[Journal of Applied Farm Economics](https://docs.lib.purdue.edu/jafe)

Volume 1 | Issue 2 Article 1

2017

# Financial Vulnerability of Midwest Grain Farms: 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, 1,200, and 2,500 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, cash flow, 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 about 13% 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

The U.S. farming sector exhibited very strong financial performance during the 2007–2013 period in terms of cash flow, high incomes, debt servicing, and equity accumulation. However, that strong performance has been accompanied by increased volatility. The increased volatility is a result of wide fluctuations in crop product prices, input costs, and volatile production due to weather events. This volatility has created more operational and financial risk for farm businesses. Even though the variability of prices as a percentage of the average price has not changed much compared to the past, higher costs and the fixed nature of some of these costs has increased the variability of both operating margins and net income on both an absolute and relative basis dramatically.

The amount of financial leverage (debt relative to equity capital) in the industry generally declined from 1990 to 2013, with debt to equity falling to a low near 13% in 2013. This suggests that debt-servicing risk for the sector is less than it was in, for example, the 1980s. However, since 2013 farm debt has once again been rising (USDA-ERS n.d.b). While debt levels are still modest sector wide, industry averages do not accurately reflect the true financial risk for individual farms. Larger-scale farmers who have been growing rapidly have

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leverage positions more than double the industry average (Hoppe & Banker, 2010).

Low-interest rates are another factor that may be masking the dangers of debt-servicing capacity. Interest rates on debt have been abnormally low. Rising rates will increase the debt-servicing requirements for farmers who have not converted from variable to fixed-rate loans. In addition, operating credit lines have increased for many producers, and interest rates on these loans are reset at renewal and thus will increase when market rates rise.

Debt-servicing ability can also be impacted by high cash rents. Some farmers have been aggressive in signing high fixed-rate cash rent leases (in some cases for multiple years) to obtain control of land rather than purchase that land, and these cash rents have been declining slowly. These arrangements result in fixed cash flow commitments irrespective of productivity and prices, much like a principal and interest payment on a mortgage. Farmers are also facing more strategic risks than they have in the past, such as disruptions in market access and in supplier relationships including the possible loss of a lender, loss of landlords, regulatory and policy changes, food safety disruptions, reputation risk, etc.

U.S. agriculture is notorious for its boom and bust cycles. Strong global food demand and robust biofuels markets strained global production capacity during the 2007–2013 period. The prospects of tight global supplies spurred booming farm incomes. Historically low interest rates quickly capitalized these high incomes into record-high farmland values. But as with past booms, the prospects of a permanent golden era in agriculture quickly faded. High farm incomes stimulated world production, and the promise of global demand growth rates weakened, resulting in lower agricultural commodity prices and incomes. These leaner farm incomes were unable to support the record-high farmland prices. As a result, many farmers who thought they were seizing the emerging opportunities may be left empty-handed as market and financial conditions have changed.

Consequently, farmers, lenders, policy makers, and the academic world are asking many "what if" questions: What if commodity prices continue to be depressed? What if seed prices don't go down more or cash rents don't adjust? What if land values decline further? With all the "what if" questions in mind, farmers and economists are concerned about the incidence and intensity of financial stress that the farming sector might encounter in the future. The focus of this analysis is the implications of the current uncertain market and financial conditions on the resiliency and vulnerability of Midwest grain farms.

## THE ANALYSIS

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, and 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 that farms of various sizes, tenure status, and 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 were 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 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, 1,200, and 2,500 acres. Each of the three sizes of farms displayed in this table has an initial debt-to-asset ratio of 25% and a farmland ownership percentage of 85%; different debt-to-asset and farm ownership percentage are

**Table 1. Specifications of illustrative farms**

| Model Farm | Size (Acres) | Debt-to-Asset Ratio | % of Land Ownership |
|---|---|---|---|
| Size comparison | 550 | 25% | 50% |
| | 1,200 | 25% | 50% |
| | 2,500 | 25% | 50% |
| Land tenure comparison | 550 | 25% | 85% |
| | 550 | 25% | 50% |
| | 550 | 25% | 15% |
| Debt-to-asset ratio comparison | 2,500 | 25% | 50% |
| | 2,500 | 50% | 50% |

**Table 2. Starting balance sheets of illustrative farms**

| | *550 Acres* | | *1,200 Acres* | | *2,500 Acres* | |
|---|---|---|---|---|---|---|
| 01/01/2012 | $ | % | $ | % | $ | % |
| **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 and 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 | |
| **Equity** | 776,365 | 75% | | | 1,516,814 | 75% |

illustrative of farms that have similar asset and liability compositions (percentages) adjusted for the appropriate asset ownership and debt levels. The simulation period is three years; @Risk in Excel is used for the analysis, with 10,000 iterations for each simulation.

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, n.d.b). Crop yields measured in bushels per acre for corn and soybeans were obtained for the eleven counties of central Illinois from U.S. Department of Agriculture National Agricultural Statistic Service (USDA-NASS, n.d.a) through the period 1925–2011. 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 the Economic Research Service (USDA-ERS, n.d.a) through the period 1971–2011. Illinois statewide land values and cash rents in dollars per acre from 1970–2011 were available from the National Agricultural Statistics Service (USDA-NASS, n.d.b).

A sequential approach was used to estimate and then simulate price and yield observations to ensure that the correlations observed among price and yield for corn and soybeans along with fertilizer price, farmland value, and cash rent remained 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 constant conditional correlation autoregressive conditional heteroskedasticity process due to the fact that futures prices of corn and soybeans were found to be highly correlated (Engle, 1982). Based on the outcome of the simulated future prices, local cash price at harvest time and yield data for corn and soybeans were simulated based on the regressions fit to available model input data. Spring fertilizer prices were then 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 (1988). Details of the estimation and the use of those estimated equations in the simulation model are provided in Li (2012). 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.

Crop insurance and preharvest 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 (n.d.a). 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 preharvest hedge with futures is included in the model. It is assumed that 60% of the expected production is hedged using December futures contracts for corn and soybeans in April in order to protect against downside price risk and that 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 (2012). Cash flow is the key indicator of the farm business's liquidity and financial

**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 |

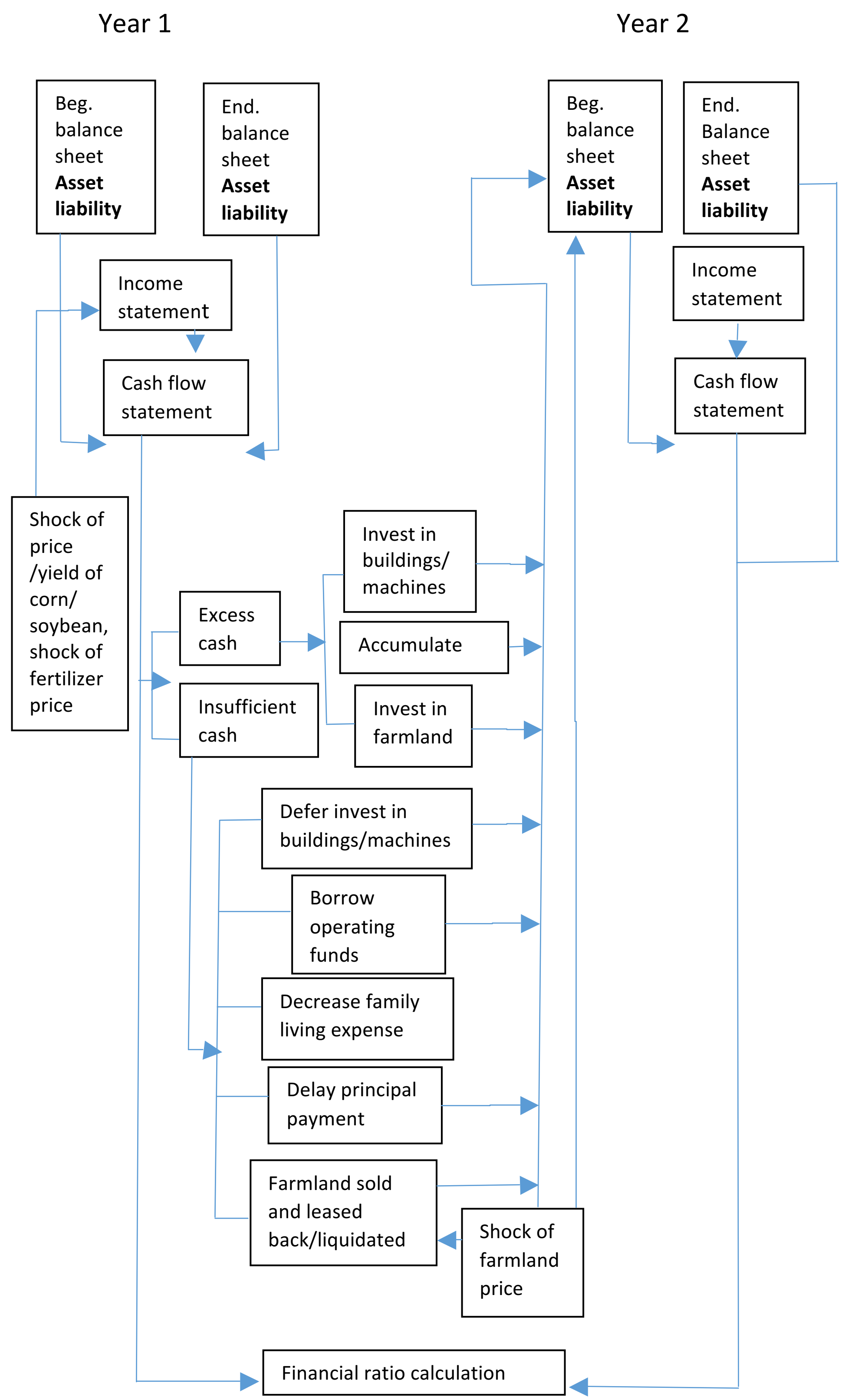


**Figure 1.** Simulation structure

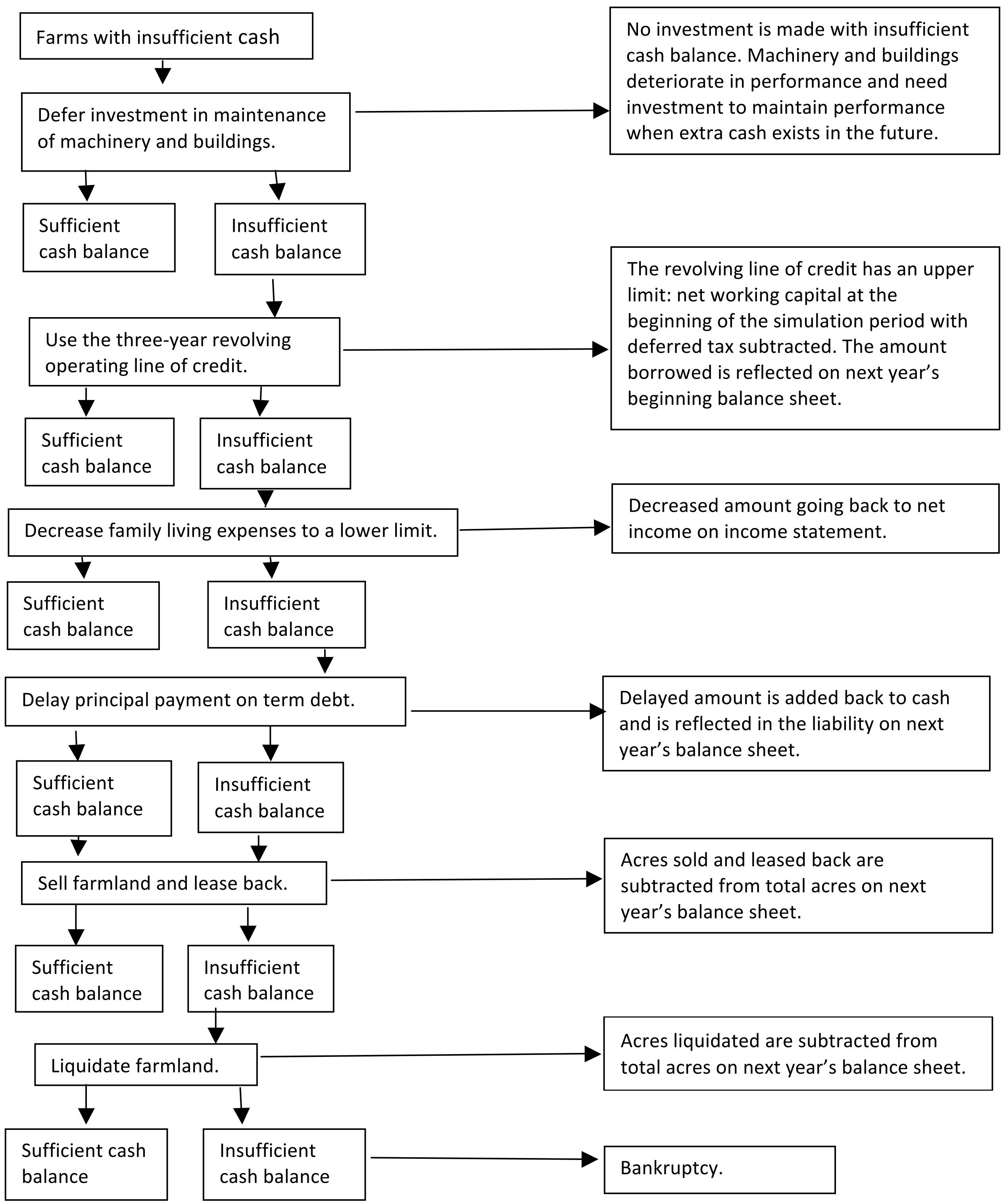


**Figure 2.** Adjustments with insufficient cash balance

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 1,200-acre farm, and $170,000 for the 2,500-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 (USDA-ERS, n.d.c).

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

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 remeasured to consider the necessity of further adjustments (Figure 2). The hierarchy of the adjustments is informed 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 noncurrent 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 noncapital 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 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, the 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.

## 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 (ROE), 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 an ROE greater than 10%. Over 98% of farms with 2,500 acres have a positive cash balance after meeting all financial obligations and family living expenses, and 20% of them have a rate of ROE over 10%. The mean net farm income of 2,500-acre farms is about four times that of 1,200-acre farms, while the mean net farm income of 1,200-acre farms and 550-acre farms are very similar. The variability of net farm income of 2,500-acre farms is much higher than that of 1,200-acre farms, and 1,200-acre farms have higher variability in income than 550-acre farms. The distribution of net farm income for 2,500-acre farms is wider than for 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 2,500-acre farms increases by 30% at the end of the simulation period, while it increases by only 7% for the 1,200-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 year 1, 0.3% in year 2, and 0.7% in year 3), after subtracting family living expenses the probabilities of negative change in earned net worth are relatively high for this size farm (65% in year 1, 85% in year 2, and 62% in year 3). The negative change in earned net worth, together with negative change in valuation equity (30% in year 1, 33% in year 2, and 34% in year 3 of 550-acre farms have 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 farm sizes drops

**Table 4. Comparison of farm size with 50% land owned and 25% debt-to-asset ratio**

| | | *Size of Farm (Acres)* | | |
|---|---|---|---|---|
| | | 550 | 1,200 | 2,500 |
| **Annual net farm income (mean)** | | $49,800 | $37,600 | $166,200 |
| **Change in net worth (3 years) (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% |

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 1,200 acres and 2,500 acres that have a debt-to-asset ratio greater than 25% are 0.1% and 0.0%, respectively, which means that 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 1,200 acres and 2,500 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, 1,200-acre, and 2,500-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 repayment reserves and thus must either borrow money or use open accounts to service debt and pay farmland rent. The 550-acre farm has a 73.1% probability that the TDCR falls below 1.1 at the end of the third year, whereas the probabilities for the 1,200-acre and 2,500-acre farms to have less than 1.1 TDCR are 23.9% and 2.1%, 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 expenses, 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% 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 1,200-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 1,200-acre farms generate extra cash that improves liquidity or can be used to expand the farm business.

For the 2,500-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 2,500 acre farms generate extra cash; the mean extra cash balance beyond the minimum level required for future production is $70,000.

### *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 an ROE greater than 10%. About 75% of farms with 85% farmland ownership have a positive cash balance after meeting all financial obligations and family living expenses, and 11.7% of them have a rate of ROE 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 farms 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 amount and 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 3, 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%. About 90% of the farms with 15% farmland ownership have a debt-to-asset ratio

**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 years) (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* < 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% |

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 and 85%-ownership farms to have less than 1.1 TDCR are 76.8% and 16.2%, respectively.

By the end of year 3 over 98.5% of 15%-ownership farms use up the operating line of credit and have to decrease family living expenses, 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% needed to generate extra cash.

### Debt-to-Asset Ratios

Controlling farmland ownership at 50%, two different levels of debt-to-asset ratios (25% and 50%) for the 2,500-acre farms are compared (Table 6). About 98% of the farms with 25% debt-to-asset ratios have a positive cash balance after meeting all financial obligations and family living expenses, while only 53.7% 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.

**Table 6.** **Comparison of debt-to asset ratio for 2,500-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 years) (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 > 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% |

When a farm business's ROE exceeds ROA, this 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 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 3, 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 ratios are 1.5 and 1.1, respectively. The 50% debt-to-asset ratio farm has a 38.2% 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 3, over 57% of 50% debt-to-asset farms have fully used the operating line of credit and have to decrease family living expenses, 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 expand the farm business.

## 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 a three-year projection period. Illustrative farms of 550, 1,200, and 2,500 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, cash flow, 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 expenses 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 ROE 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 WC/VFP ratio, and there is a higher percentage of farms with the WC/VFP ratio exceeding 35% (99.9%) for the 2,500 acre farms compared to only 43.0% for the 550 acre farms. Repayment capacity is also higher for larger farms (87.9% for 2,500 acre compared to 22.9% for the 550 acre farms). These results suggest that smaller farms with 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 550-acre farming operations. Those 550-acre farms with 85% of the land they operate owned farmland and are able to accumulate additional equity over the three-year period ($26,000) and reduce their leverage position from 25% to 17.1%, and they 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 2,500 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 of 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 because the current low use of debt in the industry (an average of about 13% 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 business and lender portfolios to these shocks.

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