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External Equity in Agriculture: Risk Sharing and Incentives in a Principal-Agent Relationship

Zijun Wang, David J. Leatham, and Thanapat Chaisantikulawat

Abstract

The moral hazard problem which obstructs external equity financing of farm businesses is studied using the principal-agent framework. We assume that the supplier of external equity capital (the principal) cannot directly observe the farmer's (agent's) effort, but can observe the random outcome of the effort. We solve for the optimal farm income-sharing rule that includes an extra share to the agent. The extra share is dependent on the random outcome and is provided to induce optimal effort from the agent. Results show a farmer's effort is inversely related to the level of risk aversion and the riskiness of the project. Thus, an investor must share more income when a farmer is more risk averse or a project is more risky.

Key words: agricultural finance, external equity, principal-agent, risk sharing

Researchers in agricultural economics have long recognized the potential benefits of external equity financing for farm business. The issue has generated considerable discussion about the feasibility of establishing an equity market for the farm sector (Collins and Bourn; Crane and Leatham, 1993, 1995; Fiske, Batte, and Lee; Lowenberg-DeBoer, Featherstone, and Leatham; Matthews and Harrington; Raup). External equity is equity capital derived from sources other than the retained earnings, or the internal capital of the firm. If available, external equity could be used partially or totally to replace debt financing of farm assets.¹

It has long been known that debt financing (holding equity constant) increases a firm's risk (Kalecki). The additional risk associated with debt financing is often referred to as financial risk. Thus, a firm could use external equity to reduce financial risk. Moreover, external equity mitigates farm liquidity constraints imposed by limited debt-capacity and credit rationing (Fiske, Batte, and Lee).

The availability of external equity would allow farmers to expand and attain more efficient production levels or to take full advantage of their management ability without incurring excessive financial risk.

¹ Alternatives to debt and owner equity financing include leasing and external equity capital (Penson and Duncan). Leasing is often the easiest alternative, but is similar to debt financing in that with a cash lease there is a fixed expense independent of earnings. In addition, with both cash and share leasing agreements, the capital gains accrue to the landowner, and there is the lack of continuity that comes with ownership.

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from high levels of debt. Some farmers may choose to retain their current size but decrease debt levels. The agricultural sector would potentially benefit because a reduction in financial risk would lower the probability of bankruptcy in periods of financial stress. It would also lower the incidences of credit problems such as those experienced in the farm sector in the early 1980s.

Many researchers agree on the benefits of and the need for external equity. In addition, investors who provide external equity may benefit from diversification and the opportunity to obtain higher rates of return on their capital. However, the relatively high transaction costs of equity investment and the possible distortion of management incentives in equity sharing arrangements (Lowenberg-DeBoer, Featherstone, and Leatham) have been found to hinder the development of an equity market to accommodate the flow of investment funds into agriculture. Further, Calomiris, Hubbard, and Stock suggest potential agency costs are the most likely factor in explaining why farmers do not obtain new equity from nonfarmers.

Examining the economic conditions surrounding external equity financing, Collins and Bourn conclude: “Therefore it appears that the potential for a sizable market may exist [for external equity], and the primary obstacle is the lack of appropriate financial institutions and instruments” (p. 1336). Collins and Bourn also recognize the importance of agency cost, and note that any institutions or instruments developed to provide this intermediation function must also address the principal-agent or agency problem between the equity provider and the farmer.

Crane and Leatham (1993) propose that the profit and loss sharing (PLS) principles of Islamic banking could be applied as an agricultural finance innovation to aid the flow of equity capital from the nonfarm to the farm sector. In a subsequent study, Crane and Leatham (1995) used selected PLS principles as a guideline and outlined a proposed financial market structure for overcoming the barriers to external equity identified by Collins and Bourn.

No formal analysis, however, has been conducted to provide a guideline for constructing an equity contract to resolve the principal-agent problem and simultaneously achieve optimal risk sharing. For example, in a recent study, Schmid considered equity financing of the entrepreneurial firm, but did not explicitly address the principal-agency problem.

The principal-agent problem is common to all market organizations with asymmetric information. The moral hazard associated with the principal-agent problem can cause the market to be less efficient or even collapse. The principal-agent framework has been applied to study land renting (Allen and Lueck; Lajili, Barry, Sonka, and Mahoney), agrit-environmental policy (Choe and Fraser; Moxey, White, and Ozanne), and agricultural research (Huffman and Just).

The primary objective of this study is to show how moral hazard can be accounted for in farm equity contracts by deriving appropriate compensation schemes under the principal-agent framework. We derive an incentive-compatible, risk-sharing payment scheme under this framework that provides both parties with an optimal sharing rule.

Principal-Agent Model for Farm Equity

External equity financing for agricultural production can be studied under the principal-agent framework. We consider two key players—one is the principal (an
investment firm) who provides equity capital and the other is the agent (farmer) who provides the effort and management skill. Both are assumed rational and the goal is to maximize the expected utility of their end-of-period income.

The model we consider here is the hidden action model employed by Shavell and by Holmstrom (1979, 1982). In this model, the principal and agent both have the same information about the farm investment and the distribution of its outcome. Moreover, at the end of the investment period, they mutually observe the realized outcome.

The differential information in the model is the agent’s effort. While the agent has perfect knowledge about his own effort, the principal cannot directly observe it. The effort is considered a disutility to the agent, but is considered a value to the principal because it increases the possibility of obtaining a preferable outcome.

The goal of the principal is to solve this conflicting incentive by tying the payment or the sharing rule to the observed outcome. Although the principal cannot directly observe the agent’s effort, the level of effort can be inferred by observing the outcome. It is assumed the outcome from the higher level of effort first-order stochastically dominates the outcome from the lower level effort. This simply means that the high level effort yields a better outcome than lower level effort in every state of nature.

Difficulties arise, however, as the principal attempts to tie the sharing rule to the

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3A related model is the hidden information model. As its name suggests, under this type of model the agent possesses some information not observable to the principal. The agent bases his action on this information and this action affects the principal’s welfare on this information. A problem frequently associated with this type of model is “adverse selection.” Interested readers may find Arrow a good introduction to these two types of models, and Kesser and Willinger provide a recent application.

outcome because the outcome is not only influenced by the agent’s effort but is also governed by random events outside the agent’s control. Consequently, the principal cannot clearly distinguish the effects of the agent’s effort from those of the random events. The solution to the principal-agent problem requires that a sharing rule be chosen which offers the right incentive, in the presence of uncertainty, for the agent to provide the optimal effort.

A farmer must finance farm assets and operating capital. We assume the farmer can raise the capital through two alternative sources: farmer equity and external equity. We further assume external equity financing is obtained from an investment firm. In the process, the farmer reveals all information about the project to the investment firm so the investors are well informed about the farming situation.

The total investment for the project is denoted A. The farmer and the investor agree on the portion of the investment to be financed by the farmer through his own equity, $\delta$, ($0 < \delta < 1$). The remainder of the equity $(1 - \delta)$ is financed by the investment firm whose alternative investment return rate (opportunity cost) is $r^*$. The investment firm agrees to pay the farmer an amount of the gross income ($S$) to compensate for the farmer’s effort. Consequently, the farmer’s share and the investment firm’s share of the remaining gross income will be $\delta$ and $(1 - \delta)$, respectively.

To induce effort, the amount $S$ is made a function of performance measured by the rate of return on assets ($R$). Thus, we write $S$ as $S(R)$. $R$, in turn, is calculated before $S$ is taken into account. The agent’s effort ($e$) and some exogenous risk ($\theta$),

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4Our model can be extended to solve the simultaneous optimality of equity and debt financing. However, this effort is beyond the scope of the current study. Interested readers are referred to Santos.
designating the state of nature, affect $R$. Consequently, $R$ can be written as $R(e, \theta)$. We assume there are no taxes, and the only way for either the investor or the farmer to withdraw investment from the venture before the termination date of the contract is to sell the equity. The end-of-period income of the investment firm derived from this joint venture ($\Pi_p$) then can be written as:

$$\Pi_p = (1 - \delta)[R(e, \theta)A - S(R)],$$

and the end-of-period income of the farmer ($\Pi_a$) is specified as:

$$\Pi_a = \delta[R(e, \theta)A - S(R)] + S(R),$$

where the farmer invests $\delta$, and the farmer receives $\delta$ percent share of the gross profit and a payment for effort according to the sharing rule $S(R)$.

Let $V(\cdot)$ and $U(\cdot)$ represent the Von Neumann-Morgenstern utility function of the principal and the agent, respectively. Both can be assumed to be risk averse (Peterson and Anderson); however, in our analysis we assume the principal is risk neutral. This assumption is justifiable because the investment firm can eliminate most of the risk through portfolio diversification (Luporini and Parigi; Fuentes).

We further assume the farmer’s disutility is separable from the utility function and is represented as a function of effort by the utility equivalent of $c(e)$. Consequently, the expected utility of the farmer can be written as:

$$E(U(\Pi_a, e)) = \int U(\Pi_a) f(R, e) dR - c(e),$$

where $\Pi_a = \Pi_a(R, e, \theta, S)$, and $f(R, e)$ is the conditional distribution function of the random outcome $R$ given effort level $e$.

To solve the principal-agent problem, we find the Pareto optimal sharing rule, $S^*(R)$ in the sense that there is no alternative $S$ whereby one can be made better off without making the other worse off. If $S^*(R)$ is Pareto optimal, no one will have an incentive to deviate from the rule. To be Pareto optimal, $S^*$ is solved as:

$$\text{Max}_s \int V(\Pi_p) f(R, e) dR$$

subject to:

$$\int U(\Pi_a) f(R, e') dR - c(e') \geq \bar{U}$$

and

$$e' \in \arg \max \int U(\Pi_a) f(R, e) dR - c(e),$$

where $\Pi_p = \Pi_p(R, e, \theta, S)$. It is assumed the distribution $f(R, e)$ is agreeable to both the farmer and the investor. $\bar{U}$ in equation (5) is the farmer’s reservation utility level (Haubrich; Allen and Lueck). Also, $\partial U/\partial e < 0$ because the effort $e$ is a disutility to the farmer.

Equation (4) maximizes the investor’s welfare (expected utility of the end-of-period income) by choosing the compensation scheme that will induce optimal effort. However, the farmer will accept the scheme only if it guarantees certain reservation welfare. This condition is referred to as the participation or individual rationality constraint [equation (5)]. It requires, at the optimum, that the sharing rule provide the agent with an expected utility which is no less than the reservation level. Market forces predetermine the reservation utility level.

Finally, the compensation scheme offered by the investor will succeed in inducing the optimal effort if the induced effort gives the farmer the highest level of welfare. Thus, the farmer would not have an incentive to shirk responsibilities [equation (6)]. This provision is called the incentive compatible constraint.

The solution obtained from the expected utility maximization subject to the above constraints is the second-best solution. In the case where the principal can fully observe the agent’s effort, the agent can force the contract by imposing a penalty if
a desired level of effort is not provided. In this case, there would not be any differential information between the principal and the agent. Consequently, the sharing rule would be tied to the level of effort directly and the problem therefore would amount to maximizing the principal’s expected utility over S and e subject to only the first constraint [equation (5)].

The resulting solution is called the first-best solution. However, in the world of asymmetric information, only the second-best solution can be achieved. Clearly, the first-best solution is always at least as good as the second-best solution because it involves a maximization problem with fewer constraints than the second-best case.

To explicitly solve this problem, we specify the functions and variables according to the Linear-Exponential-Normal (LEN) model used by Spremann. First, the performance \( R(e, \hat{\theta}) \) is assumed linear in effort and risk and has the form:

\[
(7) \quad R(e, \hat{\theta}) = e + \hat{\theta},
\]

where \( e \) is a constant. The risk (\( \hat{\theta} \)) makes the investor unable to identify the farmer’s effort directly from the performance. The distribution assumption of \( \hat{\theta} \) is stated below.

The compensation scheme (or the sharing rule), \( S(R) \), is also assumed linear in performance and has the form:

\[
(8) \quad S(R) = w + bR,
\]

where \( w \) is the fixed component of the scheme and \( b \) is the variable component. Under no circumstances should the agent pay a variable compensation to the principal as a punishment for better return. We hence restrict \( b \) to be nonnegative. However, we do not impose the same restriction on \( w \). (This approach is discussed further after the solution is presented.)

Nonlinear and more complex schemes have been studied in the literature (see Mirrlees). However, Arrow pointed out that these complex schemes are not generally observed in reality, and the simple linear specification still allows the agent to have “a rather rich action space” (Hart and Holmstrom).

Second, we assume both the principal’s and the agent’s utility functions are exponential, and the farmer’s utility function has bounds. The farmer is risk averse with a Pratt-Arrow coefficient of absolute risk aversion (ARA) of \( \alpha \).

Third, the risk parameter, \( \hat{\theta} \), is assumed to be normally distributed with zero mean and variance \( \sigma^2 \); that is, \( \hat{\theta} \sim N(0, \sigma^2) \). We assume the variance is determined by weather, market conditions, and other exogenous random factors, but is independent of the farmer’s effort.\(^5\) The normality and the linearity assumptions

\(^5\) Empirically, the variance of return (\( \sigma^2 \)) may be reduced by the farmer’s effort (\( e \)); i.e., \( \sigma^2 \) is a regular decreasing function of \( e, f(e) \), where \( f(e) \) is second-order differentiable, the derivatives are \( f'(e) < 0 \) and \( f''(e) > 0 \) by assumption. Then the first-order condition [text equation (16)] will become:

\[
\delta A + (1 - \delta)b - 2e - \frac{\alpha}{2}[\delta A + (1 - \delta)b]f'(e) = 0.
\]

To investigate the effects of \( \delta \) and \( b \) on the farmer’s effort \( e \) under this assumption, we calculate two comparative statistics, presented below:

\[
de = \frac{(A - b - \frac{\alpha}{2}[\delta A^2 - (1 - \delta)b^2 + A(1 - 2\delta)b])}{2},
\]

\[
db = \frac{\alpha}{2}f''[\delta A^2 + (1 - \delta)b^2 + 2\delta A(1 - \delta)b].
\]

It is easy to confirm that the denominator is positive; the nominator is nonnegative provided that \( b \) is no larger than \( A \), which is true because the variable compensation cannot be larger than total return [e.g., see discussion on text equation (24)]. So, \( de/db > 0 \). Similarly,

\[
de = \frac{(A - b - \frac{\alpha}{2}[\delta A(1 - \delta) + b(1 - \delta)^2])}{2},
\]

\[
db = \frac{\alpha}{2}f''[\delta A^2 + (1 - \delta)b^2 + 2\delta A(1 - \delta)b].
\]

the nominator, is no less than 0, so \( de/db \) is also nonnegative. Therefore, the new assumption that the variance of return is negatively correlated with the effort does not change the nature of the solution derived under the simplified assumption we employed in the text, but introduces much complication. In fact, the simplified independence assumption is also maintained in some existing literatures (Hart and Holmstrom). Based upon this, we will proceed assuming no correlation between the two.
imply that $R(e, \theta)$ and $S(R)$ are also normally distributed.

The second and third assumptions together imply that the expected utility-maximization problem is reduced to the maximization of the certainty equivalent of wealth ($\Pi_a^{ce}$). For the risk-averse farmer, the problem becomes:

$$\text{(9)} \quad \text{Max } E(U) = \Pi_a^{ce}$$
$$= \text{Max } \left[ E(\Pi_a) - \frac{a}{2} \text{ var } (\Pi_a) \right].$$

The risk-neutral investment firm has an ARA of zero; therefore, the expected utility maximization is equivalent to the maximization of the expected value:

$$\text{(10)} \quad \text{Max } E(V) = \text{Max } E(\Pi_p).$$

Furthermore, we assume the disutility of effort, $c(e)$, is quadratic, reflecting an increasing marginal disutility (Huffman and Just):

$$\text{(11)} \quad c(e) = e^2.$$

With the above specifications, the optimal compensation scheme can be solved in three steps. First, the investor decides how the farmer responds to a given compensation scheme. The farmer chooses the response that maximizes expected utility [equation (6)]. Second, the principal determines the compensation scheme that will be accepted by the farmer. The farmer will accept the scheme if it offers the level of welfare at least as great as $\bar{U}$ [equation (5)]. Finally, the principal opts for the scheme that is welfare maximizing [equation (4)].

**The Farmer's Level of Effort**

The farmer's wealth, $\Pi_a$, can be rewritten as:

$$\text{(12)} \quad \Pi_a = \delta[(e + \theta)A - w - b(e + \theta)] + w + b(e + \theta) - e^2.$$

The farmer's expected wealth, $E(\Pi_a)$, is denoted by

$$\text{(13)} \quad E(\Pi_a) = \delta A e + (1 - \delta) b e - e^2 + (1 - \delta) w,$$
and the variance of farmer's wealth, $\text{var}(\Pi_a)$, is specified as

$$\text{(14)} \quad \text{var}(\Pi_a) = [\delta A + (1 - \delta) b]^2 \sigma^2.$$

The certainty equivalent of farmer's wealth is obtained by substituting equations (13) and (14) into equation (9):

$$\text{(15)} \quad \Pi_a^{ce} = \delta A e + (1 - \delta) b e - e^2 + (1 - \delta) w - \frac{a}{2} [\delta A + (1 - \delta) b]^2 \sigma^2.$$

Given a compensation scheme which is identified by the parameters $w$ and $b$, the farmer determines the level of effort that maximizes $E(U)$. The first-order condition of equation (15) with respect to $e$ is given by

$$\text{(16)} \quad \delta A + (1 - \delta) b - 2e = 0,$$

and the optimal level of the farmer's effort, $e^*$, is written as

$$\text{(17)} \quad e^* = \frac{1}{2} [\delta A + (1 - \delta) b].$$

The optimal effort ($e^*$) shows how a rational farmer responds to a given compensation scheme. The farmer will have no incentive to deviate from this level of effort, as no other level of effort will increase utility.

Several implications can be inferred from the optimal response. First, the level of a farmer's effort depends on two main factors: (a) the size of his total share in the investment, and (b) the size of the variable component of the compensation scheme. The farmer is willing to put forth more effort if the farmer's total investment in the project ($\delta A$) is large. In other words, the incentive problem is less when the farmer has a high stake in the investment. However, if the farmer's stake is small, the investor must induce the farmer to work harder by increasing the compensation tied to the outcome.

Second, $(1 - \delta)$ acts like a multiplier on $b$, and thus there is a tradeoff between the
size of the farmer's investment and the effect of variable compensation on the farmer's incentive. If the farmer's share of the investment ($\delta$) is large, then the use of variable compensation is less effective as a means to induce effort. In contrast, if the share is small, then the variable compensation can be effectively used to raise the farmer's incentive to put forth more effort. Therefore, the effectiveness of the variable component of the compensation ($b$) as a mechanism to induce a higher level of effort is inversely related to the farmer's equity share.

Third, the fixed component of the compensation does not affect the farmer's incentive to work because the fixed component is paid, regardless of the outcome (although it does affect the farmer's utility).

**The Individually Rational Compensation Scheme**

The farmer's expected utility at the optimum level of effort ($e^*$) in equation (15) must be at least $\bar{U}$ [see equation (5)]. From equation (17), $e^*$ is substituted into equation (15) and the farmer's expected utility, $\Pi_a^e$, is set equal to $\bar{U}$ to obtain

\[
12\left[\delta A + (1 - \delta) b\right] \\
+ (1 - \delta) w - \frac{\alpha}{2} \left[\delta A + (1 - \delta) b\right]^2 g^2 = \bar{U}.
\]

Then we solve for $w$ to obtain

\[
w^* = \frac{1}{1 - \delta} \left(\bar{U} - \frac{1}{4} \left[\delta A + (1 - \delta) b\right]^2 \\
\times (1 - 2\alpha g^2)\right),
\]

where $w^*$ represents the condition that satisfies both constraints [equations (5) and (6)]. It is the fixed component of the compensation scheme where the farmer exerts the optimal level of effort and receives the reservation level of utility.

As observed from equation (19), if the risks of the investment ($\sigma^2$) and the degree of risk aversion ($\alpha$) of the farmer are small enough so that $(1 - 2\alpha \delta g^2)$ is positive, the farmer would demand less fixed compensation. However, if the investment risk is high or the farmer is sufficiently risk averse, the last term becomes negative and the farmer would demand a higher $w$ to compensate for the risk.

Therefore, it is not necessary that a large variable component of the compensation correspond to a smaller fixed component. The relationship depends on the riskiness of the investment and the level of the farmer's risk aversion. For example, if the investor ties a significantly large portion of the compensation to the risky outcome, then the highly risk-averse farmer will demand a higher fixed compensation to hedge against the riskiness of the income.

**The Optimal Sharing Rule**

We have determined the farmer's optimal response function and the acceptable fixed component of the compensation scheme at the optimal response. The final step is to find the compensation scheme that maximizes the investor's expected utility given the farmer's incentive compatibility and individual rationality conditions are satisfied. Thus, the problem is to maximize $E(V(\Pi_p))$ over $b$ subject to equations (17) and (19).

Using the above specifications, the investor's wealth is defined as

\[
\Pi_p = (1 - \delta)(A - b)e + (1 - \delta)(A - b)\delta \\
- (1 - \delta)w,
\]

and the investor's expected utility is calculated as

\[
\max E(V(\Pi_p)) = \max [(1 - \delta)(A - b)e - (1 - \delta)w).
\]

Substituting $e^*$ from equation (17) and $w^*$ from equation (19), we obtain:

\[
\max E(V(\Pi_p)) = \max \left\{\frac{1}{4} (1 - \delta)(A - b)[\delta A + (1 - \delta) b] \\
- \left[\bar{U} - \frac{1}{4} \left[\delta A + (1 - \delta) b\right]^2(1 - 2\alpha g^2)\right]\right\}.
\]
The first-order condition with respect to \( b \) is written as:

\[
\begin{align*}
(23) & \quad -\frac{1}{2}(1-\delta)[\delta A + (1-\delta)b] \\
& + \frac{1}{2}(1-\delta)^2(A - b) + \frac{1}{2}(1-\delta) \\
& \times [\delta A + (1-\delta)b] (1 - 2\sigma^2) = 0.
\end{align*}
\]

We solve for the optimal \( b^* \) by solving for \( b \) in equation (23) and rearranging terms, thus obtaining:

\[
(24) \quad b^* = \frac{1}{(1-\delta)} \left[ \frac{1}{(1 + 2\sigma^2)} - \delta \right] A.
\]

As expected, \( b^* \) depends on the farmer’s share of investment. As the farmer’s total share of investment increases, the farmer has incentive to work harder. Therefore, \( b^* \) can be reduced as the farmer’s total share in the investment increases. Obviously, the first term within the brackets, \( 1/(1 + 2\sigma^2) \), is less than 1, so the optimal solution \( b^* \) is always no larger than \( A \). However, in order to satisfy the nonnegativity requirement for \( b \), it needs to be larger than \( \sigma \), which implies \( \sigma \) and \( \sigma^2 \) cannot be too large at the same time.

Substituting for the value of \( b^* \) from equation (24) into equations (17) and (19), respectively, we get

\[
(25) \quad e^* = \frac{1}{2} \left[ \frac{A}{(1 + 2\sigma^2)} \right]
\]

and

\[
(26) \quad w^* = \frac{1}{(1-\delta)} \left[ \frac{\bar{U} - A^2(1 - 2\sigma^2)}{4(1 + 2\sigma^2)^2} \right].
\]

It is seemingly peculiar that the farmer will supply less effort the riskier the operation [equation (25)]. There are two reasons for this finding. First, as the operation is riskier, the farmer tends to have a smaller share, which in turn discourages his willingness to work harder (from our previous discussion). Second, the equilibrium variable component \( b \) also decreases with the risk of the operation, which similarly discourages the farmer’s effort [see equation (24)]. Ultimately, the farmer’s realizable equilibrium utility will be negatively affected.

Contrary to intuition, it seems from equation (26) that the farmer is able to require a higher fixed compensation if he has a higher level of reservation utility. Yet, because this simultaneously decreases the investor’s welfare, the probability of success in reaching an agreement likewise decreases.

The respective welfare of the investment firm and the farmer at the optimum is designated by:

\[
(27) \quad E(U^*(\Pi_a)) = \bar{U}
\]

and

\[
(28) \quad E(V^*(\Pi_p)) = \frac{A^2}{(1 + 2\sigma^2)} - \bar{U}.
\]

Up to this point, whether a contract can be finally signed has not been determined. The investment firm (principal) will compare its expected utility, given by equation (28), with the opportunity cost. The two parties can negotiate successfully only if

\[
\frac{A^2}{(1 + 2\sigma^2)} - \bar{U} \geq A(1 - \delta)r^*.
\]

From the above formula, an optimal equilibrium investment share (6) also follows, and it decreases with increasing variance. This makes sense because the risk-averse farmer tends to desire a small share when the investment is riskier.

Notice that under the contract the farmer is guaranteed a reservation level of welfare \( \bar{U} \); i.e., the farmer’s welfare can fluctuate, but on average the farmer will receive \( \bar{U} \). In addition, the investor’s welfare is adversely affected by the risk of the project [equation (28)]. This means that although the investor is assumed risk neutral, the investor still dislikes risky investments. This result does not arise from the investor’s attitude toward risk, but rather from the fact that the risk reduces the farmer’s effort. Therefore, it costs the investor more to induce the same level of effort from the farmer if the investment is riskier.
The investor’s welfare is also affected negatively by the degree of the farmer’s risk aversion. It costs the investor more to induce the same level of effort from the more risk-averse farmer who demands a higher risk premium. This implies that for the same investment the investor prefers a less risk-averse farmer. Put another way, the more risk averse the farmer, or the riskier the investment project, the less likely the contract can be signed.

It is interesting that the investment share (δ) does not affect either the investor’s or the farmer’s welfare (as long as the joint-venture contract is already agreed upon). However, δ affects the compensation scheme—both the fixed and variable components. Thus, the compensation scheme can be adjusted to fit different equity structures while being used as a mechanism to provide incentive and resolve conflict.

It is also interesting to explore an extreme case where the farmer, as well as the principal, is risk neutral (κ = 0). The optimal effort made by the farmer will be $A/2$ [equation (25)], or half of the total investment in magnitude. In the compensation schedule, the variable component will be exactly $A$; hence the fixed component $u^*$ must be negative so that (8) still holds.

Under this contract, the farmer receives the entire surplus after paying a fixed amount fee to the investor, which is equivalent to the traditional rental land operation often seen in crop production. In this case, the landlord becomes the investor with his land as external equity; as such, the optimal contract is a fixed rent contract according to our model prediction. This result is consistent with Garvey’s prediction that a contract which stipulates a fixed payment for the principal provides no risk sharing for the agent (for an analogous treatment, see Biswas). Similarly, if $\sigma^2 = 0$, then the project is without risk and the optimal solution is again a fixed rent contract because there is no risk to share.

In reality, it is possible the farmer is highly risk averse and/or the project is rather risky ($\sigma^2$ is large). In this case, if the farmer’s reservation utility level $\bar{U}$ is low enough, then an optimal solution may still exist. However, if $\bar{U}$ is also relatively high, then the farmer will fail to attract external investment and may have to give up the project. From the supply side, the firm will be more willing to invest in agriculture if such activities are subsidized by a third party (e.g., the government). The subsidy decreases the firm’s effective required rate of return $r^*$ and hence increases the opportunity of successful negotiations even if the farmer is highly risk averse and/or the project is risky.

**Summary and Conclusion**

We apply the principal-agent theory to the problem of a farm’s external equity financing. The model employed is the hidden action model, representing the situation where the principal cannot observe the agent’s effort. In this case, the agent (a farmer) seeks external equity financing from the principal (an investment firm). Both parties then decide and agree on the level of farmer equity, and external equity that will be used to finance the farm business.

Because effort is a disutility to the farmer and effort cannot be observed directly, the investment firm ties the profit-sharing rule or the compensation scheme to the outcome of the project as measured by the profit. In an uncertain environment, problems arise because the outcome is not only influenced by the farmer’s effort, but also by random events. These random events introduce riskiness into the farmer’s compensation and cause the risk-averse farmer to demand a risk premium. The principal-agent framework allows for an optimal sharing rule or compensation scheme that preserves the farmer’s incentive to work in the world of uncertainty and asymmetric information. The resulting optimal sharing rule or compensation scheme satisfies both participation and individual rationality conditions.
Under our model, we assume a risk-averse farmer and a risk-neutral investment firm. Based on our findings, the fixed sharing rule provides no incentive for the farmer to work harder because the farmer's reservation level of utility is achieved (the participation condition). We also find that the farmer's optimal effort is inversely related to the degree of risk aversion and the riskiness of the investment. Therefore, it costs the investor more to induce the farmer to work harder when the farmer is highly risk averse or the investment is highly risky. Consequently, although the investment firm was assumed risk neutral, the less risky investment was preferred to the riskier one. In addition, investors prefer a less risk-averse farmer for investment with the same level of risk.

Our results show the optimal principal-agent arrangement is a fixed rent contract when the farmer is risk neutral (or the project is riskless). Therefore, the traditional rental land operation can also be analyzed within our framework as a special case.

In this analysis, we confined ourselves to the case of a single-period principal-agent problem. Future research may explore the implications of multi-period negotiation (e.g., see Malcolmson and Spinnewyn; Allen and Lueck). Furthermore, an alternative perspective to the principal-agent problem is to treat it as an incomplete information game where the unknown information (to the investor) would be the farmer's effort and the random effect θ. An equilibrium solution exists only if the farmer's reservation utility is expected to be met and the investment firm can expect a return rate no less than its opportunity cost.

In conclusion, although the sharing rule we proposed here has not seen many examples in the U.S. farm business arena, partly because of other information problems and high transaction costs (including the contract enforcement cost) it introduces, we believe such financial arrangements may emerge as the information exchange between agriculture and nonagriculture sectors improves (Hampson, Parsons, and Blitzer). The rapid growth of venture capital raised by nonfarm entrepreneurial firms in the 1990s provides a good example (Schmid).

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