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**THEORETICAL AND EMPIRICAL ISSUES ASSOCIATED  
WITH CREDIT MANAGEMENT, LIQUIDATION AND BANKRUPTCY**

**William G. Burghardt & Lindon J. Robison**

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**Introduction**

The purpose of this paper is to introduce two deductive investment models which examine the issues of financial stress, liquidity and credit management, and investment under risk for agricultural firms. The first, and by design less complex, model will be used to present the theoretical relationships which have been incorporated into the second model, a more complete computer simulation model. Although space limitations in this paper will limit discussion of the computer simulation model to a brief discussion of its features, complete details of the model will be contained in Burghardt's dissertation. The computer simulation model will provide the means to test the theory for the test of correspondence to applied decision environments. As an alternative to presenting the results of the computer model, numerical results obtained from the simpler empirical model will be presented to illustrate the deductive theory.

The issues which the deductive and empirical models are designed to address can be introduced succinctly with the aid of a simple graph as shown in figure 1. Consider two basically different kinds of debt free firms. The first firm, the financially secure firm with its safe but low yielding asset mix, could guarantee itself a positive net cash flow without having to resort to borrowing money or investing in risky assets. As a result of the firm's positive cash flow position and decision not to use financial leverage, the firm's probability of bankruptcy would be zero,  $\text{Pr}(\text{bankruptcy})=0$ . If the firm exercised its option to invest in higher yielding yet risky assets, the lack of adequate internal resources, would necessitate borrowing capital to acquire the additional assets. Through the combination of the stochastic nature of the risky investments and the financial leverage effect caused by the use of borrowed capital the firm would be faced with an increased probability of bankruptcy (see figure 1).

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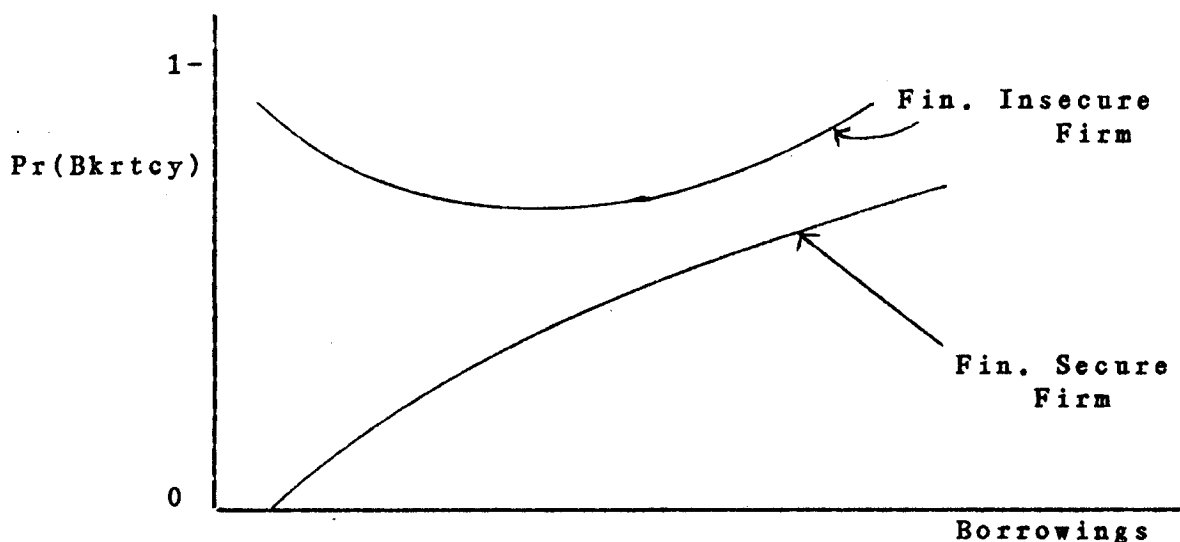


Figure 1 The Alternative Effects on the Probability of Bankruptcy of Increased Borrowings Depending on the Equity and Exogenous Cash Withdrawal Requirements of the Firm

Just the opposite relationship would be true for a financially insecure firm faced with a continuing deficit cash flow position. If the financially insecure firm's entire equity were invested in a safe investment alternative and no funds were borrowed, some portion of the firm's asset holdings would have to be liquidated to meet its cash flow requirements. If the firm maintained its investment in safe assets and continued to experience a deficit cash flow position, the probability of eventual bankruptcy would be assured,  $\text{Pr}(\text{bankruptcy})=1$ . This relationship is also illustrated in figure 1. Two quite different economic incentives, therefore exist for firms to increase their use of debt capital and both incentives depend on the firm's equity position and cash withdrawal requirements (net cash flow position). In the case of the financially secure firm, increasing the amount of funds borrowed for the acquisition of risky assets would increase both the firm's potential rate of return and its probability of bankruptcy. In the case of the financially insecure firm, however, increasing borrowings to cover a deficit cash flow position and acquisition of additional risky assets would reduce the firm's probability of bankruptcy, at least initially.<sup>1</sup>

This paper, presents a rigorously defined analytic

<sup>1</sup> It is assumed that the net rate of return on the acquired risky assets before interest expense will exceed the cost of borrowing and, thus, contribute to improving the firm's cash flow position.

investment model which explores in more detail the inter-relationship between credit reserves, liquidation costs, equity positions and cash requirements of the firm. First, however, for clarity we state the accepted definitions for credit and credit reserves. According to Barry, Hopkin and Baker credit is defined as the firm's borrowing capacity, or its ability to obtain access to additional debt capital. A firm's credit reserve represents the difference between the firm's total credit capacity and its existing debt, its unused borrowing capacity.

A credit reserve fills two major functions for a firm, it is a low cost liquidity buffer and a source of capital for the acquisition of additional assets. Research has shown that farmers, especially risk averse decision makers, use their credit reserves as a management resource in responding to both production and financial risk (Barry, Hopkin and Baker). The usefulness of credit and a firm's credit reserve depends largely on the type of financial market in which the firm operates. If we assume the market is perfect, i.e., assets can be bought and sold at the same price by all market participants, the liquidation of the firm's assets, due to a deficit cash flow would occur without cost, and the firm's credit reserve would play a minor role as a liquidity buffer. The firm's response to risk would be to adjust its holdings of those assets subject to a random rate of return. Permitting this adjustment in asset holdings is the major role credit plays in a perfect financial market.

On the other hand, if the market in which the firm's assets are traded is imperfect, the firm's credit reserve assumes a more important role in liquidity management. For example, if a firm were to experience an unfavorable outcome leading to a negative cash flow, the firm's access to a credit reserve would usually prove to be a lower cost source of liquidity than liquidating assets, which would both disrupt the firm's asset structure and impose a liquidation cost on the firm.

The other role that credit performs is to facilitate the acquisition of additional assets in response to a favorable investment opportunity. It is well documented in the finance literature that an increase in financial leverage will increase both a firm's expected profitability and its total risk position. A firm's optimal leverage position, therefore, depends upon the investor's attitudes towards risk and expected returns as determined by the properties of the decision maker's utility function. In addition, after a firm decides upon an optimal debt strategy, changes in macro and micro parameters will necessitate adjustment in the operational and organizational aspects of the firm. If an unacceptable increase in risk,

for example, is expected to persist for some time, possible alternatives would be to reduce the firm's holdings of risky assets and prepay debt, thereby reducing the firm's leverage position. However, in the near term an increase in risk combined with high cash flow obligations may jeopardize a firm's survival and bring it close to insolvency and bankruptcy. In this case, it would not be unusual to see an otherwise risk averse decision maker assume more financial leverage in response to his firm's increased probability of business failure (Robison and Lev).

Both aspects of credit reserves are important. In the models to be presented, both features are integrated into the decision maker's objective function.

### Literature Review

Several significant efforts have been made in the agricultural economics literature to model firm level borrowing behavior under risk. Sanint constructed a quadratic programming model to describe the decision making process. Postulating normal distributions associated with the variability of rates of returns on assets and interest costs (including the cost of credit), Sanint, Barry and Baker and Sanint derived the expected results which predict lower loan demand to higher expected interest costs and lower expected returns on assets. The expected interest costs were augmented, however, to account for the variance in credit availability and, hence, the value of credit used up with the firm's returns.

Another modeling effort made a similiar attempt to measure the liquidity aspect of the firm's decisions. Chen, Jen and Zions argued that if the demand for cash were stochastic, assets whose returns were high when cash demands were high would be preferred. They demonstrated this relationship, again in a mean variance model by adding a covariance term to capture the stochastic relationship.

Interest rate volatility and its affect on borrower behavior was the focus of a recent study by Leatham. He observed that lenders had shifted interest rate risk to borrowers by offering the borrowers flexible interest rate loans. Leatham's multiperiod discrete stochastic programming model predicted that farm borrowers generally would be unwilling to pay the premium required to secure a fixed interest rate loan.

A still different model has been developed by Robison and Barry. Robison and Barry recognized that credit availability would depend on the lender's perception of the borrower's financial condition. Such features as the firm's

average liquidity premium, variability of income potential and existing financial leverage would be the major factors influencing credit availability. However, the analytic interdependency and 'nearly intractible results' of their key variables forced Robison and Barry to develop their credit availability model in a rather deterministic manner based on the modeled firm's financial position in the previous period, rather than based on the current period. They stated that this timing assumption allowed them to present their model results in a more 'tractible' manner.

Robison and Brake suggested a model which also incorporated asset liquidity into their model. In their model, interactions between the borrower and lender determined credit availability to the firm. All these features, they suggested, could be developed in the context of mean-variance portfolio models. They analyze a borrowers response to single risky and safe investment opportunities using a mean-variance model under varying degrees of financial stress. Robison and Brake imposed a constraint which required the firm to meet all cash flow obligations. In the event of a deficit cash flow, and credit exhaustion, liquidation of risky assets imposed a liquidation premium on the firm. If an extremely unfavorable outcome were to occur, bankruptcy might result. The possibility of such a disastrous outcome might produce extremely risk preferring behavior on the part of otherwise risk averse manager as described by Robison and Lev in their 'Woody Chip' paper.

Robison and Lev hypothesize that a risk averse decision maker, when faced with limited liability in the event of a disastrous outcome such as bankruptcy, may select a risk preferring action choice in order to save his business. They discuss the need to map outcome variable distributions to reflect both the initial and final variable distribution. Their limited liability example demonstrates an increase in the preference for the final outcome distribution relative to the initial outcome variable. The final outcome mapping results in the truncation of the PDF distribution which makes the initially riskier distribution more attractive. With the truncation and shifting of the adverse outcomes to the 'disaster point', there may result a reversal of preference ordering of action choices for some risk averters. Robison and Lev's approach provides the theoretical basis for understanding the apparently risk preferring behavior by highly leveraged, normally risk averse decision makers who continue to borrow money when faced with increasing probability of bankruptcy.

It is apparent from the literature review and from observing borrowers and lenders that certain features of credit reserve management and optimal debt usage are important theoretically and, therefore, should be included in any

model concerning the subject. These features provide a framework for constructing the deductive model described in this paper.

First, since firms generally have opportunities to invest in both risky and riskless investments, they can choose their preferred risk/return relationship.

Second, firms have no choice but to meet cash flow obligations. In the case of unfavorable outcomes (deficit cash flows), firms may balance cash flows through increased borrowings or asset liquidation.

Third, at least part of any firm's balance sheet is composed of assets, which when liquidated, would generate less cash than the corresponding reduction in the firm's value (loss of equity). The liquidation of these illiquid assets result in the firm incurring a transaction cost which is referred to as a liquidation premium. The possibility of increasing liquidation costs either because of macro or micro variables such as stochastic cash demands or because of unfavorable outcomes relative to interest costs or asset returns is referred to here as liquidity risk.

Fourth, the credit reserve extended to the borrower by the lender can vary considerably depending on such factors as the firm's existing debt and asset structure, asset liquidation premiums, the firm's liquidity position and the borrower's variability of income and net cash flow. Increased importance must be placed on credit reserve management and measurement by both lenders and borrowers.

Fifth, it is likely that credit rationing will become an increasingly important tool for lender response to loan demand and changing economic variables. While as Barry, Baker, and Sanint have pointed out, agricultural lenders have used a number of nonprice responses to discriminate amongst their borrowers. With increased competition for higher quality loans, lenders will likely be forced to utilize more price discriminating responses in their marketing strategies in order to maintain and increase their loan portfolio volume and quality.

And last, the demand for loan funds depends on the borrowers' financial security. For instance, Robison and Lev have used their woody chip football example to demonstrate this point. Ahead in the fourth quarter, the team with the lead may choose to fall down on the ball to protect against a possible fumble or pass interception, while a team trailing in the final seconds of a game will likely go for the 'Hail Mary' pass to pull out a win. We would expect a model dealing with the issue of optimal debt useage to recognize this risk preference reversal by an otherwise risk averse



decision makers (selecting a risk preferring action choice). With these features in mind, we now turn to the first of the credit reserve models.

### Introducing the Model

The first feature considered crucial in the construction of a firm level borrowing model is asset illiquidity. An asset is illiquid if it is traded in an imperfect market. An asset price traded in an imperfect market depends on who is selling or buying. The difference between an asset's acquisition price or its sale price is the transaction cost or liquidity premium equal to  $\rho$  percent of the asset's value to its firm.

The rate of return risk is associated with investments in the risky asset. In the deductive model a single class of assets  $A_t$  are assumed risky which earn a rate of return  $(r+\epsilon)$  where  $\epsilon$  is the stochastic element with an expected mean of zero and a variance of  $\sigma^2$ . It is assumed that the assets are durables and divisible in both acquisition and sale.

The interest rate  $i$ , charged by the firm's creditors is deterministic and applies to the firm's single classification of debt  $D_t$ . Negative holdings of debt, on the other hand, represent savings by the firm, which earn the safe return ' $i$ ' percent. In this regard, our firm level model does not capture the interest rate risk modeled by Sanint, but as we will point out, does capture liquidity risk explicitly rather than including it in an ad hoc manner as an addition to interest rate risk.

The firm's beginning equity position is represented by the variable  $E_t$ . The firm's equity position is critical in the lender's assessment of the firm's borrowing potential and credit reserve. The accounting identity  $A_t = D_t + E_t$ , that is, the firm's assets in time period  $t$  equals debt plus equity, is taken as a given. A summary of the accounting relationships for this simplified model and highlights of the various cash flow reconciliation alternatives available to the firm are presented in table 1.

The firm has the option of acquiring additional risky assets ( $X_2$ ), up to the dollar limit imposed by the firm's beginning of the period restricted credit reserve. For a firm to utilize all of its available credit reserve for asset purchase, would, in the event of a deficit cash flow, force the firm to liquidate assets. In the event of forced asset liquidation, the dollar amount of the asset to be sold ( $X_1$ ) is determined as:

$$X_1 = \hat{E} - C_t^b / (1 - \rho)$$

TABLE 1  
TRANSACTION TABLE FOR A FIRM WHOSE SURVIVAL IS AT RISK  
AND WHO IS SUBJECT TO LENDER IMPOSED CREDIT LIMITS

ACTIVITIES	ASSETS	DEBT	EQUITY	CREDIT RESERVE	CASH FLOW
Beginning of Period Balance Sheet	$A_t^B + X_2$	$D_t^B - D_{t-1}^E + X_2$	$E_t^B - E_{t-1}^E$	$CR_t = L(1-\phi)E_t^B - D_t^B$	$(1+\phi)A_t^B$
Net Asset Returns					$-1D_t^B$
Interest Paid on Debt					$-W$
Cash Withdrawals					$+\hat{E}$
Cash Flow Balancing		$+\hat{E}$	$-\hat{E}$		
Cash Flow Reconciliation If: $\hat{E} > 0$ and $CR = 0$ then forced asset liquidation	$-X_1$		$-X_1$		$+X_1$
End of Period Balance Sheet	$A_t^E - A_t^B - X_1$	$D_t^E - D_t^B + \hat{E}$	$E_t^E - E_t^B - \hat{E} - X_1$		
End of Period Transactions If: $CR > 0$ and $0 < X_2 < CR$ then Acquire Assets	$+X_2$	$+X_2$		$-X_2$	
Beginning of Period Balance Sheet	$A_{t+1}^B - A_t^E + X_2$	$D_{t+1}^B - D_t^E + X_2$	$E_{t+1}^B - E_t^E$	$CR_{t+1} = L(1-\phi)E_{t+1}^B - D_{t+1}^B$	
Cash Flow Summary Statement			$(1+\phi)A_t^B - 1D_t^B - W + \hat{E} + X_2 + X_1 = 0$		

If  $\hat{E} < 0$  and  $CR = 0$ , then  $X_1 > 0$ : otherwise  $X_1 = 0$   
given  $CR > \text{deficit } \hat{E}$ .

As a result of the single risky asset classification, all positive (negative) net cash flow is used to amortize (increase) the firm's debt through the cash flow balancing equation. The firm's credit reserve is then recalculated at the end of the period to reflect the periods stochastic outcome.

### Introducing a Cash Flow Constraint

While the firm's balance sheet and income statement provide the lender with evidence of the firm's financial strength and previous operating effectiveness, it is the firm's cash flow statement which provides an indication of the firm's ability to meet its financial obligations. The firm's cash flow expression can be summarized as

$$\begin{aligned} (1) \quad \Delta E &= (r+s)A_t - iD_t - W \\ &= (r+s-i)D_t + (r+s)E_t - W \end{aligned}$$

where  $W$  equals a deterministic exogenous demand for the firm's resources. A positive cash flow ( $\hat{E} > 0$ ) permits the firm to withdraw funds for family living and apply the residual cash flow toward debt payment commitments without liquidating assets or increasing borrowings. Because the assumption of a single risky asset classification precludes holding a residual cash balance in the event of a positive cash flow in this model, the entire net cash flow after withdrawals must be applied toward the amortization of the firm's outstanding debt. Moreover, a surplus cash flow provides additional evidence to the lender that the firm is credit worthy.

In the event of a negative cash flow, either the firm must access its credit reserve and borrow additional debt to balance the deficit or in the event of exhausting the firm's credit reserve be forced to liquidate assets. In the event of liquidation the firm will incur the additional expense of liquidation equal to  $p$  percent and will likely experience a disruption to its future earnings potential. The firm's credit reserve, therefore, serves as both a liquidity buffer against adverse cash flow outcomes and as the only source of capital for the acquisition of additional risky assets.

### Derivation of the Firm's Credit Reserve

The traditional expression for a firm's credit reserve or maximum debt position is represented by

$$(2a) \quad D_t \leq LE_t$$

which can be rewritten as an equality to reflect unused borrowing capacity at time  $t$ ,  $C_t$ :

$$(2b) \quad D_t + C_t = LE_t$$

How does the lender determine  $L$ ? Clearly it should reflect the liquidity of the borrower's assets and the riskiness of the firm's investments. Let the  $\rho$  or liquidation premium reflect the liquidation premium associated with the firm's assets. The borrower recognizes that the maximum recoverable amount of the firm's assets is  $(1-\rho)A_t$ . Thus, the maximum debt available to the firm, based on the lenders's perception that  $\rho$  is the relevant liquidation premium, is

$$(3) \quad D_{t,max} = (1-\rho)A_t$$

Substituting the accounting equality  $A_t = D_{t,max} + E_t$  for  $A_t$ , the firm's maximum debt can be expressed as:

$$(4) \quad D_{t,max} = (1-\rho)E_t / \rho$$

Thus, the leverage ratio  $L$  in (2a) can now be related to the firm's liquidity position by the expression:

$$(5) \quad L = (1-\rho) / \rho$$

Replacing the firm's maximum debt level  $D_{t,max}$  with its existing debt plus the unused borrowing capacity  $C$  yields the firm's credit constraint:

$$(6) \quad C_t = (1-\rho) / \rho E_t - D_t$$

Clearly  $C_t$  decreases with an increase in either  $\rho$  and or  $D_t$ , and will increase with an increase in the firm's  $E_t$ :

$$dC_t / d\rho < 0$$

$$dC_t / dD_t < 0$$

$$dC_t / dE_t > 0$$

#### Derivation of the Firm's Critical Bankruptcy Outcome: $\varepsilon_0$

To model the liquidation feature of a firm's credit reserve and to endogenize the probability of bankruptcy, we need an expression which combines both the firm's credit reserve with the cash flow expression. The outcome of the stochastic element  $\varepsilon$ , associated with the firm's risky asset rate of return determines the response behavior of the firm. If the  $\varepsilon$  outcome is such that  $\hat{E} > 0$  and the firm's credit reserve exceeds the cash flow deficit, the firm will borrow additional debt. However, an  $\varepsilon$  outcome such that  $\varepsilon < \varepsilon_0$ , where  $\varepsilon_0$  represents the firm's critical bankruptcy point,

will result in complete liquidation of the firm's assets.

To solve for the critical  $E_0$  expression, we insert into the firm's end-of-the-period credit reserve expression the change in equity  $E$  and debt associated with the effects of the cash flow results:

$$(7) \quad C_t^e = (1-\rho)/\rho(E_t^b + \hat{E}) - (D_t^b - \hat{E})$$

Suppose the outcome  $\varepsilon_0$  exhausts the firm's credit reserve. To solve for the critical  $\varepsilon_0$  point, substitute  $\varepsilon_0$  for  $\varepsilon$  in the cash flow expression, and then substitute the cash flow expression (1) into the credit reserve equation set equal to zero. The result is:

$$(8) \quad \varepsilon_0 = (D_t - LE_t)/(1+L)(D_t + E_t) + (W + iD_t)/(D_t + E_t) - r$$

A graphic illustration of  $\varepsilon_0$  is presented in Figure 2. The location of  $\varepsilon_0$  in Figure 2 is the firm's bankruptcy or disaster outcome. For outcomes of  $\varepsilon_0$  and below, the firm has exhausted its credit reserve. Further, because the firm's equity is only sufficient to cover liquidation costs, the firm is technically insolvent and would be bankrupt at  $\varepsilon_0$ . The probability of bankruptcy is the cumulative distribution of the probability distribution described in Figure 2 or  $F(\varepsilon_0)$  as described in Figure 1 when:

$$(9) \quad F(\varepsilon_0) = \int_{-\infty}^{\varepsilon_0} f(\varepsilon) d\varepsilon$$

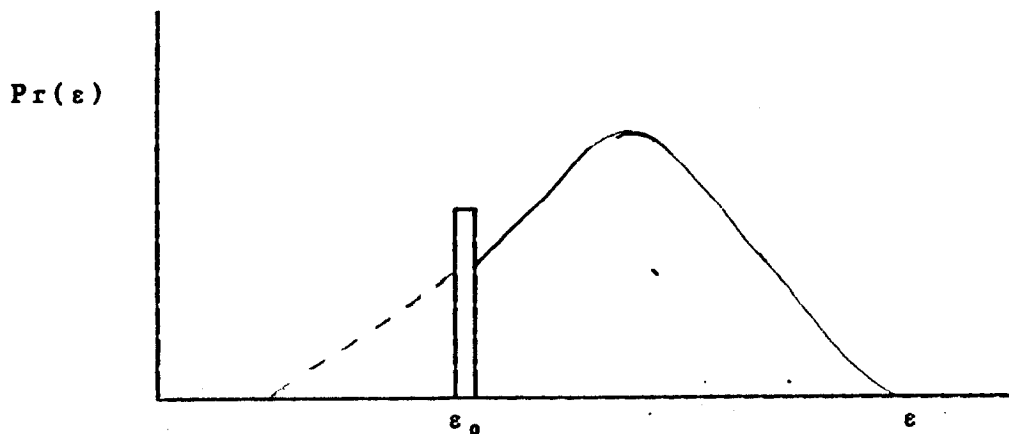


Figure 2 The Probability Density Function Associated with Stochastic Returns on Investments

The value of  $\varepsilon_0$  changes and, hence, the cumulative distribution  $F(\varepsilon_0)$  changes unambiguously in response to increases in  $r$ ,  $i$ ,  $W$ , and  $E_t$ :

$$dF(\varepsilon_0)/dr < 0,$$

$$dF(\varepsilon_0)/di > 0,$$

$$dF(\varepsilon_0)/dW > 0, \text{ and}$$

$$dF(\varepsilon_0)/dE_t < 0$$

The changes in the likelihood of bankruptcy, however are ambiguous in response to a change in the firm's debt holdings. In fact,

$$\begin{aligned} (10) \quad dF(\varepsilon_0)/dD_t &= f(\varepsilon_0) \partial \varepsilon_0 / \partial D_t \\ &= f(\varepsilon_0) [(1+i)E_t - W] / (D_t + E_t)^2 \quad \leq 0 \end{aligned}$$

The ambiguous results in equation (10) is the same as was described in Figure 1. For the financially secure firm, if the firm's safe earnings plus its equity is sufficient to meet exogenous cash requirements,  $W$ , the probability of bankruptcy without debt is zero. Increasing the firm's holdings of risky assets can only increase its likelihood of default. For the financially insecure firm which cannot meet exogenous cash requirements without borrowing, it is only by increasing debt obligations, and  $(r+\varepsilon)i$  that the likelihood that the firm will go bankrupt can be reduced below 1.

The important feature which the model just described contains is its interaction between the stochastic earnings of the firm and the credit extended by the lender. By restricting cash flows to be satisfied, the credit is automatically adjusted. Thus, the model captures what many have claimed to be an important feature of firm borrowing behavior.

#### Determining the Firm's 'Restricted' Credit Reserve

Although the first credit reserve expression incorporated the lender's 'theoretical' maximum leverage ratio,  $L = (1-p)/p$ , in practice, most lenders are far more conservative and use a leverage ratio such that  $L < L_{\max}$ . This restricted leverage ratio can be expressed as:

$$(11) \quad L = (1-p)(1-\delta)/p$$

where  $(0 < \delta < 1)$  and at the theoretical  $L_{\max}$ ,  $\delta = 0$ .

Using this restricted leverage ratio provides for differentiation between the liquidation costs associated

with collateral valuation  $p$ , and allows for the introduction of a creditworthiness variable  $\delta$ . The delta  $\delta$  can be constructed to reflect a weighted composite variable consisting of such factors as prior years' credit performance, enterprise risk, and financial position. To illustrate the use of the restricted leverage ratio, note that when  $\delta=0$  and  $p=.2$  then  $L_{res}=4.0$ . If we assume a  $\delta$  of .25 is associated with excellent credit, the lender's recommended restricted leverage ratio for the firm is 3.0. Now in the case of a firm with a poor credit rating or high operational risk exposure, we could assign a  $\delta=.75$  with the result being a recommended leverage ratio of 1.0. This approach to determining the appropriate leverage ratio to use combines both credit administration and collateral liquidation guidelines for the particular farm operation being analyzed.

Incorporating this leverage ratio into our model results in the following expression for the firm's restricted end of the period credit reserve:

$$(12) C_t^e = (1-p)(1-\delta)/p (E_t^b + \hat{E}) - (D_t^b - \hat{E})$$

Now to solve for the firm's credit exhaustion point, that is the point where  $C_t=0$ , substitute  $s_1$  for  $s$  in the cash flow and credit reserve<sup>t</sup> expressions and solve for  $s_1$ :

$$(13) s_1 = pD_t^b - (1-p)(1-\delta)E_t^b / ((1-p)(1-\delta) + p)(D_t^b + E_t^b) + (iD_t^b + W) / (D_t^b + E_t^b) - r$$

The sign on each of the  $s_1$  derivatives is unambiguous and is as expected with the exception of  $ds_1/dD_{t-1}^e$  derivative. In addition, the sign on each of the  $s_1$  derivatives is the same as for those obtained for the  $s_0$  derivatives.

Using a leverage ratio  $L < L_{max}$  results in a second partition point on the probability density function distribution for  $s$ . This enhancement along with truncating the probability of bankruptcy ( $s < s_0$ ) at  $s_0$  is illustrated in Figure 3. Because of the probability shift from the left hand tail of the PDF, the new distribution is absolutely less risky than the initial untruncated distribution for  $s$ . In response to this decreased risk, the firm's optimal debt solution will be higher, reflecting both the firm's increased expected mean rate of return and reduced variance from the initial  $s$  distribution. This increase in the expected mean value and reduction in variance increases the expected utility of the final impact distribution for the risk averse decision maker while increasing the probability the firm will go bankrupt ( $s_0$  shifted right).

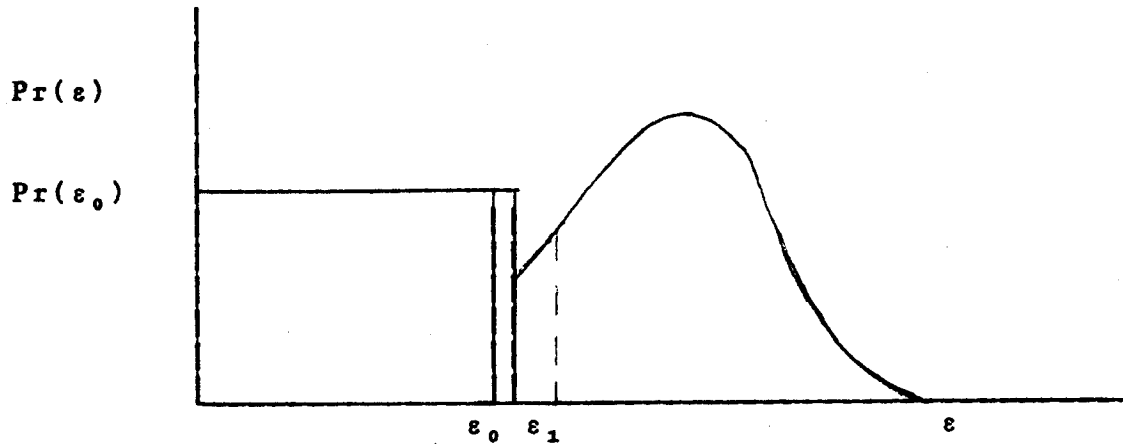


Figure 3 The Probability Density Function Illustrating the Credit Reserve Exhaustion:  $\varepsilon_1$  Point

With the introduction of the restricted credit reserve, the firm must now approach investment decisions recognizing its options include not only a 'declaration of bankruptcy' point but also a credit reserve 'exhaustion' point. With this as an introduction to the deductive model, we now operationalize the model to investigate empirically the effect that changing each independent variable has on the firm's optimal debt position and credit reserve management.

#### Empirical Evaluation of the Credit Reserve Model

To validate the test of workability and correspondence, the restricted credit reserve model was operationalized and solutions were obtained for a baseline set of input assumptions.

These baserun assumptions were:

<u>Symbol</u>	<u>Input Variable</u>	<u>BaseRun Value</u>
$A_t^b$	Beginning Total Asset Position	100,000
$D_t^b$	Beginning Total Debt	25,000
$E_t^b$	Beginning Equity Position	75,000
W	Exogeneous Cash Withdrawals	2,000
p	Liquidity Premium	.15
δ	Credit Policy Variable	.5
i	Interest Rate on Debt	.10
r	Average Expected Net Rate of Return before Interest Expense	.12
λ	Absolute Risk Coefficient	.00001



$$\begin{array}{ll} L_{\max} = 5.67 & C_t^b = 400,000 \\ L_{\text{res}} = 2.83 & C_t^b = 187,500 \end{array}$$

Five possible rates of return for  $r$  were used: .05, .07, .10, .16, and .22 with the stochastic term  $\varepsilon$  having a mean of zero and a variance of  $\sigma^2$ . The positive lamda value for the absolute risk coefficient indicates risk averse nature on the part of the decision maker. The assumption of a positive risk aversion coefficient is consistent with previous research findings for agricultural decision makers.

Given the initial deterministic and stochastic input parameters, the hypothetical firm's optimum debt position is 183,951 dollars. Based on the initial debt position of 25,000, the firm would maximize its end of the period equity position if it were to acquire an additional 158,951 in risky assets by using 100 percent debt capital. With a beginning of the period credit reserve of 187,500 dollars, after the purchase of the assets the firm had 28,549 dollars available for a liquidity buffer against a possible deficit cash flow. The firm's optimal debt position represented 86.6 percent of the firm's credit capacity.

It is important to note, however, that the firm can not absorb a loss equal to 28,549 without resulting in a deficit credit reserve at the end of the fiscal period. As a consequence of the dual but offsetting action that a deficit cash flow has on both the firm's debt and equity accounts (see Table 1), the maximum operating loss which the firm could incur while maintaining a end of the period restricted credit reserve equal to zero is 7448 dollars. The maximum operating loss 'maxloss' which the firm can experience before exhausting it's restricted credit reserve is obtained with the expression:

$$(14) \text{ maxloss} = [(E_t - p\alpha)(1-p)(1-\delta) - p(D_t - (1-p)\alpha)] / ((1-p)(1-\delta) + p)$$

$$\text{where} \quad \alpha = [|C_{t,\text{res}}^b| / (1-p)] * 2$$

In the worst case, a maximum operating loss of 31,851 would force the firm into bankruptcy ( $\varepsilon < \varepsilon_0$ ).

Table 2a and 2b presents the sensitivity of the firm's optimal debt solution based on the baseline parameters for selected percentage changes. As the table 2a highlights, there is nearly symmetric adjustment of the optimal debt solution over the +/-50 percent range for assets, debt and exogeneous cash withdrawals. Senitivity of

Table 2a

	<u>ASSETS #</u>			<u>DEBT *</u>			<u>EQUITY</u>			<u>WITHDRAWALS</u>		
	VARIABLE VALUE	OPTIMAL DEBT	% CHANGE	VARIABLE VALUE	OPTIMAL DEBT	% CHANGE	VARIABLE VALUE	OPTIMAL DEBT	% CHANGE	VARIABLE VALUE	OPTIMAL DEBT	% CHANGE
+50Z	\$ 150,000	\$ 310,875**	69.00	\$ 37,500	\$ 152,220	-17.25	\$ 112,500	\$ 279,143#**	57.75	\$ 3,000	\$ 180,736	-1.75
+25Z	125,000	247,413**	34.50	31,250	168,087	- 8.62	93,750	231,547**	25.87	2,500	182,343	- .87
+ 1Z	101,000	186,490	1.38	25,250	183,318	- .34	75,750	184,586	.35	2,020	183,886	- .04
<u>Base Run</u>	100,000	183,951	---	25,000	183,951	---	75,000	183,951	---	2,000	183,951	---
- 1Z	99,000	181,411	- 1.38	24,750	184,586	.35	74,250	182,047	- 1.04	1,980	184,014	.03
-25Z	75,000	132,212@	-28.13	18,750	199,815	8.62	56,250	146,981	-20.10	1,500	185,559	.87
-50Z	50,000	62,669@	-65.93	12,500	215,682**	17.25	37,500	97,439	-47.03	1,000	187,167	1.75

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# holds debt at \$25,000; changes equity

\* holds assets at \$100,000; changes either Debt or Equity

\*\* still less than Credit Reserve Restricted

@ Equity equals Assets, greater than \$100,000

@ Optimal Debt is greater than Credit Reserve Restricted

Table 2b

BONEDELTAINTEREST  
RATEAVERAGE RATE  
OF RETURN

	VARIABLE		Δ	VARIABLE		Δ	VARIABLE		Δ	VARIABLE		Δ
	VALUE	OPTIMAL DEBT	CHANGE	VALUE	OPTIMAL DEBT	CHANGE	VALUE	OPTIMAL DEBT	CHANGE	VALUE	OPTIMAL DEBT	CHANGE
+50%	.225	\$ 117,886	- 35.91	.75	\$ 98,570	- 46.42	.15	\$ 25,000	- 86.4	.180	\$ 212,500**	15.52
+25%	.1875	145,072	- 21.14	.625	142,567	- 22.50	.125	25,000	- 86.4	.150	212,500**	15.52
+ 1%	.1515	182,079	- 1.02	.5050	182,342	- .87	.1010	183,362	- .32	.1212	184,956	.55
Base Run	.15	183,951	---	.5	183,951	---	.10	183,951	---	.12	183,951	---
- 1%	.1485	185,857	1.04	.4950	185,556	.87	.099	184,544	.32	.1188	182,956	- .54
-25%	.1125	259,784	41.22	.375	222,944	21.20	.075	212,500*	15.52	.09	25,000	-86.41
-50%	.075	373,918	103.27	.25	259,753	41.21	.05	212,500*	15.52	.06	25,000	-86.41

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\* Credit Reserve Maximum is less than the Optimal Debt but  
greater than the Credit Reserve Restricted

\*\* The Optimal Debt is greater than the Credit Reserve Restricted

the equity account shows that a 25 percent increase in equity, holding all other variables constant, resulted in a 25.9 percent increase in optimal debt from the baseline scenario, while a 25 percent reduction in the firm's equity reduced optimal debt by 20.1 percent.

For the liquidation premium ( $p$ ) and credit policy ( $\delta$ ) variables the results were quite different (table 2b). For example, a 50 percent reduction in  $p$ , the liquidation premium, to .075 increased the firm's optimal debt position to 373,918 dollars, a 99.4 percent increase from the baseline result. However, a 50 percent increase in  $p$  reduced the firm's optimal debt by 35.9 percent. Similar percentage changes in the  $\delta$  variable yielded less variability in the firm's optimal debt level.

Finally, the interest rate and expected net rate of return variables demonstrated equal but opposite rate of change in the firm's optimal debt strategy beyond a threshold level. For example, given a baserun analysis with a 10 percent interest rate resulted in an optimal debt level of 183,951. As the interest rate is increased, optimal debt gradually declines but within a relatively small percentage point range around the baseline result. For the interest rate variable (holding all other variables constant), the debt usage threshold is between 11.563% and 11.63%. At this interest rate level the firm's optimal debt strategy declines to the firm's initial debt position of 25,000. At the threshold interest rate defined as  $i > (r+s)$ , the firm should minimize its use of debt.

Similar but opposite results were achieved for the net rate of return variable as an increase in  $r$  resulted in a favorable (leftward) shift in the  $s_0$  and  $s_1$  expressions. This shift reduced the firm's probability of bankruptcy and thus lessen the likelihood of credit reserve exhaustion. This is reflected in the fact that the firm's optimal debt strategy was to use 100 percent of the firm's available restricted credit reserve for the purchase of additional risky assets.

The base run analysis confirms the sign on all of the partial derivatives for the  $s_0$  and  $s_1$  expressions. Because of the interactive complexity between the variables and the magnitude of the variables, caution must be used in drawing conclusions or extrapolating results that go much beyond the specific parameter values examined. Keep in mind that only one case example was presented in this paper. Additional simulation for different initial debt to equity cases along with a larger number of stochastic rates of return would provide useful insight.

Further, it should be noted that empirical evaluation of this credit reserve model over a wide range of input parameter specifications produced simulated results which were consistent with the Robison and Lev risk preference reversal hypothesis. The results indicated that a risk averse decision maker if faced with increasing probability of business failure would select an optimal debt strategy that called for still greater use of debt. The selection of increased debt useage in this situation is in response to the rightward shift of the bankruptcy truncation point  $s_0$  (refer to figure 3), accompanied by an increased mean expected rate of return and reduced variance of outcome. In summary, the decision makers only hope for survival is to accept the additional debt and hope for a favorable stochastic draw. In the next section, a brief description of Burghardt's enhanced computer simulation thesis model will be presented.

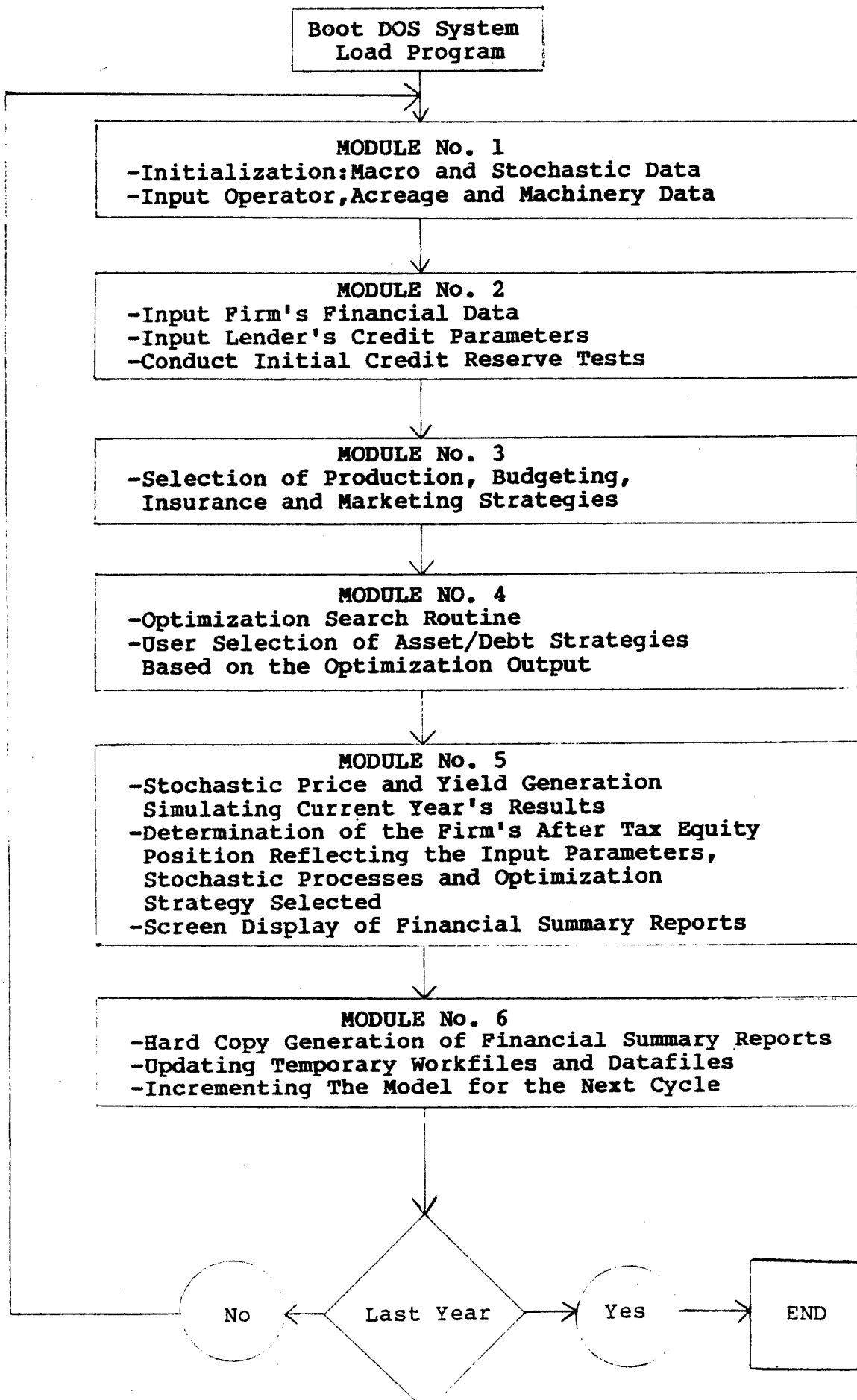
### Computer Simulation Model

The intertemporal computer simulation model was designed to integrate the deductive credit reserve theory of the firm presented earlier with the production, marketing and risk management strategies of a typical midwest cash grain farm. The computer model provides for categorizing assets and liabilities into three groups current, intermediate and fixed/long term. In conjunction with this grouping of the balance sheet categories, the firm's credit reserve measurement is expanded to include eight credit reserve calculations, a maximum and restricted reserve for each category along with integrated maximum and restricted credit reserve measures for the firm as whole.

A management simulation model of this type provides an excellent pedagogical tool for incorporating the complexities of decision making under uncertainty with the latest advances in financial and economic theory such as expected utility theory and integrated risk management. A well designed user-friendly software program written for use with micro computers provides a low cost interactive format for both educational and applied decision making purposes.

Due to software programming limitations with compiled basic along with accessible RAM memory allocation constraints, the model was designed in modules. Refer to Figure 3 for an overview of the model's flow chart. Each of the model's six modules contains between 6 to 13 related subroutines which leads the user through the input, production, marketing and financial functions of the firm. The program permits the user to supply his/her own input values while also providing for access to standardized production budgets, all-risk insurance information, crop price

## SIMULATION MODEL FLOW CHART



forecasts and marketing strategies for ease of initializing the model.

Once the firm's historical balance sheet and supporting information has been entered the model begins an exhaustive iterative search for the production strategy which will optimize the firm's after tax equity position. During the search routine the firm's expected utility position is evaluated and compared to the results from all other possible land (owned and leased) and machinery combinations based on the firm's beginning of the period available resources. The firm's available credit reserves, cash availability for investment and the projected operational cash flows from each strategy are incorporated to arrive at the recommended financial and operations strategy.

The user is then given the choice of selecting up to the recommended investment strategy or hold the firm's asset position at its present level. The model will then generate stochastic yields and prices to simulate an actual cash flow outcome for the period. The user is then provided with an option to select from a complete set of financial and operational reports to review his/her performance for the period under the strategies selected. In summary, the simulation model therefore provides an educational environment for incorporating the complexities of financial and operational decision making under uncertainty while permitting the user to benefit from the timeliness of micro computer based analysis.

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