

Hedging in Futures

Futures contracts provide farmers (as well as processors, merchandisers, and others) with a method for reducing their risks. Futures contracts were almost exclusively traded on commodity prices in the past, although innovations in recent decades also have introduced contracts on interest rates, foreign exchange rates, price indexes, and crop yields. A primary use of futures involves shifting risk from a firm that desires less risk (the hedger) to a party who is willing to accept the risk in exchange for an expected profit (the speculator). Also, hedgers with opposite positions in the market trade with each other, and speculators with opposing views of the market may also trade.

A futures contract is an agreement priced and entered on an exchange to trade at a specified future time a commodity or other asset with specified attributes (or in the case of cash settlement, an equivalent amount of money). The U.S. exchanges that trade agricultural futures contracts are the Chicago Board of Trade; the Chicago Mercantile Exchange; the Kansas City Board of Trade; the Minneapolis Grain Exchange; the New York Coffee, Sugar, and Cocoa Exchange; and the New York Cotton Exchange. Trading is conducted either through “open outcry” on the floor of the exchange or electronically. The December corn contract traded on the Chicago Board of Trade, for example, specifies lots of 5,000 bushels for No. 2 yellow corn and a December delivery period. Contracts for major field crops (including corn, wheat, soybeans, cotton), four types of livestock and animal products (live cattle, feeder cattle, live hogs, and pork bellies), and sugar and frozen concentrated orange juice have been traded for years. More recently, futures contracts for rice, boneless beef, and dairy products have been intro-

duced. Because contracts are standardized, the only issue to be negotiated at trading time is price.

Enforcing contract terms is a key function of the exchanges where trading occurs, and guaranteeing contracts is a key function of the exchange clearinghouse.

Most futures contracts are offset by opposite trades before delivery time, with each party to the transaction selling (or buying) a futures contract that was initially bought (or sold). For example, if a farmer (through his or her brokerage house and its trader on the Chicago Board of Trade) sells a corn contract in May for December delivery, his or her position may be offset by buying a December corn contract at any time before the end of the delivery period, which is about December 20. Such an offset usually occurs because the major motive in trading futures is to hold a temporary position, and then trade for money, and not to physically deliver or acquire a commodity (Hieronymus). Most hedgers offset because making or taking delivery on futures would be more costly than delivering through normal channels, while speculators generally do not want to own the actual commodity.

Because futures contracts are commitments to trade in the future, actual delivery and payment are not required until the contract matures. However, both buyers and sellers are required to make margin deposits with their brokers to guarantee their respective commitments. Because the margin deposit is small (typically 5-10 percent of the underlying value of the contract), speculators (who provide liquidity) are attracted to the market. The exchanges set minimum margins by contract, which can be raised by brokers to provide the protection they deem necessary. Using the December corn contract as an example, and assuming a \$2.00 per bushel price quote, a cattle feeder who buys one contract

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(5,000 bushels) makes a \$10,000 commitment. With a 10-percent margin, the feeder must post \$1,000 with his or her broker. A “margin call” occurs when the price of the contract moves against the trader, say to \$1.90 in this example. When a margin call occurs, the producer must post additional margin with his or her broker to cover the loss and restore the deposit. Similarly, when the price moves favorably for the trader by a specified amount, money can be withdrawn from the margin deposit.

Because futures prices reflect values of commodities at futures delivery points, the local cash prices confronted by farmers usually vary from futures contract quotes at a given point in time. The differences between futures and cash prices are termed “basis,” and reflect differences in price across space (due to transportation costs), time (which are associated with storage costs), or quality (such as differences in protein premiums for wheat). The basis is calculated as the difference between the cash price (at a given location and at a given point in time) and the futures price (associated with a specified exchange and contract month).¹¹ The basis varies over time, and reflects only transportation costs and quality differences as the contract reaches maturity. As seen below, hedging largely eliminates price level uncertainty, but not basis uncertainty, which generally has a smaller variance.

Two categories of hedging exist: “long” hedging (where a futures contract is purchased) and “short” hedging (where a futures contract

¹¹Basis is sometimes calculated as cash price minus futures price and sometimes as futures price minus cash price, as mutually understood by the parties involved. Cash prices may be quoted relative to the futures, such as “10 cents over” or “20 cents under” the futures price. In this report, basis is calculated as cash minus futures, so that an “under” basis has a negative sign and an “over” basis has a positive sign.

is sold). Either type of hedge involves holding a futures position in anticipation of a later transaction in the cash market, and in both cases, the futures position is opposite to the cash position. Because futures and cash prices tend to move up and down together, losses and gains in the two markets tend to offset each other, leaving the hedger with a return near what was expected (the initial futures price plus the end-of-period basis—see later discussion). Thus, hedging helps protect the business from changes in price levels. Farmers may choose to hedge in many different situations, including the following:

- *Storage hedging*—Farmers or merchants who own a commodity can protect themselves from declines in the commodity’s price by short hedging. This involves selling futures contracts as the commodity is harvested or acquired, holding the resulting short futures position during the storage period, and buying it out when the cash commodity is sold. Losses (gains) in the value of the cash commodity due to unexpected price changes will be largely offset by gains (losses) in the value of the futures position leaving the owner of the commodity with approximately the expected return from storage.
- *Production hedging*—Crop and livestock producers can protect themselves from declines in prices of expected outputs by short hedging. This generally involves selling futures contracts at the beginning of or during the growing or feeding period, holding the resulting short futures position until the product is ready to sell, and buying the futures as the output is sold. Losses (gains) in the value of the output due to unexpected price changes tend to be offset by gains (losses) in the value of

the futures position. However, yield variability reduces the risk-reducing effectiveness of hedging for crop growers and generally makes it inadvisable to sell futures equal to more than one-half to two-thirds of the expected crop.

- *Hedging expected purchases*—Livestock feeders anticipating the purchase of corn or feeder cattle can protect themselves from price increases by long hedging. This involves buying corn or feeder cattle futures contracts to match anticipated requirements and selling the resulting long futures positions as these inputs are purchased on the cash market. Increases (declines) in the cost of feeders or feed due to unexpected price changes will be partly offset by gains (losses) in the value of the futures position leaving the feeder with approximately the expected costs of inputs. Feeders' overall price risks may be further reduced by selling futures on prospective outputs, as discussed above.

To better understand the importance of basis risk in hedging, consider the example of a corn producer with irrigated acreage who is considering the pricing of his growing crop. Because the producer irrigates and faces few other natural perils, he knows the size of his crop with a great deal of certainty and is concerned only with price risk. If the farmer does not hedge, his risk is solely associated with the harvest cash price (P_2), which can also be calculated as the harvest futures price (F_2) plus the harvest basis (B_2). Thus, the farmer's net return in a cash-sale-at-harvest situation (R_u) can be calculated as the cash price ($F_2 + B_2$) at harvest multiplied by actual production (Y_2), minus production costs (C):

$$R_u = [(F_2 + B_2) * Y_2] - C.$$

Suppose now that the producer places a short hedge (for example, sells a futures contract) to reduce the risk of a price decline and a lower sales price for his growing crop. The expected final net return at harvest (R_h) is based on the cash price at harvest ($F_2 + B_2$), and the profit or loss associated with the farmer's futures market position ($F_1 - F_2$). The farmer's actual level of production is designated as Y_2 in the following equation, and the quantity hedged is $h * Y_1$, where h is the hedge ratio and Y_1 is expected production:

$$R_h = [(F_2 + B_2) * Y_2] + [(F_1 - F_2) * (h * Y_1)] - C.$$

Assuming that output is known with certainty at the time the hedge is placed, and that actual production equals the quantity hedged (for example, $Y_2 = h * Y_1$), gives the following:¹²

$$R_h = [(F_2 + B_2) * Y_2] + [(F_1 - F_2) * Y_2] - C,$$

or:

$$R_h = [Y_2 * (F_1 + B_2)] - C.$$

This last equation indicates that the price component of the farmer's net return depends on the futures price at the time the hedge is placed plus the harvest basis. Because the futures price is known with certainty at planting, and output is known with certainty in this example, the only risk faced by the farmer is the risk associated with the harvest basis. Thus, price level risk is eliminated by this anticipatory hedge, and the only risk faced by the grower is basis risk (the uncertain nature of B_2).

The existence of basis risk is a key factor distinguishing the risk associated with futures hedging and the use of many types of cash for-

¹²This example also applies to a storage hedge, where output is known with certainty.

When output is known with certainty, the hedger eliminates price level risk and only confronts basis risk.

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ward contracts (see previous section). When a producer enters into a “flat price” forward contract with his or her local elevator, for example, the basis risk he or she faces is zero. In addition, forward contracts are generally less standardized than futures contracts, and specific terms may vary across elevators. Physical delivery to the local elevator at harvest is generally required, and no margin calls exist when cash forward contracts are used (table 9).

Using a numerical example to illustrate hedging, suppose the corn producer discussed earlier wishes to reduce his income uncertainty by selling a futures contract at planting time. Because the farmer irrigates his corn crop, he is not concerned about yield risk, and the hedge quantity is assumed to equal actual output. The farmer in this example observes a \$2.75 per bushel futures price at planting time. He expects a harvest basis of -\$0.25, giving an expected cash price of \$2.75 plus -\$0.25, or

\$2.50 per bushel (table 10). Two outcomes are shown in the table, a \$0.25-price decrease between planting and harvest, and a \$0.25-price rise. In both cases, the realized harvest basis is -\$0.25, as expected.¹³ With hedging, the return per bushel is \$2.50 in both cases. This return can be calculated as (1) the futures price at planting time (\$2.75) plus the harvest basis (-\$0.25 in both scenarios), or (2) the cash price at harvest (\$2.25 or \$2.75, depending on the scenario) plus the gain or loss from the futures market position (+\$0.25 or -\$0.25).

Reality differs from the example illustrated above in that neither basis nor yields can be anticipated with certainty, even for an irrigated farm. Table 11 illustrates such yield and price risk for a 500-acre corn farm. The corn farmer's

¹³The level of the basis varies with proximity to major markets, and in major corn growing areas, tends to be between \$0.10 and \$0.30 per bushel below the futures price at harvest.

Table 9—A comparison of “flat price” cash forward contracts and futures hedging

Characteristic	“Flat price” cash forward contracts	Futures hedging
Competitiveness of price	Depends on margin taken by elevator	Yes
Basis risk	No	Yes
Default risk	Some	No
Ease of recontracting or offset	Depends	Yes
Physical delivery	Yes	Seldom
Margin calls	No	Yes

Source: For more information, see Heifner, Richard G., Bruce H. Wright, and Gerald E. Plato, *Using Cash, Futures, and Options Contracts in the Farm Business*, AIB-665. U.S. Dept. Agr., Econ. Res. Serv., April 1993.

Table 10—Effects of hedging on a hypothetical corn grower's return per bushel

Cash/futures price	Price decrease scenario	Price increase scenario
<i>Dollars per bushel</i>		
Cash price expected at harvest	2.50	2.50
Cash price realized at harvest	2.25	2.75
Futures price at planting	2.75	2.75
Futures price at harvest	2.50	3.00
Futures return to the producer	+0.25	-0.25
Net price realized with hedging	2.50	2.50

Source: Hypothetical example developed by ERS.

Table 11—Returns to a cash sale at harvest and a futures hedge for a hypothetical corn producer

Scenario	Production <i>Bushels</i>	Harvest	Spring	Harvest	Revenue from crop	Net return	Net return	Difference in returns
		cash price	futures	futures		from cash sale at harvest	with hedging	
		<i>Dollars per bushel</i>			<i>Dollars</i>			
1	80,000	2.60	3.20	2.85	208,000	58,000	68,080	10,080
2	80,000	2.75	2.90	3.00	220,000	70,000	67,000	-3,000
3	50,000	3.15	2.70	3.40	157,500	7,500	-13,500	-21,000
4	50,000	2.80	3.15	3.05	140,000	-10,000	-7,000	3,000
5	30,000	3.15	3.65	3.40	94,500	-55,500	-48,000	7,500
6	30,000	3.30	3.65	3.55	99,000	-51,000	-48,000	3,000
Average net return	--	--	--	--	--	19,000	18,580	-420

-- = Not applicable.

Note: This illustration assumes that a producer has a 500-acre farm. The average yield for those acres varies across scenarios, from 160 bushels per acre in scenarios 1 and 2 to 100 bushels per acre in scenarios 3 and 4 to 60 bushels per acre in scenarios 5 and 6. The producer hedges six contracts at 5,000 bushels per contract. The commission on the purchase and sale of the contract is \$35. For a total of six round-turn transactions, the cost is 6 * \$70, or \$420. The farmer's production costs total \$150,000.

Source: Hypothetical example developed by ERS.

return from a cash sale at harvest (with no short hedge) ranges from -\$55,500 to +\$70,000 across the six scenarios. Now suppose that the farmer weighs his alternatives and decides to hedge in the spring. He anticipates that his output will not likely fall below 30,000 bushels in any given year, and thus considers his optimal hedge level to be six contracts (at 5,000 bushels per contract). At harvest time, he lifts his short hedge by buying back his futures contract, and sells his cash crop in the marketplace. He receives the proceeds from the cash sale of the crop (less production costs of \$150,000) plus the gains or losses associated with the futures transaction (less commission charges of \$420). Over the six scenarios, the producer's net return, including the return to the hedge, varies from -\$48,000 to +\$68,080. The variability in returns indicates that the return to hedging is less variable (as measured by either the range of outcomes or the standard deviation) than is associated with a cash-sale only strategy. The expected return over time, however, is approximately identical in both cases.

As can be seen by this example, the estimation of hedging amounts and risk reduction is much more

complicated in the presence of yield risk. Generally, the effectiveness of hedging in reducing risk diminishes as yield variability increases and the correlation between prices and yields becomes more negative. Although hedging can reduce income uncertainty for many farmers, it never completely eliminates such uncertainty.

In addition to the considerations discussed previously in this section, hedging involves possible costs for interest forgone on margin deposits and for bias in futures prices. These costs generally are small relative to the value of the positions taken, but they partly offset the risk-reducing benefits from hedging (see box on "The Cost of Forward Pricing"). The possibilities that expected incomes can actually be increased by hedging are discussed in a later section of this report.

An extensive literature addresses farmer hedging. Much of this literature analyzes the risk reduction associated with hedging and the calculation of optimal (generally risk-minimizing) hedge ratios, which specify the proportion of the commodity that would be hedged to minimize risk. When output is certain, risk-minimizing hedge ratios are generally close to, but

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slightly less than, 1.0 (100 percent of the commodity would be hedged).¹⁴ In contrast, when output is uncertain (such as would be the case for a growing season hedge when a producer does not irrigate), the hedge quantity is usually substantially less than 100 percent of expected output. This situation exists due to the correlation between random production and random price. Because these variables are negatively correlated in most cases, a “natural hedge” stabilizing revenue is inherent in the system and the optimal strategy is to hedge a quantity lower than the producer’s expected output (McKinnon).

Many optimal hedge models exist, and vary in their assumptions about futures and cash price determination, the unbiasedness of futures prices, risk aversion, and other factors (Berck; Miller and Kahl; Rolfo; Plato; Ward and Fletcher). In one study, Grant, for instance, examined the risk-minimizing optimal hedge for corn and soybean farmers in Iowa, Nebraska, and North Carolina in the presence of price and yield risk. His findings indicated that selling futures equal to 50-80 percent of expected production minimizes revenue risks for most corn and soybean producers in those States. These hedges would, on average, eliminate less than 50 percent of producers’ revenue variance over the growing season due to basis and yield risk. Because selling futures involves costs for commissions and interest forgone on margin deposits and a 20-percentage-point reduction in the optimal hedge has a relatively small effect on risk reduction, Grant concluded that the best strategy may be for farmers to hedge between 30 and 50 percent of their expected crop.

¹⁴When output is known, basis risk generally causes the optimal hedge to be less than 1.0.

Recently, studies have explored other aspects of hedging. Lapan and Moschini examined the hedging problem, and assumed that price, output, and basis are random variables. Their findings indicate that, unlike earlier results using different approaches, the optimal hedge depends on the level of a producer’s risk aversion. Further, they conclude that the effects of unhedgeable basis risk are exacerbated by yield risk. Other studies have, among other topics, examined the effectiveness of futures in providing revenue protection over a period of several years (Plato; Gardner, 1989).

Futures and options contracts have been traded on crop yields as well as prices. The Chicago Board of Trade introduced Iowa corn yield futures and options trading in 1995. Subsequently, trading in corn yields for four other Corn Belt States and the United States was added (Chicago Board of Trade, 1998; Grenchik and Campbell). Yield futures contracts remaining open at maturity are settled by cash payments based on USDA’s National Agricultural Statistics Service (NASS) yield estimates. Although yield futures and options contracts provide potential hedging vehicles for crop insurers as well as farmers, trading volume has been low. Relatively low correlations between individual farm yields and State yields limit the effectiveness of such contracts in shifting farmers’ yield risks. In addition, insurers appear to find the reinsurance provided by USDA through the Standard Reinsurance Agreement under the Federal crop insurance program satisfactory for shifting risk (Maurice; Lehman).

Recent research that examines hedging in both price and yield futures found that a risk-minimizing firm can reduce its income variance by simultaneously hedging in both price and yield futures (Vukina, Li, and Holthausen;

The Cost of Forward Pricing

When hedging with futures, farmers must pay commissions and forgo interest or higher earning potential on money placed in margin deposits. Those who use cash forward contracts may incur such costs indirectly, to the degree that local buyers lower prices paid to cover their hedging costs. Moreover, the prices obtained by hedgers may differ from the price expected at delivery by the amount that speculators require as compensation for standing by to take hedgers' trades and/or for bearing risks.

Commissions for futures trading vary by brokerage house and by size of trade, but typically the commission to both buy and sell is less than one-half percent of the value of the contract. Margin requirements also vary. For example, if the margin deposit averages 10 percent for 6 months, the interest forgone on the money at a 6 percent interest rate would be $0.1 \times 6/12 \times 0.06 = 0.3$ percent. Traders who meet margin requirements by depositing government securities with their brokers avoid such interest costs, although they may sacrifice some income by holding securities that yield lower returns than could be earned with other investments.

Farmers avoid directly paying commissions or making margin deposits by forward contracting with local buyers. However, elevators and other firms who buy from farmers generally incur hedging costs that must be covered. Such firms usually avoid interest costs on margin deposits by depositing government securities. Moreover, forward contracting assures them a flow of commodities through their facilities, which may increase their returns. Thus, they may or may not seek to recover their commission costs by paying slightly lower prices to farmers.

Futures markets facilitate forward pricing because short-term speculators ("scalpers") are present to take the opposite sides of sell or buy orders as they arrive from traders outside the exchange. Scalpers then quickly trade out of their positions with the expectation of a small profit, say one-quarter to one-half cent per bushel. This profit, which compensates scalpers for helping make the market liquid, constitutes a modest cost for hedgers.

Futures prices also may be less than expected cash prices because speculators require a risk premium for carrying hedgers' risks. Keynes suggested that such risk premiums could be expected in markets where short hedging exceeds long hedging. Dusak later pointed out that any such bias should be small because low transactions costs allow such risks to be spread very efficiently. Empirical studies indicate that futures price biases are small or nonexistent for most commodities, particularly for the grains, where active long hedging helps balance short hedging (Zulauf and Irwin; Bessembinder; Kolb). However, the issue is not fully resolved.

In summary, forward pricing involves costs that appear modest compared with the risk reduction obtained for most farmers, but that may make forward pricing more attractive to farmers who are very risk averse.

Hedging involves costs that appear modest compared with the risk reduction for most farmers.

McNew; Heifner and Coble, 1996). Vukina, Li, and Holthausen found that such hedging in both types of contracts can be more effective than using price futures alone,

with the effectiveness of the two-instrument hedge depending on the volatility of the yield contract. As the variance of the underlying yield increases, the effectiveness of

Options provide protection against unfavorable events similar to that provided by insurance policies.

hedging in both price and yield futures declines relative to hedging in price futures alone. They also concluded that hedging effectiveness depends critically on the price and yield bases.

Futures Options Contracts

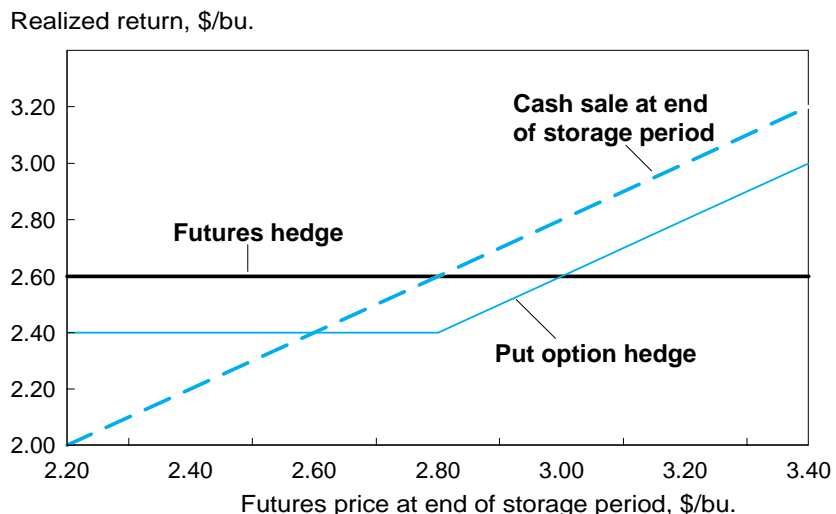
A commodity option gives the holder the right, but not the obligation, to take a futures position at a specified price before a specified date. The value of an option reflects the expected return from exercising this right before it expires and disposing of the futures position obtained. If the futures price changes in favor of the option holder, a profit may be realized either by exercising the option or selling the option at a price higher than paid. If prices move so that exercising the option is unfavorable, then the option may be allowed to expire. Options provide protection against adverse price movements, while allowing the option holder to gain from favorable movements in the cash price. In this sense, options provide protection against unfavorable events similar to that provided by insurance policies. To gain this protection, a hedger in an

options contract must pay a premium, as one would pay for insurance.

Options markets are closely tied to underlying futures markets. Options that give the right to sell a futures contract are known as “put” options, while options that give the right to buy a futures contract are known as “call” options. The price at which the futures contract underlying the option may be bought (for a call option) or sold (for a put option) is called the “exercise” or “strike” price. As an example, suppose a wheat producer purchases a put option having a strike price of \$3.00 per bushel. If futures prices move to \$2.80, the option may be exercised for a net profit of \$0.20 (\$3.00-\$2.80), minus the premium paid for the option. If the harvest cash price is \$2.70 per bushel, the farmer’s return is \$2.90 per bushel (\$2.70 plus \$0.20), minus the premium.

The effects on realized returns from hedging with futures and put options are compared for a range of possible futures price outcomes in figure 7. In this example, corn is stored in November and sold in May, output risk is absent, and the

Figure 7
Effects of futures and options hedging on exposure to price variation at marketing time, a storage example



Source: Hypothetical example developed by ERS.