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The Effects of Holding Nonfarm Related Financial Assets On Risk-Adjusted Farm Income

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Abstract

A discrete stochastic programming model is formulated to study the gains from diversification when farming operations are augmented with off-farm financial assets that are not highly correlated with returns from farming. We extend past research by considering the dynamics of accumulating these financial assets and the farm's leverage and tenure position. Results show that farmers' income level and stability can be improved by including nonfarm financial assets in their portfolios.

Key words: Agricultural finance, certainty equivalents, discrete stochastic programming, land investment, off-farm investments

The 1980s were difficult for the farm sector, including agricultural lenders. For example, while only 4.6 percent of the direct loans made by the Farmer's Home Administration were delinquent in 1980, the figure stood at 34.5 percent by 1988 (United States Department of Agriculture). In 1982, commercial banks reported that 2.5 percent of the farm production loans were nonperforming, but this figure jumped to 4.0 percent by 1988 (Board of Governors of the Federal Reserve System). High interest rates and weak agricultural commodity prices have forced many farmers and farm lenders out of business. This has further fueled the need to develop longer-term perspectives on how to manage risk.

Several studies have concentrated on nonfarm equity holdings in agriculture (Fiske et al.; Collins and Bourn; Matthews and Harrington; and

Raup). Less work has been done in the area of holding nonfarm financial securities in a farm portfolio to bring more stability to farm enterprises. Young and Barry examined the possible gains in risk efficiency as greater proportions of financial assets were introduced into the asset structure of farm portfolios. They did not consider, however, the dynamics of accumulating these financial assets and the liquidity implications involved, the direct liquidity characteristics of the financial assets, the tax effects, or the farm's tenure position. In this study we explicitly incorporate these features as we investigate the effect of holding mutual fund shares and Certificates of Deposit (CDs) in a farm portfolio on a farmer's expected returns and total risk exposure. The paper is organized as follows: first, we present the conceptual framework; second, we describe the model itself; and finally, we present the results and conclusions.

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Conceptual Framework

Risks Faced by the Farmer

Farmers are exposed to business risk and financial risk. Business risk is that risk inherent to an operation, no matter how this operation is financed. This business risk comes mainly from yield and product price variations, although internal factors, such as investment decisions and management skills, play a role. Financial risk, however, is the added variability in the return on equity due to fixed financial obligation associated with debt financing and cash leasing (Gabriel and Baker).

Business and financial risk have liquidity implications on the entire farming operation. Liquidity considerations arise through the combination of uncertain cash flows, changes in asset liquidity values and available credit, and the evolution of a firm's sources and uses of cash flows (Featherstone et al., 1990). A reduction in collateral value, for example, leads to a reduction in credit-reserves that are important for the liquidity of a farming operation. Liquidity management is especially important when reduced collateral value coincides with or follows closely the years of unfavorable cash flows.

There are several approaches used to mitigate this risk, including insurance, government programs, irrigation, marketing strategies, and improved technology (e.g., disease resistant varieties). In our study, we use portfolio theory to study total farm-risk reduction when farmers place part of their available funds into off-farm investments. Such diversification would stabilize net cash flows and credit reserves, making the portfolio more liquid.

Discrete Stochastic Programming

Every year, a farm operator must make decisions on investment, production, financing, and consumption. But, as stated in the discussion on business and financial risk above, the relevant information needed to arrive at these decisions — such as input and product prices, interest rates, government farm programs — is not certain. Furthermore, most farm operators must plan for more than one year. Thus, not only is there a

stochastic component in the operator's decision making process (to reflect the uncertainty in the available information) but also a dynamic component (to reflect the multiperiod nature of the planning horizon). The latter component requires that linkages between current and future decisions be considered when deciding the current year's strategy.

Discrete stochastic programming (DSP) is useful in modeling the stochastic and sequential nature of farm decisions. It allows for joint modeling of the uncertainties associated with the objective function, the technical coefficients, and the available resources over time. DSP was developed by Cocks in 1968 and has been applied in agricultural economic studies (Apland and Kaiser; McCarl, Reid, and Tew). However, its use in investment and financing decisions has been limited. The most recent applications include Featherstone and Baker; Leatham and Baker; Turvey and Baker; and Featherstone, Preckel, and Baker.

Farm Situation

This study is based on a representative farm in the Texas Rolling Plains. Historically, the two predominant crops produced in the Rolling Plains region of north Texas are wheat and cotton. It was assumed that the farmer grows these crops in equal proportions. It was also assumed that a farmer could a) own land, paying all the costs of production and receiving all the revenue, b) share-lease land, sharing the costs of production and the revenue according to the lease terms, or c) a combination of both. The share lease arrangement used in this study is based on the budgets for the Texas Rolling Plains prepared by the Texas Agricultural Extension Service. Net returns to farming for a lessee were calculated as follows.

First, a lessee's gross revenues from wheat were computed as wheat yield multiplied by the price of wheat, and a deficiency payment, all weighted by 0.67, the lessee's share of total wheat revenue. Costs were divided into two categories. The first category consisted of those expenses of which the lessee incurred 100 percent (i.e., the cost of machinery used (excluding harvesting) and any associated costs like fuel and lube, repairs, and labor; cost of seed; and interest on operating capital). The second category consisted of those

expenses of which the lessee incurred 67 percent (i.e., the cost of fertilizer, crop insurance, insecticide, custom harvesting, and custom hauling). Net wheat revenue to the lessee, therefore, was computed as the weighted gross revenue from wheat, minus the weighted costs, where the weights reflect the lessee's share of revenues and costs. A similar computation was done for cotton revenues and costs, and a portfolio of the two crops was formed, with the assumption that each crop contributed 50 percent to the total crop portfolio.

Investment Opportunities

In this study, a farmer has the opportunity to invest in land, stocks, and CDs in addition to other farm assets. The farmer can purchase land either to operate or to lease to someone else. When a farmer owns the land being operated, the total return on the farming operation is kept, along with any accrued capital gains (or capital losses). For example, in constant 1987 dollars, land prices increased from \$401 per acre in 1970 to \$531 per acre in 1982, a 32.4 percent increase. However, there is a risk of a capital loss because the price fell to 435.30 dollars by 1987. Another advantage of investing in farmland — as opposed to renting — is that the farmer removes the uncertainty of the availability of land to rent each year within a preferred location (although long term leases can be used to mitigate some of this risk). Moreover, land can be used as collateral against debt.

Another investment opportunity is stock. Because of the diversified composition of mutual funds, they offer a return that is less risky than individual stocks. Nine mutual funds were initially picked based on the availability of historical data, and the composition of their portfolio. The funds picked had most of their funds invested in utilities, pharmaceuticals, chemicals, office equipment, and other industries not considered highly correlated with agriculture. A simple pair wise correlation coefficient was computed for historical returns on farm assets and equity, and returns on the mutual fund¹. These correlations ranged from a low of -0.48 to a high of -0.19. The Massachusetts Investors Trust fund was picked from the list of nine mutual funds and was subsequently used in the rest of the study because its returns were the least correlated with the returns on agriculture.² This low

relationship enhances income stability and liquidity of the farm portfolio because high stock returns may compensate for losses in poor farm income years, which will stabilize the cash flows of the farm.

The farmer can also invest in Certificates of Deposit (CDs). Short term CDs are liquid and their liquidity feature can be enhanced when purchased in staggered sets, so that every month a set of CDs is maturing. Another important feature of CDs is that they have almost zero risk because their principal and coupon payments are guaranteed. However, a short term CD has higher reinvestment risk because the frequent reinvestment of the principal and interest received has to be done at the prevailing and possibly lower rate.

Model Specification

The Objective Function

The objective function maximizes a farmer's negative exponential expected utility function:

$$(1) \quad E[U(x)] = \sum_{i=1}^N P_i (1 - e^{-\rho x_i})$$

where $E[U(x)]$ is the expected utility function; P_i is the probability of occurrence for the i th state of nature; e is the natural exponent; x_i is the present value of ending wealth in the i th state of nature; and ρ is the Pratt risk aversion parameter. We assume that each ending state of nature is equally likely, given by $1/N$, where N is the total number of ending states of nature. Ending wealth in the i th ending state of nature is given by ending equity in the last stage, and any cash withdrawals from the business before and including the last stage, all discounted to the present. The Pratt risk aversion parameter, $r(x)$, is given by $-U''(x)/U'(x)$, which is equal to ρ . Since ρ is a constant when the negative exponential utility function is used, this farmer is assumed to exhibit constant risk aversion (Pratt).

In this study, we specify the risk aversion parameter *a priori*. Following McCarl and Bessler, an upper bound of the risk aversion parameter is established, given by five divided by the standard deviation of the risky prospect.

We also computed the farmer's certainty equivalent of ending wealth for various levels of risk aversion under different investment alternatives. The certainty equivalent of a risky prospect is that value of return with the same expected utility as the risky prospect, but with zero variance. Hence a utility maximizing farmer would choose a portfolio of assets that offers the highest certainty equivalent. Given the negative exponential utility function $E[U(x)] = (1 - e^{-\rho x})$, where x is the farmer's certainty equivalent of ending wealth and the rest of the variables are as previously defined, the certainty equivalent can be computed by solving for x . Therefore, $x = \ln\{1 - E[U(x)]\} / -\rho$, where \ln is the natural logarithm.

Model Activities and Constraints

Restraints were specified for production, investment, financing investments and cash short falls, and linkages of resources between periods. It was assumed that the farmer operates 500 acres in all years, operating owned land or leased land. Land is leased under a share lease agreement.

As stated earlier, the farmer can invest in land, mutual funds and/or CDs. The farmer operates 500 acres. Therefore, if more than 500 acres of land is owned, the extra land is leased to someone else. However, if less than 500 acres is owned, land is leased to cover the shortage. It is assumed that land can be leased as needed.

Investment decisions were constrained by sources and uses of funds. Debt acquisition was allowed up to twice the farmer's equity position. Equity was computed at the end of each year. Taxing constraints for regular income and capital gains were included. To adequately account for capital gains, it was assumed that the farmer would sell the land and stock in the last year of the planning horizon³.

Liquidity is important to the farmer so that short falls in revenue can be covered during unprofitable years. To account for liquidity aspects in the model, sources and uses of funds for each state of nature were included, along with disinvestment activities for assets in which sale prices depend on the state of nature.

The leverage effect on the financing and investment decision was captured by having stochastic product prices, yields and the cost of debt, return on assets, family withdrawals and taxes. The tax system used in the model follows the 1988 Tax Rate Schedules of the Internal Revenue Service, specifically Schedule Y-1.

Specification of Stochastic Variables and States of Nature

Data for use in the DSP model were generated in a two-step process. In the first phase, we formulated expectations on ten stochastic variables (described below) that served as input in the construction of the final set used to define the states of nature in the DSP model. For example, expectations on cotton yield, cotton price, wheat yield, and wheat price in the first phase were used to generate the variable "crop returns to a lessee" ultimately used in the DSP model. In the second phase, we formulated states of nature and picked representative parameters from each state for the variables used in the DSP model. The following stochastic variables were used in the DSP model: the price of land and the price of the Massachusetts Investors Trust mutual fund, the returns on the mutual fund, the crop returns to a lessee, the crop returns to a land-owner, the interest rate on debt, the interest rate on CDs, the discount rates, and the family withdrawals. We did not directly model intermediate term assets (e.g., machinery) and short term assets, nor did we model short term debt. We incorporated them into the net farm income computations. The following is a detailed description of how both sets of variables were generated.

First Phase: Specification of Stochastic Variables

First, expectations were formulated on ten stochastic variables: inflation rate, money growth rate, returns on a three-month Treasury Bill, returns on stock, cotton and wheat yields, cotton and wheat prices, land price, and stock price (table 1). Following Young and Barry, these are simple expectational equations because the goal of this study is not to develop sophisticated forecasting models or behavioral expectational models. All dollar values were measured in real terms. The inflation rate in period t was regressed against

Table 1. Expectational Equations for Ten Stochastic Variables Used in the Model^a (the Subscripts on the Variables Refer to the Time Period)

Inflation Rate ($\bar{R}^2 = 0.77$)	
$GNPDEF_t = -0.008 + 0.689 GNPDEF_{t-1} + 0.322 M2GRATE_{t-3} + 0.003 TBILL3M_{t-1}$	(0.013) (0.136) (0.086) (0.001)
Money Growth Rate ($\bar{R}^2 = 0.84$)	
$M2GRATE_t = M2GRATE_{t-1} + error_{mg}$	
Three Month Treasury Bill	
$TBILL3M_t = 0.624 + 0.392 TBILL3M_{t-1} + 20.842 MGRATE_{t-2} - 3.043 DUM$	(1.120) (0.187) (8.345) (1.009)
Return on the Mutual Fund ($\bar{R}^2 = 0.42$)	
$STOCKRTN_t = 0.147 + 0.003 STOCKPCE_{t-2} + 0.011 TREND$	(0.075) (0.003) (0.001)
Cotton Yield	
$COTTONYLD_t = COTTONYLD_{t-1} + error_{cy}$	
Cotton Price	
$COTTONPCE_t = COTTONPCE_{t-1} + error_{cp}$	
Wheat Yield ($\bar{R}^2 = 0.53$)	
$WHEATYLD_t = 20.917 + 0.774 TREND - 0.621 WHEATYLD_{t-1}$	(3.343) (0.172) (0.194)
Wheat Price ($\bar{R}^2 = 0.62$)	
$WHEATPCE_t = 7.683 + 0.461 WHEATPCE_{t-1} - 0.152 WHEATPCE_{t-2} - 0.121 WHEATPCE_{t-3}$	(2.125) (0.169) (0.049) (0.056)
Land Price ($\bar{R}^2 = 0.66$)	
$LANDPCE_t = 111.270 + 0.681 LANDPCE_{t-1} + 557.349 GNPRATE_{t-1}$	(63.661) (0.169) (303.948)
Stock Price ($\bar{R}^2 = 0.94$)	
$STOCKPCE_t = 3.334 + 0.460 STOCKPCE_{t-1} + 0.252 STOCKPCE_{t-3}$	(1.265) (0.169) (0.124)

^aVariable Definitions

<i>GNPDEF</i>	= percentage change in the gross national product implicit price deflator in time <i>t</i> .
<i>M2GRATE</i>	= growth rate in the M2 money supply.
<i>TBILL3M</i>	= real return on a 3-month treasury bill.
<i>STOCKRTN</i>	= return on the Massachusetts Investors Trust mutual fund (dollars/share).
<i>COTTONYLD</i>	= cotton yield (pounds/acre).
<i>COTTONPCE</i>	= cotton price (cents/pound).
<i>WHEATYLD</i>	= wheat yield (bushels/acre).
<i>WHEATPCE</i>	= wheat price (dollars/bushel).
<i>LANDPCE</i>	= land price (dollars/acre).
<i>STOCKPCE</i>	= price of the Massachusetts Investors Trust mutual fund stock (dollars/share).

lagged values for inflation rate, the M2 money supply growth rate, and annualized real rates of return on the three-month Treasury Bills. The M2 money growth rate forecasts were obtained from a random walk process. The three-month Treasury Bill equation was regressed against its own lagged real returns, M2 money supply growth rates, and a dummy variable to account for the 1979 Federal Reserve Board policy change from targeting interest rates to targeting monetary aggregates. Real return on the mutual fund had a trend term and lagged real mutual fund prices as the regressors. Cotton yield and cotton prices were assumed to follow a random

walk process. An expected wheat yield was estimated as a function of the lagged wheat yields and a trend term, while the real wheat price was estimated as a function of both the lagged wheat price and the lagged wheat yield. The regressors for real land price were the lagged real land price and the inflation rate. The regressors for the mutual fund price were its lagged values.

Second, a variance-covariance matrix of the residuals from these equations was computed and was used in a Monte Carlo simulation, along with the means of the residuals, to generate 50 random

observations for each variable. These were then added to the expected values obtained from each ten forecast equations at the beginning of each year to generate the distribution of expected values for each variable.

The 50 values for crop prices, crop yields, and interest rates were used to generate stochastic returns on farming based on crop budgets prepared by the Texas Agricultural Extension Service. Two sets of returns on farming were generated: returns to a lessee (a farmer who operates leased land) and returns to a landowner. If a farmer owns land being operated, then the farmer receives both sets of returns. Although prices, yields, and interest rates were endogenously decided in the model every year, real machinery costs, and other costs, were assumed to be constant over the planning horizon. However, costs like hauling charges that depend upon the volume of the harvest (thus on the yield) were allowed to vary according to yield. Nominal values were obtained by adjusting real values for inflation. Because inflation was stochastically decided in the model, nominal machinery and other costs were also stochastic.

Second Phase: Specification of States of Nature

To reduce the matrix of 50 observations for each of the 12 variables (10 variables representing the 10 expectational equations, and two variables from the farm return computations) into discrete states of nature, an equation reflecting the rate of growth in equity was specified using returns on farming, returns on off-farm investment and interest rates paid on debt. Each state of nature was defined by the growth rate of farm equity (i.e., high, intermediate, and low growth). To do this, the rate of growth in equity (g) was specified:

$$(2) \quad g = [r_a + L(r_a - i)](1 - t)(1 - c),$$

where r_a is the average pretax rate of return on total farm assets; i is the average interest rate paid on debt; t is the average tax rate on income; c is the average rate of withdrawals for family consumption; and L is the ratio of debt to equity. Every year, a new set of stochastic prices, stochastic yields, and stochastic interest rates was generated and was used

to compute new stochastic returns on farming operations. The average net rate of return on assets can further be specified as:

$$(3) \quad r_a = WGHT \frac{ROWN + ROPER}{PLND + COSTMACH} + (1 - WGHT) \frac{RSTK}{PSTK},$$

where $WGHT$ is the proportion of the farming operation in the farmer's total portfolio, $(1 - WGHT)$ is the proportion of stock in the farmer's total portfolio, $ROPER$ is the (dollar) return on crop sharing, net of the landowner's share, $ROWN$ is the (dollar) return to the land owner (i.e. the land owner's share of the total return on farming), $PLND$ is the price of land per acre, $COSTMACH$ is the cost of machinery used per acre, $RSTK$ is the (dollar) return on stock, and $PSTK$ is the price of stock.

The above equation says that the return on total assets is equal to the return on farming operations, and the return on off-farm investments, all weighted by their respective proportions in the farmer's portfolio. The average interest rate paid on debt was specified as:

$$(4) \quad i = TBILL + 0.05,$$

where $TBILL$ is the yield on a three-month Treasury Bill. The interest rate paid on farm debt was assumed to be five percentage points above the Treasury Bill rate, reflecting the historical spread between farm loans and the three-month Treasury Bill rate.

It is important to note that returns on farming operations are in turn functions of the price and yield of wheat, the price and yield of cotton, and the interest rate paid on operating capital. The g was used to rank the variables because of the association between the stochastic variables and g . The reorganized matrix was split into equal blocks where each block represented a state of nature for a given stage and the median value of each block was picked as the representative value for that state of nature.

Finally, we generated the set of nominal variables for use in the DSP model (the ones referred to at the beginning of this section). All real variables were converted to nominal values to correctly account for taxes. A cost of 5 percent of the price of land was charged for land selling activities, and stock transactions were charged 2 percent of the price of the stock. Nominal returns to a lessee, land owner, and stockholder were computed as real returns and adjusted for inflation. The discount rate was assumed to be equal to the interest rate on farm debt. The interest rate on CDs was assumed to be equal to the yield on three-month Treasury Bills. The farmer was assumed to have a minimum consumption of 10,000 dollars, which was adjusted for inflation every year. Above this minimum, the farmer was assumed to have a marginal propensity to consume of 20 percent of income.

The decision maker's planning horizon was divided into stages, with states of nature within each stage. A planning horizon of five stages (years) was used, with six states in the first stage, four in the second, two in the third, and one in the fourth and fifth stage. This resulted in forty-eight ending states of nature in the fifth stage. All the states of nature had an equal probability of occurrence. As Featherstone and Baker noted, there is a tradeoff between the number of states of nature and the number of stages that one can model because of the curse of dimensionality. Following Featherstone and Baker, we chose fewer states in more distant periods because a decision maker is more likely to be able to formulate and describe detailed probability information in the near term than in the long term.

In summary, data for use in the DSP model was generated as follows. First, expectations on the model variables were generated. Using a Monte Carlo simulation, random observations for each variable were generated, and then used to compute g . The values of g were ranked from lowest to highest. For six states of nature, for example, six groups of g 's would be formed. The median value of each group was selected to represent the state of nature. Thus the state of nature is the set of events that affect each of the variables that define g . Given that these g 's are ranked from lowest to highest, they reflect the least favorable to the most

favorable set of events. For example, poor weather is an event that would lower g via lower crop yields, thus it would imply a less favorable state of nature, holding everything else constant. Note that because the covariances of these variables have been included in the model, these events are interlinked with one another. For each stage, the above sequence is repeated. These variables were then used in the DSP model that was solved using the MINOS computer program. Summary statistics for the variables used in the model are presented in table 2.

Annual data for the period 1967 - 1987 were used in the study. Data on crop yields and prices were taken from the *Texas Agricultural Cash Receipts and Price Statistics*, and land prices are from the *Texas Real Estate Research Center* at Texas A&M University. Data on money growth rates, inflation, and three-month Treasury Bills are from the *Economic Report of the President* and mutual fund data are from *Wiesenberger Investment Companies Service* annual publications. Historical returns on farm assets are from the *Agricultural Finance Databook* of the Board of Governors of the Federal Reserve System. Returns to a share lessee and/or an owner operator are computed using procedures employed by the Texas Agricultural Extension Service for the Texas Rolling Plains.

Investment Scenarios

Seven investment scenarios were simulated (table 3). In all the scenarios, the farmer operates 500 acres of land that is a representative size of farming operations in the Texas Rolling Plains. However, the farmer does not necessarily own all the 500 acres, as described below. The farmer starts with an initial equity of 75,000 dollars and holds cash in CDs. This initial equity is not assumed to include the farmer's equity in machinery. These scenarios represent the different investment opportunities available to the farmer.

In the first scenario, the farmer owns 250 acres of the 500 acres operated. The remaining 250 acres is operated under a share lease arrangement. In this scenario, the farmer does not have the opportunity to invest in mutual funds. The second scenario differs from the first only by giving the farmer the opportunity to invest in additional land.

Table 2. Descriptive Statistics of the States of Nature for the Stochastic Variables used in the DSP Model (All Dollar Values are Nominal)

Year	Mean	Standard Deviation	Minimum	Maximum
-----Price of Land (dollars/acre)-----				
1	439 27	21 75	415 41	472 99
2	464 87	34 64	389 02	522 77
3	476 12	40 84	395 07	553.01
4	504 36	51 20	403 10	635 76
5	532 80	79 60	378 31	696 66
-----Price of Stock (dollars/share)-----				
1	12 99	1 79	10 13	15 19
2	13 63	1 85	8 86	17 52
3	14 07	2 34	9 45	18 68
4	14 92	3 03	8 64	20 69
5	15 61	3 32	8 45	23 09
-----Interest on Debt-----				
1	0 11	0 02	0 08	0 14
2	0 12	0 19	0 08	0 16
3	0 13	0 02	0 09	0 19
4	0 13	0 04	0 07	0 23
5	0 14	0 04	0 07	0 23
-----Farm Return to the Operator (dollars/acre)-----				
1	37 94	19 60	9 23	66 48
2	35 50	25 27	-11 66	78 28
3	37 64	32 39	-26 53	108 75
4	39 08	30 70	-32 22	107 85
5	44 53	34 09	-30 05	132 12
-----Farmer Return to the Landowner (dollars/acre)-----				
1	43 70	7 00	32 99	53 80
2	43 95	8 38	28 85	59 12
3	46 30	10 93	23 53	70 16
4	48 39	10 17	25 64	71 66
5	51 85	11 75	26 36	80 92
-----Return on Stock-----				
1	0 11	0 02	0 08	0 15
2	0 13	0 02	0 08	0 18
3	0 14	0 02	0 09	0 20
4	0 16	0 04	0 10	0 26
5	0 17	0 03	0 11	0 25
-----Return on Certificates of Deposit-----				
1	0 06	0 02	0 03	0 09
2	0 07	0 01	0 03	0 11
3	0 08	0 02	0 04	0 14
4	0 08	0 04	0 02	0 18
5	0 09	0 04	0 02	0 18

Table 3. Investment Alternatives Simulated in the Model

Scenario	Land Owned (acres)	Stocks	CDs	Land Operated (acres)	Initial Equity (dollars)	Initial Debt (dollars)
1	= 250	No	Yes	500	75,000	32,500
2	≥ 250	No	Yes	500	75,000	32,500
3	= 250	Yes	Yes	500	75,000	32,500
4	≥ 250	Yes	Yes	500	75,000	32,500
5	= 20	Yes	Yes	500	75,000	0
6	≥ 20	Yes	Yes	500	75,000	0
7	≥ 20	No	Yes	500	75,000	0

Thus, besides the 250 acres already held, the farmer can purchase more land. In the third scenario, the farmer does not have the option of investing in additional land, but can invest in mutual funds. The fourth scenario, however, gives the farmer both the options of investing in additional land and mutual funds. The fifth scenario simulates a farmer with an even smaller initial land investment. The farmer holds 20 acres of land, and has the option to invest in mutual funds. The sixth scenario allows for further purchases of land besides the mutual fund option. The seventh scenario does not have the mutual fund option. Each of the seven investment scenarios was run under eleven different risk aversion levels and the corresponding certainty equivalents of ending wealth were compared.

Results

The certainty equivalents of ending wealth for the seven alternative investment scenarios were computed at eleven different risk aversion levels (table 4). In the first scenario, a "highly" risk-averse farmer (e.g. Pratt risk aversion parameter = 0.0001) had a certainty equivalent of ending wealth of 72.15 thousand dollars, compared to 123.22 thousand dollars for a less risk-averse farmer (e.g., Pratt risk aversion parameter = 0.000009). When the opportunity to invest in more than 250 acres was available (second scenario), there was a marginal increase in the certainty equivalent of ending wealth (a change of 1.69 thousand dollars for the highly risk-averse case, and 3.9 thousand dollars for the least risk-averse case). As expected, the increase for the least risk-averse case was more than the increase experienced by the highly risk-averse case. The latter invested in more additional land than the former. However, when the option to invest in mutual funds replaced the option to invest in additional land (third scenario), the highly risk-averse case obtained a certainty equivalent of ending wealth of 119.62 thousand dollars, an increase of 47.52 thousand dollars over the corresponding figure in the first scenario. The least risk-averse case experienced an increase of 42.39 thousand dollars over the corresponding figure in the first scenario, but had 45.94 thousand dollars more when it was compared to the third-scenario's highly risk-averse case. The option to invest in mutual funds enhanced the liquidity and stability of the farm income. The increases in the fourth scenario over the levels in the third scenario were

very modest (0.22 thousand dollars for the highly risk-averse case and 2.49 thousand dollars for the least risk-averse case) showing that the option to invest in more land provided less farm revenue than the mutual fund option.

In the fifth scenario, the farmer was assumed to hold 20 acres of land (around the homestead). This meant that there was less equity tied up in land and, consequently, more equity available for investment in mutual funds. There was a 9.1 thousand-dollar increase in the certainty equivalent of ending wealth over the previous scenario for the highly risk-averse case, and a corresponding 4.96 thousand dollar increase for the least risk-averse case. Perhaps the most interesting scenario was the sixth, where both options (land and mutual fund investments) were available to the farmer and the initial land investment was only 20 acres. As expected, because the farmer had the most flexibility, this scenario showed the highest gains, with the highly risk-averse farmer achieving a certainty equivalent of 130.41 thousand dollars, and the least risk-averse farmer achieving a certainty equivalent of 177.34 thousand dollars. An additional scenario without a mutual fund option was also run, but, as expected, only did better than scenarios one and two. A farmer without a large portion of equity in land is in a better position to diversify using off-farm investments.

The effect of stock investment on firm risk is presented by showing the coefficient of variation of ending wealth for selected levels of risk aversion and three investment alternatives: (1) investment in at least 250 acres of land, with no mutual fund option; (2) investment in at least 250 acres of land with a mutual fund option; and (3) investment in at least 20 acres of land with a mutual fund option (figure 1). The investment alternative with the least initial land commitment and a mutual fund option had the lowest risk for every dollar of expected ending wealth, and the investment alternative without a mutual fund option had the highest risk per dollar of expected ending wealth for all risk aversion levels. Thus, the presence of mutual funds in the farmer's portfolio helped stabilize the farm income.

The cumulative probability distributions for ending wealth were derived from solutions at a medium level of risk aversion ($\rho=0.00005$) for two

Table 4. Certainty Equivalents of Ending Wealth^a for the Different Investment Scenarios Solved at Selected Risk Aversion Levels (\$1,000s)

Risk Level ^c	Scenario ^b :						
	[1]	[2]	[3]	[4]	[5]	[6]	[7]
0.0001	72.15	73.84	119.89	119.89	128.99	130.41	76.65
0.00009	75.14	76.96	123.23	123.66	133.33	135.14	79.60
0.00008	78.65	80.61	126.78	127.06	138.74	140.41	83.02
0.00007	82.78	84.87	130.26	130.93	142.45	144.67	86.98
0.00006	87.62	89.88	134.23	135.06	146.52	149.04	91.57
0.00005	93.29	95.70	138.71	139.68	150.37	153.20	96.86
0.00004	99.79	102.36	143.93	145.17	154.66	157.72	102.52
0.00003	107.02	109.80	149.95	151.45	159.56	162.88	109.52
0.00002	114.71	117.84	156.85	158.70	165.31	168.98	116.79
0.00001	122.46	126.26	164.74	167.18	172.28	176.50	124.52
0.000009	123.22	127.12	165.61	168.10	173.06	177.34	125.32

^aEnding Wealth is defined as the present value of ending equity and cash withdrawals from the business.

^bSee Table 3

^cPratt Risk Aversion Parameter

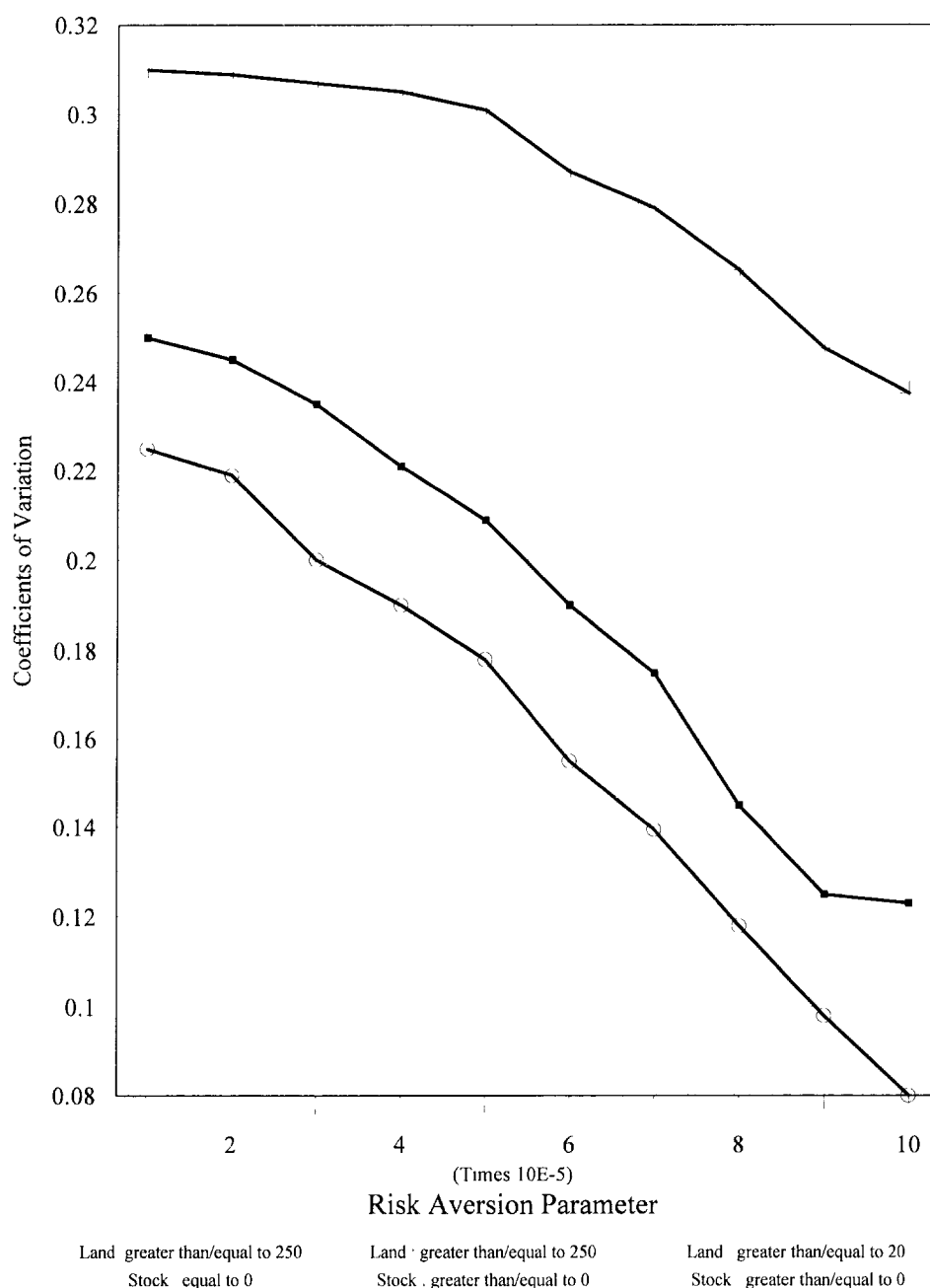
investment alternatives: 1) the farmer holds at least 250 acres of land without a mutual fund option; and 2) the farmer holds at least 250 acres of land with a mutual fund option (figure 2). The difference between the two scenarios is that off-farm investment is possible in the second but is not possible in the first. It is clear from the graphs that the second investment alternative dominates the first by first-degree stochastic dominance. Ending wealth ranged from 100,000 dollars to 268,000 dollars with a mutual fund option, but only ranged from 39,000 dollars to 218,000 dollars without a mutual fund option. Moreover, the farmer had a 50 percent chance of achieving ending wealth of at least 180,000 dollars with a mutual fund option but only a 12 percent chance of achieving ending wealth of at least 180,000 dollars without a mutual fund option.

Next, the average portfolio composition over the investment horizon is reported for three investment alternatives solved at a medium risk aversion level (tables 5, 6, and 7). For the scenario in which the farmer had the opportunity to invest in land (besides 250 acres already owned) but not in mutual funds, at least 97 percent of the farmer's

investment was in land in any given year (table 5). However, when both the land and mutual fund options were available to the farmer, land investment ranged from a low of 42.08 percent to a high of 72.09 percent of the total investment (table 6). In four out of the five years in the farmer's investment horizon, less than 50.00 percent of the total investment was in land. When only 20 acres of land were initially held, with both land and mutual fund investment options available, land investment as a percentage of total investment ranged from 5.79 percent to 33.66 percent, whereas mutual fund investment ranged from 66.11 percent to 94.21 percent (table 7). Although these statistics vary for different risk aversion levels, the relationship is the same.

The numerical results of this study are, of course, dependent on the data used for this study. For example the high investment in mutual funds may be higher than expected because of the favorable returns on stock over the historical period modeled. Moreover, this study did not model an "implicit return" to land ownership. This implicit return exists because ownership eliminates the uncertainty of finding land to lease. Ignoring this

Figure 1. Coefficients of Variation of Ending Wealth Plotted Against Risk Aversion Parameters for Selected Investment Scenarios



implicit return leads to an understatement of the value of farm ownership.

Divergence between farm level investment behavior and model results is also possible because of model assumptions and simplifications. First, the

choice of off-farm investments that are profitable and not highly correlated with the farm net returns may require a level of investment sophistication not available to all farmers. Also, obtaining such information can be costly. Second, this study constrained the farm to grow wheat and cotton, the

Figure 2. Cumulative Probability Distributions of Ending Wealth for Two Investment Scenarios (Pratt Risk Aversion Parameter = 0.00005)

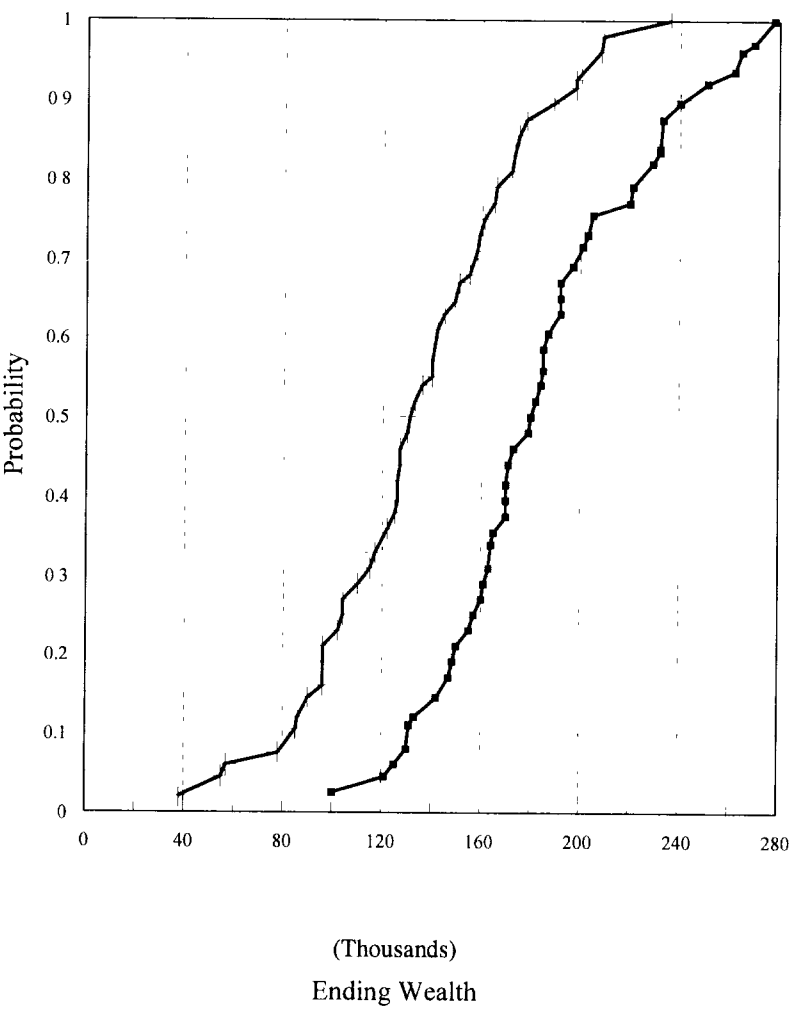


Table 5. Average Portfolio Composition of the Investment Alternative that Holds at Least 250 Acres of Land, and No Mutual Funds Solved at a Medium Risk Level

Year (Beginning)	Land		Stock		CDs		Total	
	Dollars	Percentage	Dollars	Percentage	Dollars	Percentage	Dollars	Percentage
1	115,058	100.0	0	0.0	0	0.0	115,058	100.0
2	151,664	100.0	0	0.0	0	0.0	151,664	100.0
3	179,449	98.0	0	0.0	3,743	2.0	183,192	100.0
4	255,633	99.4	0	0.0	1,570	0.6	257,203	100.0
5	207,366	97.8	0	0.0	4,738	2.2	212,104	100.0

Table 7. Average Portfolio Composition of the Investment Alternative that Holds at Least 20 Acres of Land, and Some Mutual Funds Solved at a Medium Risk Level

Year (Beginning)	Land		Stock		CDs		Total	
	Dollars	Percentage	Dollars	Percentage	Dollars	Percentage	Dollars	Percentage
1	8,594	5.8	139,906	94.2	0	0.0	148,500	100.0
2	81,390	33.7	160,388	66.3	0	0.0	241,778	100.0
3	87,774	27.2	213,222	66.1	21,545	6.7	322,541	100.0
4	92,297	23.0	282,843	70.3	27,080	6.7	402,220	100.0
5	82,242	22.2	250,069	67.5	38,202	10.3	370,513	100.0

Table 6. Average Portfolio Composition of the Investment Alternative that Holds at Least 250 Acres of Land, and Some Mutual Funds Solved at a Medium Risk Level

Year (Beginning)	Land		Stock		CDs		Total	
	Dollars	Percentage	Dollars	Percentage	Dollars	Percentage	Dollars	Percentage
1	107,420	72.1	41,580	27.9	0	0	149,000	100.0
2	135,082	49.0	140,637	51.0	0	0	275,719	100.0
3	159,264	45.2	175,332	49.7	17,926	5.1	352,522	100.0
4	184,418	42.0	241,290	55.1	12,574	2.9	438,282	100.0
5	175,943	43.3	202,767	49.9	27,554	6.8	406,264	100.0

two principal crops grown in the Texas Rolling Plains, in fixed proportions. However farmers may have greater crop diversification that may reduce the need for off-farm investments. Third, the model's planning horizon was limited to five years due to computational considerations. However, farmers' planning horizons may exceed five years, and this may affect on-farm and off-farm investment decisions. In spite of the possible divergence from the observed investment behavior at the farm level, this study provides a methodological framework that can be modified to address the issues raised above.

Summary and Conclusions

A multiyear, discrete stochastic programming model was formulated to study the gains from diversification when farming is augmented with land investment and off-farm investments like mutual funds and CDs. Farming data from the Texas Rolling Plains were used for empirical analysis. This framework made it possible to model uncertainties in the objective function, the technical coefficients, and the available

resources. The results of the analysis showed that farmers obtained higher certainty equivalents of ending wealth when their farm portfolios included mutual funds than when these off-farm investments were excluded. The farmers that were the least averse to risk achieved the highest gains from off-farm investments.

This study has shown that off-farm investments can help reduce variability in net income. Further research should be done in identifying groups of off-farm investments with returns that are less correlated with returns on agriculture. For example, oil stocks or funds that are heavily invested in oil stocks might help stabilize farmers' portfolio performance because high oil prices may hurt agriculture but boost oil stocks. Losses incurred on the farm operation can be partially offset by gains on share prices of these stocks or in the value of mutual funds heavily invested in these stocks. Much work has been done in the area of risk mitigation through options and futures, but little work has been done in the use of

off-farm investments and the advantages this approach could have over the traditional methods.

Some farmers may lack sufficient aggregate resources to allow for an efficient farming enterprise if funds are diverted to stock investments. Other farmers may benefit, however, from including stock in their investment portfolio. Part-time farmers who are less heavily invested in agriculture may have surplus capital to invest in non-farm investments. Farmers that own land have the opportunity to sell part of their land holdings and invest the proceeds in off-farm investments. Also, some farmers would

benefit from investing retained earnings in off-farm investments instead of making additional land purchases. It should be noted, however, that some farmers may have difficulty acquiring land to operate if it is not owned.

More research is needed to assess the extent to which farmers engage in off-farm investments and how this involvement varies among different categories of farmers. It is also important to assess farmers' attitudes toward financial markets and the constraints that might impede their participation in them.

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Endnotes

1. The mean return on the mutual funds for a 25 year period ranged from a low of 6.73 percent to a high of 12.45 percent. The following funds were studied (with the mean returns in parentheses): Oppenheimer Fund (12.45 percent), Affiliated Fund (9.25 percent), American Balanced Fund (7.42 percent), American Mutual Fund (9.78 percent), Financial Industrial Income (10.86 percent), Massachusetts Investors Trust (6.73 percent), Sigma Investment Shares (7.59 percent), United Accumulative Fund (7.81 percent), and the Value Line Income Fund (9.30 percent).
2. To test whether the low relationship between farm returns and mutual fund returns observed in the historical data was maintained during the modeling process, a pairwise correlation was also done, using farm returns and mutual fund returns generated from this model. The results showed that this relationship was maintained in the model.
3. It is not assumed that the farmer will go out of business. This is just a simple way of getting a measure of the farm's financial position and contingent taxes at that point in time.