(Edelman, Schmiesing, and Olsen). Hog and fed cattle producers, however, were more likely to hedge than to use options.

The conclusions of the literature, however, are not definitive as to the effectiveness of options contracts in reducing risk, based on different underlying assumptions. One study, for example, analyzes production, hedging, and speculative decisions in futures and options markets given the presence of basis risk (Lapan, Moschini, and Hanson). These researchers, assuming no production risk, found that options are a redundant hedging tool when futures and options markets are unbiased and when cash prices are a linear function of futures prices. They indicate that the optimal hedging strategy involves using only futures contracts (the returns of which are linear in futures prices) because they dominate options contracts (the returns of which are nonlinear in futures prices). If futures prices or options premiums are biased, however, the results indicate that options, used along with futures, provide the optimal strategy for insuring against price risk. They conclude that options are more appealing as a speculative tool to exploit private information about price distributions than as a hedging tool.

Intrigued by a comparison of survey findings with the Lapan, Moschini, and Hanson research, Sakong, Hayes, and Hallam questioned the conditions under which producers find options useful for hedging. Introducing both output and price uncertainty, these authors found that it is almost always optimal for farmers to buy put options and to underhedge on the futures market. Their results lend support to the practice of hedging the minimum expected yield on the futures market, while hedging the remainder of expected output against downside price risk using put options. These researchers also found that their results are strengthened if the producer expects local production to influence national prices and if risk aversion is higher at low income levels.

Maintaining Financial Reserves and Leveraging

Leveraging refers to the producer's use of debt to finance the operation. Increasing the degree of leverage increases the likelihood that in a year of low farm returns the producer will be unable to meet his or her financial obligations, and heightens the potential for bankruptcy. Thus, in general, highly leveraged producers operate in an environment of greater financial risk than do producers who choose a less highly leveraged farm structure.[15]

A producer's choice of debt (relative to equity) depends on many factors, including the farmer's risk aversion, the size and type of operation, the farmer's market relationships with input suppliers and output purchasers, lenders' willingness to provide loans, and the availability of government programs for managing risk. Increasing the farm's leverage (that is, borrowing) increases the capital available for production, allowing expansion of the business, but also entails incurring a repayment obligation and creates the risk of loan default because of the risks inherent in the farming operation. Because of these many factors, a farmer's use of debt to finance the operation interacts with both the production and marketing risks faced by the producer (Barry and Baker; Gabriel and Baker).

Highly leveraged producers operate in an environment of greater financial risk than do producers who choose a less highly leveraged farm structure.

[15]An increase in leveraging means that the farmer is at increased risk. In contrast, farmers who increase their use of most other risk management tools covered in the accompanying sections—such as hedging and insurance—reduce their risk.

Commodity Options Quotes Provide Estimates of Anticipated Price Randomness

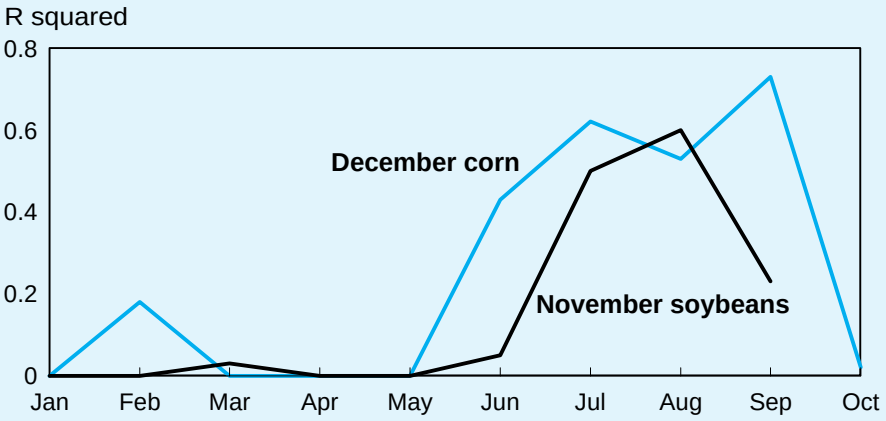
Information about anticipated price variability within a given year can be obtained from commodity options quotes. The value of a commodity option depends on the volatility of the underlying futures price, the futures price level, the strike price, the interest rate, and the time to maturity (Black). Holding the last four variables constant, a higher volatility implies a higher price for both puts and calls. Volatility cannot be observed until after the fact. However, if an options price is observed along with the last four variables, an "implied volatility" can be calculated. Such implied volatilities embody the current judgments of traders—who have money on the line—as to the actual volatility likely to be realized.

To examine traders' ability to anticipate volatility in corn and soybean prices, the actual volatility was regressed on implicit volatility for the years 1987-95 using the December corn contract and the November soybean contract. The actual volatility (the dependent variable) was calculated using the log (P_t / P_{t-1}) procedure applied to futures prices from the end of each month to the last trading day preceding the futures delivery month. For the February estimate of corn price volatility, for example, actual volatility was captured by the standard deviation of the daily log of relative futures prices from March 1 to November 30. Implicit volatility (the independent variable) was calculated by applying the Black formula to at-the-money puts and averaging over the trading days in the month (for February, using the previous example). The R^2 from this equation is illustrated in the accompanying figure for each month prior to expiration of the December corn contract and the November soybean contract. The chart indicates that options traders can anticipate price volatility from May and June through the growing season, but not very well prior to planting time when such information would be most valuable.

Options traders can anticipate price volatility throughout the growing season, but not very well prior to planting time.

Farmers and marketers can potentially use implied volatilities in making planting and storage decisions. Implied futures price volatilities, together with futures quotes, the producer's expected yields, and the producer's expectation of yield variability, may indicate that planting corn, for example, would result in higher and less volatile returns than planting soybeans (or vice versa). Farmers or marketers who are storing a crop may be able to make more use of implied price volatility information than those who are making planting decisions because output risk can be disregarded when storing.

Proportion of corn price volatility to harvest anticipated by options traders by month



Source: Estimated by ERS from Chicago Board of Trade prices.

The risk management decision confronting a farmer who must choose the degree of leverage can be illustrated using the portfolio approach. Table 13 illustrates the effect of borrowing on the variability of returns to owned equity, where the expected rate of return to farming (R_a) is 12.5 percent and the interest rate for both borrowing and saving (i_d) is assumed to be 7.5 percent. The standard deviation of farming returns (σ_a) is 5 percent, and the standard deviation of the risk-free asset (σ_d) is zero. The higher rate of return to farming is consistent with the assumption that returns must be higher than the risk-free rate of return or risk-averse individuals would not invest in farming.

The first column of the table reports various levels of debt-to-equity ratios. A negative debt-to-equity ratio reflects a farm that has invested a portion of its equity in risk-free savings at a 7.5-percent return. In contrast, a positive debt-to-equity ratio indicates that the operator has borrowed to expand the operation. The expected return to equity capital (R_e) is:

$$R_e = (R_a * P_a) - (i_d * P_d)$$

In the equation, P_a and P_d are proportions of the two assets relative to equity, with the holdings of the risky asset (P_a) plus holdings of the risk-free asset (P_d) equaling 1.0 in the total portfolio. Leveraging implies negative holdings of the risk-free asset, resulting in a minus sign in the equation. This information is used in the second and third columns, which illustrate the tradeoff between expected returns and the variability of returns, with the standard deviation of the return to equity calculated as the weighted standard deviation of the risky asset:

$$\sigma_e = \sigma_a P_a$$

As an example, consider a debt-to-equity ratio of 0.25. In this case, holdings of the risky asset are 1.25 and holdings of the risk-free asset are -0.25. Thus, the expected return is calculated as (1.25 * 0.125) - (0.25 * 0.075), or 13.75 percent. The standard deviation of the return to equity is (0.05 * 1.25), or 6.25 percent.

As shown in the table, the -0.5 debt-to-equity ratio results in the lowest expected return and the lowest level of risk. In this situation, the producer holds the greatest proportion of his or her assets in the low-return risk-free investment, and the smallest proportion in the higher return risky asset. As more capital is invested in the higher risk, higher return farming operation, expected returns increase, as does the

In this example, the more highly leveraged the farm becomes, the greater the risk and the greater the expected return—which may not always be the case for a farmer in real life.

Table 13—An example of the effect of borrowing on the variability of returns to owned capital

Debt/equity ratio	Expected return to equity (R_e)	Standard deviation of expected return (σ_e)
	Percent	
-0.50	10.00	2.50
-0.25	11.25	3.75
0.00	12.50	5.00
0.25	13.75	6.25
0.50	15.00	7.50
0.75	16.25	8.75
1.00	17.50	10.00
1.25	18.75	11.25

Note: The expected return to farming equals 12.5 percent, with a standard deviation of 5 percent. The expected interest rate is 7.5 percent, with a standard deviation of zero.

Source: Adapted by ERS from Barry, Peter J., and C. B. Baker, "Financial Responses to Risk in Agriculture," *Risk Management in Agriculture*, ed. Peter J. Barry, Ames: Iowa State University Press, 1984, pp. 183-199.

standard deviation of returns to equity. Thus, the more aggressively the farmer borrows, the more highly leveraged the farm becomes and, in this example, the greater the risk and the greater the expected return.

Research indicates that farm policies that create a lower risk business environment might induce financial choices that increase total farm risk

Various research studies have examined producers' use of leveraging. For example, a recent study examined the sources of capital used by farm operators across the United States, averaging data from the 1991-93 Agricultural Resource Management Study (ARMS). Over the 3 years, lenders were found to supply 10 percent of the $638 million in total capital managed by commercial farms. Most commercial farm capital was held either as owned equity (55 percent) or was leased (35 percent), generally from landlords (table 14). As anticipated, reliance on debt and leased capital financing declined as wealth and age increased (Koenig and Dodson).

In another study, use of debt repayment capacity, measured as the ratio of actual debt relative to the maximum amount of debt supported by net cash income available for loan payments, was analyzed for various sales class sizes (Ryan). Use of debt repayment capacity was found to increase across all commercial farm size classes between 1991 and 1994, especially in the smallest category (defined as $40,000 to $99,999). In this category, use rose from less than 50 percent in 1991 to over 70 percent in 1994.

For those producers who are highly leveraged, understanding and managing price and yield risk can assume heightened importance. This is because highly leveraged farmers must be concerned about meeting their financial obligations, and high yield and price risk in such situations may increase the likelihood of insolvency and bankruptcy. Thus, farmers' decisions about leveraging (and hence, the financial risk they confront) must be considered in the context of the business risks they confront on their operations.

Several studies have examined this interaction between price and yield (business) risk and producer behavior with regard to financial risk. In particular, one line of research has addressed the topic of "risk balancing," and considered

Table 14—Sources of capital for various groups of commercial farm operators, 1991-93 average

Item	Young commercial[1]			Older commercial[2]			All commercial
	Low-resource	Aspiring	Wealthy	Low-resource	Traditional	Wealthy	
				Percent			
Share of total managed capital that is:							
Leased capital	69	52	27	60	34	21	35
Debt capital	17	12	10	15	10	8	10
Owner capital	14	36	62	25	56	71	55
Total	100	100	100	100	100	100	100
Farms							
Number of farms	40,260	66,845	33,062	180,194	240,105	67,576	562,866
Dollars							
Average total managed capital per farm	543,361	805,375	1,937,478	587,534	952,741	2,827,468	1,133,906

[1]Young farmers are under 40 years of age. The category definitions are low resource (less than $150,000 net worth), aspiring ($150,000-$500,000 net worth), and wealthy (greater than $500,000 net worth).

[2]Older farmers are over 40 years of age. The category definitions are low resource (less than $250,000 net worth), traditional ($250,000-$1 million net worth), and wealthy (greater than $1 million net worth).

Source: Excerpted by ERS from Koenig, Steven R., and Charles B. Dodson, "Sources of Capital for Commercial Farm Operators," *Regulatory, Efficiency, and Management Issues Affecting Rural Financial Markets*, Proceedings of the NC-207 Regional Committee, Staff paper SP0196, ed. Bruce L. Ahrendsen, Fayetteville: University of Arkansas, Department of Agricultural Economics and Rural Sociology, January 1996, pp. 70-83.

the producer's financial leveraging strategy in the presence of government farm programs that help stabilize prices and/or yields. In this context, "risk-balancing" refers to adjustments in business and financial risk that result from an exogenous shock (such as a stabilizing policy) that affects the existing balance. The seminal work in this area was conducted by Gabriel and Baker, who developed a conceptual framework that linked production, investment, and financing decisions via a risk constraint. Their model indicated that, in the aggregate, farmers make financial adjustments leading to decreased (or increased) financial risk in response to a rise (or fall) in business risk. Thus, farm policies that create a lower risk business environment might induce financial choices that increase total farm risk.

In further investigating "risk balancing," other research has examined the impacts of income-supporting farm policies on leverage. Collins, for example, developed a structural model of a risk-averse producer's overall debt-equity decision, supporting Gabriel and Baker's conclusions that risk-reducing farm policies may well increase financial risk-taking behavior on the part of producers. Collins also concluded that, for risk-averse producers, greater risk-taking behavior also may be associated with policies intended to raise expected farm income. Other work has shown that risk-reducing and income-enhancing policies may, due to increased leveraging, increase the likelihood of farmers losing part of their equity or going bankrupt (Featherstone, Moss, Baker, and Preckel). Further, research that includes more complex specifications, such as tax laws, credit subsidies, and other factors, reach similar conclusions (Moss, Ford, and Boggess; Ahrendsen, Collender, and Dixon).

In addition to approaches that have examined the links between financial risk and business risk, other research has examined optimal farm decisionmaking, including links that span financial, marketing, and production considerations. The underlying tenet of this line of research is that certain marketing strategies often work to stabilize business risk, and also to reduce the risks associated with debt repayment by ensuring more predictable incomes. Thus, a farmer may choose either a forward contracting, hedging, or other business risk strategy accommodating lenders' preferences for greater liquidity (see next section) and loan repayment certainty (Barry and Baker). These models often are based on risk programming and stochastic simulations, and typically assume risk aversion on the part of the producer.

Several of these studies have focused on hedging (a financial strategy for which data are readily available) and its relationship to a producer's use of leverage. These studies generally conclude that hedging tends to increase as the farm's debt level rises. Using an optimal hedging model that explicitly accounts for the financial structure of the farm, one such theoretical article concludes that hedging is positively related to debt because hedging reduces business risk, offsetting to some extent the increased financial risk associated with leveraging (Turvey and Baker, 1989).

Empirical research tends to support these findings, including studies focusing on a hypothetical corn and soybean farm in Indiana (Turvey and Baker, 1990) and Florida orange growers (Moss and van Blokland; Moss, Ford, and Castejon). A survey of Indiana farmers also indicates that highly leveraged farmers are more likely to hedge than other producers because they perceive that hedging

Studies indicate that highly leveraged farmers are more likely to hedge than other producers.

could increase their net returns and/or reduce their risk (Shapiro and Brorsen). Farmer's use of leveraging (and the resulting debt payment obligations) is closely related to liquidity management, the topic of the next section.

Liquidity

Another aspect of financial risk management is liquidity, which involves the farmer's ability to generate cash quickly and efficiently in order to meet his or her financial obligations (Barry and Baker). The liquidity issue relates to cash flow and addresses the question: "When adverse events occur, does a farmer have assets (or other monetary sources) that can easily be converted to cash to meet his or her financial demands?"

The more highly leveraged the farm, the greater the need for careful liquidity management in order to make timely payments on loans and other obligations.

Asset liquidity depends on the relationship between the firm's assets and the expected cash proceeds from the sale of each of those assets (Barry, Baker, and Sanint). An asset is perfectly liquid if its sale generates cash equal to, or greater than, the reduction in the value of the firm due to the sale. Illiquid assets, in contrast, cannot be quickly sold without a producer's accepting a discount, reducing the value accruing to the firm by more than the expected sale price. Examples of liquid assets include grain in storage, cash, and company stock holdings, while illiquid assets include land, machinery, and other fixed assets. Factors that influence liquidity include marketability of the asset, the length of time allowed for liquidation before the cash is needed, transactions costs, and the asset's income-generating role in the firm (Barry, Baker, and Sanint; Pierce).

Liquidity management is interrelated with risk responses in production and marketing, and also with the farm's degree of leverage. The more highly leveraged the farm, everything else being equal, the greater the need for careful liquidity management in order to make timely payments on loans and other farm financial obligations. Some of the methods that farmers use to manage liquidity, and hence their financial risk, include the following:

- *Selling Assets*—A producer's willingness to sell assets is an important financial response to risk, particularly in crisis situations (Barry and Baker). If a farmer faces a low net income in a given year, selling liquid assets (such as stored grain or nonfarm assets, such as stocks) is a first step in meeting expenses for the year. Holding liquid assets, however, may be costly because they typically earn lower returns than when used in the production process (assuming the economic viability of the operation). If the use of liquid assets is not adequate to meet financial demands, additional steps—such as the sale of less liquid assets—may be necessary. Because many farmers are heavily invested in illiquid assets, such as land, livestock, and machinery, maintaining liquidity to meet shortfalls in returns may at times be difficult.
- *Managing the Pacing of Investments and Withdrawals*—Maintaining flexibility in the timing of farm investments and withdrawals is also a response to financial risk. In low income periods, for example, a producer may postpone the purchase of new machines and other equipment. This is an approach favored by many producers during times of adversity. It avoids large financial outlays during such periods, builds equity, reduces indebtedness, and allows the strengthening of profitability in a rapidly expanding farm operation (Barry and Baker).