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IMPLICATIONS OF PRICE, YIELD

AND COST SHOCKS

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Abstract

Recent years have witnessed increasing volatility in crop prices and yields, fertilizer prices, and farm asset values. In this study, the financial performance of illustrative Midwest grain farms with different scales, tenure status, and capital structures was examined under the shocks of volatile crop prices, yields, fertilizer prices, farmland value, and cash rent. Illustrative farms of 550, 1200, and 2500 acres were constructed reflecting the production activity for these farms with three different farmland ownership structures (15%, 50%, and 85% of land owned) and two capital structures measured by debt-to-asset ratio (25% and 50%). Absolute measures and financial ratios were used to evaluate the income, cashflow, debt servicing and equity position of these illustrative farms. The "stress test" results suggest that farms with modest size (i.e. 550 acres) and a large proportion of their land rented are very vulnerable irrespective of their leverage positions. Large size farms with modest leverage (25% debt-to-asset ratio) that combine rental and ownership of the land they operated have strong financial performance and limited vulnerability to price, cost, yield, and asset value shocks. And these farms can increase their leverage positions significantly (from 25% to 50% in this study) with only modest deterioration in their financial performance and a slight increase in their vulnerability. These results suggest that the perspective that farmers are resilient to price, cost, yield and asset value shocks because of the current low use of debt in the industry (an average of approximately 10% debt-to-asset ratio for the farming sector) does not adequately recognize the financial vulnerable of many typical family farms to those shocks.

Keywords: Financial Vulnerability, risk, farm financial stress, shock testing

JEL Codes: Q12, Q14

Introduction

Farming is a risky business. Farm businesses in the U.S. are exposed to increasing variations in commodity production and price, input costs, and capital asset values. These variations have a significant effect on the farm business's profitability and financial performance, and even their survivability. Crop prices in the United States, especially corn and soybean prices have steadily increased since 2007 due to global biofuel programs, a growing export market, and unstable weather conditions. Severe weather variability, the recent drought in the U.S. Midwest creates yield variability. Increased crop production resulting from high commodity prices as witnessed over recent years has also increased fertilizer demand, resulting in higher fertilizer prices, which further impacts the profitability of farm businesses.

Farm real estate is the major asset on the balance sheet of the farm sector, accounting for almost 85% of the total value of U.S. farm assets in 2012 (NASS/USDA). Therefore, the values of farmland are an important indicator of the financial performance and well-being of the farm sector and agricultural producers (Nickerson, et al, 2012). Soaring farmland values have driven many to worry that the farm sector might encounter a repeat of the farmland value bubble that collapsed in the 1980s. The National Agricultural Statistic Service reports indicate that Indiana farm real estate values have more than doubled since 2001, with a compounded growth rate of 7.4% per year.

With current record high farm net income, $128.2 billion projected for 2013 (USDA, 2013), far-sighted farmers and the academic world must be asking many "what if" questions: What if commodity prices turn down? What if fertilizer prices continue to increase? What if farmland cash rent continues to increase? What if land values decline? With all the "what if" questions in mind, farmers and economists are concerned about the incidence and intensity of financial stress the farming sector might encounter in the future.

Studies of farm risks typically focus on one or two aspects of crop price and yield, fertilizer price, farmland value, cash rent etc. Few of them have studied the combined impacts of all these risks on farms' financial performance. Few have been devoted to comparisons of the incidence and intensity of financial stress of individual farms with different scales, tenure status and capital structures. This study attempts to fill that gap by conducting financial stress tests for illustrative farms with different sizes, tenure status and capital structures to shocks in crop prices and yields, fertilizer prices, farmland value and cash rent.

The Context

During the mid-1980s, U.S. farmers experienced extreme financial stress. They had experienced a prosperous decade during the 1970's with prices and farm incomes at record levels. Farmers expanded their operations, made capital investments, purchased land, and upgraded machinery. And some of them incurred relatively heavy debt to make these investments - - a strategy that had enabled good farm managers to achieve more rapid growth in their income and wealth. Then in the 1980's incomes declined dramatically, and land values dropped as much as 60 percent in some regions from the late 1970s to early 1980s. Farm foreclosures and bankruptcies increased to a level not seen since the Great Depression.

The financial crisis of the 1980's was caused by a number of factors (Doye, 1986). Farmers' financial structure changed significantly from the 1970s to the 1980s because of lower credit cost and a more favorable attitude about borrowing. At the same time, appreciating asset values added to farmers' borrowing capacity by providing better collateral to support loan requests. Credit became a very important tool to grow as well as adjust to external forces, which made farms more vulnerable to risk from income variability, collateral and equity erosion, interest rate volatility, and changes in lenders' policy. Debt accumulation surpassed the pace of growth in net farm income, and debt servicing consumed a larger share of income. The ratio of debt to net cash income of the farm sector increased from 3.0 in 1970 to 5.4 in 1984, and interest as a percent of gross cash income rose from 6.2 in 1970 to 14.7 in 1982. At the same time, farm liquidity problems arose, not only due to the change in the debt structure but also to the low return to agriculture's assets. Low rates of return and high interest expense caused cash flow problems, and at the same time significant real capital gains collateralized large increases in the debt load (Doye, 1986).

Today, U.S. agriculture is said to be in the midst of another farm boom, similar to the one in the 1940s when soaring wartime food demand boosted U.S. agricultural exports, and the one in the 1970s where a spike in U.S. agricultural exports sparked another surge in U.S. farm income (Henderson, Gloy, and Boehlje, 2011). Exports are at a record high because of strong global demand from expanding populations and rising incomes in developing countries. Fiscal 2013 agricultural exports are forecasted at almost $140 billion (USDA Outlook for U.S. Agricultural Trade).

At the same time, the Renewable Fuels Standard which was established in 2005 substantially increased the demand for grains and oilseeds, especially com. According to USDA, the amount of corn used in ethanol production surged from less than 650 million bushels to nearly 5 billion bushels from 2000 to 2011 (Henderson, Gloy, and Boehlje, 2011).

Crop prices have soared since 2006 and spiked in 2011; livestock prices have also reached record highs with robust export demand (Henderson, Gloy, and Boehlje, 2011). With high agricultural commodity prices and increased productivity, farm profits have reached the highest level since the mid-1970s. On the other hand, today's interest rates have reached a record low, which has fostered the capitalization of rising farm incomes into record high farmland values. The capitalization of income into farmland values has accelerated, with the average price of U.S. farmland rising 25 percent from 2004 to 2011. (Henderson, Gloy, and Boehlje, 2011)

<u>The Analysis</u>

A financial simulation model is used to analyze the effect of shocks of crop prices and yields, fertilizer prices, farmland value and cash rent on the financial performance of Midwest illustrative farms. This study focuses on grain farms in Central Illinois - - the attributes used to classify the farms are size of farm, tenure status (percentage of land ownership), and debt-to-asset ratios. Previous studies show farms of various sizes, tenure status, and the debt-to-asset ratios differ from each other in production and financial positions and have different capabilities to survive financial stress (Jolly et al., 1985). Eight representative farms are constructed with different specifications of farm size, percentage of ownership, and debt-to-asset ratio. The characteristics of those eight farms are displayed in Table 1.

Table 1. Specifications of Illustrative Farms

Model farm	Size(Acres)	Debt-to-Asset Ratio	% of Land Ownership
Size Comparison	550	25%	50%
	1200	25%	50%
	2500	25%	50%
Land Tenure Comparison	550	25%	85%
	550	25%	50%
	550	25%	15%
Debt to Asset Ratio Comparison	2500	25%	50%
	2500	50%	50%

Table 2 lists the levels and percentage of assets and liabilities on beginning year balance sheets of the first year of the simulation period for the model farms of 550, 1200, and 2500 acres. Each of the three sizes of farms displayed in this table has an initial debt-to-asset ratio of 25% and farmland ownership percentage of 85%; different debt-to-asset and farm ownership percentage illustrative farms have similar asset and liability compositions (percentages) adjusted for the appropriate asset ownership and debt levels. The simulation period is the 3 year period from 2012 to 2015; @Risk in Excel is used for the analysis with 10,000 iterations for each simulation.

Table 2. Starting Balance Sheets of Illustrative Farms

01/01/2012	550 Acres		1200 Acres		2500 Acres	
	$	%	$	%	$	%
Asset	1,167,996	100%	2,310,686	100%	4,589,664	100%
Current Assets	282,445	24.2%	537,250	23.3%	1,055,955	23.0%
Cash	55,000	4.7%	85,000	3.7%	180,000	3.9%
Cash invested in growing crops	8,481	0.7%	17,619	0.8%	59,072	1.3%
Crop inventory	107,164	9.2%	220,000	9.5%	413,883	9.0%
Accounts receivable	90,000	7.7%	174,231	7.5%	300,000	6.5%
Prepaid expenses	21,800	1.9%	40,400	1.7%	103,000	2.2%
Noncurrent Assets						
Machinery & equipment	266,865	22.8%	413,577	17.9%	771,502	16.8%
Land	864,765	56.7%	1,886,761	61.1%	3,930,752	63.3%
Buildings	110,000	9.4%	250,000	10.8%	450,000	9.8%
Liabilities	391,631	25%	793,872	25%	1,591,689	25%
Current Liabilities	98,684	6.5%	193,576	6.3%	483,293	7.8%
Operation loan	43,135	2.8%	76,282	2.5%	275,662	4.4%
Accrued taxes	1,579	0.1%	2,792	0.1%	10,089	0.8%
Accounts payable	9,773	0.6%	16,678	0.5%	46,705	0.8%
Current portion of term debt		2.3%		2.5%		1.8%
Buildings	3,329		7,628		12,259	
Machinery	17,256		26,960		44,903	
Land	14,091		43,727		57,652	
Accrued interest		0.6%		0.6%		0.6%
Buildings	835		1,914		3,076	
Machinery	1,738		2,715		4,522	
Land	6,948		14,881		28,425	
Noncurrent liabilities (principal due beyond 12 months)		19.2%		19.4%		17.9%
Buildings	25,704		58,892		94,647	
Machinery	53,469		83,536		139,134	
Land	213,774		14,881		874,615	

The simulation model used to analyze the effect of shocks of crop prices and yields, fertilizer prices, farmland value and cash rent on the financial performance of the illustrative farms requires distributions of these variables. Daily corn and soybean futures prices data were obtained for the December contracts traded on the Chicago Board of Trade from 1975 through 2011(Farmdoc/University of Illinois). Crop yields measured in bushels per acre for corn and soybeans were obtained for the eleven counties of Central Illinois from National Agricultural Statistic Service (NASS/USDA) through the period of 1925 to 2011. U.S. farm prices of selected fertilizers (anhydrous ammonia (NH3), diammonium phosphate 18-4-0 (DAP) and potash) measured in dollars per ton were obtained from Economic Research Service (ERS/USDA) through the period of 1971 to 2011. Illinois state wide land values and cash rents in dollars per acre from 1970-2011 were available from National Agricultural Statistics Service (NASS/USDA) and Farmdoc/University of Illinois.

A sequential approach was used to estimate and then simulate price and yield observations to ensure the correlations observed among price and yield for corn and soybeans along with fertilizer price, farmland value and cash rent remain intact. Regression equations were estimated based on a prior knowledge and the relationships observed in the model input. December corn futures prices and soybean futures prices were estimated and simulated together through the bivariate CCC_ARCH process due to the fact that futures prices of corn and soybean were found to be highly correlated. Based on the outcome of the simulated future prices, local cash price at harvest time and yield data for corn and soybean were simulated based on the regressions fit to available model input data. Spring fertilizer prices were them simulated based on the regression with corn futures prices because fertilizer prices are correlated with futures prices for corn. In the final step, farmland value and cash rent were simulated with a model developed based on the concept of capitalized future earnings by Featherstone and Baker in 1988. Details of the estimation and the use of those estimated equations in the simulation model are provided in Li. Table 3 lists the mean, standard deviation, maximum, minimum, 95% percentile, and 5% percentile of the estimated distributions for price and yield of corn and soybeans, fertilizer prices, cash rent and farmland price used in the model.

Table 3. Distributions of Stochastic Variables

	Mean	Standard Deviation	Maximum	Minimum	95% percentile	5% percentile
Corn Price ($/bu)	4.91	0.25	5.95	3.79	5.31	4.50
Corn Yield (bu/acre)	183.73	28.92	303.59	80.77	231.50	136.30
Soybean Price ($/bu)	9.65	0.89	14.79	6.36	11.17	8.26
Soybean Yield (bu/acre)	52.84	5.67	80.62	31.98	62.27	43.60
NH3 Price ($/pounds)	0.32	0.05	0.63	0.20	0.41	0.26
DAP Price ($/pounds)	0.32	0.03	0.47	0.21	0.38	0.27
Potash Price ($/pounds)	0.26	0.04	0.46	0.03	0.32	0.19
Cash Rent ($/acre)	271.96	13.42	359.64	213.00	294.60	251.20
Land Price ($/acre)	6067.64	344.63	7803.82	3970.64	6625.00	5502.00

Crop insurance and pre-harvest hedging using futures are implemented in the model as risk management strategies. Two insurance options are modeled for the illustrative farms - - COMBO

Revenue Protection (RP) and COMBO Yield Protection (YP). The insurance premiums for the two policies are estimated using the iFarm Crop Insurance Premium Calculator developed by Farmdoc, University of Illinois. Premiums are calculated for Woodford County, Illinois at the 75% coverage level; they are $8.76 and $16.02 per acre for corn COMBO YP and COMBO RP respectively; and $5.60 and $9.01 per acre for soybean COMBO YP and COMBO RP, respectively. A pre-harvest hedge with futures is included in the model. It is assumed that 60% of the expected production is hedged using December future contracts for corn and soybeans in April in order to protect against downside price risk, and the short position is offset at harvest time.

The basic structure of the simulation model is summarized in Figure 1 - - a detailed description is provided in Li. Cash flow is the key indicator of the farm business's liquidity and financial stress status. If a farm business is out of cash, it cannot meet financial obligations including production expenses, capital expenditures, debt payments, and family living expenditures. At the end of each year of the simulation period, the cash balances of the illustrative farms are evaluated. The farms are assumed to have to maintain a cash balance higher than a minimum value in order to prepay expenses or purchase inputs to maintain normal production activities. The minimum cash levels required for the illustrative farms are as follows: $50,000 for the 500-acre farm, $80,000 for the 1200-acre farm, and $170,000 for the 2500 acre farm. These cash levels are averages of cash holdings on balance sheets of these size farms in 2010 as reported in *ARMS Farm Financial and Crop Production Practices*.

Farms with an excess cash balance have the opportunity to expand the asset base of the business. The extra cash is invested in maintenance of machinery and buildings, used to purchase farmland which will improve production potential of the farm, or simply be accumulated as cash for future liquidity.

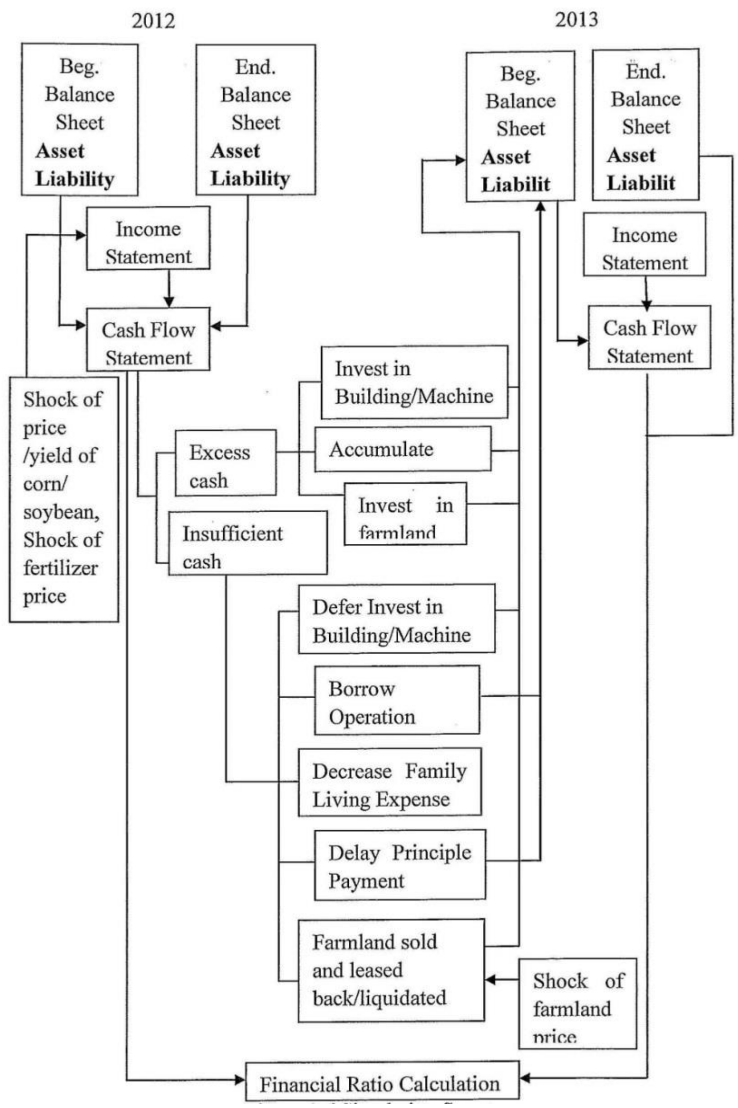

Figure 1. Simulation Structure

Farms with a cash balance that falls below the minimum level are regarded as having an insufficient cash balance. Adjustments are necessary to maintain the business and avoid bankruptcy. These adjustments are assumed to be implemented in a specified order, and after each adjustment the cash balance is re-measured to consider the necessity of further adjustments. The hierarchy of the adjustments is inspired by the study of Doye, 1986 as follows:

- Defer investment in maintenance of machinery and buildings - -Investment in maintenance of machine and buildings with an amount equal to the magnitude of depreciation of these two non-current assets is assumed to be made in a year with excess cash balance. When the cash balance is below the minimum level, the investment is deferred into future years. The gap between the magnitude of depreciation and investment is accumulated until the farm business generates excess cash.

- Revolving operating line of credit - - A three-year revolving line of credit is assumed to be available for all representative farms with insufficient cash balance. Farms can borrow funds any time during the three-year simulation period when cash is needed as long as the outstanding balance doesn't exceed the credit limit. The credit limit is determined by the farms' net working capital at the beginning of the simulation period.

- Decrease family living expense - - After the revolving line of credit reaches the upper limit, farms that still have insufficient cash balances are assumed to decrease their family living expense to a lower limit, which is $67,606 – the average non-capital living expense for farm households from the Illinois Farm Business Farm Management Association in 2010.

- Delay principal payment - - The amount of cash provided by decreasing family living expense is limited. If the farm is still short of cash, it is assumed that the owner of the farm can negotiate a one year delay of the principal and interest payment on term debt. The accumulated delayed payment through the simulation period cannot exceed one - third of the farm's equity.

- Sell farmland and lease back - - The opportunity of selling the farmland and leasing it back is assumed to be available. The acreage that needs to be sold and leased back to cover the shortage of the cash balance is calculated as the cash shortfall divided by the net price of farmland reduced by the deferred taxes.

- Liquidate farmland - - If selling farmland and leasing it back is still insufficient to cover the cash shortfall, liquidating farmland is the last resort for the farm to recover from the financial difficulties. If all the farmland owned is sold and the farm is still short of cash to meet all financial obligations, this farm is regarded as bankrupt. The acreage of farmland that must be liquidated is calculated as the cash shortfall divided by the after deferred tax price of farmland.

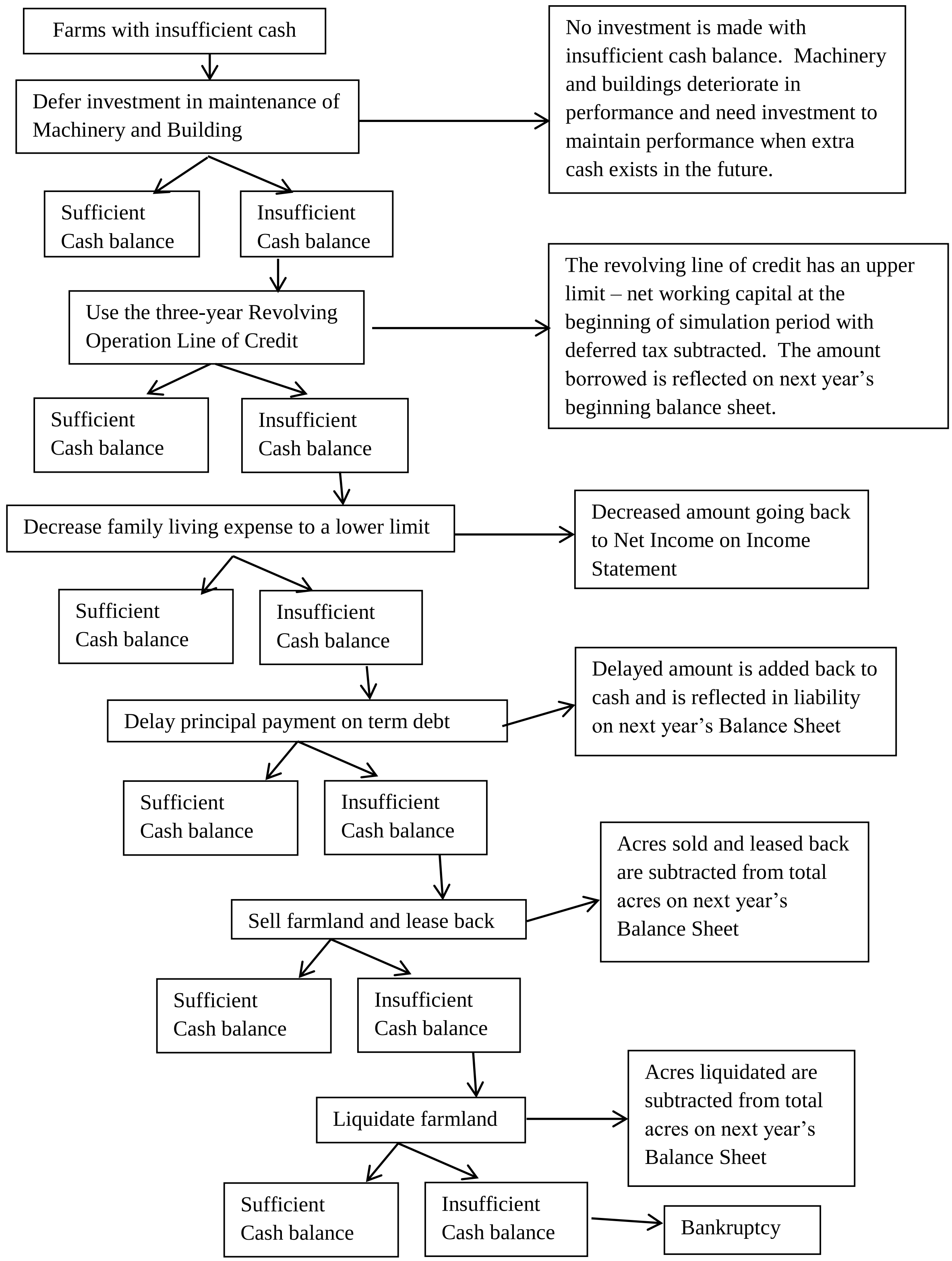

Figure 2. Adjustments with Insufficient Cash Balance

The Results

The financial performance of the illustrative farms will be evaluated by examining several key financial characteristics of the farm business. The mean as well as the distributions for the following financial measures will be discussed: net income, change in net worth, debt-to-asset ratio, term debt and capital lease coverage ratio, working capital, cash balance, return on equity, operating line utilization, term debt payment delay and land liquidation.

Size of Farm

The results of the financial measures in the last year of the three-year simulation period for farms with different sizes when the ownership of farmland and debt-to-asset ratio are specified to be 50% and 25% respectively are presented in Table 4. With 50% ownership of farmland and a 25% debt-to-asset ratio, farms of larger sizes have higher probabilities of a positive cash balance and a return on equity (ROE) greater than 10%. Over 98% of farms with 2500 acres have a positive cash balance after meeting all financial obligations and family living expense, and 20% of them have a rate of return on equity over 10%. The mean net farm income of 2500-acre farms is about four times that of 1200-acre farms, while the mean net farm income of 1200-acre farms and 550-acre farms are very similar. The variability of net farm income of 2500-acre farms is much higher than that of 1200-acre farms, and 1200-acre farms have higher variability in income than 550-acre farms. The distribution of net farm income for 2500-acre farms is wider than the other two, especially on the right side, which indicates a higher possibility for larger farms to earn higher net farm income.

With higher net farm income, the larger farms are able to contribute more to net worth than smaller farms. The mean net worth for 2500-acre farms increases by 30% at the end of the simulation period, while it increases only by 7% for the 1200-acre farms and decreases by 4% for 550-acre farms. Although the probabilities of negative net farm income for the 550-acre farms are low throughout the simulation period (1% in 2012, 0.3% in 2013, and 0.7% in 2014), after subtracting family living expense the probabilities of negative change in earned net worth are relatively high for this size farm (65% in 2012, 85% in 2013, and 62% in 2014). The negative change in earned net worth, together with negative change in valuation equity (30% in 2012, 33% in 2013, and 34% in 2014 of 550-acre farms having negative change in valuation equity because of expected declines in mean land values) significantly depletes the net worth of the 550-acre farm over the simulation period.

By the end of the three year period, the mean debt-to-asset ratio for all three size farms drops below the initial 25%. But for farms with 550 acres, 36% have a debt-to-asset ratio greater than 25% at the end of three years, indicating that over one - third of the farms with this acreage increase their leverage positions. The percentages of farms with 1200 acres and 2500 acres that have a debt-to-asset ratio greater than 25% are 0.1% and 0.0% respectively, which means almost all farms of these two sizes successfully reduce their leverage positions during the three year period. For all 10,000 iterations, 100% of farms with both 1200 acres and 2500 acres have a debt-to-asset ratio below 30%.

The Term Debt Coverage Ratio (TDCR) reflects the capability of the farm business to produce enough income to cover debt and lease payments. The mean levels of TDCR for 550-acre, 1200-acre, and 2500-acre farms are 0.9, 1.2 and 1.5 respectively. A ratio of less than 1.1 indicates that the farm business has no cushion and this must either borrow money or use open accounts to service debt and pay farmland rent. The 550-acre farm has a 62% probability that the TDCR falls below 1.1 at the end of the third year, whereas the probabilities for the 1200-acre and 2500-acre farms to have less than 1.1 TDCR are 12% and 0.7% respectively.

During the three year period, over 62% of the 550-acre farms use the full operating line of credit and have to decrease family living expense, and 30% of them have to delay all term debt payments that are due. Liquidating farmland is the last choice to avoid bankruptcy; for the 550-acre farms the mean acreage of farmland that must be sold and leased back to meet cash flow requirements is 1.4 acres with a maximum of 28 acres. Over 57% of the 550-acre farms have weak liquidity as indicated by less than 35% working capital/value of farm production (WC/VFP), and the probability that the farm generates a cash balance greater than a minimum level required for future normal production activity is only 0.6%.

In comparison, only 11% of the 1200-acre farms use the full operating line of credit; 99.6% can repay at least part, if not all, of the term debt at the scheduled time; and only 0.4% have to sell farmland. Over 16% of 1200 acre farms generate extra cash that improves liquidity or can be used to expand the farm business.

For the 2500-acre farms, the probability that the line of credit is fully used drops to only 5%, and 0% of them need to liquidate farmland to meet financial obligations.

Almost 40% of the 2500 acre farms generate extra cash; the mean extra cash balance beyond the minimum level required for future production is $70,000.

Table 4. Comparison of Farm Size with 50% Land Owned and 25% Debt-to-Asset Ratio

	Size of Farm (acres)		
	550	**1200**	**2500**
Annual Net Farm Income (Mean)	$49,800	$37,600	$166,200
Change in Net Worth (3 year) – (Mean)	$36,800	$114,900	$926,900
Working Capital/Value of Farm Production			
Mean	33.0%	45.5%	49.5%
Percent < 35%	57.0%	3.9%	0.1%
Debt-to-Asset Ratio			
Mean	21.5%	15.8%	13.0%
Percent > 55%	0.0%	0.0%	0.0%
Term Debt Coverage Ratio			
Mean	0.9	1.2	1.5
Percent < 1.1	73.1%	23.9%	2.1%
Percent Positive Cash	24.6%	83.8%	98.4%
Percent ROE > 10%	0.4%	7.6%	20.1%

Levels of Farmland Ownership

Three different levels of farmland ownership (85%, 50%, and 15% of the acreage operated) for the 550-acre farm with a debt-to-asset ratio of 25% are compared in terms of their financial performance (Table 5). The 550-acre farms with higher percentages of farmland ownership have much higher probabilities of a positive cash balance and ROE greater than 10%. Approximately 75% of farms with 85% farmland ownership have a positive cash balance after meeting all financial obligations and family living expense, and 11.7% of them have a rate of return on equity over 10%. The mean net farm income of the 85%-ownership farms is about two times that of 50%-ownership farms, while the mean net farm income of 15%-ownership farms is less than zero. The 85%-ownership farms are the only ones that have a mean net worth at the end of the three year period greater than the initial value; the mean net worth for the 85%-ownership farms increases by 7%, while it decreases by 4% for the 50%-ownership farms and by 21% for 15%-ownership farms.

The ratios of cash rent to value of farm production were calculated for 85%-ownership, 50%-ownership, and 15%-ownership farms. For the 15%-ownership farms, the mean ratio of cash rent to value of farm production is 42%, while the mean ratios for the 50%-ownership and 85%-ownership are only 25% and 7%, respectively. On average, cash rent expense accounts for half of total production cost for the 15%-ownership farm, and in the worst case it accounts for 60% of total production cost. The variability of cash rent has a dramatic impact on profitability and liquidity of farms with a low level of farmland ownership.

At the end of year three, the mean debt-to-asset ratio for the 85%-ownership and 50%-ownership farms drops below the initial 25%, while the mean debt-to-asset ratio for the 15%-ownership farms is higher than 25%. Approximately 90% of the farms with 15% farmland ownership have a debt-to-asset higher than 25% at the end of three years and thus are not able to meet all financial obligations without borrowing further funds. In contrast, the percentages of farms with 50% ownership and 85% ownership with a debt-to-asset ratio greater than 25% are 11.4% and 0.9%, respectively. The mean levels of TDCR for 85%-ownership, 50%-ownership, and 15%-ownership farms are 1.7, 0.9, and 0.6 respectively. For the 15%-ownership farms, the probability that the TDCR falls below 1.1 at the end of the third year is 99.5%; the probabilities for 50%-ownership farms and 85%-ownership farms to have less than 1.1 TDCR are 76.8% and 16.2%, respectively.

By the end of year three over 98.5% of 15%-ownership farms use up the operating line of credit and have to decrease family living expense, and 85.7% of them have to delay term debt payments and liquidate farmland. The mean acreage of farmland that is sold and leased back is 9.3 acres with a maximum of 50 acres. Over 99.5% of 15%-ownership farms have weak liquidity indicated by less than 35% WC/VFP, and the probability that the farm generates a cash balance greater than the minimum required for future normal production activity is only 0.1%.

In comparison, only 20% of the 85%-ownership farms fully use the operating line of credit, 97.8% of them can repay at least part, if not all, of the term debt due at the scheduled time, and only 2.2% have to sell farmland. Over 20% of the 85% ownership farms can generate extra cash that improves liquidity or can be used to expand the farm business. For 50%-ownership farms, the probability that the line of credit is fully used is 63%; 32% needed to liquidate farmland to meet financial obligations; and 0.8% generate extra cash.

Table 5. Comparison of Land Tenure for 550 Acre Farms with 25% Debt-to-Asset Ratio

	% of Land Owned		
	85%	50%	15%
Annual Net Farm Income (Mean)	$98,900	$49,800	$2,100
Change in Net Worth (3 year) (Mean)	$76,000	$32,300	$130,400
Working Capital/Value Of Farm Production			
Mean	49.6%	32.9%	17.3%
Percent < 35%	9.2%	56.9%	99.5%
Debt to Asset Ratio			
Mean	17.1%	22.1%	32.6%
Percent > 55%	0.0%	0.0%	0.0%
Term Debt Coverage Ratio			
Mean	1.7%	0.9%	0.6%
Percent , than 1.1%	16.2%	76.8%	99.5%
Percent Positive Cash	74.8%	24.3%	0.3%
Percent ROE > than 10%	11.7%	0.5%	0.1%

Debt-to-Asset Ratios

Controlling farmland ownership at 50%, two different levels of debt-to-asset ratios (25% and 50%) for the 2500-acre farms are compared (Table 6). Approximately 98% of the farms with 25% debt-to-asset ratios have a positive cash balance after meeting all financial obligations and family living expense, while only 54% of farms with 50% debt-to-asset ratios have a positive cash balance. However, farms with 50% debt-to-asset ratios have a 41.7% probability of greater than 10% ROE compared to 21.1% for farms with a 25% debt-to-asset ratio. The ROE distribution for farms with a 50% debt-to-asset ratio is wider than that for the 25% debt-to-asset ratio with both a higher maximum and a lower minimum ROE.

When a farm business's ROE exceeds ROA, it indicates that the farm assets financed through borrowing money are generating enough return to cover interest costs and generate additional profits. The mean ROA for both the 50%-debt-to-asset and the 25%-debt-to-asset farms are higher than the mean ROE. But for farms with a debt-to-asset ratio of 50%, the standard deviation of the ROE is 58% greater than that of the ROA. This higher volatility in ROE reflects the financial risks caused by the higher debt level. For farms with a 25% debt-to-asset ratio, the difference between the distributions for ROA and ROE is substantially less.

By the end of year three, 100% of the farms with both 25% and 50% debt-to-asset ratios reduce their leverage below the initial debt-to-asset levels. The mean levels of TDCR for farms with 25% and 50% debt-to-asset ratio are 1.5 and 1.1 respectively. The 50%-debt-to-asset ratio farm has a 38% probability that the TDCR falls below 1.1 at the end of the third year; the probability for 25%-debt-to-asset farms to have less than 1.1 TDCR is only 2.6%.

By the end of year three, over 57% of 50%-debt-to-asset farms have fully used the operating line of credit and have to decrease family living expense, but only 0.8% of them have to delay term debt payments. About half of the 50% debt-to-asset farms have liquidity less than 35% WC/VFP, and the probability that the farm generates a cash balance greater than a minimum level required for future normal production activity is 4%. The 50% debt-to-asset ratio farms are able to reduce debt loads, but are unable to expand the farm business. In comparison, only 4% of the 25%-debt-to-asset farms fully use the operating line of credit, and almost all of them can repay most of the term debt due at the scheduled time. Over 40% of the 25% debt-to-asset farms generate extra cash to improve liquidity or is available to be used to expand the farm business.

Table 6. Comparison of Debt-to Asset Ratio for 2500 Acre Farms with 50% of Land Owned

	Debt-to-Asset Ratio	
	25%	**50%**
Annual Net Farm Income (Mean)	$160,500	$134,800
Change In Net Worth (3 Year) (Mean)	$459,100	$474,900
Working Capital/Value of Farm Production		
Mean	49.5%	30.1%
Percent < 35%	0.1%	54.4%
Debt-to-Asset Ratio		
Mean	13.0%	35.6%
Percent > than 55%	0.0%	0.0%
Term Debt Coverage Ratio		
Mean	1.5%	1.1%
Percent < 1.1	2.6%	38.2%
Percent Positive Cash	98.1%	53.7%
Percent ROE > 10%	21.1%	41.7%

Conclusion

Recent years have witnessed increasing volatility in crop prices and yields, fertilizer prices, and farm asset values. Farmers and economists have been increasingly concerned about the financial health of farms that are exposed to various risks. In this study, the financial performance of illustrative Midwest grain farms with different scales, tenure status, and capital structures was examined under the shocks of volatile crop prices, yields, fertilizer prices, farmland value, and cash rent. Monte Carlo methods were used to generate simulated crop prices and yields, fertilizer prices, farmland value and cash rent for the period from 2012 to 2015. Illustrative farms of 550, 1200, and 2500 acres were constructed reflecting the production activity for these farms with three different farmland ownership structures (15%, 50%, and 85% of land owned) and two capital structures measured by debt-to-asset ratio (25% and 50%). Absolute measures and financial ratios were used to evaluate the income, cashflow, debt servicing and equity position of these illustrative farms.

Given a specific tenure status and capital structure, the percentage of farms that have a positive cash balance after meeting all the financial obligations and family living expense increases with farm size. In fact, almost 75% of the smaller farms (550 acres) have a negative cash position by the end of the planning horizon. The percentage with greater than 10% rate of return on equity is also higher for larger acreage farms. Larger farms have better profitability measured by net income and operating profit margin ratio, as well as lower volatility (standard deviation) of these measures.

At the end of the simulation period, larger farms have a higher average working capital to value of farm production (WC/VFP) ratio, and a higher percentage of farms with the WC/VFP ratio exceeding 35% (99.9% for the 2500 acre farms compared to only 43.0% for the 550 acre farms). Repayment capacity is also higher for larger farms (87.9% for 2500 acre compared to 22.9% for the 550 acre farms). These results suggest that smaller farms with one-half or more of their farmland rented and even modest leverage (25% debt-to-asset ratio) as is typical with farmers early in their farming career, are very vulnerable to price, cost, yield and asset value shocks. Larger size farms with similar tenure and financial characteristics are much more financially resilient.

Different land tenure arrangements have a dramatic impact on the vulnerability of the smaller (550 acre) farming operations. Those 550 acre farms with 85% of the land they operate owned not only have substantially higher incomes than those who rent a higher proportion of their farmland, they are able to accumulate additional equity over the three year period ($26,000), reduce their leverage position from 25% to 17.1% and have strong working capital and cash positions. In contrast, farms with only 15% of their acreage operated that is owned have negative net income ($2,100), lose equity ($130, 400), increase their leverage position from 25% to 32.6%, and have very weak term debt repayment capacity (an average TDRC of 0.6 with 99.5% less than 1.1). These farms that rent a large proportion of their land are very vulnerable to financial stress from price, cost, yield or asset value shocks even with crop insurance and hedging strategies in place.

As expected, those operations with higher leverage are more vulnerable to price, cost, yield and asset value shocks. For the larger farms of 2500 acres with 50% of their land owned, increasing the leverage position from 25% to 50% reduced income only modestly (from $160,500 with a 25% debt-to-asset ratio to $134,800 with a 50% debt-to-asset ratio); and equity accumulation even less (only $15,800 less change in net worth). Thus, larger farms as characterized in this study have only modest vulnerability to higher leverage positions and more resilience to shocks in prices, costs, yields and asset values.

These "stress test" results suggest that the financial vulnerability and resiliency of Midwest grain farms to price, cost, yield and asset value shocks are, not surprisingly, dependent on their size, tenure and leverage positions. Farms with modest size (i.e. 550 acres) and a large proportion of their land rented are very vulnerable irrespective of their leverage positions. These same modest size farms are more financially resilient if they have a higher proportion of their acreage that is owned rather than rented. Large size farms with modest leverage (25% debt-to-asset ratio) that combine rental and ownership of the land they operate have strong financial performance and limited vulnerability to price, cost, yield and asset value shocks. And these farms can increase their leverage positions significantly (from 25% to 50% in this study) with only modest deterioration in their financial performance and a slight increase in their vulnerability. These results suggest that the perspective that farmers are resilient to price, cost, yield and asset value shocks because of the current low use of debt in the industry (an average of approximately 10% debt-to-asset ratio for the farming sector) does not adequately recognize the financial vulnerable of many typical family farms to those shocks. Stress testing of individual farm businesses by farmers and their lenders is essential to accurately assess the vulnerability and resiliency of these businesses and lender portfolios to these shocks.

REFERENCES

Doye, D.G. (1986). Financial Adjustment in U.S. Agriculture. Ann Arbor: PH.D. Thesis, Iowa State University, University Microfilms International.

Engle, R. F. (1982, July). Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdome Inflation. Econometrica, pp. Vol. 50, No. 4, 987-1008.

Feathersone, M.A., & Baker, G.T. (July., 1988). Effects of Reduced Price and Income Supports on Farmland Rent and Value. North Central Journal of Agricultural Economics, Vol. 10, No. 2, 177-189.

Henderson, J., Gloys, B., & Boehlje, M. (2011, Fourth Quarter). Agriculture's Boom-Bust Cycles: Is This Time Different? Economic Review.

Jolly, W. R., Paulsen, A., Johnson D. J., Baum H. K., & Prescott, R. (1985). Incidence, Intensity, and Duration of Financial Stress among Farm Firms. American Journal Of Agricultural Economics, Vol. 67, No. 5, 1108-1115.

Nickerson, C., Morehart, M., Kuethe, T., Beckman, J., Ifft, J., & Williams, R. (2012). Trends in U.S. Farmland Values and Ownership. U.S. Department of Agriculture, Economic Research Service, Economic Information Bulletin Number 92.