational design of firms are even more common and more heterogeneous in a nation that is underlying rapid transition and development. Novel incentive practices emerging in these economies both reflect the themes of modern economic theory and provide an unique opportunity for empirically testing the theoretical literature on incentives (McMillan, 1997). At the same time our work on incentive complementarity also will contribute to the understanding of the mechanisms of growth in China's rural industrial sector, a sector in which such incentive practices are pervasive.

The remainder of the paper is organized as follows. Section 2 establishes the context of the study by describing rural industry in China and provides a description of the data. Section 3 presents a multi-task moral hazard model of contracting with multiple incentive mechanisms, and derives the main hypotheses of this study. Section 4 describes incentive contracting practices observed in our sample and provides descriptive evidence on the hypotheses derived from the theoretical model. Finally, in sections 5 and 6, we describe the econometric estimation strategy to formally test the hypotheses of the theoretical model, present the main empirical findings, and conclude.

## **1.2 Incentive Contracts and Incentive Complementarity: Context and Data**

While researchers in China have claimed that management incentive contracts contributed importantly to the success of China's rural industries during the late 1980s and 1990s (e.g., Walder, 1995; Jin and Qian, 1997), the empirical evidence on the performance effect of incentive contracts for China's rural firms is ambiguous.<sup>1</sup> Studies have reported conflicting findings. Chang et al. (2003) use historical data from the period 1984 to 1993 on 80 rural non-state firms in China and find that introducing managerial profit sharing incentives has no significant effect on firm performance. Hsiao et al. (1998), using data on 200 firms between 1985 and 1990, find that stronger profit sharing incentives for managers actually decrease firm performance. One explanation, given the trend towards fixed-rent contracting in the late 1980s is that rural firm owners are not maximizing profits but are pursuing non-economic goals. In contrast Whiting (1996) and Chen and Rozelle (1999) find that profit-sharing managerial contracts induce better firm performance.

While it is possible the differences among the studies reflect differences among

samples, time periods of analysis and data quality, the conflicting findings may not necessarily reflect inconsistencies in the effect of incentive contracts on the performance of China's rural firms. Rather, the inconsistencies may be due to the fact that previous studies considered only a single dimension of the managerial contract. Typically, studies assume that an incentive contract ( $C$ ) is composed of a sharing rule ( $g$ ) according to which the firm's current period profits are distributed between the owner and the manager. Using this formulation, studies evaluate the effects of incentive contracts on firm performance,  $P$ , by estimating the effect of  $g$  on a measure of firm performance, or  $P = f(C(g))$ . The focus on  $g$  alone may be justified if  $g$  captures the complete set of effects of incentives on firm performance. However, there may be other dimensions of the contract,  $X$  (such as a bonus payment offered to the manager), that also affect firm performance directly or in conjunction with  $g$ . If true, previous studies are implicitly using  $g$  as a proxy for  $C(g, X)$ . A problem arises in cases where  $X$  is relevant and where  $g$  and  $X$  are correlated; if so, the econometric estimates of the coefficient on the  $g$  parameter is prone to omitted variable bias. Even if other factors including  $X$  are held constant, the focus on  $g$  alone captures only the partial effect of an incentive contract on firm performance, not the total effect.

Therefore, it may be important to study other aspects of contracting in China's rural firms beyond current incentives. Specifically, we focus on asset maintenance and the incentives, such as investment bonding, which encourage managers to take care of the firm's assets. Since it is plausible that investment bonding may be correlated with arrangements for profit sharing, if bonding is ignored it may affect the quality of the estimates of the

relationship between contractual incentives and performance. In our field interviews, firm owners agreed that sharing profits was important for motivating managers to work hard, but also emphasized the need for asset maintenance incentives. A number of interviewees said that their contractual provisions often included more than one type of incentives as shown by the following excerpt from an interview of a county government official in Henan province:

“...yes, of course, with a fixed rent contract managers are not going to be accountable for anything. Few times in the past our village's leaders have had to deal with managers who had damaged the machines during their contract term. Hence, we have taken explicit steps to ensure that this does not happen. Sometimes we tried to use longer term agreements. However, with this arrangement we lost control over the manager. In recent years we have started to make the manager invest in the firm itself. According to this arrangement, the manager, is given a short term profit sharing contract and is required to put in an investment into the firm. We have found that this makes the manager have an interest in the longer run performance of the firm and he is more careful at taking care of the capital equipment.” (County Government Official, YuanYang County, Henen province, 2001).

In another interview, an owner of a successful wheat milling plant reported that one of the main reasons for the firm's success was that the firm's management system was created by the use of investments together with profit sharing contracts which linked the manager's current and future earnings to the firm's performance.

“...[In our township,] we have two ways to induce managers to work hard and manage the firm well. First, our company shares its profits with managers according to their performance. Second, we ask the manager to make an investment of capital into the firm and based on this investment we in fact are offering him a share of the firm's future profits. After doing so we made managers explicitly responsible for machine maintenance. This is important as the manager's remuneration is often tied to profits. We want them to increase our sales but at the same time we want them to be careful and not cause us losses by breaking the machine equipment. A few of our managers that have not invested, have to put up security deposits which, in the event that a machine under the manager's care breaks, is taken by the company. Sometimes we write the names of the managers on the equipment itself indicating that they are responsible for its maintenance. (CEO Wheat milling plant, Yuangyan county and Zhenzhou city, Henan province, 2001).

Based on our interviews, then, it is clear that at least in some of the firms we visited, contracts are multi-dimensional. The discussions with the leaders and managers also show that both profit sharing and investment bonding will affect firm performance. Hence, in our theoretical and empirical work we explicitly model both contractual provisions.

### **1.2.1 Data**

Our empirical work draws from a unique set of data from a nationally representative survey of local officials and factory managers in eight provinces in China. The survey included over 200 villages. In each village enumerators asked a series of questions to three leaders--the party secretary, the village head and the accountant--during 5 to 8 hour interview sessions spanning 1 to 2 days. Village leaders provided information on the organization of village's enterprises, the span of market activities and the presence of other institutions of exchange. Leaders also provided information on income, infrastructure and the level of economic development of the village. The section of the survey on the village's enterprise was filled out in part by leaders and in part by the enterprise's manager.

In this paper we rely heavily on the information on 56 rural firms that were observed during the 1988 and 1995 time periods. Most firm data came from the firm's manager. In cases in which the firm was still fully run by the village leader, however, some key pieces of information were collected during the village leader survey. The data from the village firm form provide information on the institutional features of the firm, such as the type of incentive contract adopted by the firm for the manager; whether the firm was under a fixed wage, pure share or fixed rent contractual agreement; whether the firm received managerial

investments; and the size of such investment. Enumerators also asked questions about the human capital of leaders and managers. Enumerators collected information on most variables for 1988 and 1995. For a subset of the variables such as the firm's performance leaders also provided information for 1993 and 1994.

### **1.3 A Model of Contracting in China's Rural Firms**

In this section we present a model that analyzes the contractual relationship between the leader (firm owner) and the hired manager. The owner's payoff is dependent on the effort exerted by the manager. Effort is costly for the manager and cannot be observed by the owner, so there is a moral hazard problem. In the presence of moral hazard, economic theory suggests at least two ways of inducing effort: a.) a share contract, where the manager receives a portion of the realized profits, or a fixed rent contract, where the manager is the full residual claimant of profits after paying the owner a fixed fee; and b.) a bonding contract where the manager posts a performance bond. Here we focus on a case in which profit sharing (share or fixed rent) and bonding are used jointly within a single contract to accomplish the multiple objectives of the owner. The theoretical model yields simple testable hypotheses regarding the individual and joint effects of profit sharing and investment bonding on firm performance.

The owner's objective is to maximize the firm's overall performance by persuading the manager to work hard. The owner's objective has two components: a.) current profits, the value of the firm's current period production realization; and b.) future profits, represented by the value of the firm's assets at the end of the current production period. Both depend upon managerial effort. Current profits depend on the manager's *production effort*, the supervision

of the firm's immediate production activities. Future profits depend on the manager's *maintenance effort*, the care of the firm's capital equipment and other assets.

The manager's effort at increasing firm performance, however, is private information and not observed costlessly by the owner. The owner cannot deduce the manager's effort by observing the firm's performance, because performance is a stochastic function of managerial effort. There are outside influences on output beyond the manager's control, such as outside economic conditions and input quality variations. Likewise, the level of maintenance effort also cannot be verified by the owner *ex post* due to the uncertain nature of the firm's production process, and because the effect of maintenance effort on future earnings cannot be distinguished from the effect of future period production effort.

Under these assumptions, in the absence of an effective incentive mechanism, we assume that the manager will shirk, which will hurt firm performance. Given the owner's objective, shirking may encompass a range of behavior, from the manager underproviding production effort to the manager overproviding production effort and overexploiting the firm's capital equipment. In order to ensure that the manager does not shirk the owner must provide him with both production and maintenance incentives.

To ensure that the manager works hard, the owner must provide the manager not only with incentives but needs to put together a package that meets the manager's objectives. At the very least the owner must provide the manager with the same level of utility that he would obtain from his second-best option. The manager's objective function has two components: a) returns, from either a portion of the firm's current profits obtained through the owner's *production incentive*, profit sharing, and/or a portion of the firm's future profits

obtained through the owner's *maintenance incentive*, investment bonding, and b) the disutility of production effort associated with managing the firm's current production activities, and the disutility of maintenance effort associated with caring for the firm's assets. The manager considers the returns and the costs of production and maintenance effort and chooses the levels of effort that maximize his objective. Both the manager and the owner are assumed to be risk neutral.

We formalize the above problem as follows: The owner's objective function depends upon two activities ( $y$ ): production ( $y_p$ ) and maintenance ( $y_m$ ). Managerial effort is a critical determinant of production,  $y_p(e_p)$ , and maintenance,  $y_m(e_m)$ , where  $e_i \in [0,1]$ . There are two possible outcomes for each  $y_i \in \{0,1\}, i = p, m$ , where 0 and 1 denote low ( $y_i^l$ ) and high ( $y_i^h$ ) outcome levels, respectively. We characterize the stochastic influence of the manager's efforts on the firm's performance through a probability density function. The probability of a high outcome is linear in effort, that is,  $p_i^h = e_i \forall e_i \in [0,1]$ . Thus, if the manager chooses an effort level  $e_i$ , then the high outcome,  $y_i^h$ , is realized with probability  $e_i$ , and the low outcome,  $y_i^l$ , is realized with probability  $1 - e_i$ . The owner's expected revenues are therefore  $P = \sum_i e_i y_i^h + (1 - e_i) y_i^l$ , net of all costs except managerial compensation.

The manager's utility function is additively separable in income and effort:  
 $U = m - \gamma(e_p, e_m)$ , where  $m$  denotes the manager's returns and  $\gamma(e_p, e_m)$  is the manager's disutility of work. The manager's returns  $m$  can be written as  $m = a_p y_p + a_m y_m + T$  where

$a_p$  and  $a_m$  are fixed shares of current and future profits of the firm and  $T$  is the manager's net endowment of wealth. Disutility of work is represented by the manager's cost function for effort, assumed to be twice differentiable and increasing and convex in effort,

$$y(e_p, e_m) = \frac{1}{2}e_p^2 + \frac{1}{2}e_m^2 + qe_p e_m, \text{ with } y'(e_i) > 0, y''(e_i) > 0 \text{ and } y(0) = 0.$$

In the context of this study as seen in the previous section it is reasonable to expect interactions that may arise due to substitution between the two types of effort.<sup>2</sup> In our specification the cross-partial derivative of the manager's effort cost function,  $q$ , captures this interaction. The *substitution parameter*,  $q$ , represents the proportionate increase in the marginal cost of the manager's maintenance effort due to a unit increase in his production effort. We expect that the supply of effort into the production task increases the marginal

cost of asset maintenance effort,  $\frac{\partial y(e_p, e_m)}{\partial e_m} = e_p + qe_m$ . A positive  $q$  will lead the manager to substitute between the two types of effort by taking effort out of the costly (or less rewarding) task and reallocating it to the less costly (or more rewarding) one.<sup>3</sup>

The owner's challenge is to design a contract that can elicit the most profitable level of managerial effort in each of the two tasks given the manager's utility function. To motivate production effort, the owner offers the manager a share  $a_p$  of current profits where  $a_p \in [0,1]$ . To motivate maintenance effort, the owner may require investment,  $w_e$ , in the firm's capital assets by the manager. Let  $d(I) = 1$  indicate a positive investment from the manager, or  $d(I) = 1$  if  $w_e > 0$ , and  $d(I) = 0$  if  $w_e = 0$ . Based on this investment the owner offers him a share  $a_m$  of the firm's future earnings, where  $a_m \in [0,1]$ . Finally let  $F$  denote

the rent that the owner can charge the manager. Hence, a contract between the owner and the manager is defined by four parameters:  $(a_p, a_m, d(I), F, I)$ . Given the contract offered by the owner, the manager decides whether or not to accept the contract, and, if he does, the utility-maximizing level of effort to expend on each task.

Accounting for the manager's response, the owner maximizes his expected payoff,

$$\max_{a_p, a_m, F, I} (1 - \alpha_p) e_p + (1 - d(I) \alpha_m) e_m + F + I. \quad (1)$$

Equation (1) is maximized subject to two conditions,

$$\alpha_p e_p + d(I) \alpha_m e_m - F - I - \frac{1}{2} e_p^2 - \frac{1}{2} e_m^2 - \alpha_p e_p e_m \geq 0, \text{ and} \quad (2)$$

$$e_p, e_m \in \arg \max (\alpha_p e_p + \alpha_m e_m - \frac{1}{2} e_p^2 - \frac{1}{2} e_m^2 - \alpha_p e_p e_m - F - I). \quad (3)$$

Equation (2) describes the participation constraint of the manager. To induce participation, the owner must pay the manager at least his reservation wage (which we normalize to zero).

Equation (3) denotes the incentive compatibility, condition which reflects the fact that the manager chooses  $d(I)$  and effort levels,  $e_i$ , to maximize utility.

As a benchmark case, we derive optimal levels of effort for the first-best case when there is no moral hazard, so the incentive compatibility constraint does not bind. This would be the case if the owner runs the firm himself, or could observe the manager's actions perfectly. Under this set of assumptions, the first-best levels can be derived by maximizing the total surplus, that is, the sum of the utilities of the manager and the owner,

$$e_p + e_m - \frac{1}{2} e_p^2 - \frac{1}{2} e_m^2 - \alpha_p e_p e_m.$$

Differentiating the total surplus function with respect to each type of effort we obtain,

$$e_i^{FB} = \frac{1-q}{1-q^2}. \quad (4)$$

In the first best case (i.e., when the leader runs the firm and there is no moral hazard) the first best levels of effort decrease as the degree of substitution,  $q$ , rises (Equation 4). This is because when the owner increases production effort, maintenance costs increase in proportion to  $q$ . Consequently, the owner who owns the assets of the firm and cares about its maintenance will find it optimal to supply less than the full amount of production effort, which is normalized to 1 in our case. However, if we depart from the first best case (i.e., when the manager runs the firm and there is moral hazard), the manager, who does not own the assets of the firm and does not internalize maintenance costs, will supply the maximum level of production effort without regard for its effect on maintenance.

With the first-best effort levels from the baseline scenario established above, from Equations (1) to (3) we derive the optimal levels of effort under asymmetric information,<sup>4</sup>

$$e_i = \frac{a_i - qa_j}{1-q^2}. \quad (5)$$

Comparing the effort levels in (5) to the first best levels in (4), the manager's choice of efforts can deviate from the first best case in one of two directions. In some cases the manager may provide less production effort, which lower current profits. This problem of *Marshallian inefficiency* can be seen by evaluating the manager's production effort choice in Equation (5). Other things constant, if the manager's production incentive,  $a_i$ , is less than one then the manager will provide less production effort relative to the first best case. Only when the manager is made the full residual claimant (or alternatively when  $a_i = 1$ ) in

Equation (5), does the manager provide full production effort.

In other cases the manager may provide an excess of production effort at the expense of maintenance effort, abuse the assets of the firm and decrease the firm's future earnings relative to the first best case. In terms of Equation (5), when the manager's maintenance incentive,  $a_j$ , is less than one the manager will provide an excess of production effort at the expense of maintenance effort, relative to the first best case. This will be true as long as the substitution parameter,  $q$ , is positive. This problem of *asset exploitation* occurs because the owner, by encouraging production effort, indirectly crowds out the manager's maintenance effort. In such a case, the owner must realize that a stronger production incentive, such as a fixed rent contract, may increase profits in the current period but may be detrimental to the overall performance of the firm in the long run, since it will divert the manager's attention away from asset maintenance. Only when the manager is given claims on the value of the firms assets through an investment bonding contract, or alternatively when  $a_j = 1$ , in Equation (5), does the manager provide full maintenance effort.

Thus, given the tradeoff associated with motivating the manager to put production effort on one hand and maintenance effort on the other, the owner must balance the incentives across the tasks in a manner that increases the firm's performance. To see this reconsider the owner's objective in Equation (1) taking into account the manager's actions,  $e_p$  and  $e_m$ , derived from Equation (5),

$$\max_{a_p, a_m} P = \frac{\bullet_p - q\bullet_m}{1-q^2} + \frac{\bullet_m - q\bullet_p}{1-q^2} - \frac{1}{2} \left\{ \frac{\bullet_p - q\bullet_m}{1-q^2} \right\}^2 - \frac{1}{2} \left\{ \frac{\bullet_m - q\bullet_p}{1-q^2} \right\}^2 - q \left\{ \left( \frac{\bullet_p - q\bullet_m}{1-q^2} \right) \left( \frac{\bullet_m - q\bullet_p}{1-q^2} \right) \right\}.$$

(6)

Differentiating (6) with respect to  $a_p$  and  $a_m$ , and rearranging terms we get

$$a_p = 1 - q + a_m q \quad (7)$$

Equation (7) shows how the owner must balance the two incentive instruments  $a_p$  and  $a_m$ .

If the owner increases the level of incentives for current period production then he must simultaneously increase the level of incentives for maintenance, and vice versa. Otherwise, the manager will focus attention on one task and neglect the other. By offering the manager the appropriate intensity of incentive for each task, the owner can obtain the first best levels of effort in both production and maintenance even though there is asymmetric information.

The appropriate intensity of incentives depends on the value of the substitution parameter,  $q$ , which denotes the sensitivity of the manager's maintenance costs to his production effort.

### 1.3.1 Incentive Complementarity and the Hypotheses

The observation that incentives need to be balanced across the two tasks suggests that the incentive instruments may be complementary. We follow the approach of Athey and Stern (1998) to show whether or not profit sharing and investment bonding are complementary incentive instruments. Two incentives instruments are complementary if the owner's objective function can be shown to be *supermodular* in the incentive variables, which implies that the sum of increasing each incentive variable separately increases the owner's objective by less than increasing all of them simultaneously.

Following this approach, we evaluate the owner's objective function, defined in Equation (1), in terms of the expected payoffs from implementing each of the four possible

types of contractual agreements:  $P(1,1)$ , *profit sharing and investment bonding*;  $P(1,0)$ , *profit sharing only*;  $P(0,1)$ , *investment bonding only*; and  $P(0,0)$ , the *fixed wage* category (or when there are no incentives). Complementarity requires that the owner's expected payoff from using both instruments together is greater than the sum of the expected payoffs from using each separately, or, in terms of Equation (1),

$$[P(1,1) - P(0,0)] - [P(1,0) + P(0,1) - 2P(0,0)] \geq \frac{\bullet}{1 - \bullet^2} \quad (8)$$

The left hand side of Equation (8) denotes the difference between the performance increase from jointly implementing both profit sharing and investment bonding together, and the sum of the performance increase from implementing profit sharing in isolation and investment bonding in isolation. Complementarity requires that this difference be positive. Since the convexity of the cost function implies that  $(1 - \bullet^2) > 0$ , and  $\bullet > 0$  when the two types of efforts are substitutes. If the difference is positive the two instruments are complementary (see the appendix for a formal derivation of Equation (8)).

The expression for complementarity in Equation (8) also describes the individual and joint effects of incentives on firm performance, and can be used for generating testable hypotheses. As seen in Equation (8), the individual and joint effects of incentives on the owner's payoff are dependent on the value of the substitution parameter,  $q$ . By simulating the owner's payoffs for implementing each of the four cases (both profit sharing and investment bonding, profit sharing only, investment bonding only, and the non-contract, fixed wage category) at different values of the substitution parameter we isolate the individual and joint effects of incentives and generate testable hypotheses.

The simulation results reveal how different incentive instruments may affect firm performance depending upon the substitutability between the manager's production and maintenance efforts (Figure 1). When the substitution between efforts is negative (i.e., when exerting production effort makes it easier for the manager to maintain the firm's assets) the use of a single incentive instrument (profit sharing only or investment bonding only) is most profitable for the firm (region A). When the substitution between efforts is zero, that is, when exerting production effort has no impact on the manager's asset maintenance effort, using a single incentive instrument or both incentive instruments together has the same effect on performance (point B).

While the case of negative or neutral substitution effects is interesting, based on our discussion and fieldwork we believe that the more relevant case for rural China is when the substitution parameter is positive. When the substitution between the two types of effort is positive the effects are different but depend on the degree of substitutability. When it is small, the use of a single incentive instrument by itself still may be more profitable than the non-contract, fixed wage case but less profitable than the case where both are used jointly (Figure 1, region C). In contrast when the substitution between the manager's efforts is large (i.e., when exerting production effort substantially increases maintenance costs) the use of a single incentive instrument can actually decrease firm performance while the joint use of both incentive instruments continues to increase it (region D).

From the above discussion, then, we can state three testable hypotheses about the effects of incentives:

**Hypothesis One:** *Without investment bonding, profit sharing may result in insufficient asset*

*maintenance; hence, the firm's overall performance may decrease relative to the non-contract, fixed wage case*

**Hypothesis Two:** *Without profit sharing, investment bonding may result in insufficient production; hence, the firm's overall performance may decrease relative to the non-contract, fixed wage case.*

**Hypothesis Three:** *Profit sharing and investment bonding are complementary. Used jointly, profit sharing and investment bonding will have larger effects on firm performance than the sum of the effects when each incentive is used individually.*

#### **1.4 Descriptive Analysis**

The descriptive results, like the rest of the literature on contracting in China's rural firms (e.g., Whiting, 1996; Chen and Rozelle, 1999), identify the emergence of incentive contracting in the late 1980s and its evolving nature during the 1990s (Table 1).

Unsurprisingly, inspired by the widespread success of decollectivization in agriculture, by 1988 almost 74 percent of the sample firms had begun to adopt some form of incentive contracting. For example, 50 percent of the firms in the sample used fixed rent contracts and 24 percent used share contracts. Nonetheless, during the same period some firms (26 percent) did not use any type of incentive contract and were run either by village leaders themselves, or at most by managers/forepersons who were only paid a fixed wage. In 1995 this mix shifted towards fixed rent contracting (column 2). The share of fixed wage contracts fell to about 16 percent while fixed rent contracts increased to about 60 percent.

While incentive contracting evolved during the study period local governments in different areas varied in the way they chose to manage their firms (Table 1, columns 3-6).

Specifically, the change in contracting practices over time seems to be related to the level of economic development of a region. Contracts have evolved from fixed wage to fixed rent at a faster pace in developed regions than in less developed ones. Between 1988 and 1995, fixed wage contracts in developed regions fell from 27 to 6 percent in developed areas. Fixed rent contracts increased from 51 to 65 percent. Share contracts also increased slightly from 23 to 26 percent. In the less developed regions the evolution was slower.

Unlike previous work on China's rural firms, however, we identify another feature of contracting, investment bonding, which is widely prevalent in rural China. Hired managers invested in about 35 percent of the firms (Table 2). The magnitude of the investments from the manager also was substantial, accounting for a major component of total investment into the firm, about 24 percent. In fact, the proportion of total investment into the firm by the manager is higher than that secured through bank loans (22 percent, column 1).

The pattern in which investment bonding contracts have emerged across the sample shows that managers are typically making investments in firms in which owners also have given them incentives to maximize current period profits (Table 2, column 2). Most managerial investments (74 percent) occur in firms that also have given their managers fixed rent contracts. Managerial investments also account for a much higher share of total investment in fixed rent contract firms (columns 2-3, row 4)

Taken together our data show that owners are using profit sharing and investment bonding in a way consistent with incentive complementarity. When the owner offers the manager high production incentives through a fixed rent contract, it also is likely that he will offer the manager maintenance incentives through an investment bonding contract. In this

sense these observations are consistent with the predictions of Holmstrom and Milgrom, (1991) and Athey and Stern, (1998), which show that when incentives instruments are complementary they will be positively correlated with each other within a cross-section of firms.

Support for our hypotheses also appear when linking a firm's contractual practices with its performance (Figure 2). For example, when firms use profit sharing only, they earn lower profits. It is conceivable that profits are lower because higher production incentives from profit sharing encourage the manager to run the firm's capital equipment down. The data also reveal that firms that use investment bonding only earn lower profits.

The interpretation changes, however, when considering firms that use both profit sharing and investment bonding (Figure 2). Firms that adopt both experience sharp rises in performance. Importantly the gap between the performance of firms that use both contracts and those that use either a single, or no contract, widens over time.

In summary the patterns of contracting and performance in the descriptive data suggest that the success of profit sharing in increasing profits depends on investment bonding and vice versa. From the findings, the two incentive instruments appear to be complementary. However, the evidence presented above is not sufficient to conclude that they are complementary. We do not know if the differences are statistically valid or if there are other factors that affect performance. To further explore the hypotheses we need econometric analysis.

## **1.5 Econometric Analysis**

In this section we econometrically estimate the individual and complementary effects

of profit sharing and investment bonding on the performance of the firm. We use both OLS and fixed-effects models. The OLS estimates establish a baseline of the effect of contracts on the performance of the firm. We use a fixed-effects model to control for differences in firm quality and other non-time varying, unobserved effects that may simultaneously affect both the performance of the firm and its choice of contracts. To account for the possibility that some of the quality effects and other unobservables may change over time we supplement the fixed effects method with an instrumental variable method. Any residual correlation between the contract variables and performance would then have a higher probability of being from pure incentive effects of the contracts. Correcting for endogeneity helps identify the complementary effects of incentive mechanisms and avoid common criticisms to other empirical studies on complementarities (e.g., Brynjolfsson and Hitt, 1998; Ichniowski et al., 1997). Anticipating the results, we find evidence on the existence of complementarity between profit sharing and investment bonding and the findings are robust across a number of specifications.

### 1.5.1 Baseline Specification

To estimate the incentive effects of contracts on firm performance, we initially use OLS. Drawing on the theoretical findings (Equation 8) the baseline econometric specification can be written as:

$$p_{it} = \sum_{j=1}^J b_j C_{ijt} + aX_{it} + dZ_i + x_{it} \quad (9)$$

where  $p_{it}$  is the performance of the  $i^{th}$  firm at time  $t$ ,  $C_{ijt}$  is a vector of dummy variables that take on a value of 1 if the  $i^{th}$  firm at time  $t$  is under the  $j^{th}$  type of contract practice and 0

otherwise. The four contract practices denoted by  $j = 1..4$  are, respectively, profit sharing *and* investment bonding, profit sharing *only*, investment bonding *only* and the non-contract, fixed wage case. The corresponding coefficients on the four contract practices are respectively denoted by  $b_{hh}$ ,  $b_{hl}$ ,  $b_{lh}$  and  $b_{ll}$ , and represent the average performance of a firm when it is being run under the  $j^{th}$  type of contract.

In addition to the incentive variables we include control variables that hold constant a number of different effects. The variable  $X_{it}$  is equal to one if the manager is an *outsider* and not related to the leader in any way. Following Frydman et al. (1999), we include  $Z$  which represents a set of industry indicators that control for the effect of differences in technology and market conditions that may affect firms within the same industry group. We interact the industry indicators with the contract variables to allow incentive effects to vary across industry classifications.<sup>5</sup> The error term  $\epsilon_{it}$ , captures the remaining deviations in firm performance due to unobservable factors. To examine the robustness of the findings, we examine different versions of the baseline specification, with some regressions including  $Z$  and  $X$  (full specification) and some including only the contract variables (partial specification).

In the baseline analysis, we use two alternative measures of the dependent variable: profits per unit of asset value and the technical efficiency of the firm. The first measure is computed as the ratio of the firm's profits to the value of its assets. The second measure is computed as the difference between the observed and the potential performance of the firm which we derive using the method of data envelopment analysis (DEA). According to DEA a firm is classified as technically efficient if it is not possible to reduce the amount of any of

the firm's inputs without reducing the amount of its output. If it is possible to reduce the firm's use of one or all inputs without decreasing output then there exists a difference between the firm's observed performance and its potential performance, and the firm is classified as inefficient. In the context of our study we assume that the inefficiency involves either the overuse of the firm's capital equipment under profit sharing only, or the underprovision of effort for managing immediate production under investment bonding. Such inefficiencies appear as a deviation from the production frontier, or a fall in estimated technical efficiency.<sup>6</sup>

Since the technical efficiency measure is bounded between 0 and 1, we use a Tobit regression model for estimating the models that use technical efficiency as the dependent variable. Unfortunately, our data allow the calculation of the technical efficiency indicator only for the 1995 time period. Therefore the regressions based on technical efficiency as a performance measure use only the data from the 1995 time period.

### **1.5.2 Findings Of The Baseline OLS (And Tobit) Models**

The OLS and Tobit estimates using both the partial and full specifications perform fairly well (Table 3). The R-squared statistics range between 0.07 and 0.38. The coefficients on the control variables are consistent across models and most have expected signs. For example, the coefficient on the variable 'outsider' is negative and significant suggesting that insider managers are associated with better performing firms, a finding identical to that in Li and Rozelle (2000) and Frydman et al. (1999). The coefficients on the variables representing industry effects, however, are not significant in the profit-asset ratio regressions.

To evaluate if a given incentive instrument has the predicted effect on a firm's

performance we must compare its coefficient to the base non-contract, fixed wage category. Thus, using the estimated incentive parameters reported in Table 3, we conduct a series of tests to evaluate the first two hypotheses regarding the individual effects of contracts on performance: a) without investment bonding, profit sharing may result in insufficient asset maintenance, hence, the firm's overall performance may decrease relative to the non-contract, fixed wage case; and b) without profit sharing, investment bonding may result in insufficient production, hence, the firm's overall performance may decrease relative to the non-contract, fixed wage case. The null hypotheses for testing the two hypotheses regarding the marginal effects of profit sharing and investment bonding are, respectively,

$$H_0: b_{hl} - b_{ll} = 0 \quad (10)$$

$$H_0: b_{lh} - b_{ll} = 0 \quad (11)$$

Most importantly, using the estimated incentive parameters and the results of the theoretical section we also test for the third hypothesis, the existence of complementarity between profit sharing and investment bonding: c) Profit sharing and investment bonding are complementary. Used jointly, profit sharing and investment bonding will have larger effects on firm performance than the sum of the effects when each is used individually:

$$H_0: (b_{hh} - b_{ll}) > (b_{lh} - b_{ll}) + (b_{hl} - b_{ll}) \quad (12)$$

Taken together the above three tests evaluate the three hypotheses regarding the individual and joint effects of contracts on the performance of firms.

The baseline specification lends support to the hypotheses regarding the individual and complementary incentive effects of contracts on firm performance. First, we find that profit sharing only decreases the performance of the firm. The magnitude of the coefficient

on the variable profit sharing only is less than the magnitude of the coefficient on the non-contract category (Table 3). This observation is consistent across both the partial and full specifications and across both types of dependent variables. The F-test (Equation 10), however, reveals that although the magnitudes of the coefficients differ, they do not differ statistically. This is true across the first three models in the baseline specification (Table 4, row 1). In the technical efficiency Equation the difference in magnitudes of the two coefficients is significant (Table 4, column 4, row 1). These findings provide support for the hypothesis that profit sharing by itself can actually decrease the performance of the firm, although the magnitude of the decline is small.

Second, we find that investment bonding only also decreases the performance of the firm. In almost all specifications in Table (3) the magnitude of the coefficient on the investment bonding only variable is less than the magnitude of the coefficient on the non-contract category. The F-test (Equation 11), however, reveals that the difference is not statistically significant, a finding that is consistent across all of the estimated models (Table 4, row 2). The above results provide support for the hypothesis that investment bonding by itself decreases the performance of the firm, although the magnitude of the decrease also is small.

In contrast to the above two findings the results suggest that the joint effects of profit sharing and investment bonding are significant and positive. We find strong evidence in favor of the hypothesis of complementarity between the two incentive instruments. The coefficient on the profit sharing and investment bonding variable is highly significant and positive in both the partial and full baseline specifications (Table 3). The magnitude of this

coefficient also is consistently greater than the magnitude of the coefficient on the non-contract category. Most importantly, the test for complementarity (Equation 12) proves that that the effect of using both contracts jointly is greater than the sum of the effects of using each individually. Hence, profit sharing and investment bonding are complements (Table 4, row 4) and there is support for the hypothesis that profit sharing and investment bonding are complementary, and consequently the simultaneous use of the two incentive instruments increases firm performance relative to the use of either profit sharing only or investment bonding only.

### **1.5.3 Accounting For Quality Effects**

In our analysis so far we have assumed that all firm-level heterogeneity is observable and adequately accounted for in our econometric specification. Given this assumption we have provided rich evidence supporting the existence of complementary incentive effects. But it is likely that unobserved characteristics of firms determine the benefits of adopting profit sharing and/or investment bonding. These unobserved “quality” differences among firms may include factors such as managerial ability, governance and organization of the firm, social and capital network access of the owner—organizational characteristics that are difficult to measure but which effect both the motivation and profitability of adopting incentive mechanisms. Consequently, ignoring these differences may lead to biased estimates of incentive effects.

In the context of our study there is particular concern regarding two types of off-setting problems that may arise due to differences in firm quality. First, it may be that lower quality firms, due to their lower performance levels, may self select into adopting

performance-increasing practices such as incentive contracting. If true, the incentive coefficients  $b_j$  in our baseline specification (Equation 9) will include the differential performance of a firm due to its lower quality, rather than simply capturing the differential performance due to incentive use. In other words, we would expect the incentive effect estimates to be biased downwards. A second type of problem may arise if investment bonding is a means of obtaining finance for firms plagued by credit problems. In such cases, the baseline estimate of the effect of investment bonding will capture the change in performance triggered by the flow of finances in the form of managerial investments, rather than capturing the change in performance due to the use of investment bonding as an incentive. In such situations we would expect the estimate of investment bonding to be biased upwards.

Our approach at controlling for both types of quality-induced performance differentials among firms is to use firm level fixed effects and instrumental variables (IV). The use of fixed effects, which eliminates all firm-specific unobserved effects including differences in firm quality, helps purge out the differential performance levels due to quality differences. While the use of fixed effects holds constant non-time varying changes, it does not account for time varying effects. To account for the possibility that some quality effects may change over time we re-estimate the fixed effects model after instrumenting the contract variables. The instruments used are the human capital characteristics of the village leader (the firm owner), which may be assumed to affect the performance of the firm only through the leader's choice of contracts. However, if the leader's characteristics directly affect the firm's profitability then the validity of the instruments is weaker. Therefore we also augment

the set of instruments (human capital characteristics of the leader such as his age and education) with statistical instruments using the Lewbel approach. According to this approach, consistent instrumental variables estimators for endogenous regressors can be constructed using functions of the dependent variables, proxies and perfectly measured regressors as instruments (Lewbel, 1999).<sup>7</sup>

#### **1.5.4 Findings of the Fixed-Effects and IV Model**

The findings of the fixed-effects model support the results of the baseline regressions (Table 5, column 1). The marginal effect of the individual categories (profit sharing only and investment bonding only) relative to the non-contract, fixed wage case is found to be statistically insignificant (Table 6 row 1 and 2). The coefficient on profit sharing and bonding, however, is significant and positive (Table 5). Hence, even after controlling for quality effects we find evidence in support of the earlier conclusions that the joint use of contracts significantly increases firm performance relative to the non-contract case (Table 6 row 3) and that the two contracts are complementary (row 4). Interestingly, once we eliminate firm-specific quality effects the magnitude of the coefficient on the non-contract category is not significantly different from zero (Table 5). Hence, some of the original difference in performance between firms that used incentive contracts and firms that did not, may have been due to unobserved quality differences.

The findings of the instrumental variables model also are qualitatively identical to the fixed effects results and support the baseline findings (Table 5, column 2). The marginal effect of the individual categories relative to the non-contract case is found to be statistically

insignificant (Table 6 row 1 and 2). However, even after using instrumental variables and fixed effects the results show the complementary between profit sharing and investment bonding. In fact, the instrumental variables specification provides the strongest support for complementarity as seen in the magnitude of the F-statistics reported in Table 6, row 4.

## **1.6 Conclusion**

In this paper we present compelling evidence that firm owners use multiple incentive instruments under a single contract to motivate their managers, and that the incentive instruments are highly complementary. We use a multi-task principal-agent framework to model the use of production and asset maintenance incentives (i.e., profit sharing and investment bonding), by owners in rural China, and derive testable hypothesis. The first two hypotheses of our theoretical model suggest that each instrument when used separately may be ineffective at raising performance. In contrast, our third hypothesis suggests that the two instruments are complementary and, used together, will increase performance.

We test the hypothesis of our theoretical model using descriptive analysis, and a series of econometric methods that employ different measures of firm performance and control for quality differences across firms and across industry classifications. Our descriptive results provide support for the hypothesis of the theoretical model. Firms that use only one of the instruments do not experience increases in profitability. In contrast firms that use both incentive instruments benefit. Effectively the two incentives are found to be complementary. Our baseline panel regressions confirm our descriptive findings. Our fixed effects and instrumental variables regressions, which control for unobserved firm and industry level differences, also support our hypotheses of incentive complementarity.

Based on the above findings this paper has three main contributions. First, it provides direct empirical evidence on how in practice firm owners use multiple incentive provisions under a single contract. Our empirical findings also substantiate the existence of incentive complementarity, a concept that for the most part has remained theoretical with little supporting empirical evidence from the literature on contract and mechanism design. Second, our findings shed light on the debate regarding the effectiveness of incentive contracts at raising performance. Our results show that while a single incentive instrument may have no significant effect on performance, the incentive contract taken as a whole raises performance through complementary incentive effects. Therefore, in order to address the debate on whether incentives work studies need to consider all dimensions of the contract simultaneously, rather than considering one dimension at a time.

Finally, our findings will also help inform policy makers on re-organizing the management structure of firms, particularly in rural China. While China's rural industrial sector has fuelled much of China's post reform economic growth, the recent deceleration of growth of some firms in this sector has sparked a heated debate regarding the organization of these firms and particularly regarding the efficacy of their incentive contracting practices (Nyberg and Rozelle, 1999). Our findings, in contrast with the findings of recent studies, reveal that incentive contracts as predicted by theory increase economic performance. However, it is important to note that contracting in this economy is more complex than previously envisioned. By helping understand of the mechanisms of growth in China's rural industrial sector our findings will help policymakers and firm-owners of both state and non-state firms, design better and more effective mechanisms for increasing efficiency.

**Table 1. Profit Sharing**

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	All Regions		More Developed Regions		Less Developed Regions	
<i>Contract type</i>	<i>1988</i>	<i>1995</i>	<i>1988</i>	<i>1995</i>	<i>1988</i>	<i>1995</i>
Fixed wage	26	16	26	6	27	32
Share	24	25	23	29	23	18
Fixed rent	50	59	51	65	50	50

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\* More developed regions include the coastal provinces of Zhejiang, Shandong, Liaoning and the province of Hubei. The less developed regions include Sichuan, Shaanxi, Yunnan and Hebei.

**Table 2. Investment Bonding**

	<u>All firms</u>	<u>Fixed rent firms</u>	<u>Non-fixed rent firms</u>
Percentage of firms with Investment bonding	.35	.74	.26
Investment amounts-all sources (as a percentage of total investment)			
Managers	24	35.30	8.66
Village funds	26	20.12	34.75
Bank loans	22	14.81	31.07
Individual loans	12	11.01	13.73
Firm's own funds	12	13.10	10.90
Village lenders	4	5.59	0.81

**Table 3. The Effect Of Incentives On Firm Performance: Baseline Regressions**

Independent variables	<i>OLS. Dependent variable</i> <i>profit- asset ratio</i>		<i>Tobit. Dependent variable:</i> <i>technical efficiency</i>	
	(1)	(2)	(3)	(4)
<b>Incentive parameters</b>				
Profit sharing and bonding	0.388 (6.58)**	0.634 (5.39)**	0.311 (13.76)**	0.320 (7.64)**
Profit sharing only	0.166 (3.75)**	0.319 (2.91)**	0.097 (4.57)**	-0.043 (1.39)
Bonding only	0.041 (0.30)	0.212 (1.27)	0.053 (0.830)	0.234 (2.95)**
Non-contracting	0.246 (3.04)**	0.374 (3.6)**	0.140 (2.20)**	0.137 (.073)*
<b>Group and contract specific effects</b>				
Investment bonding*Industry 1		-0.123 (0.890)		-0.366 (5.79)**
Profit sharing*Industry 1		-0.006 (0.070)		0.363 (8.59)**
Investment bonding*Industry 2		-0.354 (1.47)		-0.194 (1.61)
Profit sharing*Industry 2		-0.022 (0.18)		0.004 (.090)
<b>Manager Effect</b>				
Manager's relationship to leader		-0.041 (2.22)**		0.001 (.56)
Time (1995) dummy		.026 (.41)		
Adjusted R <sup>2</sup>	.36	.38	.035	.075

Notes:

<sup>1</sup> Absolute value of t-statistic in parentheses. \*indicates significance at the 10% level, \*\* indicates significance at the 5% level.

<sup>2</sup> Industry 1 is a dummy variable for firms whose main products are machinery and construction. Industry 2 is a dummy variable for firms whose main products are fabric and food processing. Firms whose products are services and transportation are used as the base category.

<sup>3</sup> The variable on the manager's relationship to leader: a larger value of this variable means that the manager is an outsider.

**Table 4. Tests For The Individual And Complementary Effects Of Incentives On Firm Performance: Baseline Model**

	<i>OLS. Dependent variable profit-asset ratio</i>		<i>Tobit. Dependent variable: technical efficiency</i>	
Test for the significance of :	(1)	(2)	(3)	(4)
Profit sharing only: ( $\bullet_{hl} \bullet_{ll} = 0$ )	.75	.28	.40	5.19**
Investment bonding only: ( $\bullet_{lh} \bullet_{ll} = 0$ )	1.67	.79	.94	.82
Profit sharing and bonding: ( $\bullet_{hh} \bullet_{ll} = 0$ )	2.02	5.24**	6.38**	4.8**
Complementarity: $\{\bullet_{hh} \bullet_{ll}\} = \{\bullet_{hl} \bullet_{ll}\} + \{\bullet_{lh} \bullet_{ll}\}$	5.96**	7.10**	9.97**	5.94**

Notes:

<sup>1</sup>Absolute value of F-statistic in parentheses. \*indicates significance at the 10% level, \*\* indicates significance at the 5% level.

**Table 5. The Effect Of Incentives On Firm Performance: Fixed Effect And Instrumental Variable Regressions**

Independent variables	<i>OLS with fixed effects: Dependent variable profit- asset ratio</i>	<i>Instrumental Variables: Dependent variable profit- asset ratio</i>
Incentive parameters		
Profit sharing and bonding	0.998 (4.44)**	1.11 (4.86)**
Profit sharing only	0.710 (2.94)**	.821 (3.34)**
Bonding only	0.371 (1.69)*	.256 (1.14)
Non-contracting	0.407 (1.58)	.443 (1.66)
Group and contract specific effects		
Investment bonding*Industry 1	-0.179 (1.26)	-.281 (1.73)*
Profit sharing*Industry 1	-0.305 (1.48)	-.056 (.19)
Investment bonding*Industry 2	-0.410 (1.81)*	-.416 (1.88)*
Profit sharing*Industry 2	-0.715 (2.47)**	-.852 (2.84)**
Manager Effect		
Manager's relationship to leader	0.056 (.83)	.057 (.85)
Time (1995) dummy	0.016 (.32)	.015 (.28)
Adjusted R <sup>2</sup>	.63	.65

Notes:

Dependent variable of the OLS regressions is profit per unit of asset; dependent variable of the Tobit regressions is an indicator of technical efficiency of the firm<sup>iii</sup> Absolute value of t-statistic in parentheses. \*indicates significance at the 10% level, \*\* indicates significance at the 5% level.

**Table 6. Tests For The Individual And Complementary Effects Of Incentives On Firm Performance: Fixed Effects And Instrumental Variables Model**

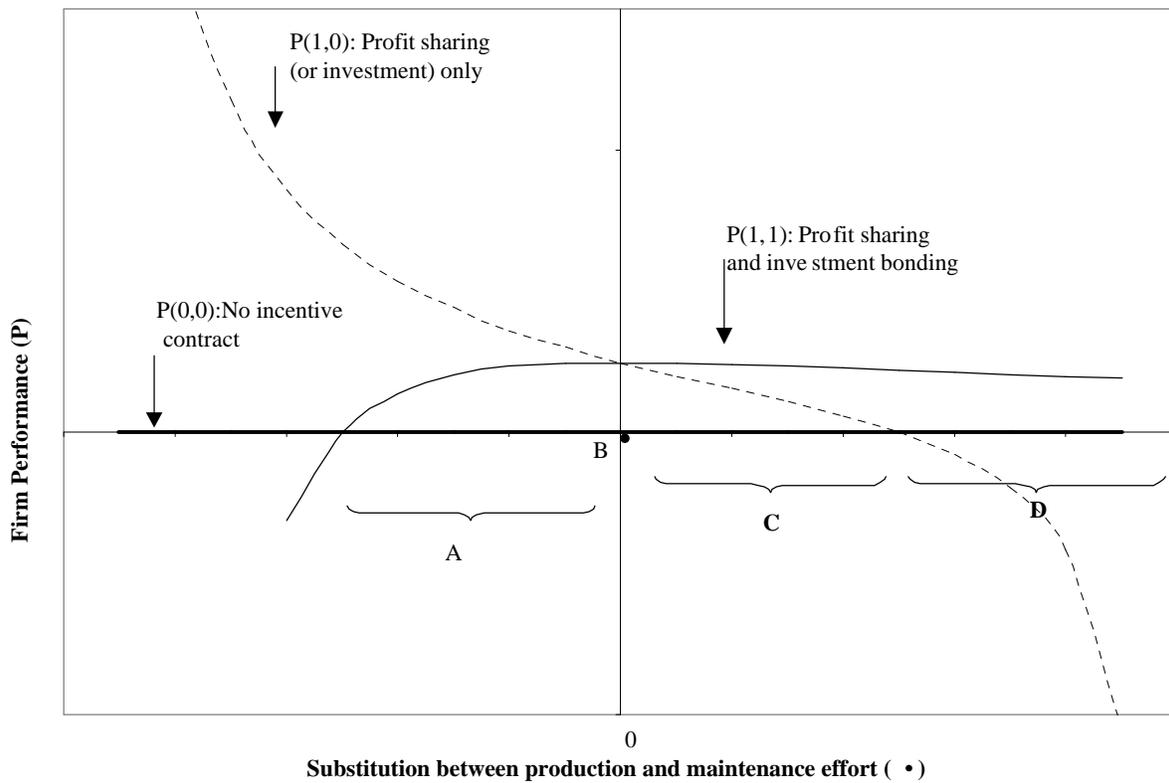
	<i>OLS with fixed effects: Dependent variable profit- asset ratio</i>	<i>Instrumental Variables: Dependent variable profit- asset ratio</i>
Test for the significance of :	(1)	(2)
Profit sharing only: ( $\bullet_{hl} \bullet_{ll} = 0$ )	2.39	2.78
	.85	.68
Investment bonding only: ( $\bullet_{lh} \bullet_{ll} = 0$ )		
	7.76**	8.23**
Profit sharing and bonding: ( $\bullet_{hh} \bullet_{ll} = 0$ )		
	2.92*	4.55**
Complementarity: $\{ \bullet_{hh} \bullet_{ll} \} = \{ \bullet_{hl} \bullet_{ll} \} + \{ \bullet_{lh} \bullet_{ll} \}$		

Notes:

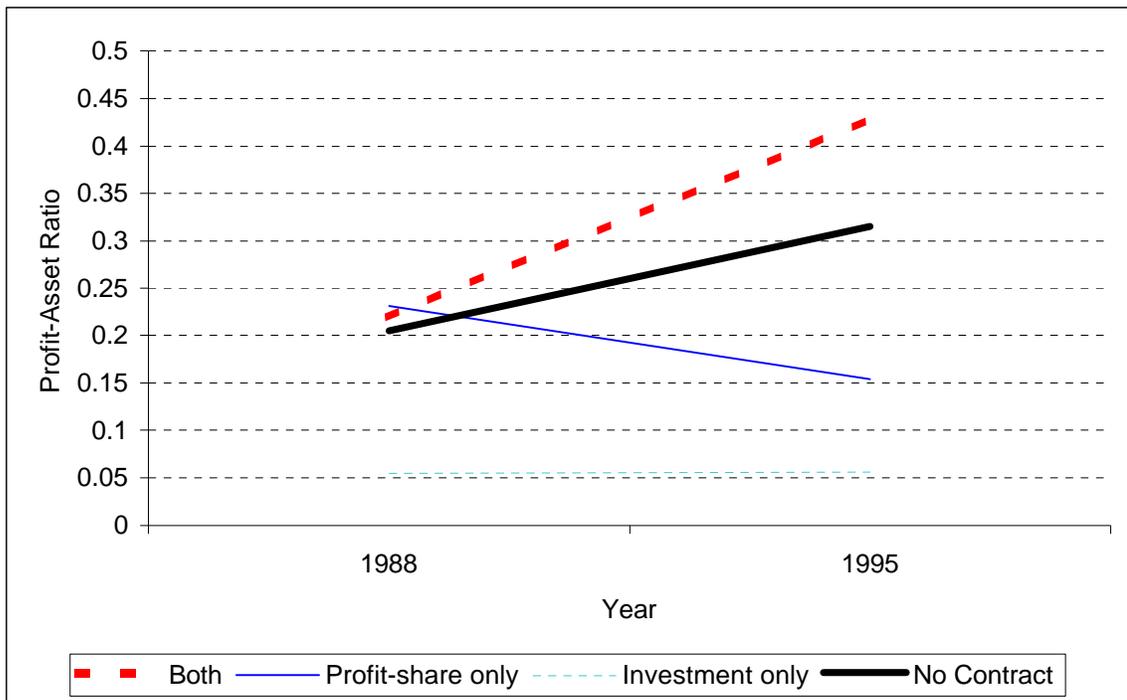
<sup>1</sup>Absolute value of F-statistic in parentheses. \*indicates significance at the 10% level, \*\* indicates significance at the 5% level..

**Figure 1. Hypotheses: Simulated Effects Of Incentives On Performance**

Region	Owner's Relative Payoffs
A:	$P(1,0) > P(1,1) > P(0,0)$
B:	$P(1,0) = P(1,1) > P(0,0)$
C:	$P(1,1) > P(1,0) > P(0,0)$
D:	$P(1,1) > P(0,0) > P(1,0)$



**Figure 2. Incentive Complementarity: Descriptive Evidence**



## Appendix

### Incentive Complementarity

To examine complementarity between the profit sharing ( $a_p$ ) and investment bonding ( $a_m$ ) consider the basic definition of supermodularity: A function  $P(z)$  (in this case, the owner's objective function,  $P(a_p, a_m)$ ), is supermodular over the set  $Z$  (the set of contract choices) if  $\forall z, z' \in Z$

$$P(Z | X) + P(Z' | X) \leq P(Z \vee Z' | X) + P(Z \wedge Z' | X) \quad (13)$$

where  $Z$  is a lattice defined by the partial order  $\geq$ ,  $Z \vee Z'$  is the element that forms the lowest upper bound of  $z$  and  $z'$  (the join),  $Z \wedge Z'$  is the element that forms the highest lower bound of  $z$  and  $z'$  (the meet), and  $x$  is a vector of all other firm-specific characteristics. If the firm's objective function is supermodular in production and asset maintenance incentive practices then the two practices are complementary. In Equation (13), supermodularity of the owner's objective effectively implies that the sum of the performance increase from implementing profit sharing in isolation and the performance increase from implementing investment bonding in isolation will be less than the performance increase from jointly implementing both.

To evaluate if the above condition is satisfied, we evaluate it by substituting in the owner's payoffs from implementing different incentive designs. The owner's choices of incentive practices involve the use of profit sharing only,  $P(1,0)$ , investment bonding only,  $P(0,1)$ , both profit sharing and investment bonding,  $P(1,1)$ , or, the non-contract fixed wage case),  $P(0,0)$ . The payoffs to the owner from these choices can be written as:

$$P(1,1) = 2\left(\frac{1-q}{1-q^2}\right) - \left(\frac{1-q}{1-q^2}\right)^2 - \frac{1}{2}\left(\frac{1-q}{1-q^2}\right)^2 - q\left(\frac{(1-q)^2}{(1-q^2)^2}\right) \quad (14)$$

$$P(1,0) = P(0,1) = \frac{1-q}{1-q^2} - \frac{1}{2}\left(\frac{1}{1-q^2}\right)^2 - \frac{1}{2}\left(\frac{-q}{1-q^2}\right)^2 + \left(\frac{q^2}{(1-q^2)^2}\right) \quad (15)$$

$$P(0,0) = 0 \quad (16)$$

Substituting the above payoffs into (13), we obtain:

$$P(Z | X) + P(Z' | X) - P(Z \vee Z' | X) - P(Z \wedge Z' | X) \leq -\frac{q}{1-q^2} \quad (17)$$

The convexity of the cost function implies that  $1-q^2 \geq 0$ . If the manager's efforts in the two tasks are substitutes,  $q \geq 0$ , then the owner's objective function is supermodular in production and maintenance incentives. That is, profit sharing and investment bonding are complements.

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<sup>1</sup> Local leaders rely upon revenues from the rural firms for relaxing tight government budgets during their term in office and are, therefore, interested in protecting the long term profitability of the "firm". Due to being busy with governing affairs, they often rent their firms out to hired managers under short-term contracts. Delegating authority to the manager helps free up the leader's time for pursuing other objectives (Meng, 1990; Rozelle and Boisvert, 1994; Zhu, 1998).

<sup>2</sup> In my fieldwork interviews in rural China, firm-managers revealed that their responsibilities in the two tasks, production and asset maintenance, conflicted. Managers filling larger production orders face faster depreciation of the firm's assets, causing higher maintenance costs (but potentially increasing the firm's current period profits).

<sup>3</sup> The importance of the substitution parameter,  $Q$ , in my analysis can be seen by examining how it affects the relationship between production effort and maintenance effort. If the value of  $Q$  is zero, then increasing production effort will have no effect on maintenance costs. An example of this would be a garment knitting firm for which the main equipment is knitting needles. Knitting needles are inexpensive, do not wear down easily and so are not sensitive to the intensity of their use. Since production effort has no effect on maintenance costs, neither it will have any effect on maintenance effort. In contrast, if the value of  $Q$  is positive then increasing production effort will increase the cost of maintenance. For example, in the case of the wheat processing firm that we visited during my fieldwork, production effort and maintenance costs were critically related. Increasing production effort raises the cost of maintenance. For example, if the manager run the machines harder to increase production it would also wear down the machines faster. Since maintenance is costly, without maintenance incentives, the manager would not find it in his interest to exert maintenance effort.

<sup>4</sup> We exclude the possibility of contract renegotiation. In the context of rural China, firm owners or local leaders elected by their constituents and are accountable to them. We assume that reputational effects force the leaders to not renege on the contract and, hence, make the leader's offer credible (Li, 2001).

<sup>5</sup> For instance, in industries such as machine production where depreciation rates of capital equipment are relatively low, the manager's marginal cost of maintenance effort may not increase significantly with greater levels of production effort. This may not be true in other industries such as such as transportation and services, where production directly increases the marginal cost of maintenance.

<sup>6</sup> The method for computing the technical efficiency measure is as follows: consider the output level  $y$ , and use of labor and capital inputs  $x$ , for each firm in the sample. I assume that the technology of the firm can be

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represented by the production function  $y_i = f(l_i, x_i)$  where  $l_i \in [0,1]$ . If  $l_i$  is less than 1 then the firm's use of inputs can be reduced without reducing its output level, that is, the firm is technically inefficient. On the other hand if  $l_i$  is equal to 1 then it is not possible for the firm to reduce the amount of any of its inputs without reducing the amount of its output, that is, the firm is technically efficient.

<sup>7</sup> The first stage regression of the instrumental variable approach is implemented by using a multinomial logit model of the  $j$  exclusive contractual choices available to the firm. In the second stage, the baseline specification in Equation (9) is estimated by replacing the contract variables with predicted probabilities from the multinomial logit model