The Financial Economics of Agriculture and Farm Managment

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Abstract

Financial economics of agriculture and farm management is the study of capital allocation in the agricultural production process. Financial decisions in agriculture focus on the use of equity or debt with the majority of the agricultural operations financing through debt. This chapter reviews theoretic models used in understanding the farm financial market and discusses relevant empirical studies. We discuss capital market theory, the market for farmland, the Capital Asset Pricing Model, DuPont Analysis, risk balancing/optimal debt, and credit rationing.

1 Introduction

Economics is the study of the allocation of scarce resources. A subfield of economics, agricultural economics, focuses on the analysis of policies in the agriculture and food and fiber sectors of the economy. The area of financial economics of agriculture and farm management is the study of capital allocation in the agricultural production process. By capital, we are referring to a stock of pre-produced goods, including machinery and other productive inputs used in production; natural resources such as land; and financial capital.

This overall definition of agricultural finance is somewhat different than standard undergraduate textbook definitions. One approach to agricultural finance is from the standpoint of **Financial Management** that studies an individual farm operator's financial decisions. For example, should a farmer buy a tractor or tract of farmland? If the farmer purchases the tractor, how should it be financed? Alternatively, more general economics courses may frame the problem in the context of **Financial Economics** that studies the supply and demand for capital including the effects of monetary and fiscal policy. The approach taken here is the "middle ground," discussing the general market for assets and ownership.

In agricultural finance, a farmer must obtain use rights to inputs used in production. A farmer must rent or purchase land; obtain the services of machinery such as tractors; purchase inputs that will be consumed in the production process such as fertilizer and hired labor; and access financial capital. To obtain these resources, the farmer could use own savings or obtain financial resources from other individuals through contracts (e.g., either debt contracts that specify a fixed return to a lender or equity agreements that specify arrangement to a share of the profits from the production activity). Hence, financial analysis involves two markets: (1) the market for physical or real capital, and (2) the market for financial capital. Financial decisions are defined by the acquisition of inputs in both the real capital and financial capital markets.

For a variety of reasons that we will develop through this chapter, the farmer can choose to finance production through equity or debt. In agriculture, the most common practice is to finance through debt. However, the debt market is not homogeneous. We discuss three sections of the debt market based on the time covered by the contract and for what the proceeds of the loan are to be used:

- **Operating Credit** (operating capital) is the short-term credit market used to purchase inputs that are used up in a single production period (i.e., fertilizer, fuel, labor).
- **Intermediate Credit** is associated with the purchase of factors of production that have a life greater than one year but less than ten years (i.e., combines, tractors, and buildings).
- **Long-term Credit** (trade credit) is associated with the purchase of long-term assets such as farmland (real estate debt).

These lines of credit are not set-in-stone because cash can be fungible. There may be farmers who use cash generated through long-term borrowing to meet short-term capital needs.

In this chapter, we will focus on the agricultural debt market to discuss capital market theory, the market for farmland, the Capital Asset Pricing Model, DuPont Analysis, risk balancing/optimal debt, and credit rationing. This discussion marks a difference between agricultural finance and the more general discipline of finance which focuses primarily on the valuation of traded instruments such as stocks and bonds.

2 Austrian and Neoclassical Capital Market Theories

The discussion on the value of production assets and ownership has evolved through different schools of thought. There is a tendency in most modern capital theory to abstract away from the asset to focus on the "aggregate value of capital". When we do so, we are no longer concerned with tractors, but with the dollar value of tractors plus the dollar value of combines. One of the primary contributions of the Austrian theory of capital was the focus on **Real Capital**. The Austrian school contends that the focus on dollars of capital confuses or hides the value of the real capital item. For example, consider Roscher's development of capital:

> Suppose a nation of fisher-folk, with no private ownership in land or capital, dwelling naked in caves and living on fish caught by hands in pools left by the ebbing tide. All the workers here may be supposed equal, and each man catches and eats three fish per

> day. But now one prudent man limits his consumption to two fish per day for 100 days, lays up in this way a stock of 100 fish, and makes use of this stock to enable him to apply his whole labour-power to making a boat and a net. By the aid of this capital he catches from the first perhaps thirty fish a day.
>
> Here the Physical Productivity of capital is manifest in the fact that the fisher, by aid of capital, catches more fish than he would otherwise caught - thirty instead of three. Or to put it quite correctly, a number somewhat under thirty. For the thirty fish which are now caught in a day are the result of more than one day's work.... In this surplus is manifested by the physical productivity of capital (Bawerk, 2007, II.I).

The question asked by Roscher and the other Austrians was how much value proceeds from the physical item (i.e., the fish net and boat) versus from the investment activity (i.e., the fact that the fisherman lives on less fish for a time to construct the boat and net). There is also an implicit capital market. Suppose that one person is willing to forgo consumption while another builds the net and boat (e.g., the first person invests in the net or boat by paying for the second person's consumption while building the boat or net). What is the return to the physical asset versus the capital investment? The real asset has a claim on the return; in essence, a portion of the return is the value of the marginal product of the boat. Based on the Austrian theory, we separate the physical asset from the purchasing power.

In the modern context, there is a supply and demand for physical assets such as tractors and other equipment. A tractor has a marginal value product (MVP) over time (a technique that accounts for the time value of money discussed later). In an efficient market, the present value of this MVP should equal the cost of purchasing the tractor. This relationship should hold no matter the source of financing (i.e. either through equity or debt). The source of financing, either by forgoing consumption or by investment, implies a price of acquiring capital in the capital market. This price of postponed consumption dictates the present value of capital. We should stress at this point that macroeconomic policies could affect the capital market through the effect of these policies on interest rates.

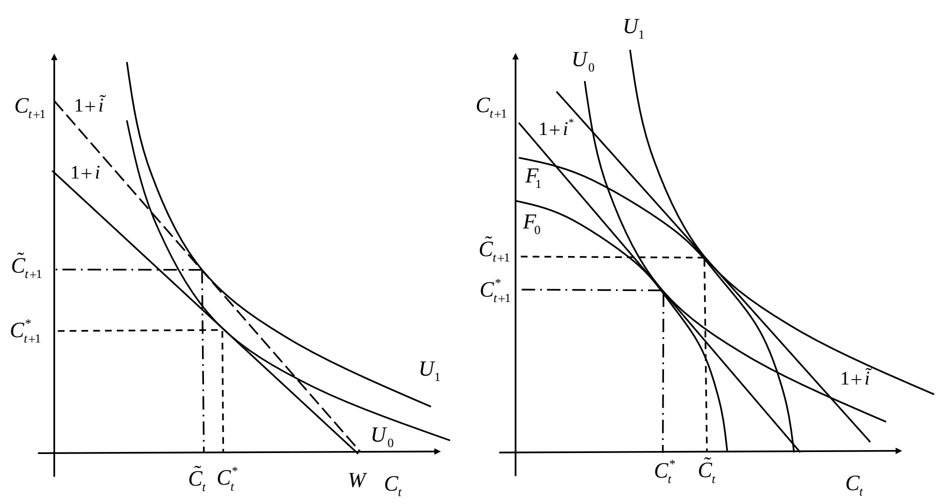
To develop the neoclassical capital market, we start with a slight reformation of the consumer's optimization problem

$$\begin{aligned} &\max_{C_t, C_{t+1}} U\left(C_t, C_{t+1}\right) \\ &\text{s.t. } C_t + \frac{1}{1+i} C_{t+1} \leq W \end{aligned} . \tag{1}$$

where C_t is the consumption at time t, C_{t+1} is the consumption at time $t+1$, i is the market interest rate, and W is the consumer's initial wealth which is often referred to as the endowment. To understand the implied investment problem, consider the implications of the budget constraint. Rearranging the budget inequality in Equation 1 slightly yields

$$C_{t+1} \leq \left(W - C_t\right)(1+i) \tag{2}$$

The consumption in period $t+1$ is the principal invested plus interest rate earned by investing in the capital market. Hence, the consumer's problem involves finding the point where the marginal rate of substitution of consumption between periods equals the return in the capital market. This point is depicted as the combination $\left\{ C_t^*, C_{t+1}^* \right\}$ in Figure 1(a). In Figure 1(a), the quantity $W - C_t^*$ is invested at time t so that $\left(W - C_t^*\right)(1+i)$ is available for consumption at time $t+1$.



(a) Consumption Choice with Investor as Price Taker

(b) Consumption Choice with Investor in Robinson Crusoe World

Figure 1: Consumption decisions between two periods in time

Next, consider what happens if the interest rate increases from i to $\tilde{i}$. As depicted in Figure 1(a), an increase in the interest rate from i to $\tilde{i}$ causes consumption at time t to decline (e.g., because consumption at time t has become relatively more expensive in terms of consumption at time $t+1$). Hence, the optimal decision involves investing more today (e.g., $W - \tilde{C}_t > W - C_t^*$) and as a result the amount consumed in period $t+1$ ($\tilde{C}_{t+1}$) increases. Note that this increase in consumption at time $t+1$ is due to two factors: (1) the increased interest rate implies that the return on investment increases so the same level of investment at time t will yield a higher rate of consumption at time $t+1$, and (2) the consumer chooses to invest more, thus decreasing consumption at time t to shift consumption to time $t+1$.

Building on the basic consumer model presented in Figure 1(a), we add the concept that the consumer is also a producer in Figure 1(b). Specifically, we replace the standard budget line that we have used to represent the capital market with a production possibilities frontier. Thus, we assume that the individual makes a decision to produce combinations of goods at time t and $t+1$ which the individual then consumes. In this case the consumer maximizes utility by equating the marginal rate of substitution for the utility function (e.g., the ratio of the marginal utility of consumption at time t to the marginal utility of consumption at time $t+1$) with the marginal rate of transformation for the production possibility frontier (e.g., the ratio of the marginal cost of production at time t to the marginal cost of production at time $t+1$). This tangency yields an implicit interest rate (i.e., relative price of consumption at time t in terms of consumption at time $t+1$) comparable with the preceding formulation. The formulation in Figure 1(b) is often referred to as the Robinson Crusoe or no-trade economy. For example, we assume that F_0 is the production possibilities frontier of some initial endowment (i.e., ten goats and twenty bushels of corn). With this endowment, Robinson Crusoe chooses to produce and consume $\left\{ C_t^*, C_{t+1}^* \right\}$. At this point, the tangencies imply an interest rate of i^*. Next, we assume that the production possibilities frontier shifts out from F_0 to F_1. Several factors could cause such a shift. First, Robinson Crusoe's endowment could increase (i.e., two goats could wander into his camp). Second, a technological change could occur (i.e., Crusoe could discover something about cultivating corn). Either shift would cause an increase in consumption in both time periods. In addition, the shift could result in a change in the implied interest rate.

The development of the consumption/production model moves us closer to a model of investment. We could envision a family of production possibilities frontiers that are functions of the investors initial wealth $F_0^j(W)$, $j = 1, \cdots J$. One of these frontiers being the budget constraint in Figure 1(a). Under this scenario, $F_0(W)$ is the union of all such production possibility sets. Alternatively, we could envision F_0 as a set of investment opportunities facing an investor such as a farmer. In either case, Figure 1 is typically assumed to be a no-trade scenario. There is no market for trading consumption today for consumption tomorrow.

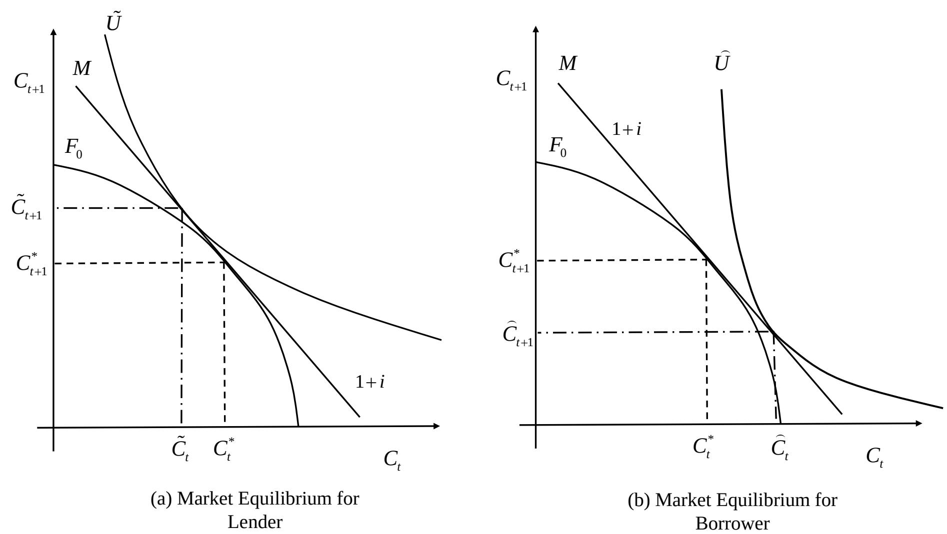


Figure 2: Consumption decisions with a capital market

Figure 2 introduces the possibility of trade in the capital market. Starting with Figure 2(a), F_0 is the production possibility frontier from Figure 2(b) and $\tilde{U}$ is the investors utility function. In this case, we assume that the investor has access to a capital market represented by the line M where the investor can borrow or lend at an interest rate of i. The existence of this capital market separates the investor's decision into two different decisions. First, the investor determines what combination $\{ C_t, C_{t+1}\}$ to produce based on the tangency between the production possibilities frontier and the capital market line M. In Figure 2(a), the investor chooses to produce $\left\{ C_t^*, C_{t+1}^*\right\}$. This production decision then determines the feasible set for consumption (much like the decision depicted in Equation 1 and Figure 1(a)). Mathematically, the constraint for consumption is based on the investors implicit wealth (W^*)

$$W^* = C_t^* + \frac{1}{1+i} C_{t+1}^* \tag{3}$$

In Figure 2(a), the investor chooses to consume the combination $\left\{ \tilde{C}_t, \tilde{C}_{t+1} \right\}$. Again, the resources from production determines the budget line for consumption

$$\tilde{C}_t + \frac{1}{1+i} \tilde{C}_{t+1} \leq W^* = C_t^* + \frac{1}{1+i} C_{t+1}^* \tag{4}$$

Given the choice of production and consumption in Figure 2(a), the investor is a lender. Specifically, the investor lends $C_t^* - \tilde{C}_t$ to the capital market at time t and receives a payment of $\tilde{C}_t - C_{t+1}^* = \left(C_t^* - \tilde{C}_t \right) \times (1+i)$ at time $t+1$.

Figure 2(b) depicts a borrower under the same scenario. In Figure 2(b), the investor borrows $\tilde{C}_t - C_t^*$ at time t and pays $C_{t+1}^* - \tilde{C}_{t+1} = \left(\tilde{C}_t - C_t^* \right) \times (1+i)$ at time $t+1$. Given that the production possibilities frontiers and interest rates are the same in each panel of Figure 2, the differences in the utility functions determines which individuals are lenders and which individuals are borrowers. However, it is possible that two investors with similar indifference functions may face different production possibilities frontiers. In this case, it is the slopes of the production possibilities frontiers that determine which investor is the borrower while the other is the lender.

It is worthwhile to briefly introduce the concept of an equilibrium in the capital market. Figure 2 implicitly takes the interest rate as a given. However, if we limit the market to the two individuals depicted, the interest rate would be the price in the capital market – the equilibrium interest rate would be determined by that interest rate such that borrowing equaled lending (e.g., $C_t^*(i) - \tilde{C}_t(i) = \hat{C}_t(i) - C_t^{**}(i)$).

The important implication of the capital market is that the market is always preferred to the no-trade equilibrium. Intuitively, we could rotate the market line for the lender scenario until the market solution equals the no-trade point (i.e., as we decrease the interest rate, the lender offers less money to the capital market until the lender no longer lends any money). At the interest rate where the lender offers no money to the capital market, the solution is identical to the no-trade solution in Figure 1(b). Thus, the no-trade equilibrium forms a lower bound to the utility generated by the capital market. Second, the capital market separates the production and consumption decisions. This is referred to as **Fisher Separation**.

Aspects of the forgoing analysis have practical applications. For example, the formulation in Equation 3 can be extended to Present Value Analysis. Suppose that a decision makers current set of assets (endowments) defines his or her wealth as

$$W = C_t + \frac{1}{1+i} C_{t+1} + \frac{1}{(1+i)^2} C_{t+2} + \cdots . \quad (5)$$

Next, we consider a change in the assets owned (endowments)

$$\begin{array}{c} W + dW = (C_t + dC_t) + \frac{1}{1+i}(C_{t+1} + dC_{t+1}) \\ + \frac{1}{(1+i)^2}(C_{t+2} + dC_{t+2}) + \cdots \end{array} . \quad (6)$$

The decision maker will be better off as long as the change in wealth is positive

$$dW = dC_t + \frac{1}{1+i} dC_{t+1} + \frac{1}{(1+i)^2} dC_{t+2} + \cdots > 0. \quad (7)$$

As long as $dW > 0$, the change in assets increases the utility of the investor.

3 Markets for Agricultural Assets

Expanding on the general model of the capital market equilibrium in the preceding section, we address the question of how long-term agricultural assets are valued. Building on the implications of Equation 7, a farmer would purchase an asset if its **Net Present Value** (NPV) is non-negative

$$NPV = -I_0 + \sum_{i=1}^{N} \frac{\mathrm{E}\left[CF_t | \Omega_0\right]}{(1+i)^t} \geq 0 \quad (8)$$

where I_0 is the initial investment, $\mathrm{E}\left[CF_t | \Omega_0\right]$ is the expected cash flow from the investment in period t based on information available at time 0 where this information is denoted Ω_0, and i is the discount rate for the firm. This discount rate is usually the firm's weighted average cost of capital. The implicit "market clearing condition" from Equation 8 is a binary sum across farmers. Specifically, let $Q_m^*(I_0, \Omega_0, i) = 1$ be individual m's decision to purchase the investment because $NPV > 0$ and let $Q_m^*(I_0, \Omega_0, i) = 0$ be the decision not to purchase the asset because $NPV < 0$. For demonstration purposes, let us consider a tractor for our investment. The total demand for a tractor could then be derived as

$$x = \sum_{m=1}^{M} Q_m^*(I_0, \Omega_0, i) \tag{9}$$

where $m = 1, \cdots M$ is the set of all farmers that may be interested in the tractor in question. Intuitively, $Q_m^*(I_0, \Omega_0, i)$ is a decreasing function of the cost of the tractor (I_0) and the interest rate (i). $Q_m^*(I_0, \Omega_0, i)$ is also an increasing function of factors that increase the expected cash flow such as future commodity prices.

The demand function in Equation 9 has several "moving parts." First, it is based on expectations of the future based on current information. Inherent in this expectation process is some level of risk or uncertainty. Several approaches have been suggested to deal with risk. For our purposes, we will consider the **Capital Asset Pricing Model** (CAPM) that is typically used to value stocks (Sharpe, 1964; Lintner, 1965b,a; Mossin, 1966). The CAPM explains how the price of a security/bond depicts differences in the risk/return relationship in a well operating securities market. In general, the CAPM for security j can be written as

$$\bar{r}_j = \alpha_j + \beta_j \bar{r}_m \tag{10}$$

where $\bar{r}_j$ is the average observed return on security j, $\bar{r}_m$ is the average observed return on the market (a portfolio of investments that have a return that represents the market as a whole), and β_j is the measure of the relative cost of risk for security j. Here, β_j is estimated using regression.

Backing the analysis, the value bid-price of a security can be defined by

$$\bar{r}_j = \frac{P_{ej} - P_{pj}}{P_{0j}} = r_f + \beta_j (\bar{r}_m - r_f) \tag{11}$$

where P_{ej} is the expected future price of investment j and P_{0j} is the current period price of investment j. The idea is that P_{0j} changes according to information available to investors in such a way that the return on investment equals the risk equilibrium. Following this intuition, we can substitute the

Risk Adjusted Discount Rate (RADR) into the present value formulation in Equation 8 to yield

$$NPV = -I_0 + \sum_{i=1}^{N} \frac{\mathrm{E}\left[CF_t|\Omega_0\right]}{\left(1 + r_f + \beta_j\left[\bar{r}_m - r_f\right]\right)^t} \geq 0 \tag{12}$$

From this expression, we can conjecture a market for long-term agricultural assets such that if $NPV > 0$, farmers increase their bid for the long-term asset (e.g., I_0 increases) until an equilibrium is reached. Alternatively, if $NPV < 0$, the bid for the long-term asset declines. Given these arguments, we conjecture that the market price for long-term assets is such that

$$I_0^* = \sum_{i=1}^{N} \frac{\mathrm{E}\left[CF_t|\Omega_0\right]}{\left(1 + r_f + \beta_j\left[\bar{r}_m - r_f\right]\right)^t} \tag{13}$$

One could still raise the question, how do we estimate β_j? As indicated in our development of the risk equilibrium, most of the early work on β_j involved the estimation of risk/return relationships in security prices the equilibrium rate of return was determined by investors bidding on stocks in the capital market. Furthermore, these stocks imply ownership of a large portfolio of productive assets, not a particular asset. One concept would be to use the overall β_j to construct an overall marginal cost of capital for a firm. By extension, to the degree that firms in a particular industry have similar β_js, we may conjecture that firms in that industry have a common discount rate. Note that the firms beta (β_j) is also a function of that firm's capital structure.

While the CAPM formulation is typically used to examine differences in returns on securities arising from differences in risk, a similar formulation called a single index model can be used to adjust the discount rate for a particular investment (for a discussion of the single index model for risk see Collins (1986)). Using the empirical results from Equation 10 as the risk-coefficient for a particular investment, the present value formula in Equation 13 could be specified as

$$NPV = -I_0 + \sum_{t=1}^{N} \frac{\mathrm{E}\left[CF_t|\Omega_0\right]}{\left(1 + r^*\right)^t} \geq 0 \tag{14}$$

where r^* is the weighted average cost of capital for a particular farm. Moss et al. (1991) used this general approach to develop different discount rates for different varieties of citrus.

In much of our discussion on asset valuation, we worked with a generic asset – often using the case of a tractor. As such, we have focused primarily on the demand side – what farmers are willing to pay for tractors. Implicitly, the supply of tractors lies outside the farm sector. However, the market for farmland which has come to dominate the agricultural balance sheet is somewhat different. The total quantity of farmland available to the farm sector is largely fixed. Land may be removed from the farm sector for a variety of reasons such as urban, recreational, or environmental uses. However, the exit of farmland tends to be irreversible. That is, once farmland has been converted to other uses, particularly urban use, it seldom returns to farming. Most analysis of farmland follows a Ricardian rent approach. Specifically, the contention is that the value of farmland is the present value of excess rents to farmland (i.e., the return on farmland after all variable inputs have been paid). Furthermore, farmland is assumed to yield these returns into the infinite future (e.g., in Equation 14, $N \to \infty$). Taken together, the value of farmland is sometimes written as

$$V = \frac{p'y - w'x}{r^*} \tag{15}$$

where p is the vector of output prices, y is the vector of output levels, w is the vector of input prices, and x is the vector of input levels. Barry (1980) estimated a risk-adjusted discount rate for farmland using a variant of the CAPM model. He found that farm real estate values at the national or regional levels contributes little systematic risk to a well-diversified portfolio (Barry, 1980, p.552).

Apart from questions of valuation, changes in the value of farmland have significant implications for the farm sector. As farmland values have increased over time, farmland has become a larger share of the agricultural balance sheet. In 1960, farmland accounted for 70.7 percent of agricultural assets. By 2016, the share of the balance sheet in farmland increased to 81.9 percent This change in concentration raises two questions: (1) what are the implications for this convergence on the financial well-being of the farm sector, and (2) what is driving this concentration and will it continue over time? To answer the first question, we must consider ownership of the assets. A standard starting point for the discussion of ownership of assets is the accounting identity

$$A = L + E \tag{16}$$

where A is the total dollar value of assets controlled by the firm, L is the firms liabilities, and E is the dollar value of ownership interest or equity (developed more extensively in a following section). Thus,

$$d\,A = d\,E + d\,L. \tag{17}$$

Assuming the firms asset values from liabilities or debt is fixed by contract, yields the differential of the accounting identity

$$d\,A = d\,E \Rightarrow d\,A_L p_L + d\,p_L A_L + d\,A_O p_O + d\,p_O A_O = d\,E \tag{18}$$

where A_L is a quantity index for farmland, p_L is the price of farmland, A_O is a quantity index for other agricultural assets, and p_O is the price of those assets. Our standard assumption is that the level of farmland has either remained constant or declined slightly; hence, most of the concentration of the agricultural balance sheet is due to increases in farmland prices, disinvestment in other agricultural assets (i.e., $d\,A_O < 0$), or declines in the relative price of these non-land assets. Assuming that $d\,A_L = d\,A_O = d\,p_O = 0$ and dividing by E yields

$$\begin{aligned} \frac{d\,E}{E} &= \frac{A_L p_L}{E}\frac{d\,p_L}{p_L} \\ &= \frac{A_L p_L}{A}\frac{A}{E}\frac{d\,p_L}{p_L} \\ &= s_L \frac{1}{1-\delta}\frac{d\,p_L}{p_L} \end{aligned} \tag{19}$$

where s_L is the share of farmland in total agricultural asset values and δ is the debt-to-asset ratio. Hence, the volatility in agricultural equity is an increasing function of the share of farmland in the overall farm balance sheet and the firms leverage position (see Collins's DuPont expansion [Collins 1985]).

Equation 19 is consistent with Schmitz's discussion of the boom/bust cycle for agricultural assets (Schmitz, 1995). Specifically, Schmitz details the historical episode for farmland values beginning in 1972 and ending in 1993. In 1973, wheat prices experienced a dramatic rise as a consequence of a significant wheat purchase by the Soviet Union. This purchase provided the initial impetus for a dramatic increase in farmland values which occurred from 1972 through 1981. The later stages of this boom benefited from an expansionist monetary policy that attempted to reduce the impact of the oil crises of the mid-1970s. As farmland values increased, farmer wealth rose (consistent with Equation 17). Furthermore, the boom undoubtedly benefited from increased farm debt (e.g., as farmland prices rose, farmers used the increased value to support higher debt levels which contributed to additional upward pressures on farmland values again as supported in Equation 19. The good times for agriculture started to slow down with the radical change in monetary policy in 1979 as the Federal Reserve shifted from a policy that focused on unemployment to one that focused on price stability (e.g., reducing inflation). As the interest rate increased, the downward pressure on farmland values was amplified by reductions in agricultural exports. The gains to farmer wealth from the 1970s were quickly reversed as the sector slid into the Farm Financial Crisis of the 1980s.

Given this tendency of boom/bust cycles in farmland values to contribute to financial crises in agriculture, the question is whether the rise in farmland values starting in 2008 portends to similar financial difficulties as those experienced in the 1980s. During the boom/bust cycle from 1972 through 1993, farmland values accounted for a maximum of 78 percent of agricultural assets. In 2015, farmland values have increased to 82 percent of agricultural asset values. Partially offsetting this increased share of farmland values, however, the current level of agricultural debt is much lower than at the beginning of the last bust cycle. In addition, the most recent rise in farmland prices has been in part supported by historically low interest rates growing from the Federal Reserves attempt to offset the onset of the Great Recession in 2008 as well as policies promoting ethanol (Henderson and Gloy, 2009; Kropp and Peckham, 2015).

There has also been a great deal of research investigating the impacts of agricultural support policies on farmland values and rental rates (Weersink et al., 1999; Lence and Mishra, 2003; Kirwan, 2009; Goodwin et al., 2012). While these studies find different capitalization rates, in general, it is believed that governmental subsidies affect farmland values and are capitalized into farmland values and rental rates.

4 Farm Debt and Debt-Equity Choice

Studies of debt-equity choice are almost always embedded in the framework of Collins (1985) and Barry et al. (1981), hereafter called the Collins-Barry model. The **debt-equity choice** for the farm assumes that new capital in agriculture will come from debt or changes in asset values (either profits or capital appreciation, typically from farmland). Collins proposed a structural model taking into consideration business risk, expected return from farm operations, expected capital gains from land, and interest rates. Using a DuPont formulation, the rate of return on equity in a given period is a function of the rate of return on assets and a leverage multiplier:

$$\frac{R_{PO}}{E} = \frac{R_{PO}}{A} \times \frac{A}{E} \tag{20}$$

where R_{PO} is the return on the portfolio of assets owned by the firm, E is equity, and A is assets.

The simple representation of Equation 20 allows for formulations of the debt-equity choice. Considering leverage to be the ratio of debt to assets $\delta = D/A$ yields the following representation

$$\frac{R_{PO}}{E} = \frac{R_{PO}}{A} \frac{1}{1-\delta} \tag{21}$$

Next, we adjust the rate of return on equity r_E by subtracting out the interest expense (δi) and adding the rate of appreciation for assets held by the firm (a)

$$r_E = \left[\frac{R_{PO}}{A} + a - \delta i\right] \frac{1}{1-\delta} = [r_A - \delta i] \frac{1}{1-\delta} \tag{22}$$

where r_E is the rate of return on equity, r_A is the rate of return on assets (the sum of the operating return on assets R_{PO}/A and the rate of appreciation), and i is the cost of capital (interest rate). The above formulation introduced by Collins (1985) allows for the interest rate and the anticipated changes in asset values to be considered in the debt-equity decision.

There have been several studies that extended the Collins-Barry expected utility model of debt-equity choice and risk balancing. Featherstone et al. (1988) integrated the effect of farm program payments. Moss et al. (1989) introduced income tax considerations to examine the impact of eliminating 60 percent capital gains tax deduction on the firms optimal leverage position; based on the optimal leverage position the impact on the probability of equity loss is examined. Turvey and Baker (1989) employ the Collins-Barry model to examine how optimal hedging decisions may be impacted by debt decisions, by incorporating gains from hedging in the rate of return on assets. In addition, they consider how the optimal debt-to-asset ratio δ^* adjusts to hedging. Collins and Karp (1993) introduce a stochastic optimal control model of farm debt-equity choice that models risk attitudes and leverage choices. In their study, they consider failure risk (a scenario of a potential bankruptcy) rather than wealth variability, and they control for age, wealth, and the opportunity cost of farming. In a recent study, Moss (2014) decomposes the asset portfolio into operating assets and real estate, and presents a model where appreciation to agricultural assets accrues to farmland.

Now let us turn our attention to the impact of additional borrowing on the rate of return on equity

$$\frac{\partial}{\partial \delta}\left[(r_A - \delta i)\frac{1}{1-\delta}\right] = \frac{r_A - i}{(1-\delta)^2} \tag{23}$$

Given that $0 \leq \delta \leq 1$ an additional unit of debt increases the rate of return on equity as long as $r_A > i$ (e.g., the rate of return on assets is greater than the cost of capital). This result is obvious. However, the result in Equation 23 implicitly ignores the impact of risk and uncertainty. In practice, the effect of leverage on risk has been the topic of much of research into the choice of debt by farmers.

One of the first models focusing on the effect of leverage on firm risk was Gabriel and Baker (1980) which decomposed risk into business and financial risk. Specifically, Gabriel and Baker start by defining the business risk (e.g., risk of profitability of the firm) as the normal risk related to the risk associated with random output prices and output levels

$$p'y - w'x \text{ s.t. } p \sim \mathrm{N}(\mu_p, \Sigma_p) \text{ and } y \sim \mathrm{N}(\mu_y, \Sigma_y) \tag{24}$$

where p is a vector of output prices, y is the vector of output levels, w is the vector of input prices, x is the vector of input levels, and $p \sim \mathrm{N}(\mu_p, \Sigma_p)$ and $y \sim \mathrm{N}(\mu_y, \Sigma_y)$ denotes that the vector of prices and yields are distributed multivariate normal with a vector of means μ_p and μ_y, respectively, and a variance matrix for each vector is Σ_p and Σ_y, respectively. Hence, farmers choose a set of inputs x based on a vector of input prices w in anticipation of producing a set of outputs $y = y(x)$ that will produce a revenue of $p'y$. The insight of Gabriel and Baker is that the risk implied by this set of choices is endemic to the agricultural enterprise largely independent of financial decisions made by the firm. Based on this endemic business risk, financial decisions expand this risk exponentially where "financial risk is defined to be the added variability of the net cash flows of the owners equity that results from the fixed financial obligation associated with debt financing and cash leasing" (Gabriel and Baker, 1980, p.560).

Gabriel and Baker develop financial risk (FR) as

$$FR = \frac{\sigma_2}{\vec{c}'x - \bar{D}} - \frac{\sigma_1}{\vec{c}'x} \tag{25}$$

where σ_1 is the standard deviation of the operating cash flows (i.e., the cash flows of the farm without debt or leasing obligations), σ_2 is the standard deviation of the returns with the debt or leasing obligations, $\vec{c}'x$ is the netput profit function (i.e., a function were $x_k > 0$ denotes an output and $x_k < 0$ denotes an input), and $\bar{D}$ is the fixed level of debt obligation. Gabriel and Baker reformulate Equation 25 to focus on the financial risk component

$$FR = \frac{\sigma_2 - \sigma_1}{\vec{c}'x - \bar{D}} + \frac{\sigma_1}{\vec{c}'x}\frac{\bar{D}}{\vec{c}'x - \bar{D}} \tag{26}$$

As a starting point, we assume that leverage decisions do not change the variability of cash flows (i.e., $\sigma_2 = \sigma_1$). This scenario is consistent with the assumption that debt payments are fixed. Subtracting a constant from a sequence does not change the variance. Hence, the first term in Equation 26 drops out yielding

$$FR = \frac{\sigma_1}{\vec{c}'x}\frac{\bar{D}}{\vec{c}'x - \bar{D}} \tag{27}$$

In Equation 27, financial risk is determined by the business risk (e.g., $\sigma_1/\vec{c}'x$) and the share of cash flows that go to paying fixed debt obligations (e.g., $\bar{D}/\left(\vec{c}' - \bar{D}\right)$).

Given this definition of financial risk, Gabriel and Baker define the total risk (TR) facing the firm

$$TR = \frac{\sigma_1}{\vec{c}' - \bar{D}} = \frac{\sigma_1}{\vec{c}'x}\frac{\vec{c}'x}{\vec{c}'x - \bar{D}}. \tag{28}$$

Given this total risk, Gabriel and Baker formulate a risk constraint

$$\frac{\sigma_1}{\vec{c}'x}\frac{\vec{c}'x}{\vec{c}'x - \bar{D}} \leq \gamma \tag{29}$$

Hence, the farmer is hypothesized to choose a level of leverage or business risk such that total risk is less than or equal to some risk index (γ). Suppose that there is an exogenous change (i.e., an increase in the level of price support) so that the level of business risk declines (e.g., σ_1 declines). In this case, farmers could increase their borrowing by decreasing $\bar{c}'x - \bar{D}$. As the level of borrowing increases, the level of total risk increases. In principle, some increase in borrowing would return the overall financial risk to the original constraint in Equation 29.

In addition to the overall risk-balancing model, Gabriel and Baker suggest a formulation that incorporates the concept of liquidity. The linkage between leverage and liquidity is especially important for agriculture. The return to agricultural equity is typically from two sources: operating profits and capital gains. While operating returns provide liquidity to make loan payments, capital gains can only be accessed by selling the asset (farmland) or by additional borrowing against the increased value of the asset.

Collins (1985) provides an alternative formulation of risk-balancing based on expected utility. Specifically, Collins assumes the farmers choose the debt level that maximizes utility,

$$\begin{gathered} \max_{\delta} \ -\exp\left(-\rho W_0 \left(1 + r_E\right)\right) \\ \text{s.t. } r_E \sim \mathrm{N}\left(\frac{\mu_1 - \delta i}{1 - \delta}, \frac{\sigma_A^2}{\left(1 - \delta\right)^2}\right) \end{gathered} \tag{30}$$

where δ is the debt-to-asset ratio,ρ is the Arrow-Pratt absolute risk aversion coefficient, W_0 is the initial level of wealth, μ_a is the expected return on agricultural assets (including both operating returns and asset appreciation), and σ_A^2 is the variance of the rate of return on assets. Equation 30 follows from the linkage between the rate of return on equity and the rate of return on assets presented in Equation 22. Given this formulation, the optimal level of debt becomes

$$\delta^* = 1 - \frac{\rho \sigma_A^2}{\mu_A - i}. \tag{31}$$

Assuming that $\mu_A - i$, these results indicate that the optimal level of debt is an increasing function of the expected return on agricultural assets and a decreasing function of the variance of the rate of return on agricultural assets (e.g., the riskiness of agriculture), the cost of capital, and the farmers risk aversion.

Featherstone et al. (1988) use Collins model to demonstrate how agricultural policies that reduce risk may actually increase the probability of financial difficulties in agriculture. However, other studies such as Kropp and Katchova (2011) and Kropp and Whitaker (2011) suggest that agricultural support policies can reduce the recipients cost of borrowing, and improve liquidity and repayment ability. Specifically, agricultural programs that provide a price floor may actually cause an increase in leverage sufficient to increase the probability of financial difficulty.

Empirical models of the Collins-Barry debt-choice model have not always provided support of the risk-balancing hypothesis. This can be attributed to some strong assumptions in the Collins-Barry formulation such as the constant interest rate, borrower risk profile homogeneity, full credit access, and non-stochastic borrowing costs (Cheng and Gloy, 2008; Wu et al., 2014) in addition to the proper estimation of the variance which changes either across time or across individuals. Related studies include Moss et al. (1990); Jensen and Langemeier (1996); Ramirez et al. (1997); Escalante and Barry (2003); Turvey and Kong (2009); de May et al. (2014); Uzea et al. (2014); Ifft et al. (2015); and Bampasidou et al. (2017).

5 Asset Ownership: Choice of Debt and Equity

We now turn our attention to the ownership of assets and capital. We return to the differentiated accounting identity $d\,A = d\,E + d\,L$ (from Equation 17) and abstract a little for the point of discussion. The claim on firm asset values from liabilities or debt is fixed by contract. Hence, $d\,L$ represents new borrowing or repayment of principle. Assuming $d\,L = 0$, the change in the asset valuation is "owned" or "claimed" by the equity holders $d\,A = d\,E$.

The change in the ownership value of the firm can be decomposed as presented in Figure 3. The horizontal axis in Figure 3 is the return on the assets controlled by the firm (R_A). Following the Collins (1985) formulation described above, the firm controls A assets with δA (where $\delta A = L$) assets financed using debt and $(1-\delta)\,A$ assets financed from equity (where $(1-\delta)\,A = A - L$). The vertical axis is the return to either the owner (R_E) or the lender (R_L). We begin by assuming a zero debt level. The relationship between changes in the asset values and returns to the owner are given by curve e. Mathematically, any change in asset values (either from income or changes in the market value of assets) accrues to the owner since debt is held constant.

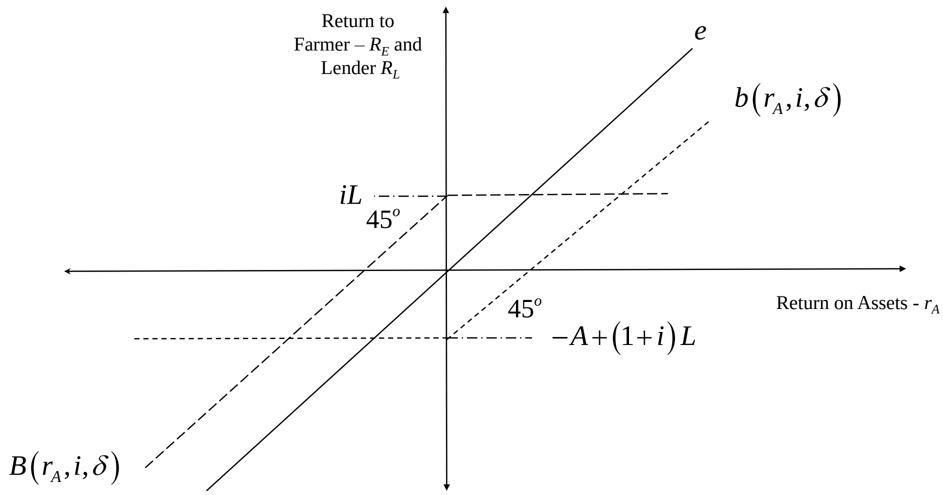


Figure 3: Equity and Ownership Claims

Next, we assume some nonzero debt level ($0 \leq \delta \leq 1$). Under normal operations, we would assume that the operator will make enough from operations to pay the loan off at the end of the production period and have money left over:

$$R_A \geq -A + (1+i)\,L \Rightarrow \begin{cases} R_E = R_A - Li \geq 0 \\ R_L = Li \end{cases} \tag{32}$$

where i is the interest rate. Notice that this is a slight change over the way one typically thinks about the return to the farmer. The result implies

$$\begin{aligned} R_A &\geq -A + L + iL \\ &\geq -E + iL \end{aligned}, \tag{33}$$

given that $A = E + L \Rightarrow E = A - L$. Thus, the result actually implies that the farmer has a positive level of equity for some return on assets. This result represents the region to the right of the axis in Figure 3.

If, on the other hand, the return is less than what is required to pay off the loan,

$$R_A < -A + (1+i)\,L \Rightarrow \left\{ \begin{array}{c} R_E = -A + L \\ R_L = R_A + [A - L] \end{array} \right. , \tag{34}$$

the decision maker is better off defaulting on the loan, losing equity of $-A+L$. The lender receives the firm's original equity $(A-L)$ plus the rate of return on assets. Also note that as the rate of return on assets approaches the point where the firm forfeits its assets from the left,

$$\lim_{R_A \to [-A+(1+i)L]^-} R_L = -A + (1+i)\,L + [A - L] = iL \tag{35}$$

Hence, the minimum return to the lender is negative infinity (although the likelihood of this event is bounded to zero) and the maximum return is iL. However, in practical terms, a lender would never seize the borrower's asset if the asset had a negative return. In fact, a lender would only seize an asset if the market value of the asset less the transactional cost of seizing the asset through foreclosure was positive, and hence the minimum loss to lender in practice is the original value of the loan. The minimum return to firm is $-A + (1+i)\,L$ while the maximum return is positive infinity (again the likelihood of this event is bounded to zero).

As a final point, we note that the sum of the returns to the lender plus the returns to the operator yields the returns to an operator without debt. For example, taking the region in Figure 3 where $R_A \geq -A + (1+i)\,L$,

$$R_T = R_E + R_L = R_A - iL + iL = R_A. \tag{36}$$

Similarly, taking the region where $R_A < -A + (1+i)\,L$,

$$R_T = R_E + R_L = -A + L + R_A + [A - L] = R_A. \tag{37}$$

This is essentially the intuition behind Modigliani and Miller (1958), where the total value of the assets remains the same regardless of how the assets are financed.

Seeking an answer to the question of whether there an alternative to the debt market, the answer is yes, firms can sell equity typically stocks or shares in limited partnerships. In these typical forms of equity investment, the investor shares proportionally in the gains. In addition, there are scenarios where the investor participates in losses. In the case of stocks, the loss is typically limited to the price of the stock (e.g., the stock value could fall to zero). In agricultural finance, we are typically interested in three ownership forms:

1. **Sole Proprietorship**: Under this organization, the individual directly owns assets that he employs in entrepreneurial activities. The liabilities and obligations of the firm are also the liabilities and obligations of the individual. The proprietor or owner/operator has a claim on any residual (excess of the value of the assets of the firm over its obligations).

2. **Partnership**: Partnerships may exist under a variety of legal frameworks from fairly informal partnerships based on handshake agreements to more elaborate limited liability partnerships. At the most basic level, a partnership is an agreement linking the interests of two individuals. The agreement specifies the intent of the collaboration, the expectations of each party, and the claim that each party will have on the proceeds from the collaboration. Under some types of partnerships, the liabilities and obligations of the firm are also the liabilities and obligations of the individual.

3. **Corporation**: A corporation is a legal entity by which a group of individuals collaborates by placing some of their assets at risk (i.e., an investment of a portion of their assets in common stock). As a legal entity, the corporation may enter into contracts that do not bind the individual owners. Importantly, the liabilities and debt of the corporation do not pass to the individuals. However, the owners of the corporation only have a claim to the assets of the corporation embodied in the terms of their stock.

Historically, most farms have been organized as sole proprietorships and depend on debt for additional capital.

In general, the various ownership forms can be formulated as financial options. An option is a contingent asset, that is, an asset that has value contingent on the value of another asset. Options give the holder the opportunity but not the obligation to buy or sell an asset. For example, a call option gives the holder the right but not the obligation to purchase an asset (such as a stock) at a given (strike) price. If the stock price is higher than the strike price, the owner of the call option will exercise his option, purchase the stock at the strike price, and then sell the stock at the market price; his return will be the difference between the market price and the strike price. A put option is a similar contract that gives the holder the right to sell an asset at a specified price.

Figure x.4 presents the payoff or profit function for call and put options along with the probability density function for a stock price at the expiration date. Comparing Figure 4 with Figure 3, the payoff function for the owner-operator resembles the call option where the strike price is a return on equity of zero. The lender's position in Figures 3 and 4 resembles "selling a put."

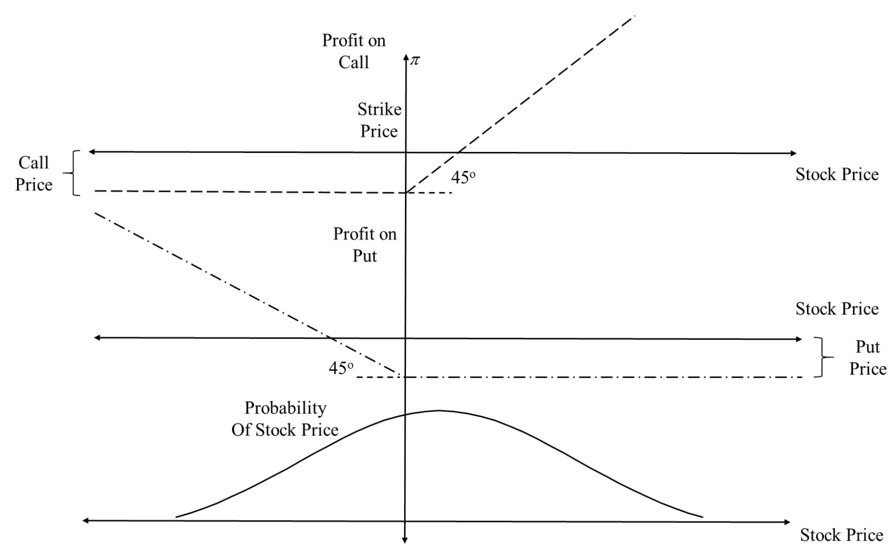


Figure 4: Payoff Functions for Call and Put Options

6 Credit Market Equilibrium

The Gabriel-Baker and the Collins models focus on the producer's choice. However, there are two players in the credit market: the borrower and the lender. In equilibrium, the interest rate charged by the lender depends on the opportunity rate of return to the bank (i.e., the return on loans with similar risk that the bank could make) as well as the demand for credit. The return to the bank increases as the interest rate charged increases. However, the interest rate that banks are able to charge is limited by the demand for credit (e.g., what producers are willing to pay). Hence, the interest rate in the credit market is determined by lending risk and the opportunity returns available to banks.

The market for agricultural debt is complicated because of information difficulties: asymmetric information and agency problems. Specifically, there are different types of borrowers. Some borrowers are good credit risks they are profitable farmers who pay their bills. Other farmers may be poor credit risks for a variety of reasons, such as the farmer may be less profitable due to managerial skills or the farmer may have accumulated past debt because of bad market outcomes (i.e., low prices). In either case, acquiring a loan is a contracting process where the farmer provides information to the banker who attempts to access the likelihood that the loan will be repaid with interest.

We assume that the farmer could be one of two types of farmers: high-risk or low-risk. The high-risk farmer has a lower expected return on assets and a higher standard deviation for those returns, while the low-risk farmer has a higher expected rate of return and a lower standard deviation for those returns. The payoff for the borrower follows the payoff function for the call presented in Figure 4. Assume that the payoff function is $B\left(r_a, i, \delta\right)$, where i is the stated interest rate and δ is the debt-to-asset ratio (or share of assets borrowed). Essentially, the borrower only retains ownership of the asset (i.e., pays off the loan) when the return is greater than the alternative. Essentially, the lowest possible return is the loss of the down payment or collateral (e.g., $1-\delta$). If the return is lower than the loss of the down payment, the borrower forfeits the down payment or collateral and gives the lender the return on assets. The expected value of loan to the borrower is then

$$\tilde{b}\left(K, \delta, \mu, \sigma^2\right) = \int_{-\infty}^{\infty} b\left(r_A, i, \delta\right) f\left(r_A; \mu, \sigma^2\right) d\, r_A. \tag{38}$$

A standard construct in finance is that participants have to be paid to accept higher risk. Hence, riskier stocks earn higher returns on average. Put slightly differently, the common assumption is that the market return separates investments in the market. We discussed this axiom earlier in our discussion of CAPM. Hence, one would expect that riskier borrowers would pay higher interest rates. However, two factors conspire to make this "separation by interest rate" difficult in the loan market. First, the lender's ability to differentiate between the two borrower types is imperfect. Second, the "kinked" return function for the borrower may make it profitable for the borrower to default on the loan.

To develop the implications for the "kinked" payoff functions, we transform the results in Equations 32 and 33 from returns to the firm and lender into the rate of return to the firm and lender. Starting with the implications for Equation 32 (where the firm pays off the loan, $R_A \geq -A + (1+i)\,L$). The rate of return to the firm becomes

$$\begin{aligned} r_E &= \frac{R_E}{E} = \frac{R_A - iL}{E} \\ &= \frac{R_A}{A}\frac{A}{E} - \frac{L}{A}\frac{A}{E}i \\ &= \frac{r_A - \delta i}{(1-\delta)} \end{aligned} \tag{39}$$

which is consistent with Equation 23. Notice for this region $r_L = i$ - the borrow pays off the loan, so the return to the lender is simply the stated interest rate. Turning to Equation 34 (where the firm defaults on the loan $R_A < -A + (1+i)\,L$), the rate of return to the firm becomes

$$R_E = \frac{R_E}{E} = \frac{-A+L}{E} = -\frac{E}{E} = -1. \tag{40}$$

The rate of return to the lender becomes

$$\begin{aligned} r_L &= \frac{R_L}{L} = \frac{R_A + A - L}{L} \\ &= \frac{R_A}{A}\frac{A}{L} + \frac{A}{L} - 1 \quad . \\ &= (r_A + 1)\,\frac{1}{\delta} - 1 \end{aligned} \tag{41}$$

As a final point, the "kink" point in the rate of return space can be derived as $r_A^* = -1\,(1+i)\,\delta$.

Given the above results, the rate of return to the borrow can be written as

$$\begin{aligned} \tilde{B}\left(i, \delta, \mu, \sigma^2\right) = \int_{-\infty}^{r_A^*} \left[\frac{r_A + 1}{\delta} - 1\right] f\left(r_A; \mu, \sigma^2\right) d\,r_A + \\ i \int_{r_A^*}^{\infty} f\left(r_A; \mu, \sigma^2\right) d\,r_A \end{aligned} \tag{42}$$

while the rate of return to the firm can be written as

$$
\begin{aligned}
\tilde{b}\left(i,\delta,\mu,\sigma^2\right) = -\int_{-\infty}^{r_A^*} f\left(r_A;\mu,\sigma^2\right) d\,r_A + \\
\int_{r_A^*}^{\infty} \left[\frac{r_A - \delta i}{1-\delta}\right] f\left(r_A;\mu,\sigma^2\right) d\,r_A
\end{aligned}
\tag{43}
$$

Note that the value to the high-risk borrower is declining throughout the range of possible interest rates regardless of the down payment requirement. Hence, there is an incentive for the high-risk borrower to mimic always reports to be less risky than the borrower actually is. However, note that the return to the low-risk borrower decreases in the interest rate because of the change in the down payment requirement.

Essentially, at the time of the loan application, the borrower knows more about the projects risk and the financial risks of the firm than the lender. However, the interest rate alone will fail to separate the high-risk and low-risk borrowers. Stiglitz and Weiss (1981) show that these informational asymmetries can lead to credit-rationing the demand for credit exceeds the supply of credit at the current market interest rate. Increasing the market interest rate to eliminate the excess demand for credit is not feasible because this would drive out the low-risk borrower and leave only the high-risk borrow in the market. As a result, lenders must take additional actions such as requiring down payments or collateral, or expending resources to monitor the borrower during the loan period (Stiglitz and Weiss, 1981). Similar work in agricultural economics includes Innes (1990).

7 Summary and Suggestions for Further Study

The agenda for current studies in agricultural finance are bounded by two events: the boom/bust cycle in agriculture in the 1970s and 1980s that ended in the farm financial crisis of the mid-1980s and the significant increase in farmer wealth from 2008 through 2013. The boom cycles significantly increased farmer wealth because farmland values increased along with increased corn prices due to global demand and policies promoting corn ethanol. Conversely, the bust cycle caused some farmers to become insolvent as farmland values fell. The potential effects of government policies on debt and financial risk can be significant. This chapter developed the financial economic models useful in understanding the farm financial market. It began by sketching out the properties of the neoclassical capital market, and then extended the neoclassical model to include the effect of risk on capital structure. Specifically, the chapter demonstrated the effect of the sector's dominant asset farmland on farmers wealth. In addition, we demonstrated how the optimal debt model follows the risk-balancing model which demonstrates how financial risk magnifies the standard business risk associated with agricultural production. Next, we sketched a general market model based on the insights from the Stiglitz and Weiss (1981) model of credit rationing.

Historically agricultural finance has been "farmer-centric." Most of the discussion of farm financial issues at the beginning of the twentieth century involved meeting the capital needs of the farm sector given the increased demand for borrowing due to increased mechanization. This period saw the establishment of the Farm Credit System and the Federal Reserve System. However, in the second decade of the twenty first century it would be hard to argue that U.S. agriculture has credit needs not met by a variety of lenders. Current issues tend to focus around the effects of the distribution of farmland. Specifically, a large share of agricultural output is increasingly concentrated on a few wealthy farm firms. This concentration is due in part to the impact of capital gains on returns to agricultural assets. As discussed in this chapter, an increasing share of agricultural income is a "holding return" from the appreciation of farmland. The interaction of the returns from operation and the returns to agricultural assets and increases in farmland prices is still cloudy. Changes in farmland prices appear to be consistent in the long-run, but the level of farmland prices or often higher than can be justified using present value analysis. Regardless of the reasons for this anomaly, the returns from holding farmland provides an impetus for growth for larger farmers providing additional pressure toward concentration of farmland ownership.

One potential area of future research in the area of agricultural finance involves the potential arbitrage between holding period returns on farmland and the operating return on agricultural assets. From the late 1990s through 2008, arbitrage of risky assets became an important component of the financial market places. This arbitrage typically involved the purchase of one asset such as a mortgage-backed security using money raised by a short-sale of another asset such as a U.S. Treasury bond. The assumption of this transaction was that the mortgage-backed security was underpriced (i.e., the interest rate was too high) compared to its relative risk. The concept was that when enough investors recognized that the mortgage-backed security was underpriced, the market price of these instruments would increase reducing the spread between mortgage-backed securities. The arbitrageur would then reverse the position sell mortgage-backed securities and buy back U.S. Treasury bonds at a profit. As the scenario sketched out suggests this transaction (and the returns to arbitrage) may imply a substantial risk. In fact, arbitrage of mortgage-backed instruments contributed to the Financial Crisis of 2008. However, the shift from a traditional buy and hold implicit in the farm mortgage market to a more arbitrage oriented market for agricultural assets may provide insights into farm financial market.

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