How Farmers Can Reduce Risk: Examples Using Hedging, Forward Contracting, Crop Insurance, and Revenue Insurance

To what extent can hedging, forward contracting, and crop and revenue insurance reduce uncertainty within the year (intrayear) and over longer periods (multiyear), and change farmers' average returns? All of these tools tend to reduce intrayear income uncertainty, but have only small or negligible effects on multiyear uncertainties. Some strategies—such as the combined use of insurance and forward pricing—tend to complement each other in reducing risks. Their risk-reducing effectiveness varies by crop and location, depending on yield variability and the degree to which farm yields and prices move together. In addition, crop and revenue insurance likely increase average returns slightly for most farmers because they are subsidized, but forward contracting and hedging, lacking subsidies, have little direct impact on average or expected returns.
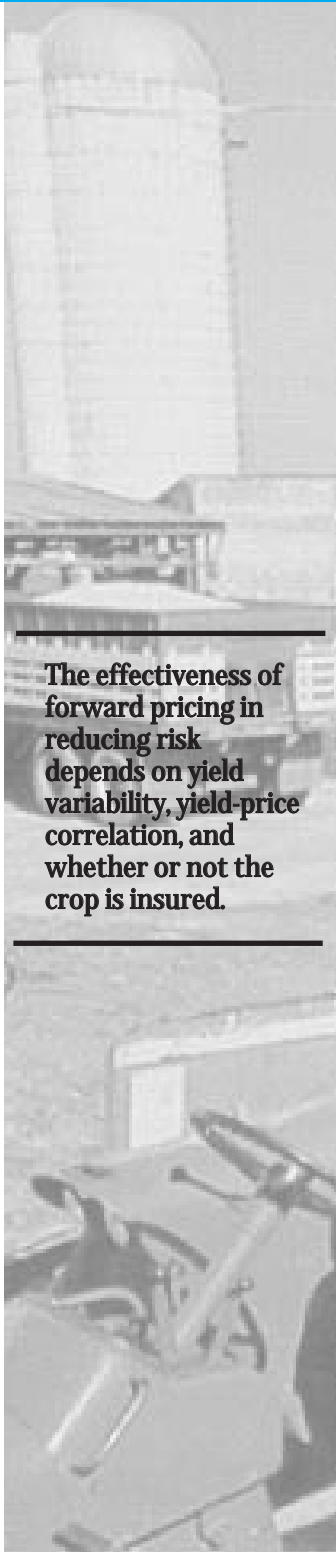
We have seen in the "How Farmers Can Manage Risk" section of this report that risk management strategies can reduce farmers' risk of income loss, at times substantially. This section provides a detailed analysis of the effectiveness of several risk management tools on income uncertainty within the year (intrayear income risk), income uncertainty between years (multiyear income risk), and farmers' average returns.

The analysis focuses on selected tools including futures hedges, cash forward contracts, crop insurance, and revenue insurance, rather than the many tools discussed earlier. There are several reasons. First, forward pricing and insurance are widely available to farmers and among the more effective risk-reducing tools. They are fairly easy to use and involve no commitment beyond the current crop year. Second, their optimal use is somewhat independent of

differences between farms in wealth, debt, rental arrangements, off-farm earning opportunities, and the use of other risk management tools. Third, focusing on this limited set of tools allows results for a few representative farms to have wide applicability.

Effects on Income Uncertainty Within the Year

The many different options available for managing income risk lead to questions about their effectiveness across different producing regions and about how they can best be combined to reduce producers' risks. A producer's choice among strategies is particularly complicated when both price and yield (output) risk is present—the case for a farmer with a growing crop in the field. In this situation, the degree to which strategies, such as forward contracting or hedging, reduce income risk depends on yield variability, the correlation between price and

> The effectiveness of forward pricing in reducing risk depends on yield variability, yield-price correlation, and whether or not the crop is insured.

yield, and whether or not the crop is insured.[25]

Recent research at the Economic Research Service (ERS) examined the effectiveness of several strategies—use of hedging,[26] crop insurance, and revenue insurance—in reducing farmers' income risks over the growing season in various corn-growing locations. These strategies were compared with the use of a "no risk-reducing strategy," which assumes that producers sell their crops at harvest for the local cash market price and do not insure. Four counties with differing yield variabilities and yield-price correlations were selected for the analysis, including the following:

- *Iroquois County*—Located in east central Illinois, this county has relatively low yield variability and a strongly negative yield-price correlation.

- *Anderson County*—In east central Kansas, this county represents an area with relatively high yield variability and a high yield-price correlation.

- *Lincoln County*—In west central Nebraska, Lincoln County represents an irrigated area where both yield variability and yield-price correlation are low.

- *Pitt County*—In east central North Carolina, this county represents an area of relatively high yield variability and low yield-price correlation.

> Revenue risk in corn growing tends to be higher outside than inside the Corn Belt.

[25]As discussed earlier, the absence of yield risk greatly simplifies decisionmaking. In the extreme case, the absence of both yield risk and basis risk means that either forward contracting or hedging can eliminate revenue uncertainty completely. For example, the owner of a harvested crop can lock in a return to storage by contracting for a fixed price at the end of the storage period. When output is known for certain, but basis risk is present, hedging can reduce (but not completely eliminate) income risk.

[26]Although hedging is used in this example, the results associated with forward contracting are similar.

For each county, a "hypothetical" corn farm was specified, and risk reduction was estimated. The risk measure used is the probability of revenues falling below 70 percent of their average or expectation. This measure is unit free (as it is expressed in percentage terms), and facilitates comparisons across farms having different average yields.

The results indicate that a representative corn farm in Anderson County, Kansas, or Pitt County, North Carolina, has a much higher likelihood of very low revenues when no strategy is used (a cash sale at harvest and no crop insurance) than a corn farm in Iroquois County, Illinois, or Lincoln County, Nebraska (fig. 14). The probabilities are 21 percent in Anderson County, 25 percent in Pitt County, 9 percent in Iroquois County, and 8 percent in Lincoln County. The risk of catastrophically low returns is considerably higher in the Kansas and North Carolina counties because yields vary more in those counties than in counties where crops are irrigated (as in Nebraska) or where weather risk is inherently low (as in central Illinois).

In addition, the "natural hedge" (the price-yield correlation) is a factor in explaining risk outcomes. In major producing areas in the Corn Belt, such as in Iroquois County, widespread low yields can significantly increase prices. Conversely, low prices are often associated with bumper-crop years. This negative relationship between prices and yields tends to stabilize farmer revenues in these areas, and contributes to the low risk of loss in Iroquois County. Pitt County, in contrast, is more likely to have low corn prices and low yields (or high prices and high yields) at the same time, making corn revenues inherently more variable. This is because such areas have less impact than the central Corn Belt on national output and prices.

Figure 14
Effect of forward pricing (hedging) and insurance on probability of revenue less than 70 percent of expectation

Probability of revenue less than 70 percent of expectation
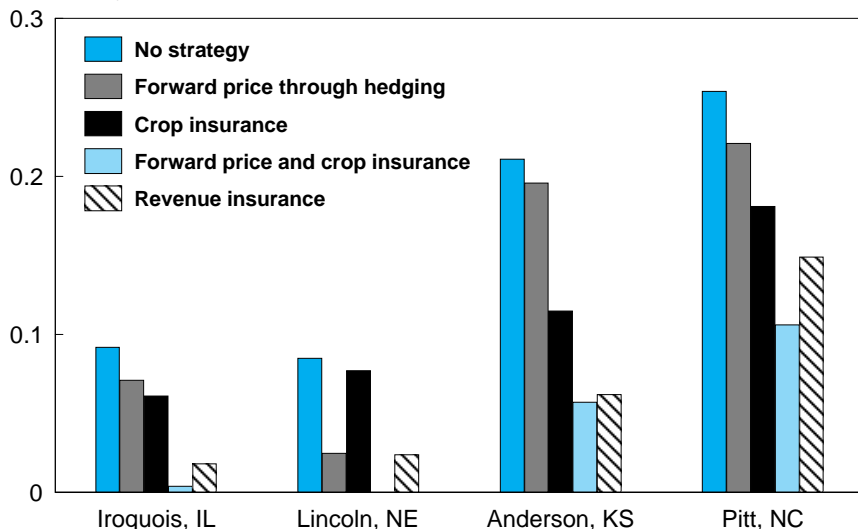
Source: Estimated by ERS.

Hedging an optimal level of expected output (shown by the second set of bars) modestly reduces revenue risk compared with the no-strategy case, although the impact varies greatly across locations.[27] The greatest impact is in Lincoln County, Nebraska, where the probability of income below 70 percent of expected income is reduced from 8 to 2 percent. The impact is most pronounced in this county because it has low yield variability due to irrigation and a weak price-yield correlation. In such locations, establishing an expected price (less harvest basis) greatly reduces revenue risk. Strong yield-price correlations or yield variabilities that exceed price variabilities prevent hedging from greatly reducing risk.

Crop insurance is generally more effective than hedging in reducing the risks of very low revenues across the four counties. When crop insurance alone is used by a producer (the third bar associated with each county),[28] the probability of very low revenues is reduced greatly in all counties except Lincoln County, Nebraska. In this county, irrigation is widely used, which protects against yield shortfalls and essentially substitutes for insurance. In the other locations, crop insurance has an advantage over forward pricing because farm-level yields generally are relatively more variable than prices.

The fourth set of bars for each county represents risk reduction when 75-percent crop insurance coverage is combined with optimal hedging. As shown in the figure, risk is reduced substantially in each of the locations, and the use of crop insurance and hedging in concert is much more effective at reducing risk than either tool used alone. By protecting both

Crop insurance reduces risk more than forward pricing in most areas, but the greatest risk reductions are obtained by combining insurance and forward pricing.

[27]Optimal hedging, as defined for the calculations, involves selling December futures in March, with the hedge magnitude set at the level resulting in the greatest risk reduction. More specifically, the optimal hedge ratio–defined as the proportion of expected output that is hedged to minimize risk–ranges from 40 percent in Anderson County, Kansas, to 60 percent in Lincoln County, Nebraska, and Pitt County, North Carolina.

[28]We assumed 75-percent yield coverage.

yield and price, the combined use of both tools is very effective, particularly in areas with a weak price-yield correlation and high yield variability.

The combined effects of crop insurance and hedging on risk reduction are similar to the situation where producers use revenue insurance (see the last set of bars associated with each county). (The revenue insurance plan assumed here is an intraseasonal guarantee based on individual farm yields and a futures price projection, and does not include a replacement coverage component—only a basic revenue guarantee. Thus, it is more similar to the Income Protection product than to Crop Revenue Coverage.) Such coverage reduces the probability of revenues less than 70 percent of expectations to near zero, except for the risks associated with differences between local prices and futures prices at harvest (e.g., basis risk).

Effects on Income Uncertainty Between Years

Farmers, like everyone else, face uncertainty about future incomes as well as current income. In particular, the payments required on the substantial debt needed to finance investments in land, machines, and equipment make a regular cash flow particularly important in farming. The importance of future income compared with current income partly depends on the farmer's ability to borrow or draw from savings to cover temporary income shortfalls. Producers who have low savings and little borrowing capacity must focus on covering their current expenses and loan obligations. In contrast, those with liquid savings or short-term borrowing capacity sufficient to cover temporary income shortfalls may be more concerned with protecting future income flows or wealth. The question posed in this

> Combinations of crop insurance and forward pricing are close substitutes for revenue insurance in reducing risk.

section is "Can the use of hedging and crop insurance help protect against income variability beyond the current year?"

The risks in farming would be substantially less if outputs could be insured and priced forward over periods more nearly matching the expected life of the specialized machines and equipment required for production. However, active trading in contracts that mature more than 18 months in the future has not evolved for agricultural commodities, and crop insurance is offered only on the current year's yields. Thus, hedging (or forward contracting) and crop insurance cannot directly assure farmers' incomes beyond 9 to 18 months.

At the same time, the use of crop insurance may *indirectly* help farmers stabilize their incomes around longer term trends. For example, a producer can anticipate expected yields in future years because insured yields change only gradually as each new yield is added to the farm's yield history. Thus, knowing that insurance will be available in future years can reduce uncertainty about those future years' incomes, even though the farmer cannot yet obtain such insurance.

The multiyear variability issues surrounding hedging (or forward contracting) are more complex. Unlike crop insurance, where yield guarantees change only gradually over time, the preplanting futures price quotes at which hedges can be made often vary markedly across years, depending on old crop stocks and anticipated demand. Tomek and Gray concluded that forward prices before planting are more stable from year to year than harvest prices for commodities that cannot be stored between crop years, such as potatoes. They also concluded that little stability was to be gained by forward pricing storable crops, such as grains.

Figures 15 and 16 illustrate how futures prices for harvest delivery varied over the season for corn and soybeans for the years 1977-96. The charts suggest that the prices at which those crops can be hedged vary almost as much from year to year as harvest prices.

There is, however, a weak tendency for harvest futures prices for corn and soybeans to be less variable in January than at contract maturity (tables 17 and 18), although this does not seem to be the case for July wheat in the preceding August (table 19).
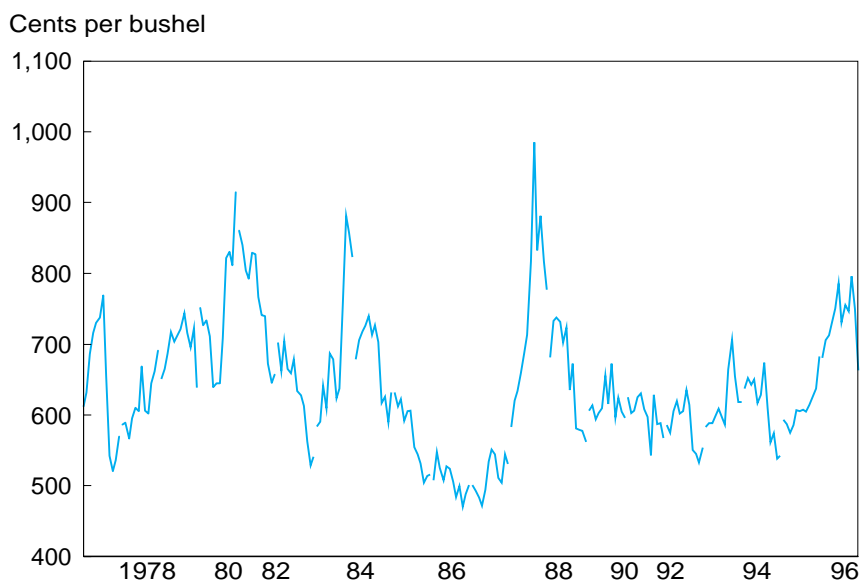
Figure 15
First of month price for December corn futures, 1977-96 contracts

Cents per bushel
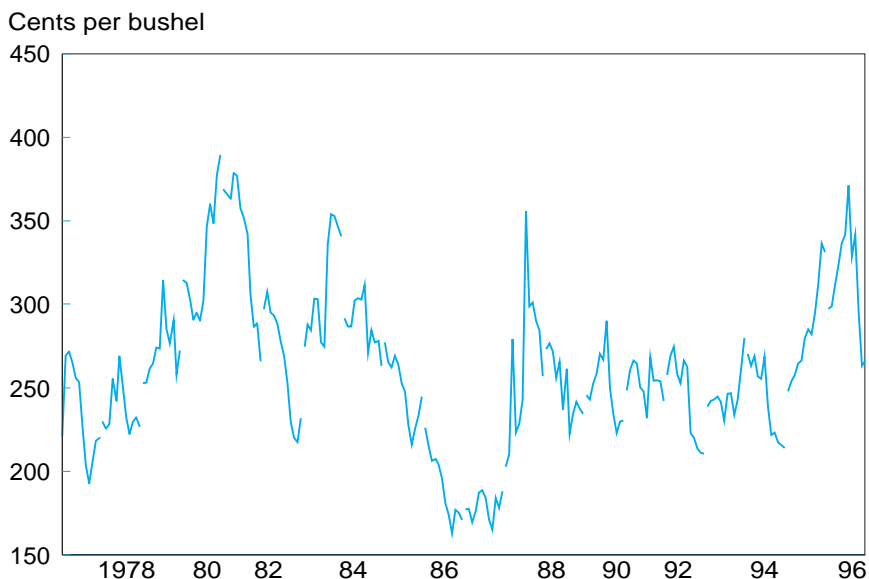
Source: Constructed by ERS from Chicago Board of Trade prices.

Forward selling has little effect on the year-to-year variability in prices received by corn and soybean producers.

Figure 16
First of month price for November soybean futures, 1977-96 contracts

Cents per bushel

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

Table 17—Mean and standard deviation of first-of-month December corn futures prices, 1977-96

Statistic	January	July	December
	Dollars per bushel		
Mean	2.62	2.73	2.54
Standard deviation	0.41	0.52	0.52

Source: Calculated by ERS from Chicago Board of Trade data.

Table 18—Mean and standard deviation of first-of-month November soybean futures prices, 1977-96

Statistic	January	July	November
	Dollars per bushel		
Mean	6.37	6.56	6.29
Standard deviation	0.78	1.07	1.08

Source: Calculated by ERS from Chicago Board of Trade data.

Table 19—Mean and standard deviation of first-of-month July wheat futures prices, 1978-97

Statistic	August	January	July
	Dollars per bushel		
Mean	3.45	3.49	3.50
Standard deviation	0.69	0.65	0.65

Source: Calculated by ERS from Chicago Board of Trade data.

Farmers' costs for hedging or forward pricing are small

Lack of futures contracts with more distant maturities has led to the consideration of using futures contracts that mature in the current year to hedge subsequent year's production. This could be accomplished by selling futures contracts to cover more than 1 year's crop production, and then sequentially rolling over the futures positions to later years as the later maturing contracts became available for trading. Gardner concluded in 1989 that such rollover hedging would not be very effective in reducing risk.

Indeed, the difficulties arising when this year's futures contracts are used to hedge next year's crops was demonstrated in 1996. Some corn and soybean producers who had entered hedge-to-arrive contracts on their 1995 crops, and lost out on the subsequent price rise, hoped to roll over the contracts to allow delivery of 1996 crops. How-ever, the low prices of futures on 1996 crops compared with 1995 crops made such rollovers unprofitable. Moreover, the elevators involved were anxious to settle the contracts, close out their futures hedges, and recover the large margin deposits that had been required.

Effects of Hedging, Forward Pricing, and Insurance on Average Returns

While many risk management tools involve trading off considerable expected return to reduce risk, forward pricing and insurance often can reduce risk with little or no sacrifice in average returns. Indeed, the use of crop insurance may increase average returns over time for many farmers due to the Government's subsidization of many crop and revenue insurance products. The costs of forward pricing, while not zero, generally are small. Thus, the farmer's optimal forward pricing and insurance strategy often can be closely approximated by minimizing risk.

The subsidization of crop and revenue insurance policies creates an interesting situation regarding the expected returns to producers. Crop (and revenue) insurance premiums are set so that expected

indemnities are approximately in balance with total premium. Total premium is shared between the farmer and the Government, with the Government paying 41.7 percent of the total premium cost at the 65/100 coverage level. In addition, the Government pays for any excess of indemnities over total premium (excess losses) in the event of disasters. Thus, subsidization of these programs causes indemnities to exceed producer-paid premiums, resulting in increased average returns to farmers as a group over the long run.

Based on these concepts, an indicator of a farmer's expected return to obtaining crop-yield insurance or crop-revenue insurance is the amount of indemnity per dollar of producer-paid premium. For crop years 1994-97, this return measure (in aggregate, across all crops and regions) ranged from $0.87 to $2.14 per dollar of farmer-paid premium (table 20). Over time, rates charged for insurance have been increased to bring expected indemnities closer in line with total premiums, reducing over the long run the likelihood of substantial excess losses to the Government. When total indemnities are divided by total premiums (including the subsidy), the resulting data in recent years are well below 1.0.

As can be seen from the subsidy structure, those producers who confront the highest total premium receive the largest premium subsidy because the dollar value of the premium subsidy is calculated as a percentage of total premium. Total per acre premium may be high due to the yield risk associated with production of that crop in the area, the value of the crop, and other factors. Figure 17 maps the per acre premium subsidy for wheat, in dollar value terms, across major growing areas in the United States. As examples, farmers in Montana received a premium subsidy of $2.85 per acre for 65/100 coverage, while wheat growers in North Dakota received an average subsidy at the 65/100 level of about $2.66 per acre.

In contrast to crop and revenue insurance, where government subsidies result in increased incomes on average for most participants, hedging and forward contracting may lower average incomes due to commissions or other costs, or from slightly lower prices received (see earlier box, "The Cost of Forward Pricing," p. 35). On the other hand, forward pricing may raise farmers' income if any of the following hold: (1) the farmer can time sales to hit higher than average prices; (2) reduced risks obtained through forward pricing allow the farmer to borrow at lower interest rates and/or expand operations; or (3) price information provided by futures quotes enables the farmer to make better decisions about production or storage.

> Because of subsidization, crop-yield insurance and crop-revenue insurance result in increased average returns to farmers as a group over the long run.

**Table 20—Indemnities, premiums, and loss ratios, 1994-97[1]**

Item	1994	1995	1996	1997
	Million dollars			
Indemnities:				
Total	601	1,400	1,342	947
Premiums:				
Total	949	1,087	1,409	1,425
Producer-paid	694	654	856	872
	Ratio			
Loss ratios (no units):				
Based on total premiums	0.63	1.29	0.95	0.66
Based on producer-paid premiums	0.87	2.14	1.57	1.09

[1]Data for 1995-97 are based on buyup policies only.

Source: Calculated by ERS from USDA, Risk Management Agency, Crop Insurance Actuarial Information Public Access Server, FTP download page, http://www.act.fcic.usda.gov/actuarial/ftpdwnld.html

Figure 17

Illustration of the per acre premium subsidy, for wheat implicit in 65/100 crop insurance coverage, selected counties and States, 1996

Subsidy per acre

- Less than $1.00
- $1.01 to $2.00
- $2.01 to $3.00
- Greater than $3.00
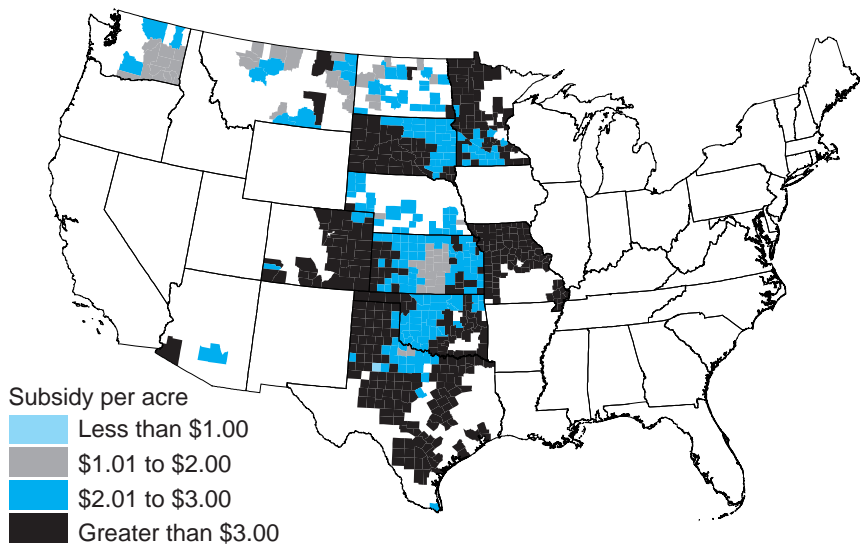
Note: Shaded areas include counties with at least 500 acres planted to wheat.
Source: Estimated by ERS from USDA, Risk Management Agency, electronic experience and yield database, 1997.

Farmers and other hedgers may profit by adjusting positions to take advantage of anticipated price changes—but only if they have superior price forecasting ability.

If the farmer can forecast futures price changes, hedges can be timed and adjusted to take advantage of the forecast. For example, if the futures price is expected to rise, a smaller short hedge or no hedge may be indicated. Alternatively, if the futures price is expected to fall, a larger short hedge may be indicated. The possibilities for timing trades are unlimited, ranging from hedging as soon as the futures or options contract is opened for trading on the exchange to simply selling at delivery. Futures contracts for corn, soybeans, and wheat are now listed for trading up to 3 years before delivery, although trading volume generally is light for contracts maturing more than 18 months in the future. Moreover, a farmer might change his/her futures position several times during the year, particularly if he/she were very confident in predicting prices.

To profitably time hedges requires the same price forecasting skills as pure speculation. Forecasts can be derived in many ways, ranging from simply looking for repeating patterns in price behavior (technical analysis) to analyzing supply/demand conditions (fundamental analysis). Grossman and Stiglitz noted that when information is costly, markets cannot reflect all possible information, which leaves room for speculative profits for those with superior access to information or analytical ability. Indications are that some speculators do profit, but the majority apparently lose (Zulauf and Irwin).

The difficulties in forecasting futures price changes can be visualized by examining historical futures price behavior, which reflects traders' expectations for the market price at contract maturity. As new information becomes available in the market, expectations change. Seasonal movements in the December corn and November soybean futures contracts for 20 years are shown in figures 15 and 16, with each line in the figures connecting successive beginning-of-month futures prices for one contract over the 12 months preceding the contract's maturity date. Gaps in the lines

reflect the transition to each successive year's harvest contracts.

The figures show that futures price movements over the season differ markedly from year to year. In 13 of the 20 years, for example, prices fell from January (the first month of trading) to December for the corn contract, and from January to November for the soybean contract. The average declines were $0.08 for corn and $0.08 for soybeans (see tables 17 and 18). In comparison, the July wheat futures prices increased from the preceding August to July in 11 of 20 years by an average of $0.05 (table 19).

The figures suggest that corn and soybean futures prices tend to peak in midsummer. For example, the average price of the December corn future on July 1 during the 1977-96 period was $2.73 per bushel, while the average price on December 1 was $2.54. Producers who routinely sold forward in early July thus averaged a $0.19 larger return per bushel than those who routinely sold immediately after harvest in December. November soybean prices exhibited a similar pattern during 1987-96, but not during the 1977-86 period.

If such seasonal patterns continued, pure speculators as well as producers could profit easily by routinely selling in July and buying in November or December. As more traders followed this practice, however, July prices would be driven down and harvest prices would be driven up, diminishing the potential for trading profits. Indeed, such profit potentials can be expected to virtually disappear

under the intense competition of futures trading. The result would be an "efficient market," where the current price captures all available information about the price to be expected at contract maturity.

There is much difference of opinion among those who advise farmers about timing sales in forward markets. Numerous studies have found possibilities for profits from particular strategies. Other studies show that futures markets appear to be quite efficient, leaving little room for profiting from timing trades. In reviewing the various studies, Zulauf and Irwin conclude that, for most producers, such strategies have limited ability to enhance income.

Can farmers convert lower risks obtained through hedging into higher average incomes? This depends on how much risks are lowered, on the farmer's financial situation, and on whether his or her lender is willing to increase loans when the farmer hedges or prices forward.

Do futures quotes provide information that farmers can use to improve production and storage decisions? For example, can farmers gain by storing if and only if the difference between the price for the future that matures at the end of the storage period exceeds the current futures price by more than the marginal cost of storage? Heifner (1966) found some evidence that this would work for storage, as did Tomek. However, others have found little evidence to support this possibility for producers (Irwin, Zulauf, and Jackson).

Forward pricing does not directly raise average prices received for most farmers, but the resulting lower risks may allow returns to be raised indirectly.