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AGENCY COSTS, FARM DEBT AND FORECLOSURE: POSITIVE AND POLICY ISSUES

by

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I. Introduction

When a farmer requires external funds for capital purchases, land acquisition or operating expenses, he invariably takes out a loan, a debt contract. That this financing mechanism plays a crucial rule in the evolution of the agricultural sector and, more importantly, farm failures, has become abundantly clear as the current agricultural depression has deepened (Baker, Barry and Lee, Boehlje and Eidman, Chambers and Lopez, Jolly, et al., Melichar, U.S.D.A.).

But why has debt become such an important financial instrument in agriculture, rather than equity alternatives?[1] The answer is not obvious. Yet, understanding the predominance of the debt instrument is a natural prerequisite to modelling the foreclosure decision and, hence, to critical analysis of policy proposals for alleviating the farm credit crisis (e.g., farm foreclosure moratoria (Alston), government purchase of farm debt, equity infusions (Brake and Boehlje)). This paper is intended to help satisfy this prerequisite by exploring one explanation for debt's genesis, the agency problem.

To raise external investment funds (i.e., funds over and above the farmer's own resources), the farmer is given a choice here between two prototypic financial instruments: (i) debt, which gives the investor the minimum of a promised fixed payment and the value of the farm; and (ii) equity, which gives the investor a fixed share of the farm. At the outset, the analysis abstracts from information problems and shows that, in this world, risk-sharing considerations favor the use of equity financing. In an endeavor to explain debt, agency costs are introduced by specifying a farmer choice variable, "effort," which cannot be observed by investors. Not surprisingly, the terms of the financial contract will affect the farmer's choice of effort. The investors, who are presumed to know the farmer's <u>choice problem</u> though not the <u>actual choice</u>, are aware of these effects and will only offer terms which give them an acceptable return, considering the indirect impact on effort. Farmers then choose from the menu of contracts acceptable to investors.

While focusing on the farmer's financial structure problem, the paper pays particular attention to the nature of his unobserved choice variable (i.e., whether it alters the mean or the risk of the profit distribution) and the implications of this farm capital market model for foreclosures and policy interventions. In addition to important differences in formulation,[2] the latter focuses distinguish this research from earlier analyses of capital structure and foreclosure problems. In particular, prior research on foreclosure (e.g., Stiglitz and Weiss (1980, 1983)) has treated financial structure as exogenous; this analysis provides an internally consistent treatment of both problems, exposing the importance of the integration.

The paper is organized as follows: Section II presents the model. Section III examines capital structure choices in the <u>absence</u> of agency problems, thereby focusing on risk-sharing considerations. Section IV analyzes capital structure choices when there is an unobservable farmer choice variable, "effort," which "improves" profit distributions in the sense of first order stochastic dominance. Section V presents a numerical example to illustrate capital structure choices in the latter setting. Section VI considers the case of an unobservable farmer choice of "risk", rather than "effort." Section VII examines the implications of the analysis for foreclosure and beneficial government intervention in farm financial markets. Finally, Section VIII provides a summary of results, with a few concluding remarks.

II. The Model

Consider the following two date model. Farmers choose an effort level, e, at $t = 0$, which, together with time 0 assets A, gives rise to a stochastic net worth of the farm, $\pi \epsilon [0,\infty)$, at $t = 1$. Increases in effort yield "improved" net worth distributions in the sense of first order stochastic dominance. Formally, with G denoting the distribution function of π, $\frac{\partial G(\pi;e,A)}{\partial e} \leq 0$ for all π, with strict inequality holding for some π.

Since the concern here is not with scale choice, A is taken as fixed at the outset and this argument is suppressed. However, the dependence of π on A is important both for interpreting the concept of net worth and for providing an alternative interpretation of effort. Net worth, π, represents both the end of period value of the farm assets and the profits earned over the period. If effort is the labor and managerial input of the farmer, it will influence the cumulative profit component of net worth directly and, perhaps via its effect on land quality, it will influence the asset value component as well. But effort can also be thought of as "negative consumption." Suppose the farmer can consume some of the assets at time 0. Consumption will directly affect both components of π. Moreover, just as lower effort increases the farmer's time 0 utility, so does higher consumption. In addition, the cost of higher consumption is the same as the cost of lower effort: a poorer end-of-period net worth distribution. Thus, with the required change of sign, the effects of consumption are analytically identical to those of effort.

On the assumption that the amount of funds raised externally, I, is costlessly observable to all agents, it is also taken as fixed without loss of generality. These "external" funds are raised with a combination of two instruments: debt and equity. With equity, the financier invests $(1-\beta)I$, where $\beta \epsilon [0,1]$ is the proportion of I raised with debt, in exchange for a given share, α, of net worth after debt payments. Debt entitles a financier to the minimum of the net worth of the farm, and a promised payment, $(1+r)\beta I$, where r is the interest rate charged.

The investors are assumed to be rational and to act as if they are risk neutral.[3] Thus, considering any indirect effects of financial structure on effort choice, investors require an expected return of ρ, the risk-free rate, on their investment in the farm. In order to avoid complicating interactions between the portfolio choice problem and the financial structure/effort choice problem of interest here, the farmer is assumed to invest all of his financial resources in the farm.[4]

Finally, the farmer obeys the Von Neumann-Morgenstern axioms and has a utility function which is additively separable in two arguments, effort and the farmer's net worth at $t = 1$. Farmer welfare can then be represented as follows:[5]

$$(1)\quad W = U(e) + E_{\pi;e}V[\max[0,(1-\alpha)(\pi - (1+r)\beta I)]]$$

where $E_{\pi;e}$ = expectation operator over farm net worth states of nature given effort e, U and V are everywhere twice continuously differentiable with $U'<0$, $U''\leq 0$, $V'>0$, and $V''\leq 0$. When e is not observable to investors and, hence, cannot be specified in the financial contract, the farmer maximizes (1) by choice of e, yielding $e^*(\alpha,r,\beta)$.

Given investor risk neutrality, the two equilibrium conditions are as follows:

$$(2)\quad \alpha E_{\pi;e}\max[0,\pi - (1+r)\beta I] = (1+\rho)(1-\beta)I$$

$$(3)\quad E_{\pi;e}\min[\pi, (1+r)\beta I] = (1+\rho)\beta I$$

When e is unobservable, (2) and (3) are both evaluated at $e^*(\alpha,r,\beta)$. When e is observable, the effort level can be specified in the financial contract and the contract parameters $\{e, \alpha, r, \beta\}$ must satisfy (2) and (3).

The farmer's capital structure choice problem can now be posed. When e is observable to investors, (2) and (3) give $r^*(e, \beta)$ and $\alpha^*(e, \beta)$; the farmer chooses e and β to maximize (1), where the latter functions are substituted for r and α.

When e is <u>un</u>observable to investors, (1), (2) and (3) can be used to express the farmer's utility as a function of β alone:

$$(4)\quad W(\beta) = U(e^*) + \int_{z^*}^{\infty} V((1-\alpha^*)(\pi-z^*))g(\pi;e^*)d\pi$$

where $z^* \equiv (1+r^*)\beta I$, $\alpha^* = \alpha^*(\beta)$ and $r^* = r^*(\beta)$ from (2) and (3), $e^* = e^*(\alpha^*, r^*, \beta)$ from maximizing (1), and $g(\pi;e^*)$ = probability of net worth π given effort e^* (assumed twice continuously differentiable in e for all π). In words, given α, r and β, investors can infer e from the farmer's effort choice problem, even though they cannot observe it. Thus, once β is determined, investors will set α and r so that they earn their required return, <u>considering the effect which these parameters have on the farmer's effort (consumption) choice</u>. The farmer, knowing this relationship between β and financial contract terms, as well as his own effort choice responses, will choose the capital structure which maximizes his utility.

Before proceeding, two observations should be made:

1) Unobservability of effort restricts the set of feasible (e, β) pairs. Thus, moral hazard can only hurt the farmer, giving rise to the term agency <u>cost</u>.[6]

2) Even without moral hazard, this specification deviates from Modigliani-Miller's (1958) world of capital structure irrelevance by prohibiting farmers from trading in their own debt. In other words, farmers are not permitted to sell the whole farm firm and then trade in the farm firm's (and other firms') securities according to their own

risk preferences; rather, the farmer's interest in the farm is constrained to be a positive equity claim. Hence, the arbitrage arguments which support the Modigliani-Miller Theorem (see Fama) cannot be employed here and, in general, capital structure matters with or without moral hazard.

In order to expose the importance of moral hazard, the next section examines the no-moral-hazard case first.

III. Risk-Sharing Considerations: The Case of No Moral Hazard

When effort is costlessly observable, the farmer has two independent choice variables, e and β. e is chosen to maximize utility, given the optimal β, and β is chosen to maximize utility, given the optimal e. Thus, the two choices reflect an allocational decision (e) and a risk-sharing decision (β). Given e, a higher β implies a larger fixed payment (debt) commitment and a lower share (equity) obligation. Now recall that equity pays off most in high-farm-profit states of nature, while debt payoffs do not increase with farm profits beyond a certain point (i.e., $\pi > z$). Thus, since investors are risk neutral, conversion from debt to equity (i.e., a decrease in β) is equivalent to the farmer trading income in high-income states of nature for income in lower-income states "dollar-for-dollar" (with dollars probability weighted). This trade makes a risk averse farmer better off due to the inverse relation between income and marginal utility. The risk neutral farmer is left indifferent.

Thus, with no moral hazard, the optimal capital structure for a risk averse farmer is all equity and there is no optimal capital structure for the risk neutral farmer. (See Appendix A for a proof.)

We are left with the apparent paradox of debt financing when risk-sharing considerations favor equity.[7] The next section explores the prospect for agency costs to resolve this paradox.

IV. Moral Hazard and Capital Structure with Effort Choices

A. The Effort Choice Problem

When effort is unobservable, its choice will be affected by the terms of the financial contract. In particular, a farmer will choose effort to equate its marginal utility benefits with the marginal utility costs. Equity and debt will give rise to different marginal benefit structures and, hence, different effort choices. To investigate this problem, consider first the farmer's first order condition for effort choice, obtained by differentiating (1) (assuming an interior solution):

$$(5)\quad U' + \int_z^{\infty} V(\pi^*)\frac{\partial g(\pi;e)}{\partial e}\, d\pi = 0$$

where $z \equiv (1+r)\beta I$ and $\pi^* \equiv (1-\alpha)(\pi-z)$. Differentiating with respect to α and z and integrating by parts, the following comparative statics expressions are derived:

$$(6)\quad \frac{de}{d\alpha} = c\left\{\int_z^{\infty} V'(\pi^*)(1-\phi(\pi^*))\frac{\partial G(\pi;e)}{\partial e}\, d\pi\right\}$$

$$(7) \quad \frac{de}{dz} = c(1-\alpha)\left\{V'(0)\,\frac{\partial G(z;e)}{\partial e} + (1-\alpha)\int_{z}^{\infty} V''(\pi^*)\,\frac{\partial G(\pi;e)}{\partial e}\,d\pi\right\}$$

where $c > 0$ (assuming satisfaction of the second order condition), and ϕ denotes the index of relative risk aversion ($-V''\pi^*/V'$).

Since $\frac{\partial G(\pi;e)}{\partial e} \leq 0$ for all π (due to the first order stochastic dominance characterization of effort's benefits), (6) indicates that effort will be increasing (decreasing) in α when relative risk aversion is everywhere greater than (less than) one. Intuitively, when α is increased, there are two offsetting effects on the marginal benefits of effort: (1) the marginal dollar returns to the farmer decline (proportionately) in every state; and (2) the lower total dollar return causes the marginal utility of income to increase in each state when the farmer is risk averse. When the farmer is very averse to risk, the second effect dominates and farmers increase effort as the share of the farm held by outside investors rises.[8] When the farmer is not very risk averse, the first effect dominates and effort declines with the external share. In particular, when ϕ is greater than (less than) one, marginal utility increases by a greater (smaller) proportion than profits decline so that the utility benefits of marginal profits, $V'(\pi)d\pi$, will be higher (lower) when π and $d\pi$ are decreased by the same proportion.[9]

In contrast, for states in which the farm is not bankrupt, an increase in the promised fixed payment, z, has only the second effect described above. In other words, since a higher promised payment lowers profits, the marginal utility of extra profits produced by additional effort is higher so long as the farmer is risk averse. However, if marginal effort transfers probability weight from one bankrupt state to another higher-value bankrupt state, this benefit is lost to the creditor. Further, if marginal effort transfers probability weight from a low-value bankrupt state to a nonbankrupt state, much of the benefit is captured by the bank. These arguments indicate that, for the risk averse farmer, effort will be increasing in the fixed payment when this payment is low and decreasing when it is high. For the risk neutral farmer, effort will be nonincreasing in the fixed payment, but will decrease by very little (if at all) when z is small. Equation (7) confirms these observations. The first bracketed term is nonpositive; it will be zero when either z is less than (or equal to) the minimum net worth level or there is no probability shift from below z to above z; it will otherwise be negative. The second bracketed term will be positive so long as there are some probability shifts above z and the farmer is risk averse. These terms correspond, respectively, to benefits lost to creditors and increased marginal utility value of effort benefits. As noted, the second effect will certainly outweigh the first when z is low and the farmer is risk averse.

To help understand the implications of these observations for financial contract terms, consider Figures 1 and 2. These figures present a case of moderate risk aversion (i.e., $0 < \phi < 1$), so that effort will be decreasing in the external equity share, α, and increasing in the fixed payments, z, when z is small.

Figure 1 illustrates an all-debt financing equilibrium. Here, the farmer's effort choice is shown as a function of the promised debt payment, z, while the promised payment which creditors require is shown as a function of effort, e. The effort supply curve has the properties just described, increasing for low z and decreasing for high z. The creditor offer curve is downward sloping because higher effort reduces the probability of default and thereby enables the bank to require a smaller fixed payment in order to achieve a given expected return. As the size of the loan (I) increases, banks will require a higher fixed payment for every effort level, giving the configuration shown in the figure. For a given investment level (I), the equilibrium (z,e) occurs at the intersection of the two curves.

Analogously, Figure 2 gives the all-equity financing equilibrium. Here, the farmer's effort choice is shown to depend negatively on the share of the firm owned by external investors, α. External equity holders require a higher share of the farm when effort is lowered so that they can realize the same required expected return level; hence, their "offer curves" are downward sloping. Again, the equilibrium occurs at the intersection of the effort supply and investor offer curves.

In the case depicted here, the beneficial incentive effects of debt permit a lower fixed payment (Figure 1) while the adverse incentive effects of external equity share force equity investors to raise α until the positive payoffs of higher share "catch up" with the negative effects on effort (Figure 2). As drawn, the favorable incentive effects of debt vis-a-vis equity also imply that maximum investment levels amenable to external financing will be higher as the proportion of debt is increased. The latter effect is illustrated by the equity offer curve for I_0, the maximum investment level amenable to all-debt financing, lying everywhere above the farmer's effort supply curve, $e^*(\alpha)$. The plausibility of this outcome is confirmed below (see Section V).

Relative incentive benefits of debt are, of course, not enough to make it the preferable instrument; when the farmer is risk averse, these benefits must be traded off with the risk sharing benefits of equity.

We turn next to this trade-off and a more complete treatment of the capital structure choice problem.

B. Capital Structure Choices

To begin, consider (4) again. Thinking of equations (3) and (2) as defining, respectively, $r^*(e,\beta)$ and $\alpha^*(e,r^*(e,\beta),\beta)$, (4) can be differentiated to give:

$$(8)\quad \frac{dW}{d\beta} = -\int_z^\infty V'(\pi^*)(\pi-z)g(\pi;e)d\pi\cdot\left\{(\alpha_e^* + \alpha_r^*\, r_e^*)\frac{de}{d\beta} + \alpha_r^*\, r_\beta^* + \alpha_\beta^*\right\}$$

$$-\int_z^\infty V'(\pi^*)(1-\alpha)\beta I g(\pi;e)d\pi \cdot \left\{r_e^*\,\frac{de}{d\beta} + r_\beta^* + \frac{(1+r^*)}{\beta}\right\}$$

where α_q^* and r_q^* denote derivatives with respect to variable q obtained by implicitly differentiating (2) and (3) (see Appendices A and B), and $de/d\beta$ can be obtained from the farmer first order condition (5). Substituting for some of the derivatives and simplifying, (8) can be written:

$$(9)\quad \frac{dW}{d\beta} = Q\frac{de}{d\beta} + \frac{\alpha}{(1-\beta)} \cdot \int_z^\infty V'(\pi^*)(\pi^* - \bar{\pi}^*)g(\pi;e)d\pi$$

where Q > 0 is given in Appendix B, and

$$\bar{\pi}^* \equiv \int_z^\infty \pi^* g(\pi;e)/(1-G(z;e))d\pi$$

The first term of (9) has the same sign as $de/d\beta$ and represents the incentive component of β's effect on farmer utility. The second term is negative (zero) when the farmer is risk averse (risk neutral) giving the risk sharing costs of higher β on farmer utility (see Appendix A). Thus, <u>a necessary condition for $dW/d\beta>0$ is that $de/d\beta>0$. For a risk neutral farmer, this condition is also sufficient</u>.

The remaining unknown in this problem is the sign of $\frac{de}{d\beta}$. We know from Part A that, with moderate or no risk aversion $(0 \leq \phi \leq 1)$, $\frac{de}{dz} > 0$ at $\beta = z = 0$. Thus, if β is increased from zero, implying that α declines and z rises, effort will rise--that is, $\frac{de}{d\beta} > 0$ for $\beta \epsilon [0, \beta^*)$, some $\beta^* > 0$.

To generalize this result, consider the following derivation of $\frac{de}{d\beta}$: First, express the farmer's first order condition (5) in functional form as follows:

$$(10)\quad F(e, \alpha^*[e, r^*(e,\beta), \beta], r^*(e,\beta), \beta) = 0$$

In order for e* to be a stable solution to the equilibrium equation (10), dF/de must be negative at e*, which will be assumed. Hence, $de/d\beta$ has the same sign as $dF/d\beta$:

(11) $\frac{de}{d\beta} = k\frac{dF}{d\beta} = k\{F_\alpha(\alpha_r^* r_\beta^* + \alpha_\beta^*) + F_r r_\beta^* + F_\beta\}$

for k > 0. With some work (see Appendix C for details), (11) can be rewritten as follows:

(12) $\frac{de}{d\beta} = -k \frac{\alpha}{(1-\beta)} \cdot \{\int_z^\infty V'(\pi^*)(\bar{\pi}^* - \pi^*) \frac{\partial g(\pi;e)}{\partial e} d\pi$

To interpret (12), define π^{**} such that $\partial g(\pi;e)/\partial e \geq 0$ for all $\pi \geq \pi^{**}$ and $\partial g(\pi;e)/\partial e \leq 0$ for all $\pi < \pi^{**}$. Due to the first order dominance characterization of effort, there exists such a π^{**} (see Innes, Appendix A). Two cases can now be distinguished:

<u>Case A</u>: $\pi^{**} \leq \bar{\pi}_C$

<u>Case B</u>: $\pi^{**} > \bar{\pi}_C$

where

$$\bar{\pi}_C \equiv \int_z^x \pi g(\pi;e)/(1-G(z;e))d\pi.$$

Consider Case A. Since $\bar{\pi}_C \geq \bar{\pi} \equiv$ unconditional mean of the net worth distribution, this case will hold when $\pi^{**} = \bar{\pi}$--that is, when increased effort shifts probability weight from below to above the mean of the distribution. Two specific examples in which π^{**} has this property are: (1) a conditional normal net worth distribution with the condition $\pi \geq 0$, mean an increasing function of e and variance constant, and (2) an exponential distribution with parameter η increasing in effort. The following condition can be shown to be sufficient for $\frac{de}{\partial\beta}>0$ in Case A (see Appendix D):

$$(13)\quad \frac{\partial G(z;e)}{\partial e} \geqslant \frac{\partial G(\bar{\pi}_C;e)}{\partial e}$$

Since $z < \bar{\pi}_C < \pi^{**}$ here, $\frac{\partial^2 G(\pi;e)}{\partial e \partial \pi} = \frac{\partial g(\pi;e)}{\partial e} < 0$ for $\pi \epsilon [z, \bar{\pi}_C]$ and (13) is always satisfied. That is, $\underline{\frac{de}{d\beta} > 0 \text{ in Case A}}$.

For Case B, signing $\frac{de}{d\beta}$ requires a constraint on preferences. Specifically (see Appendix E for proof), $\underline{\frac{de}{d\beta} > 0 \text{ in Case B if}}$:

$$(14)\quad \phi(\pi^*)((\pi^*-\bar{\pi}^*)/\pi^*) - 1 \leqslant 0,\ \pi^* \epsilon (\bar{\pi}^*, \pi^*(\pi^+))$$

where

$$\pi^+ : \int_{\bar{\pi}_C}^{\pi^{**}} \frac{\partial g(\pi;e)}{\partial e}\, d\pi = - \int_{\pi^{**}}^{\pi^+} \frac{\partial g(\pi;e)}{\partial e}\, d\pi \quad \text{and} \quad \pi^*(\pi^+) \equiv (1-\alpha)(\pi^+ - z)$$

Note that (14) will certainly be satisfied if the farmer's relative risk aversion is less than, equal or close to one.

Together with (9), the foregoing analysis implies that a <u>risk neutral farmer will choose to finance only with debt</u>.

However, for the risk averse farmer, the incentive benefits of debt must be traded off with the risk sharing benefits of equity, making the utility-maximizing choice of instruments ambiguous.

The following numerical example is presented, in part, to shed some light on the nature of this tradeoff and, more specifically, its role in capital structure choice. It is also useful for examining: (i) the magnitude and properties of effort response to capital structure; (ii) how equilibrium contract terms and effort choice behave as required external investment is varied (assets held fixed); and (iii) the relationship between maximal attainable external investment and capital structure.

V. A Numerical Example

Suppose that net worth is uniform on $[0,x(e)]$ where $x(e) = 4e^{1/2}$. Further, let $\rho = 1$, so that the financial commitment is at least medium-term. Finally, let the farmer's utility function take the following forms:

Case 1: Risk Neutral Farmer: $U(e) = -e$, $V(\pi^*) = \pi^*$.

Case 2: Risk Averse Farmer: $U(e) = -e$, $V(\pi^*) = k\ln(1+\pi^*)$,

where $k = 8/(4-\ln(5))$ and ln denotes the natural logarithm.

This specification is chosen so that, in the absence of any external financing, the optimal effort choice is one, which yields expected profits of two, in both preference cases. Further, though assets do not require specification in this model, the example is constructed with the normalization of $A = 1$ in mind.

Using a search algorithm (see Appendix F), this numerical example was solved for $\beta \epsilon [0,1]$ and $I \epsilon \{.1,...,1\}$. The results are summarized in Figures 3 and 4, which give rise to the following observations:

1) Capital structure has significant effects on effort in both risk neutral and risk averse cases, effects which increase with the size of the external investment (see part (a) of Figure 3 and 4). Further, confirming observations made earlier, the risk averse farmer's effort is (very) positively related to the promised fixed payment (z) when z is not too high, and negatively related when z is very high. (Given the positive association between I and z, Figure 4(a) illustrates the latter effect.)

2) Due to adverse incentive effects, α increases much more rapidly than I when there is all-equity financing (see part (b) of the Figures). For example, consider all-equity financing in the risk neutral case, while α and I are approximately equal for very low investment levels (e.g., I = .02 or .04), α rises to almost twice I as I approaches the maximum level amenable to external financing (.25). In contrast, when the risk neutral farmer finances with all-debt, the interest rate rises with the investment level (incentive benefits are not enough to compensate for higher default risk), but it rises very slowly for moderate I (see part (c) of Figure 3); for example, when I rises ten-fold from .025 to .25, r increases from 1.01 to only 1.15.

3) The risk averse farmer's tradeoff between risk-sharing costs and incentive benefits leads to an internal optimal capital structure for a

range of investment levels (see part (d) of Figure 4). Moreover, the optimal β is increasing in I, zero for low I, and one for high I. The latter relationship can be interpreted as follows: as the amount of investment financed with equity increases, incentive costs get very high, overwhelming risk sharing benefits.

For the risk neutral farmer, optimal β is always one, consistent with the results in Section IV.

4) As suggested at the outset, incentive benefits of debt give rise to a positive relationship between β and the maximal investment level amenable to external financing (see part (d) in the two Figures). For example, in the risk neutral case, any investment greater than .375 requires a β larger than .7.

VI. Second Order Choices

The foregoing analysis assumes that farmers choose effort levels, each of which leads to a first order stochastically distinct profit distribution. Suppose that, instead, farmers are choosing the riskiness of the profit distribution. Specifically, suppose they choose γ, where higher γ corresponds to higher risk in the sense of mean preserving spread (see Rothschild and Stiglitz). Then, for $y \geqslant 0$,

$$(15) \quad \int_0^y \partial G(\pi;\gamma)/\partial\gamma d\pi \geqslant 0$$

(with strict inequality in some interval).

For a risk neutral farmer, the capital structure choice problem is simple. With any debt at all, the farmer's payoff function is strictly convex in farm profits. Hence, higher γ will lead to a higher expected farmer payoff and <u>the risk neutral farmer will choose the highest γ possible</u>. Formally, differentiate expected farmer profit (net of financial obligations) with respect to γ:

$$(16)\quad \partial E(\max(0,(1-\alpha)(\pi-z)))/\partial\gamma = (1-\alpha)\int_z^\infty (\pi-z)\partial g(\pi;\gamma)/\partial\gamma d\pi$$

$$= -(1-\alpha)\int_z^\infty \partial G(\pi;\gamma)/\partial\gamma \, d\pi \geqslant 0$$

where the second equality follows from integration by parts and the inequality follows from (15) and $\int_0^\infty \partial G(\pi;\gamma)/\partial\gamma \, d\pi = 0$ (i.e., γ preserves mean).

If γ can be increased without bound, the payoff to debt-holders can (and will) be reduced to zero, implying no debt in the capital structure. Likewise, if the maximum level of γ cannot be observed by investors, any mixed-capital-structure contract which will be acceptable to a farmer will almost certainly (i.e., with probability one) be unprofitable for investors. Thus, <u>when farmers are risk neutral and the upper limit of γ is unbounded or unknown by investors, the equilibrium capital structure is all-equity</u>.

The risk averse case is equally simple. The best a farmer can hope to do is obtain the no-agency-cost outcome. Here, this outcome is all-equity (from Appendix A), which implies a farmer's choice of the minimum γ. But this outcome can be achieved even when investors cannot monitor γ. Thus, <u>the equilibrium capital structure for risk averse farmers is also all-equity</u>.

In summary, the capital structure implications of first order ("effort") and second order ("risk") choice variables are very different. As the following discussion of policy issues reveals, this observation should be taken to heart when economists model the effects and/or properties of debt contracting.

VII. <u>Foreclosure and Government Policy</u>

Stiglitz and Weiss (1980, 1983) and Leathers and Chavas have argued that foreclosure in competitive loan markets can be inefficient. Since both have used morally hazardous behavior to explain foreclosure, this section aims to reassess their conclusions in light of the foregoing analysis.

In the single period model developed here, foreclosure can be thought of as the unwillingness of external investors to finance any scale of operation with any (z,α) pair. Formally, for every (z,α,I) - tuple,

$$(17) \quad R(z,\alpha,I) \equiv \int_0^z \pi g(\pi;e^*,I)d\pi + (1-G(z;e^*,I))z + \alpha \int_z^\infty (\pi-z)g(\pi;e^*,I)d\pi < (1+\rho)I$$

where $e^* = e^*(z,\alpha,I)$ is the farmer's optimal effort choice and R denotes the expected payoff to the investor.

In a first-best world, equation (17) is not the appropriate foreclosure criterion. To illustrate this type of "suboptimality," consider the risk neutral farmer payoff not included in R: $(1-\alpha)\int_z^\infty (\pi-z)g(\pi;e^*,I)d\pi \equiv P(z,\alpha,I)$. Even though $R < (1+\rho)I$ for all (z,α,I), there can be (z,α,I)-tuples such that $R+P > (1+\rho)A$, where A equals I plus the farmer's own equity, E. For instance, z and α can be set to zero, with I and e thus set at their first best levels, e^* and I^*; so long as the farm is viable, $R(0,0,I^*) + P(0,0,I^*) > (1+\rho)(I^*+E)$. The earlier numerical analysis gives a concrete example of this phenomenon; from Figure 3(d), a farm will not survive if it requires an investment greater than .55; but at $z = \alpha = 0$, expected profits are two, permitting an investment level as high as one.

Not surprisingly, this cost is due to the moral hazard specification. If allocatively neutral transfers could be made, farmers could bribe investors not to foreclose. But, in fact, transfers augment the effort choice problem of farmers and thereby have allocative impacts.

This is precisely the reason why a first best standard is inappropriate. Rather, inefficiency should be judged by the Pareto criterion: considering all of their allocative effects, can interventions be made so as to make some agents better off, with all other agents just as well off? Clearly, the answer is yes if government has some informational or institutional advantage over private investors. However, this is not a very interesting (or plausible) case and will be ruled out here.

In the absence of such an advantage (and, for the moment, limiting ourselves to the present single-market model), the Pareto criterion requires that government intervention to prevent foreclosure compensates investors for their loss from nonforeclosure, paying for the compensation with taxes on farmers; otherwise, taxpayers would be made worse off by the intervention. But by what mechanism can government tax farmers? Lacking institutional advantages, the set of instruments available to government will be exactly the same as that available to private investors, namely, lump sum transfers (I) and payoff parameters (α and z).[10] In other words, if government can find a way to tax farmers so that investors are left whole, there will also be a loan contract which investors are willing to offer; that is, in the absence of intervention, foreclosure will not occur, contradicting the supposition that it would. Hence, government <u>cannot</u> achieve a Pareto improvement.

Notably, these arguments are easily extended to a multi-period setting; the number of instruments will simply increase to include, among others, contingent terminations, while the payoff functions will become more complex. But so long as the set of instruments available to private and government agents are the same, Pareto improvements cannot be made.

This conclusion contrasts sharply with those of Leathers and Chavas (LC) and Stiglitz and Weiss (SW). Employing a two-period model, LC hypothesize that the value of a continuing farm is greater that the sale value of the farm, representing a social cost of foreclosure. Hence, they argue, if government can reduce the probability of foreclosure, it can increase social welfare. The mechanism LC propose to reduce the threat of foreclosure is a lump-sum grant to the farmer (at time 0).

Two observations help explain the differences between the LC conclusions and mine:

(1) To measure the welfare benefits of their transfer proposal, LC measure the farmer's willingness to pay for the move from the no-transfer equilibrium to the equilibrium achieved with a dollar transfer. Thus, the effect of compensation on the equilibrium (i.e., the farmer's actual payment of his compensating variation (CV)) is ignored. In other words, when a dollar is transferred to a farmer, the probability of bankruptcy goes down (which is the source of social benefit); but, when he pays his CV, the probability of bankruptcy rises again. Hence, considering the equilibrium effect of compensation, a farmer's willingness-to-pay for a one dollar transfer is, not surprisingly, one dollar; there is no social benefit.

(2) In the LC model, a foreclosure moratorium is optimal.[11] However, foreclosure is not endogenous to their analysis. Thus, by explaining foreclosure, the present analysis identifies the economic forces which preclude both private agents <u>and</u> <u>government</u> from making improvements on an equilibrium which is "suboptimal" in a first-best sense.

But what about Stiglitz and Weiss? In their two-period model, foreclosure is explained as an incentive for first time borrowers to undertake less risky projects. Credibility of the termination threat can be achieved if the banker's expected payoff on the two-period loan contract for first-time borrowers exceeds that on any loan contract for second-time (middle-aged) borrowers. Surprisingly, however, SW show that these equilibrium contractual arrangements are not, in general, constrained Pareto efficient (see SW (1980)).

Again, the source of divergence between these conclusions and mine is not hard to find: SW assume that projects are financed 100 percent with debt while the borrower choice variable has both first and second order effects. When this construction is internally inconsistent--that is, when equilibrium financial structure would include some equity financing--SW find that government can intervene to correct the inconsistency by implicitly creating equity financial instruments, thereby making a Pareto improvement. As with LC's analysis, constrained Pareto inefficiency in the SW model is attributable to an assumed government advantage which is ruled out here.

Notably, the foregoing arguments do not suggest that equilibrium contractual arrangements are, in fact, constrained efficient. Rather, they imply that in the single-market models examined here and elsewhere, sources of constrained inefficiency have not been admitted. The remainder of the section will consider two prospective source of inefficiency neglected by these constructions:

(1) <u>Effort Choice Externalities</u>. When equilibria in other markets affect the farmer's effort choice, an externality is present. For example, if leisure is a substitute for effort, higher prices of leisure goods will lead to higher expenditures of effort. Hence, these high

prices will give rise to a positive externality in the loan market; essentially, they will permit the farmer to commit himself to higher effort levels--that is, to effort levels closer to the first-best optimum to which the farmer would like to be able to commit. The leisure good markets will not incorporate this external benefit; thus, as in the standard externality problem, an appropriate set of taxes will lead to welfare improvements. (See Arnott and Stiglitz for a rigorous treatment of this problem.) Needless to say, the externality here is attributable to the moral hazard specification; in the absence of moral hazard, there is no imperfection in the market for effort, giving competitive equilibrium its usual optimality properties.

(2) Tax Externalities. Another externality may be present in the market for farm financial capital, one which, to my knowledge, has escaped academic notice. Government's tax claims on a farm firm make it an implicit shareholder in the farm. However, the value of these claims does not enter the competitive process of determining the terms of farm financial contracts. Thus, the government costs (and benefits) of contract terms are not priced in the competitive market, admitting the prospect of welfare-improving intervention to correct the externality. The following example illustrates this inefficiency.

Suppose government taxes away a given share, τ, of net profits, π-A, whether belonging to a farmer or an investor, the agricultural sector or the nonagricultural sector.[12] Further, suppose that, at the margin, a dollar taken out of a foreclosed farm earns a total (pre-tax) expected return (to all claimants) of $(1+\rho)$ dollars on an investment with no systematic risk.[13] Now consider a farm which satisfies equation (17), namely, a farm which will be subject to foreclosure. With foreclosure, the government will receive expected tax revenues of $\tau\rho A$. Without foreclosure and with financial contract (z,α,I), government will receive $\tau(R(z,\alpha,I) + P(z,\alpha,I)-A)$. If the difference between these two tax payoffs is larger than the cost to investors of nonforeclosure, then government can bribe investors to keep the farm going; they will thereby increase the utilities of the farmer and taxpayers. The necessary and sufficient condition for this Pareto-improving intervention can be stated formally as follows:

$$(18) \quad \tau(R(z,\alpha,I) + P(z,\alpha,I) - (1+\rho)A) > (1+\rho)I-R(z,\alpha,I) \quad \rightarrow$$

$$(18') \quad P(z,\alpha,I) > ((1+\tau)/\tau) \cdot [(1+\rho)I-R(z,\alpha,I)] + (1+\rho)E$$

for some (z,α,I), where $E \equiv A-I$ denotes the farmer's own equity. It is easily seen that this condition in nonvacuous. For example, if $E = 0$ and the investor cost of nonforeclosure is infinitesimal, the right-hand side of (18') will be infinitesimal (with τ bounded away from zero), while the left-hand side will be strictly positive.

This example is meant to be illustrative and, hence, I do not want to exagerate its merits. Rather, it suggests that a more rigorous and complete analysis of tax externalities (one which permits government choice of tax structure) is warranted.

VIII. Summary and Conclusion

Finding that risk sharing considerations favor equity forms of agricultural finance, this paper sought to explain observed debt financing of farm firms using an agency cost model. The importance of the choice variable's stochastic dominance characteristics were investigated, as were the implications of the model for foreclosures and beneficial policy interventions.

Several conclusions emerged from the analysis:

(1) Agency costs explain debt financing in a variety of circumstances. For example, with an unobservable "effort" choice, the risk neutral farmer will finance exclusively with debt. However, any debt in the farm capital structure requires a choice variable of precisely this type, namely, one which affects the first order (rather than second order) stochastic dominance characteristics of the net worth distribution. Thus, care must be taken if one wishes to construct an internally consistent model of debt effects.

(2) With unobservable "effort" choices, equilibrium capital structures for a risk averse farmer are, in general, ambiguous. This ambiguity is attributable to the trade off between risk-sharing (favoring equity) and incentive (favoring debt) effects of capital structure. A numerical example (Section V) investigated this ambiguity, finding that debt-equity mixes predominate while the debt proportion increases with the required investment.

(3) Foreclosures can be explained by the simple model constructed here. Specifically, foreclosure occurs when, due to agency problems, a contract giving investors their required expected return does not exist. As observed in practice, this problem occurs when the farmer's own-equity is small or zero.

(4) In the single-market models examined here and in other analyses of foreclosure, competitive equilibrium contractual arrangements are constrained Pareto efficient in the absence of an informational or institutional advantage for government vis-a-vis private investors. However, these models neglect other prospective sources of inefficiency, including effort choice externalities and tax externalities, both of which admit Pareto-improving interventions. A simple example illustrates the latter phenomenon; it shows that, since government's tax claims on farmers and investors are not considered in the foreclosure decision, government can sometimes make all agents better off by paying investors not to foreclose when they otherwise would.

While contributing to our understanding of farm capital markets, perhaps the most important message of this paper is that meaningful analysis of foreclosure and agricultural finance policy requires internal explanation of contractual forms. The exploratory treatments of foreclosure and tax externalities presented here indicate both the importance of this internal consistency and the scope for research needed to broaden the conceptual base in these areas.

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FOOTNOTES

[1]Notably, equity financing of land purchases, in the form of share land rental arrangements, is not insignificant in the United States. In 1979, 44 percent of U.S. farm acreage was rented and 68 percent of land rents were share payments (U.S. Bureau of the Census). However, the prevalence of debt financing can hardly be disputed. Also in 1979, 74 percent of farm operators with sales over $20,000 had outstanding debt.

[2]While the present formulation is rooted in the principal agent literature, it differs in a number of respects from other agency based treatments of financial structure issues. Specifically, it integrates the capital structure choice problem (c.f., Jensen and Meckling), while specifying a single choice variable agency model without other sources of informational asymmetry to drive the results (e.g., unobservable farmer quality differences (c.f., Darrough and Stoughton) or ex-post profit levels (c.f., Williamson)). Moreover, the analysis characterizes the equilibrium in the only relevant market setting, namely, one with incomplete contingent claim markets (c.f., Ross) (see Footnote 5). All of these attributes are intended to expose the role of agency costs in a plausible model of farm capital structure choice.

[3]Sufficient conditions for investors to act as if they are risk neutral are (from Rubinstein): (1) homogeneous probability assignments; (2) the existence of a composite investor; and (3) independence between π and aggregate wealth. The latter condition is arguably a plausible description of the agricultural setting (Barry).

[4]This construction can be justified by the theoretical arguments presented by Leland and Pyle; unwillingness of a farmer to invest all of his time zero net worth in the farm could be interpreted as a signal of poor quality.

[5]Note that the model implicitly incorporates incomplete risk markets by defining farmer utility on residual claims which cannot be altered by state contingent trades. In contrast, a complete market specification would permit the farmer to sell the flow of state and time contingent commodities which would be produced from a given production plan; the proceeds from this sale would finance the plan and yield profits which the farmer would use to purchase a portfolio of state and time contingent consumption bundles. The debt-equity choice would not arise and the farmer would have no moral hazard.

[6]The term "moral hazard" will be used interchangeably with "agency problem" throughout.

[7]In general, tax considerations also favor equity. With partnerships and Subchapter S corporations, both debt and equity income (i.e., interest and net profits) are passed on to the security holders without tax and, thus, are subject only to personal taxation. Further, equity income can be sheltered by depreciation allowances, preproductive expenses, and formerly, investment tax credits. To the extent that these sheltering and tax credit opportunities have lower value to the farmer than to the investor (due, for example, to a lower farmer personal tax rate or farmer income which is insufficient to fully

utilize the shelters), the latter advantage favors equity rather than debt financial arrangements and, in fact, explains the equity forms used in the past to finance "tax-loss" enterprises. However, a rigorous treatment of this question, incorporating institutional details such as tax loss limits, is beyond the scope of this paper.

[8]Note that the possibility of effort increasing with the external share is not admitted by Jensen and Meckling. This phenomenon would invalidate their arguments on agency costs of equity and thereby highlights the need to give the debt-equity choice problem a unified treatment.

[9]Though Arrow's arguments indicate that relative risk aversion approximately equal to one is plausible, empirical evidence on the value of this coefficient is somewhat sketchy. For example, Binswanger estimates that these coefficients lie between .1 and 10 for farmers in rural India and predominantly in the 0 to 2 range. Antle provides further empirical support for Binswanger's findings. Myers has recently estimated relative risk aversion coefficients for U.S. farmers, deriving estimates primarily between 1 and 4.

[10]In reality, the set of available payoff parameters may be much greater than permitted in this paper. However, all that matters here is the equivalence between the instruments available to private and government agents.

[11]Notably, LC dismisses this proposal as one which would encourage excessive entry into agriculture and excessive borrowing. However, if a

moratorium is anticipated, loan contract terms will adjust to reflect the higher risks which the lack of a foreclosure option imply; thus, neither of these outcomes will be likely. If a moratorium is unanticipated and temporary, these long-term incentive effects are also implausible.

[12]Despite double taxation of corporate earnings, an assumption of no intersectoral difference in taxes is not implausible. Miller has argued that, in equilibrium, the marginal bond investor has a personal tax rate on bond income, τ_{PB}, such that $(1-\tau_{PB}) = (1-\tau_C)(1-\tau_{PE})$ where τ_C is the corporate tax rate and τ_{PE} the personal tax rate on equity earnings (considering shelter opportunities). If farmers raise investment funds with debt, τ_{PB} will also be the appropriate investor tax rate for agriculture. However, a less plausible assumption in this example is that farmers share this tax rate.

[13]The latter assumption will be satisifed if the nonagricultural sector does not have the same moral hazard problems and, thus, invests to the point at which the marginal certainty equivalent return is $(1+\rho)$.

APPENDIX A

Proposition: When effort is costlessly observable to external agents and the assumptions of Section II otherwise hold, the optimal capital structure for a risk averse farmer is all equity and there is no optimal capital structure for the risk neutral farmer.

Proof:

When effort is costlessly observable, financial contracts can be made contingent on effort. Hence, drawing on the envelope theorem, $dW/d\beta = \partial W/\partial\beta$, effort fixed. (In contrast, when effort is not observable, the farmer's first order condition does not include effects on equilibrium contract terms, α and r, and $dW/d\beta \neq \partial W/\partial\beta$, effort fixed.) Taking the partial derivative of (4) gives:

$$\text{(A1)}\quad \frac{\partial W}{\partial\beta} = -\int_z^{\infty} V'(\pi^*)\cdot\{(\alpha_r^* \, r_\beta^* + \alpha_\beta^*)(\pi-z)+(1-\alpha)((1+r^*)I+r_\beta^*\,\beta I)\}g(\pi;e)d\pi$$

where $\pi^* = (1-\alpha)(\pi-z)$, $z = (1+r)\beta I$, both evaluated at equilibrium contract terms, and α_r^* ,α_β^* and r_β^* are derivatives of the equilibrium contract terms obtained from the following restatements of (2) and (3):

$$\text{(A2)}\quad \alpha:\quad \alpha\cdot\int_z^{\infty}(\pi-z)g(\pi;e)d\pi = (1+\rho)(1-\beta)I$$

$$\text{(A3)}\quad r:\quad \int_0^{z}\pi g(\pi;e)d\pi + z(1-G(z;e)) = (1+\rho)\beta I$$

Differentiating and simplifying:

(A4) $\alpha_r^* r_\beta^* + \alpha_\beta^* = \dfrac{\alpha(\alpha-1)}{(1-\beta)}$

(A5) $\beta r_\beta^* + (1+r^*) = (1+\rho)/(1-G(z;e))$

Substituting into (A1) and simplifying:

(A6) $\dfrac{\partial W}{\partial \beta} = \dfrac{\alpha}{(1-\beta)} \cdot \int_z^\infty V'(\pi^*)(\pi^* - \bar{\pi}^*)g(\pi;e)d\pi$

where $\bar{\pi}^*$ is as defined in (9). When the farmer is risk neutral, $V'(\pi^*) = 1$ for all π^*, and, hence, $\partial W/\partial\beta = 0$ from the definition of $\bar{\pi}^*$. For the risk averse case, rewrite (A6) as follows:

(A7) $\dfrac{\partial W}{\partial \beta} = \dfrac{\alpha}{(1-\beta)} \cdot \mathrm{Cov}_{\pi>z}(V'(\pi^*),\pi^*) \cdot (1-G(z;e)) < 0$

where the covariance is conditioned on the subscript. Hence, an increase in β always makes the risk averse farmer worse off, completing the proof.

APPENDIX B

This appendix expands Q in equation (9) and demonstrates that it is positive. From (8),

$$\text{(B1)}\quad Q \equiv \{-\int_z^\infty V'(\pi^*)(\pi-z)g(\pi;e)d\pi\}\{\alpha_e^* + \alpha_r^* r_e^*\}$$

$$- \{\int_z^x V'(\pi^*)g(\pi;e)d\pi\}\{(1-\alpha)\beta I r_e^*\}$$

where $z \equiv (1+r)\beta I$. Differentiating (A2) and (A3) gives, with substitution from (A2) and integration by parts:

$$\text{(B2)}\quad \alpha_e^* = \frac{-\alpha^2}{(1+\rho)(1-\beta)I} \cdot \{\int_z^\infty (\pi-z)\frac{\partial g(\pi;e)}{\partial e}\, d\pi\}$$

$$= \frac{\alpha^2}{(1+\rho)(1-\beta)I} \cdot \{\int_z^\infty \frac{\partial G(\pi;e)}{\partial e}\, d\pi\} < 0$$

$$\text{(B3)}\quad \alpha_r^* = \frac{\alpha^2\beta I(1-G(z;e))}{(1+\rho)(1-\beta)I} > 0$$

$$\text{(B4)}\quad r_e^* = \{-\int_0^z \pi\frac{\partial g(\pi;e)}{\partial e}\, d\pi + z\,\frac{\partial G(z;e)}{\partial e}\}/\beta I(1-G(z;e))$$

$$= \{\int_0^z \frac{\partial G(\pi;e)}{\partial e}\, d\pi\}/\beta I(1-G(z;e)) < 0$$

The inequalities in (B2) and (B4) are implied by the stochastic dominance characterization of the effect which changes in effort have on the net worth distribution. These inequalities imply that Q>0.

APPENDIX C

This appendix derives equation (12), an expression for $de/d\beta$, by expanding equation (11). By differentiating (5) with respect to α, r and β, F_α, F_r and F_β are obtained as follows:

$$\text{(C1)}\quad F_\alpha = -\int_z^\infty V'(\pi^*)(\pi - z)\,\frac{\partial g(\pi;e)}{\partial e}\,d\pi$$

$$\text{(C2)}\quad F_r = -\int_z^\infty V'(\pi^*)(1-\alpha)\beta I\,\frac{\partial g(\pi;e)}{\partial e}\,d\pi$$

$$= \frac{\beta}{(1+r^*)}\,F_\beta$$

Substituting from Appendix A for $(\alpha_r^* r_\beta^* + \alpha_\beta^*)$ and $(\beta r_\beta^* + (1+r^*))$, (11) can be written:

$$\text{(C3)}\quad \frac{de}{d\beta} = k\Big\{\Big[\int_z^\infty V'(\pi^*)\pi^*\frac{\partial g(\pi;e)}{\partial e}\,d\pi\Big]\,\frac{\alpha}{(1-\beta)}$$

$$-\Big[\int_z^\infty V'(\pi^*)\frac{\partial g(\pi;e)}{\partial e}\,d\pi\Big]\,\frac{(1-\alpha)I(1+\rho)}{(1-G(z;e))}\Big\}$$

Dividing and multiplying the coefficient of the second term by $(1-\beta)$, substituting from the equity equilibrium condition (A2) and recalling the definition of $\bar{\pi}^*$ (equation (9)) gives equation (12).

APPENDIX D

Lemma: When effort is unobservable, $\pi^{**} \leqslant \bar{\pi}_C$ and (13) holds, $\frac{de}{d\beta} > 0$.

Proof:

(13) implies that there exists a $\pi^+ : z < \pi^+ < \pi^{**}$ defined by the following equation:

$$\text{(D1)} \quad -\int_{\pi^+}^{\pi^{**}} \frac{\partial g(\pi;e)}{\partial e}\, d\pi = \int_{\pi^{**}}^{\bar{\pi}_C} \frac{\partial g(\pi;e)}{\partial e}\, d\pi$$

Now note that the integral in (12) for the interval $(\pi^+, \bar{\pi}_C)$ can be written:

$$\text{(D2)} \quad (1-\alpha) \int_{\pi^{**}}^{\bar{\pi}_C} (V'(\pi^*(\pi))(\bar{\pi}_C - \pi) - V'(\pi^*(\tilde{\pi}(\pi)))(\bar{\pi}_C - \tilde{\pi}(\pi))) \frac{\partial g(\pi;e)}{\partial e}\, d\pi$$

where $\tilde{\pi}(\pi) : (\pi^{**}, \bar{\pi}_C) \rightarrow (\pi^+, \pi^{**})$ maps profits in the higher interval to profits in the lower interval by a rule which satisfies the condition:

$$\text{(D3)} \quad \int_{\pi^{**}}^{\bar{\pi}_C} \delta(\tilde{\pi}^+) \frac{\partial g(\tilde{\pi}(\pi);e)}{\partial e}\, d\pi = \frac{\partial g(\tilde{\pi}^+;e)}{\partial e} \text{ for all } \tilde{\pi}^+ \epsilon (\pi^+, \pi^{**})$$

where

$$\delta(\tilde{\pi}^+) = \begin{matrix} 1 & \text{if } \tilde{\pi}(\pi) = \tilde{\pi}^+ \\ 0 & \text{otherwise} \end{matrix}$$

Since, for every $\pi \epsilon (\pi^{**}, \bar{\pi}_C)$, $\tilde{\pi}(\pi) < \pi < \bar{\pi}_C$, the integrand in (D2) is negative everywhere in the indicated interval. Hence, the only positive portion of the integral in (12) is smaller in magnitude than one of the negative portions, ensuring that $de/d\beta > 0$.

APPENDIX E

Lemma: When effort is unobservable, $\pi^{**} > \bar{\pi}_C$, and (14) holds, $\frac{de}{d\beta} > 0$.

Proof:

The integral in (12) for the interval $(\bar{\pi}_C, \pi^+)$ can be written:

$$\text{(E1)} \quad \int_{\bar{\pi}_C}^{\pi^{**}} (V'(\pi^*(\pi))(\bar{\pi}_C-\pi)-V'(\pi^*(\tilde{\pi}(\pi)))(\bar{\pi}_C-\tilde{\pi}(\pi)))\frac{\partial g(\pi;e)}{\partial e}\, d\pi$$

where $\tilde{\pi}(\pi):(\bar{\pi}_C,\pi^{**})\text{->}(\pi^{**},\pi^+)$, with π^+ as defined in (14), maps profits in the lower interval to profits in the higher interval according to any rule which satisfies the condition:

$$\text{(E2)} \quad \int_{\bar{\pi}_C}^{\pi^{**}} \delta(\tilde{\pi}^+)\frac{\partial g(\tilde{\pi}(\pi);e)}{\partial e}\, d\pi = \frac{\partial g(\tilde{\pi}+;e)}{\partial e} \text{ for all } \tilde{\pi}^+\epsilon(\pi^{**},\pi^+)$$

where

$$\delta(\tilde{\pi}^+) = \begin{matrix} 1 & \text{if } \tilde{\pi}(\pi) = \tilde{\pi}^+ \\ 0 & \text{otherwise} \end{matrix}$$

Now note that (14) is equivalent to the condition:

$$\text{(E3)} \quad \frac{\partial\{V'(\pi^*)(\bar{\pi}_C-\pi)\}}{\partial\pi} \leqslant 0 \quad \text{for } \pi\epsilon(\bar{\pi}_C,\pi^+)$$

Therefore, since $\tilde{\pi}(\pi)>\pi$ and $\partial g(\pi;e)/\partial e<0$ for all $\pi\epsilon(\bar{\pi}_C,\pi^{**})$, (14) implies that the integrand in (E1) is negative everywhere in the indicated interval. Hence, the only positive portion of the integral in (12) is smaller in magnitude than one of the negative portions, ensuring that $de/d\beta>0$.

APPENDIX F

This appendix presents the equations and method used to perform the numerical analysis described in Section V.

Risk Neutral Case

Taking β, I and ρ as given, the equilibrium for this example is derived from the following equations. Solving the analog to equation (3) gives:

$$\text{(F1)} \quad z = 4e^{1/2}\left(1-\left[1-\frac{(1+\rho)\beta I}{2e^{1/2}}\right]^{1/2}\right)$$

Solving the analog to equation (2), substituting from (F1) and simplifying gives:

$$\text{(F2)} \quad \alpha = \frac{(1+\rho)(1-\beta)I}{2e^{1/2}-(1+\rho)\beta I}$$

Note that in order for α to be less than or equal to one, e must satisfy:

$$\text{(F3)} \quad e \geqslant [(1+\rho)I/2]^2 \equiv e_{min}$$

Finally, the analog to equation (5) is:

$$\text{(F4)} \quad F(e) = -1 + \frac{(1-\alpha)}{e^{1/2}}\,(1-[z/(4e^{1/2})]^2) = 0.$$

Substituting (F1) and (F2) into (F4) gives the analog to equation (10), which was used to solve for e. To obtain the solution, a search algorithm was used. F(e) was evaluated for e in the range $(e_{min}, 3)$ and the highest e for which F(e) was nonnegative was chosen as the equilibrium. When no such e could be found, investment was too high to permit external financing given the specified capital structure. Finally, the utility function which gave rise to (F4) was evaluated:

$$\text{(F5)} \quad W(e) = -e + (1-\alpha)(2e^{1/2}+(z^2/8e^{1/2})-z)$$

Risk Averse Case

For this case, the analogs to equations (F1) through (F3) are identical. However, (F4) and (F5) are replaced by:

$$\text{(F4')} \quad F(e) = -1 - \frac{k}{(1-\alpha)8e^{3/2}} \left\{(1-(1-\alpha)z)\ln(1+\pi^*_{max})-\pi^*_{max}\right\}$$

$$\text{(F5')} \quad W(e)=-e+\frac{k}{(1-\alpha)4e^{1/2}} \left\{(1+\pi^*_{max})\ln(1+\pi^*_{max})-\pi^*_{max}\right\}$$

where $\pi^*_{max}=(1-\alpha)(4e^{1/2}-z)$.

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FIGURE 1: DEBT

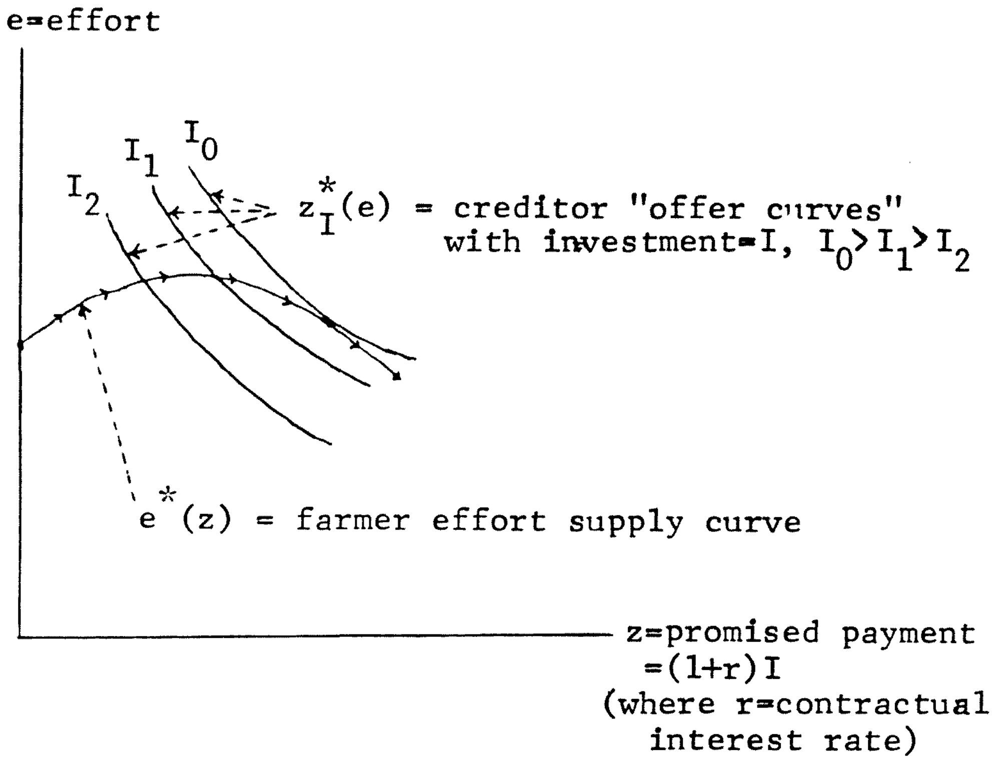


FIGURE 2: EQUITY

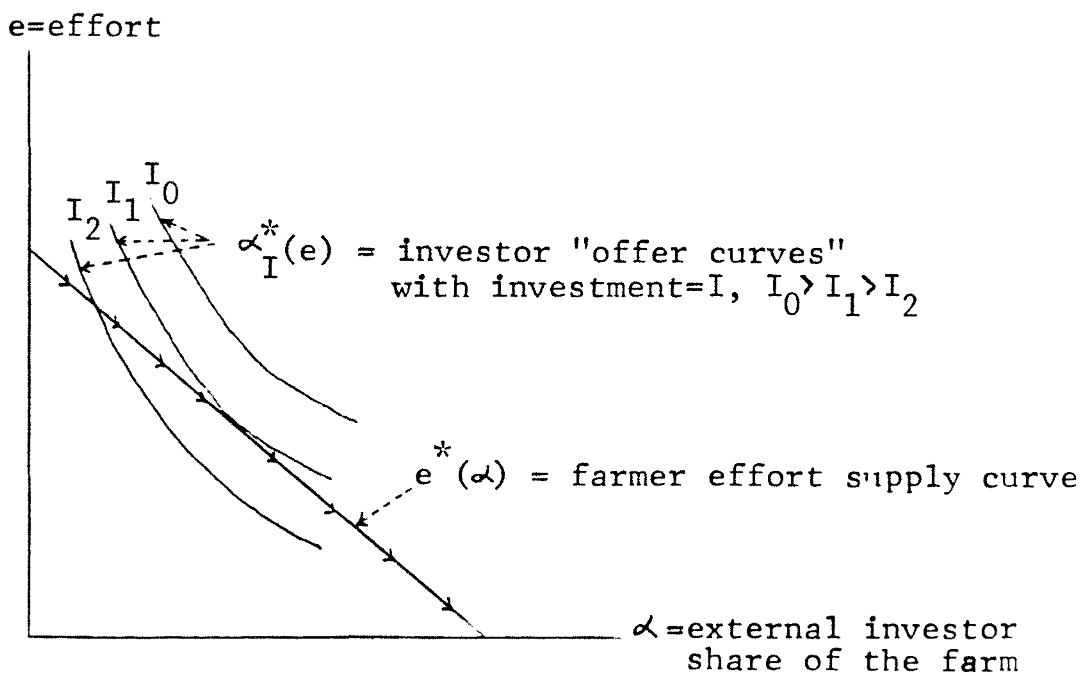
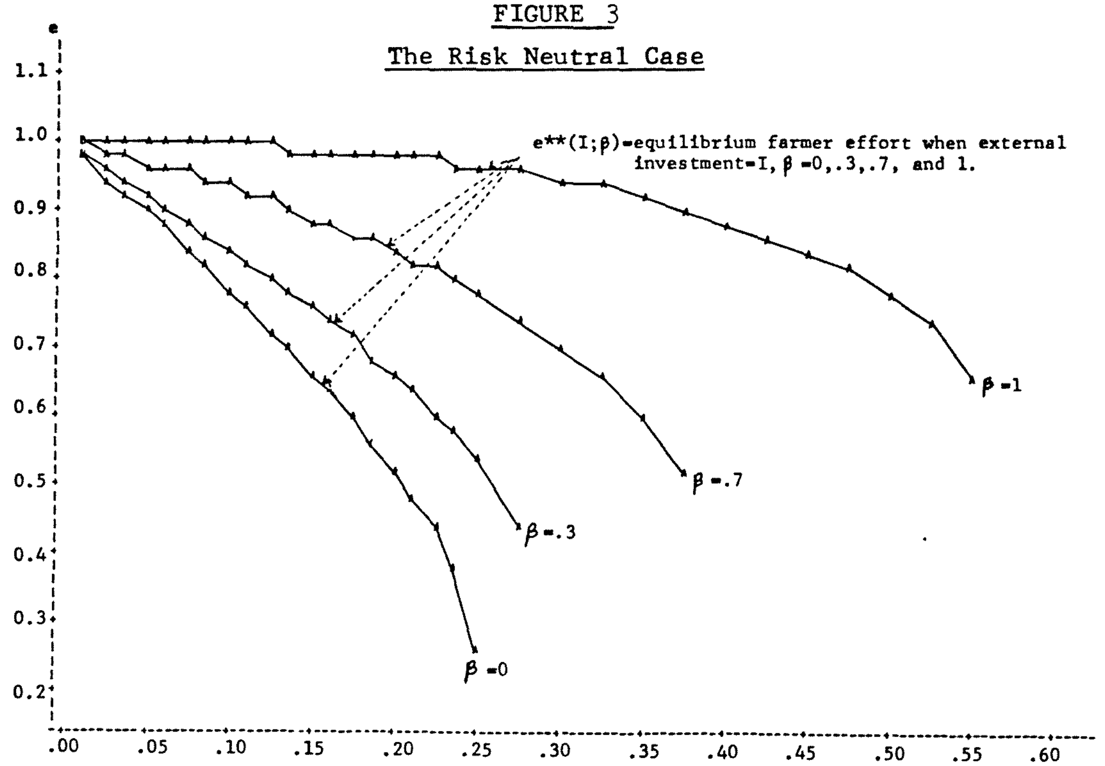


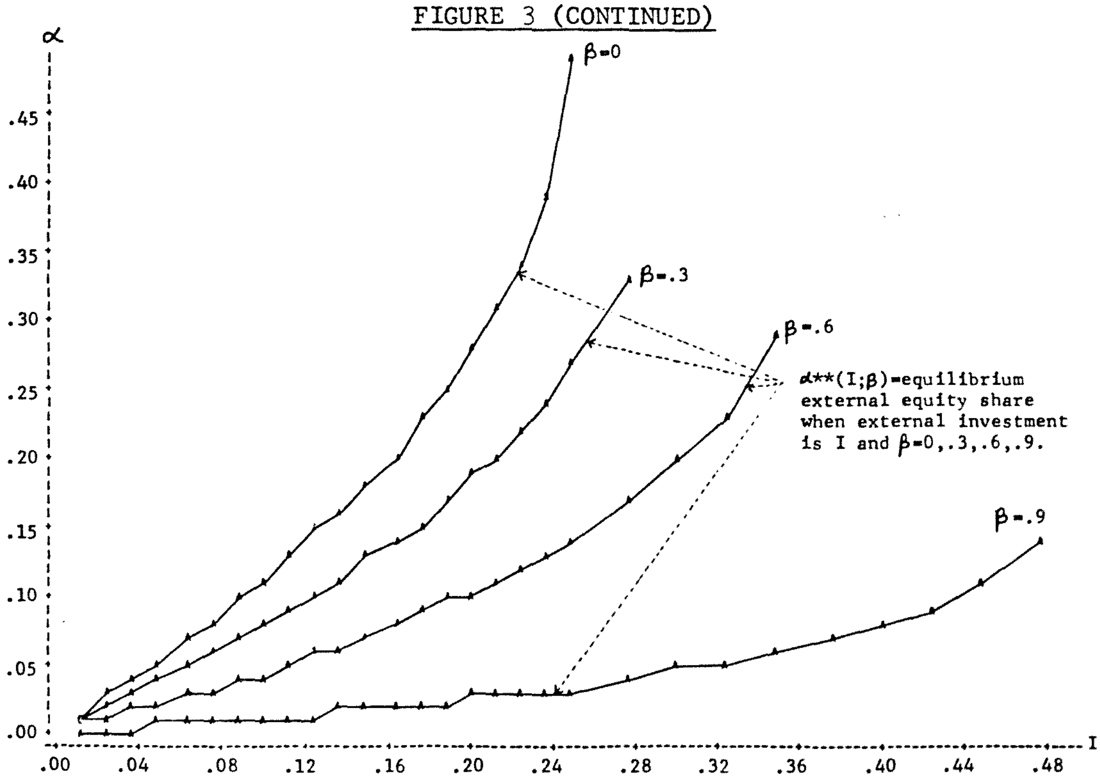
FIGURE 3

The Risk Neutral Case



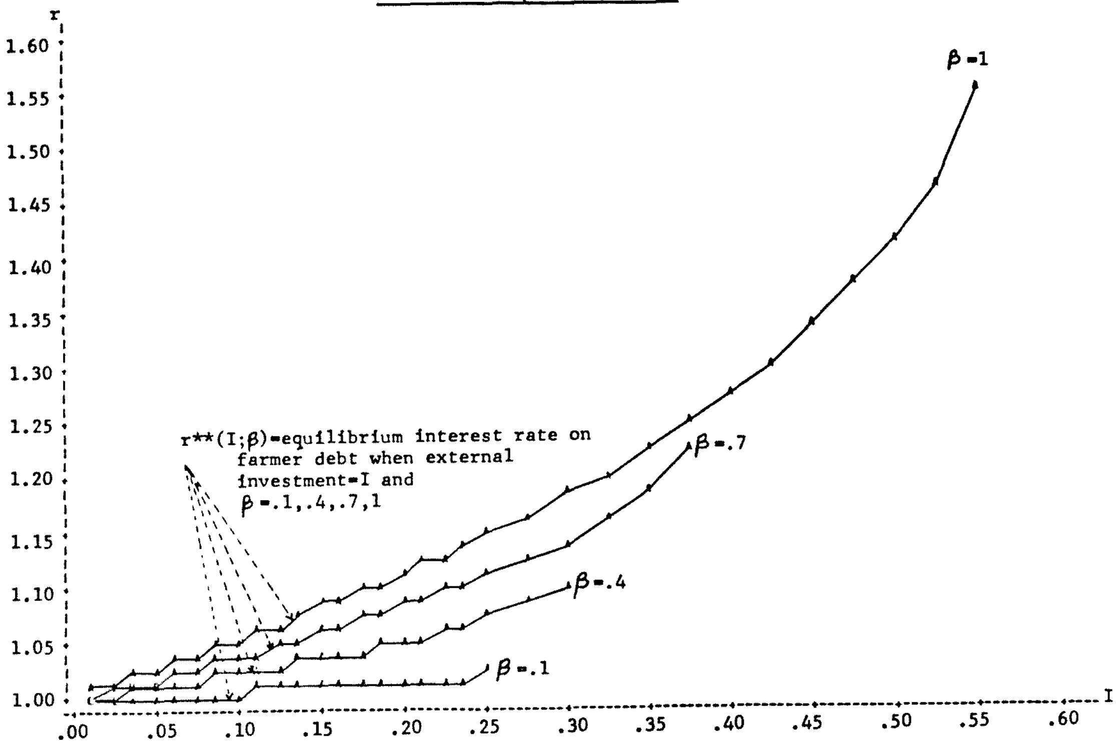
Part (a)

FIGURE 3 (CONTINUED)



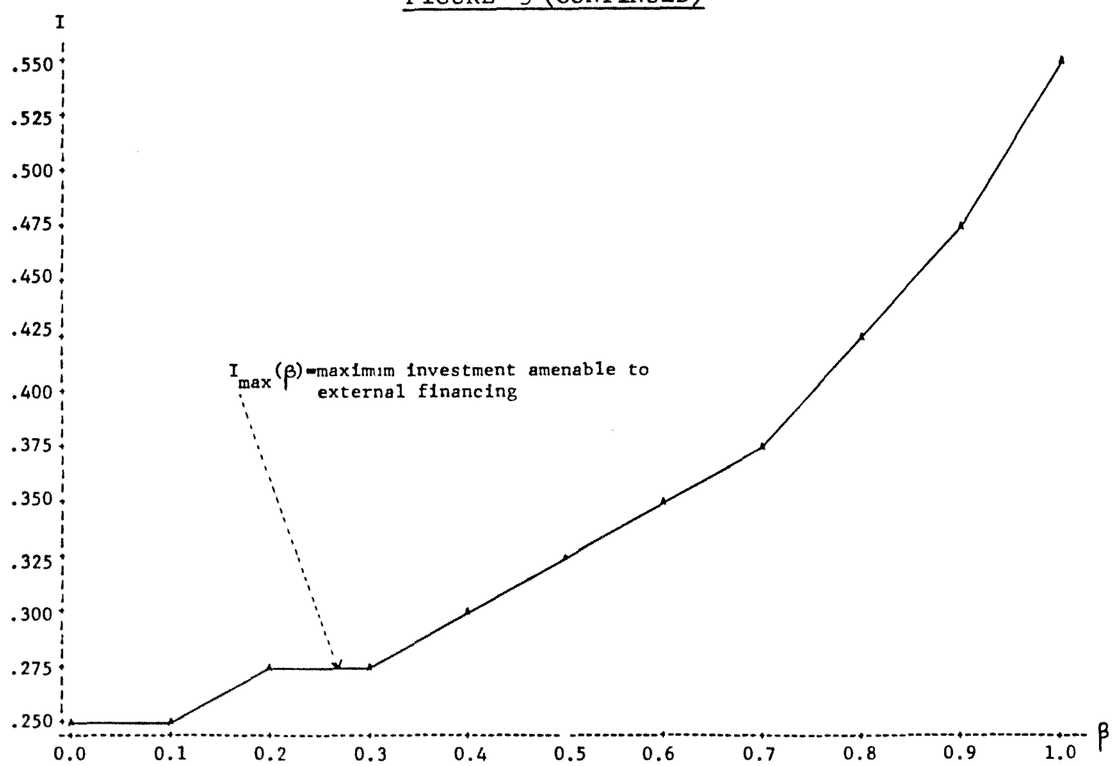
Part (b)

FIGURE 3 (CONTINUED)



Part (c)

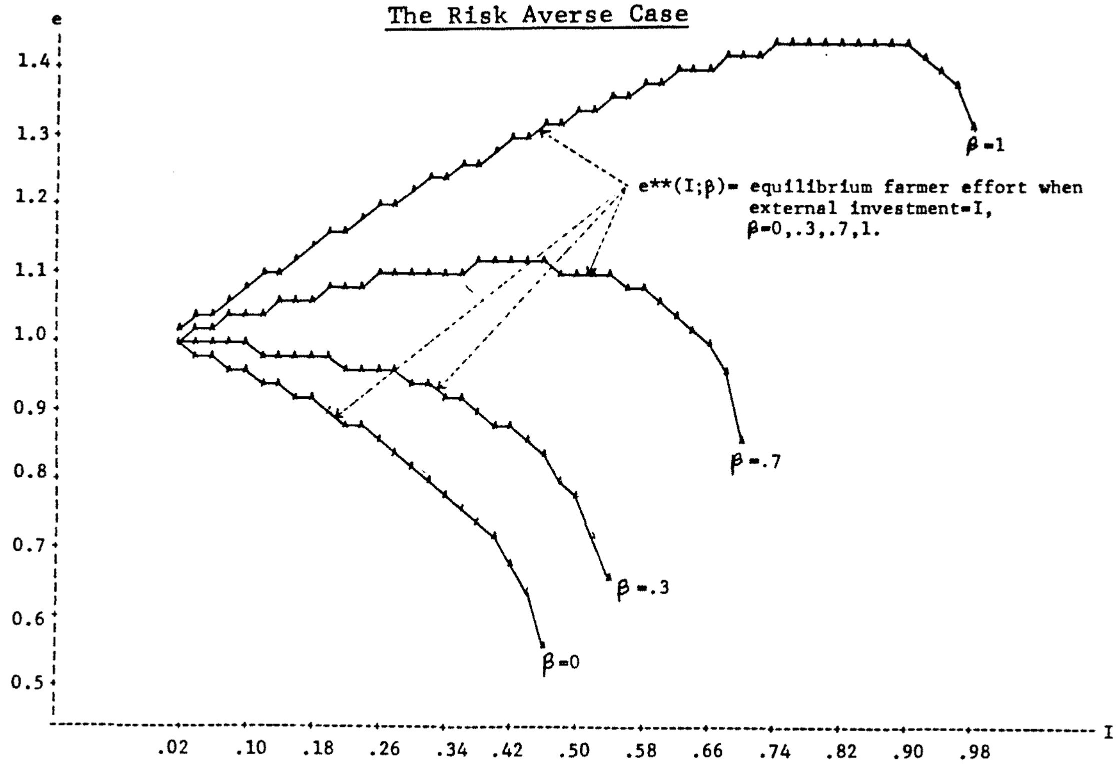
FIGURE 3 (CONTINUED)



Part (d)

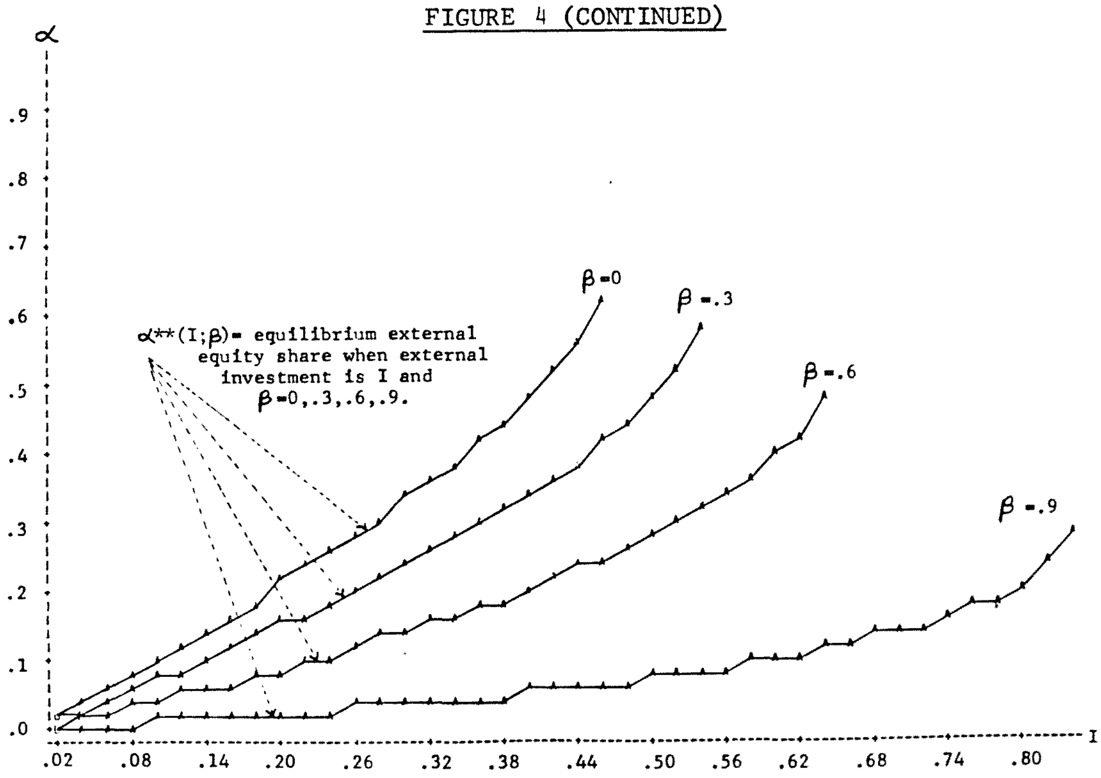
FIGURE 4

The Risk Averse Case



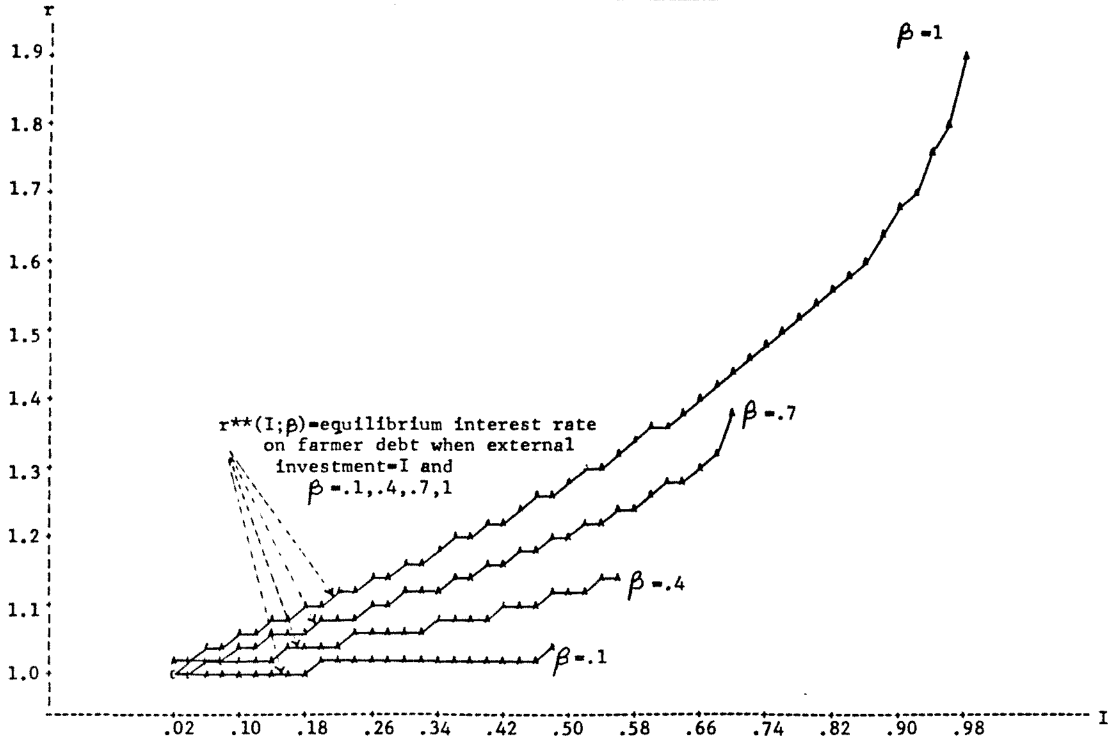
Part (a)

FIGURE 4 (CONTINUED)



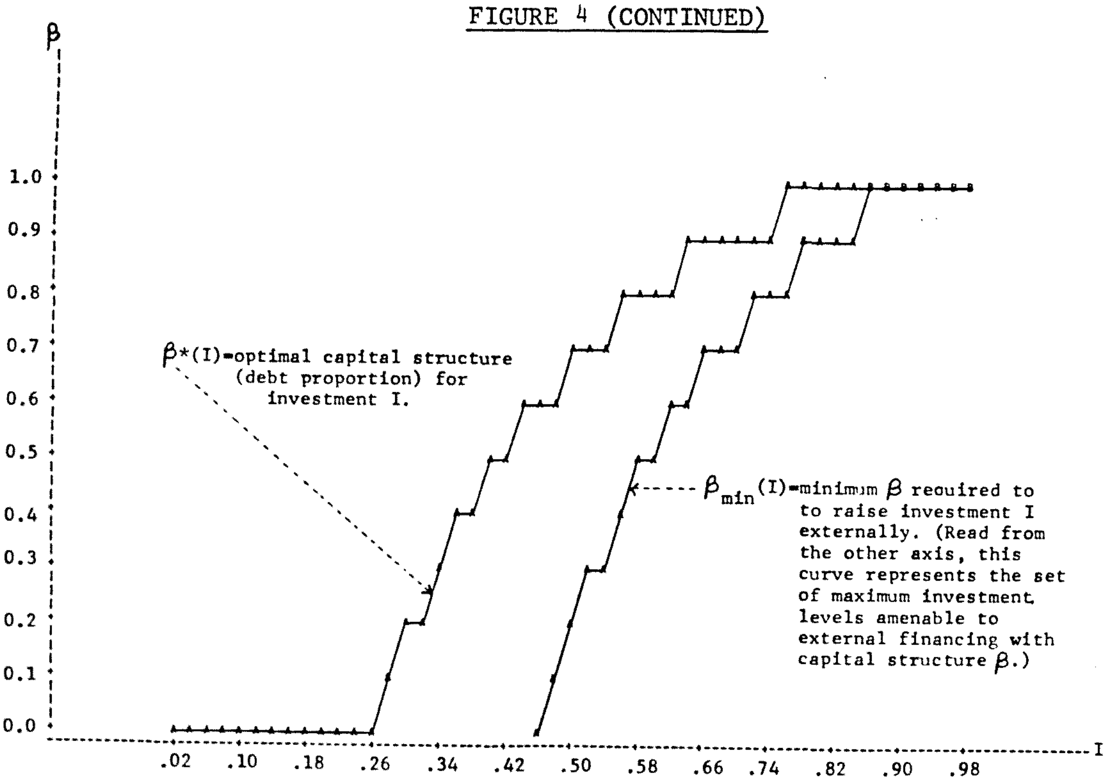
Part (b)

FIGURE 4 (CONTINUED)



Part (c)

FIGURE 4 (CONTINUED)



Part (d)