Chicago Board of Trade

# Assessing Agricultural Commodity Price Variability

Price variability is a component of market risk for both producers and consumers. Although there is no consensus as to what constitutes too much commodity price variability, it is generally agreed that price variability that cannot be managed with existing risk management tools can destabilize farm income, inhibit producers from making investments or using resources optimally, and eventually drive resources away from agriculture.

Market price volatility that is not offset by application of risk management strategies can lead to sudden and large income transfers among various market participants. For example, grain producers with high variable costs or significant debt may face increased financial stress because of unexpected downward swings in prices and income, and may be unable to repay creditors. Input suppliers, farm lenders, processors, and producers in both the grain and livestock sectors may see their business costs rise and may pass those higher costs on to consumers. And insurance companies trying to set actuarially sound revenue insurance rates when faced with increases in price variability must raise premiums charged to farmers in order to maintain actuarial soundness (*AO* August 1999).

Counterbalancing society's interest in the farm sector's ability to manage price risk is an equally important interest in preserving a "natural" degree of price variability. Price changes trigger supply and demand adjustments that make markets work more efficiently. Thus, society has an interest not only in helping market participants manage price risk via appropriate risk management tools, but also in allowing markets to function efficiently.

An improved knowledge of the patterns of commodity price variability and the forces behind it would aid policymakers in providing a policy environment conducive to good risk management practices and would help farmers to better understand and manage their price risks. USDA's Economic Research Service (ERS) has undertaken research designed to identify trends or patterns in price movements and variability over time—nominal and inflation-adjusted—and across agricultural commodities. The research also explores factors influencing price variability, such as strong seasonal patterns in production, market supply and demand conditions, and government policies.

This article continues *Agricultural Outlook's* series on risk management.

### *How Market Conditions Affect Price Variability*

Agricultural commodity prices respond rapidly to actual and anticipated changes in supply and demand conditions. Because demand and supply of farm products, particularly basic grains, are relatively price-inelastic (i.e., quantities demanded and supplied change proportionally less than prices) and because weather can produce large fluctuations in farm production, potentially large swings in farm prices and incomes have long been characteristics of the sector and a farm policy concern.

The *supply elasticity* of an agricultural commodity reflects the speed with which new supplies become available (or supply declines) in response to a price rise (fall) in a particular market. Since most grains are limited to a single annual harvest, new supply flows to market in response to a postharvest price change must come from either domestic stocks or international sources. As a result, short-term supply response to a price rise can be very limited during periods of low stock holdings, but in the longer run expanded acreage and more intensive cultivation practices can work to increase supplies. When prices fall, the cost of storage relative to the price decline helps producers determine if commodities that can be stored should be withheld from the market.

Similarly, *demand elasticity* reflects a consumer's ability and/or willingness to alter consumption when prices for the desired commodity rise or fall. This willingness to substitute another commodity when prices rise depends on several factors, including number and availability of substitutes, importance of the commodity as measured by its share of consumers' budgetary expenditures, and strength of consumers' tastes and preferences. Since the farm cost of basic grains generally comprises a very small share of the retail cost of consumer food products (e.g., wheat accounts for a small share of the price of a loaf of bread and corn represents a fraction of the retail cost of meat products), changes in grain prices have little impact on retail food prices and therefore little impact on

consumer behavior and corresponding farm-level demand.

Increasing demand for grains for *industrial use*, whether from processing industries or from rapidly expanding industrial hog and poultry operations, further reinforces the general price inelasticity of demand for many agricultural commodities. Industrial use of grains generally is not sensitive to price change, since industrial users usually try to utilize at least a minimal level of operating capacity year round. Also, in most cases, as with retail food prices, the price of the agricultural commodity represents a small share of overall production costs of agriculture-based industrial products.

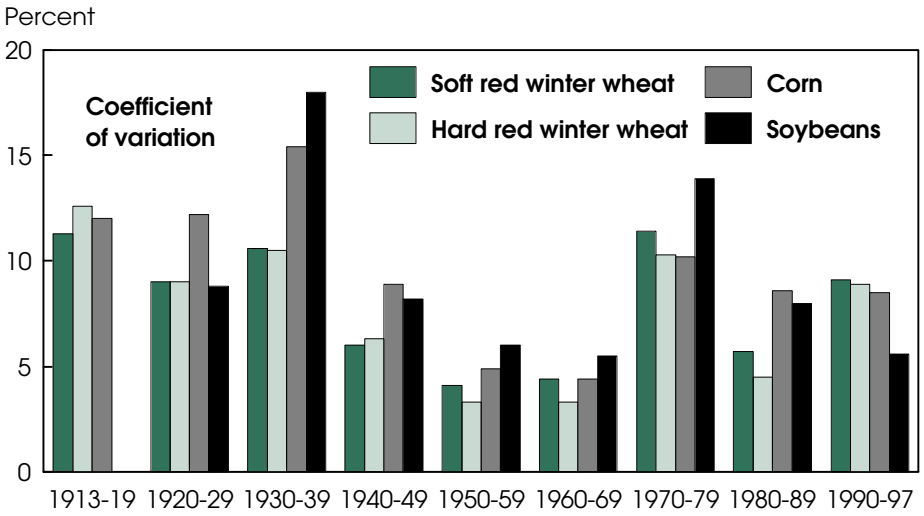
However, feed demand for grain, particularly for cattle feeding in the Southern and Northern Plains states, is far more sensitive to relative feed grain prices, since similar feed energy values may be obtained from a variety of different grains. Cattle feeders in these states are quick to vary the shares of different grains in their feed rations as relative prices change.

In general, elasticities of demand and supply for agricultural products are both low but not uniform or consistent across commodities. For example, there are several characteristics unique to wheat production in the U.S. that suggest greater supply and demand elasticity (and, since supply and demand respond somewhat faster, less dramatic price swings) relative to other field crops in the face of external supply and demand shocks—e.g., crop failure in a competing exporter country or financial crisis in a major purchasing country.

First, U.S. wheat production is marked by two independent seasons, winter and spring, with planting periods nearly 6 months apart. If it becomes apparent that winter wheat production is substantially below market expectations due to prevented plantings or weather-related declines in expected yield, some potential production losses can be offset by increased spring wheat plantings.

Second, the potential for surplus wheat production to enter agricultural markets from a large number of competing wheat exporter nations (principally Canada, Argentina, Australia, the European Union, and occasionally Eastern Europe) increases the supply responsiveness of wheat beyond that of other major grains. In addition, since two major U.S. wheat export competitors are located in the Southern Hemisphere and their production cycle runs opposite that of the U.S., still greater elasticity of supply in international markets is possible.

**Cash Price Variability Was Greatest Before World War II and the in 1970's**




Based on prices at major terminal markets. Soybean price data for 1913-19 not available. The coefficient of variation (CV) is a measure of price variability. CV = (dispersion of monthly inflation-adjusted average cash price over the season divided by mean of monthly average cash price over the season) multiplied by 100.
Source: Constructed by ERS using monthly average cash price data from Bridge News Service and USDA's Agricultural Marketing Service and the all-urban CPI deflator from the Bureau of Labor Statistics.

Economic Research Service, USDA

Argentina and Australia have the opportunity to expand planted wheat acreage in response to supply and demand circumstances in the U.S. within the same marketing year, dampening the potential year-to-year variability of prices in the U.S. market. While this potential additional supply limits price rises, it may actually deepen price declines because high storage costs and limited storage capacity frequently push surplus production into international markets even when prices are low.

Third, wheat can serve dual functions as either food or feed. The feed potential of wheat can have a dampening effect on price variability, either by introducing an additional source of demand that prevents prices from falling too low or by shutting off that same demand source when prices rise too high relative to other feed grains.

Fourth, most government-assisted export programs have been directed at wheat and have had a potential dampening effect on price variability in much the same manner as feed demand—they introduce an additional source of demand that moves opposite prices. Because export programs are funded to deliver a fixed *value* of commodities, the *volume* of U.S. program grain exports rises during periods of excess supply and relatively lower prices, but falls when supplies are tighter and prices higher.

## *Similarities Common in Commodity Price Movements*

In examining long time series of monthly average spot market prices for corn, oats, soybeans, and several classes of wheat from major terminal markets, ERS has found strong similarities in nominal and inflation-adjusted price movements and variability over time and across agricultural commodities. Price movements of corn, oats, and most wheat classes are similar mainly because of their

# Risk Management

**Wheat Price Is More Highly Correlated With Corn Price Than With Soybeans. . .**

| | Wheat | | | Corn | Soybeans |
|---|---|---|---|---|---|
| | Soft red winter | Hard red winter | Hard amber durum | | |
| | *Correlation coefficient for price* | | | | |
| Wheat: | | | | | |
| Soft red winter | **1.00** | 0.99 | 0.87 | 0.90 | 0.71 |
| Hard red winter | 0.99 | **1.00** | 0.90 | 0.90 | 0.71 |
| Hard amber durum | 0.87 | 0.90 | **1.00** | 0.81 | 0.62 |
| Corn | 0.90 | 0.90 | 0.81 | **1.00** | 0.72 |
| Soybeans | 0.71 | 0.71 | 0.62 | 0.72 | **1.00** |

**. . .but Grain Price Variability Is Less Highly Correlated Than Grain Price**

| | Wheat | | | Corn | Soybeans |
|---|---|---|---|---|---|
| | Soft red winter | Hard red winter | Hard amber durum | | |
| | *Correlation coefficient for price variability* | | | | |
| Wheat: | | | | | |
| Soft red winter | **1.00** | 0.94 | 0.71 | 0.46 | 0.39 |
| Hard red winter | 0.94 | **1.00** | 0.71 | 0.53 | 0.35 |
| Hard amber durum | 0.71 | 0.71 | **1.00** | 0.22 | 0.30 |
| Corn | 0.46 | 0.53 | 0.22 | **1.00** | 0.39 |
| Soybeans | 0.39 | 0.35 | 0.30 | 0.39 | **1.00** |

Prices are inflation-adjusted monthly spot market prices during various time periods, 1913-98. The correlation coefficient indicates similarity between two sets of variables: a coefficient of plus one (+1) indicates a perfect positive relationship, minus one (-1) a perfect negative relationship, and zero no relationship.
Price variability is coefficient of variation (CV) for market-year inflation-adjusted monthly spot market prices. CV = (dispersion of monthly inflation-adjusted average cash price over the season divided by mean inflation-adjusted monthly average cash price over the season) multiplied by 100.
Sources: Spot market prices from USDA's Agricultural Marketing Service; daily cash settlement prices from the Chicago Board of Trade; and monthly average settlement prices from Bridge News Service.

Economic Research Service, USDA

substitutability in livestock feeding, but their market-year price volatility shows greater differences because the commodities differ in their response to supply and demand shifts.

Nominal prices for these commodities, as reported by USDA's Agricultural Marketing Service, have shown a general upward trend since the early 1930's, interrupted by nearly two decades of fairly stable prices in the 1950's and 1960's. This period of relative stability ended with a dramatic price spike in the early 1970's, a tumultuous period marked by an unexpected surge in world grain demand and trade, coupled with poor harvests and rapid, dynamic macroeconomic changes (*AO* September 1996). Since the mid-1970's, nominal prices appear to have both a higher mean level and greater variability. The past three seasons (1996-98) have witnessed a precipitous plunge in nominal prices from the May 1996 spike when corn and two of the high-protein wheat classes—hard red winter and hard red spring—attained record-high monthly average spot market prices.

When monthly average price data are adjusted for inflation, a different pattern emerges—declining real prices since the late 1940's, interrupted by the dramatic upward spike in prices of the early 1970's. The pattern of inflation-adjusted price variability is less clear than the pattern of nominal price variability, but it suggests that prices were more variable during the three pre-World War II decades than since.

A common statistic for measuring the variability of a data series is the coefficient of variation (CV), which expresses the dispersion of observed data values as a percent of the mean. Since the CV is unit-free (a percent), it facilitates comparison of price changes in different directions, across different periods of time, and for different commodities. Marketing-year CV's calculated from each commodity's inflation-adjusted series of average monthly spot prices reflect the price volatility that occurred *within* each marketing year. The nature and degree of this within-year price variability affect decisions on the mix and level of farm activity, as well as on risk management and marketing strategies.

On the other hand, comparison of CV's *across* market years provides an indication of a commodity's longrun price variability. Such across-year price variability influences firm expansion and capital-asset acquisition decisions, and has a direct bearing on a firm's economic viability. In addition, the longrun variability of commodity prices across marketing years reflects the risk environment for agriculture relative to other sectors.

A shortcoming inherent in using historical averages as a forecast of price volatility is that such estimates fail to fully incorporate current market information. For example, prices are likely to be more volatile than the historical average during a year that begins with very low carryin stocks.

The degree of variability in commodity prices is traditionally believed to depend heavily on stock levels and on the nature and frequency of unexpected shifts in demand and supply. Thus, essentially all market forces affecting commodity price formation could potentially come into play in determining price variability. Such forces include own supply (carryin stocks, production, and imports), supply of substitute crops (depending on end use), and aggregate demand (domestic mill, feed, seed, and industrial use, and exports). Own supply and supplies of competitor crops are directly affected by weather, acreage, government policy, and international trade factors. Demand is directly affected by price, income, shifts in tastes and preferences for end uses, and population growth. Grain and seed characteristics—i.e., type, quality, protein content, and color—are also key factors in price formation.

The possibility of substitution in use is critical in determining strength of correlation between different commodity prices. For example, inflation-adjusted spot market prices for three winter wheat classes—soft red, hard red, and soft white winter—and hard red spring wheat are highly correlated, because they offer some similar

characteristics to end users. Hard amber durum, on the other hand, with its high protein level and specific milling and end use qualities, offers the least opportunity for substitution with other wheat classes and, as a result, tends to have slightly lower price correlations with other wheat classes.

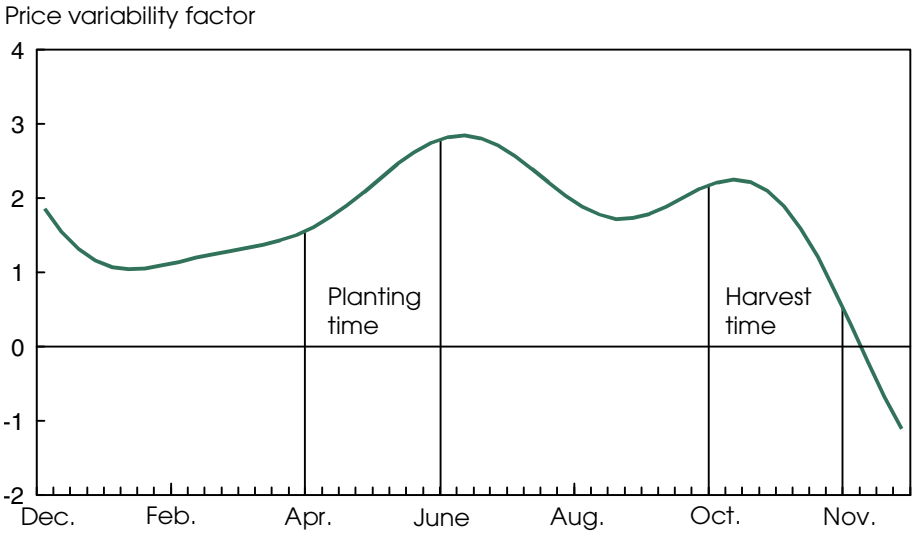
Price correlations among corn, oats, and wheat, although somewhat lower, are still very strong and likely reflect their substitutability in feed markets. Price correlations between these grains and soybeans are lower yet. Soybean prices are principally derived from demand for its joint products—oil and meal. Soybean meal is generally included in feed rations as a protein source, but may compete directly with other grains in feed rations as an energy source, depending on relative prices. However, soybean oil—used principally as a food with some minor industrial uses—has limited substitutability with grains (corn oil being the major exception), thereby weakening the soybean-grain price correlation.

Correlations of market-year price CV's for corn, oats, wheat classes, and soybeans are sharply lower compared with price-level correlations. This suggests that while general price levels for most grains and soybeans may be influenced by or move in tandem with many of the same forces, commodity price variabilities are more distinct and less strongly related to each other, due likely to disparities in their respective supply and demand responsiveness to price changes.

### *Strong Seasonal Pattern for Within-Year Price Volatility*

The principal difficulty analyzing within-year price variability is that while prices can be routinely observed for almost any time period (e.g., year, month, week), the economic supply and demand factors that likely influence price movements are generally reported only on a monthly or quarterly basis. Research conducted jointly by ERS and North Carolina State University attempted to circumvent this problem by transforming monthly and quarterly data into weekly data representations. These were used to assess the importance of relevant market information in forecasting *within-year* price variability (measured as

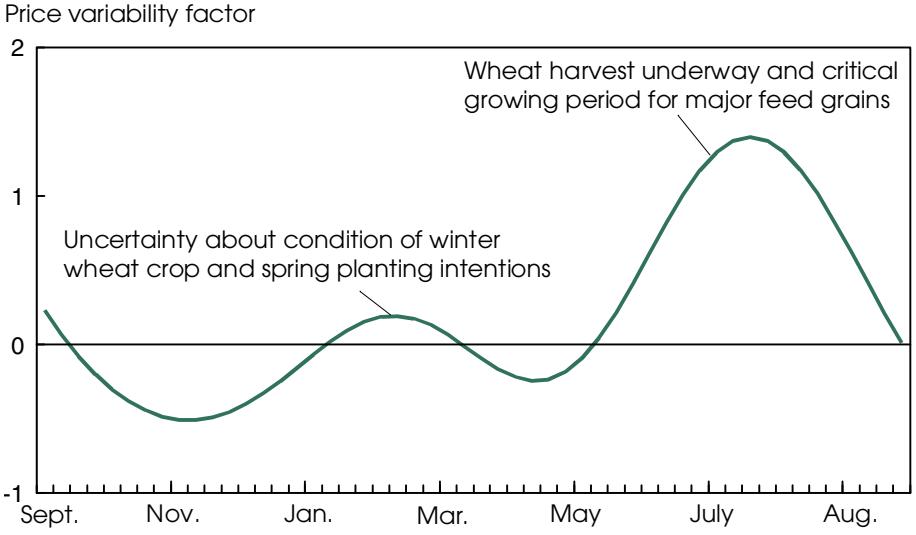
**Corn Price Variability Rises During Planting Time and Ebbs During Harvest**




Price variability factor indicates weekly deviation from expected (or forecast) price variability measured over the entire time period. Zero indicates price variability during that week is the same as expected price variability over the entire time period. Seasonal volatility estimated by an economic model of volatility using weekly Chicago Board of Trade December corn futures contract prices, 1986-97.
Source: USDA's Economic Research Service and North Carolina State University.

Economic Research Service, USDA

**Wheat Price Variability Peaks When Uncertainty Is Greatest**




Price variability factor indicates weekly deviation from expected (or forecast) price variability measured over the entire time period. Zero indicates price variability during that week is the same as expected price variability over the entire time period. Seasonal volatility estimated by an economic model of volatility using weekly Minneapolis Grain Exchange September wheat futures contract prices, 1986-97.
Source: USDA's Economic Research Service and North Carolina State University.

Economic Research Service, USDA

## Are Prices More Volatile in Recent Decades Than Earlier?

An examination of the historical record of wheat, corn, oat, and soybean prices during 1913-97 indicates the following patterns:

- Wheat prices tend to be less variable than prices for oats, corn, or soybeans over the entire period and during most selected subperiods. The most notable exception is the 1990-97 period when wheat price variability was above average while soybean and oat variability were below the average for the entire period.
- All five wheat classes, plus corn and soybeans, exhibited dramatic increases in price variability during the 1971-75 period.
- Price variability for all commodities is noticeably higher in the post-1970's era (1976-97) than during the pre-1970's period (1951-70).
- Price variability in the post-1970's period (1976-97) is slightly lower than variability during the 1913-50 period.

Studying such a long price series gives greater perspective to current levels of price variability and suggests that perhaps an anomaly with respect to price variability occurred during the 1950's and 1960's, when heavy government involvement in agricultural commodity markets—including large government stockholdings of wheat and feed grains—coupled with low absolute levels of world trade (relative to the post-1971 period) contributed to artificially stable prices.

a rate of change) of settlement prices for the Minneapolis Grain Exchange's September wheat futures contract and the Chicago Board of Trade's December corn futures contract during the 1987-96 period.

Futures prices play a critical role in facilitating seasonal market operations, because they provide a forum for forward contracting, as well as a central exchange for domestic and international market supply and demand information. Regional and local grain elevators rely on futures commodity exchanges for hedging grain purchases and generally set their grain offer prices at a discount (in areas of surplus production, such as the Corn Belt) or at a premium (in deficit production areas, such as North Carolina) to a nearby futures contract. As a result, cash prices and futures contract prices are strongly linked—i.e., both prices contain much of the same information about variability.

Both corn and wheat futures contract prices display distinct patterns of seasonal variability. For the December *corn* contract, a strong variability peak occurs in June when there is a great deal of uncertainty surrounding the true extent of plantings and likely yield outcomes for corn and other spring-planted crops. Much of the acreage uncertainty is resolved with release of USDA's June 30 *Acreage* report, while yield uncertainty is resolved in July after corn pollination has occurred. A second, weaker peak occurs in October and corresponds with the arrival of new information during the peak corn harvest period. The seasonal component of corn price volatility then declines rapidly prior to contract expiration.

This pattern suggests that the bulk of relevant information is synthesized by the corn market during the critical summer growing months when estimates of acreage and yields are largely determined. Supply news then tends to dominate markets into the fall harvest, with little new information added during the period immediately preceding contract expiration.

The seasonal pattern for September *wheat* futures contract price variability also shows two peaks, the first a weak early-season peak occurring in January-March, a time of substantial uncertainty about the true condition of the winter wheat crop and farmers' spring planting intentions. Much of the uncertainty is resolved with USDA's release of its March 28 *Planting Intentions* report.

A second, much stronger peak in variability occurs in late July and corresponds with the arrival of new information during the peak wheat harvest period and the critical growing period for the major feed grains. Domestic prices for the U.S. wheat crop also depend heavily on international supply and demand conditions, and some key market information governing international developments does not reach the market until midsummer when USDA begins forecasting major international crop production. Following the July harvest-time surge, the seasonal variability then declines rapidly prior to contract expiration.

The volatility of corn and spring wheat futures prices also shows a strong negative relationship with growing conditions—better-than-average growing conditions are associated with lower price variation. However, corn and wheat prices differ in the association of variability with many of the remaining supply and demand factors studied. This is likely due to differences in their respective supply and demand responsiveness to price changes.

For corn, increases in expected U.S. domestic demand—published monthly in USDA's *World Agricultural Supply and Demand Estimates (WASDE)* report—had a positive influence on price volatility, but changes in actual levels of corn stocks—estimated quarterly by USDA—did not appear important, probably because corn supply is estimated from a single annual crop, and because changes in stocks are primarily a residual of often offsetting changes in other market forces and therefore tend to move slowly between harvests.

For wheat, changes in expected exports and domestic demand for all wheat showed no influence on spring wheat price volatility, while increases in actual all-wheat private stocks had a dampening effect on volatility. Lack of a strong relationship between demand factors and spring wheat price volatility is likely explained by winter wheat dominance of U.S. wheat exports, by the shifting importance of wheat as government food donations versus commercial export sales, and by the interplay of food-feed markets.

The study found that the level of day trading (day traders enter and exit the market with no outstanding balance at the end of the trading day) at each commodity exchange correlated positively with both

corn and spring wheat price variability, likely because day trading allows prices to adjust to information more quickly. On the other hand, market concentration—measured using Commodity Futures Trading Commission "commitment of traders" data on holdings of the four largest traders—had a negative influence on spring wheat price volatility, suggesting that the action of large traders in highly concentrated markets may decrease the volatility of wheat prices.

### *Forces Driving Across-Year Price Variability*

In joint research to investigate determinants of *across-year* price variability, ERS and North Carolina State University constructed within-year CV's from monthly average cash prices at major terminal markets during 1944-97 for Chicago/St. Louis soft red winter wheat, Chicago corn, and Chicago/Central Illinois soybeans. Each CV reflects the price variability that occurred during a market year. Then these market-year CV's were examined in light of year-to-year changes in major supply and demand factors.

As expected, output price variability for all three commodities was found to be negatively correlated with the level of stocks relative to total disappearance; a ready supply available from stocks tends to make prices less sensitive to new market information. However, as in the within-year study, corn, soybean, and wheat price CV's exhibited key differences in their association with most of the remaining supply and demand factors studied, likely because of differences in their supply and demand responsiveness to price changes.

Since increases in production tend to dampen both prices and price variability by contributing to an increase in total supply relative to market demand, any change in acreage and yield (both of which have positive associations with production) is expected to have a negative, indirect effect on price variability through the influence on production. Change in yield shows a strong negative relationship with corn price variability, but no relationship with soybean and wheat CV's. Wheat's dual seasons (winter and spring) within a single crop year and broad geographic diversity of production likely diminish the influence of a single weather pattern on the aggregate wheat market. Change in harvested acres is negatively related to wheat price variability, but not to corn or soybean price variability.

Change in demand, on the other hand, is expected to be positively associated with price variability since increases in demand, whether domestic or international, draw down total supplies and stocks, and decreases in demand have the opposite effect. This was confirmed by a positive association between corn price variability and both domestic use and exports.

However, wheat price variability showed no relationship to change in domestic use and was negatively related to change in exports. The negative effect of wheat exports on price variability tends to confirm the smoothing effect of government export assistance programs, and suggests that U.S. wheat exports act as a residual source of supply to world markets when domestic prices fall low enough. The offsetting roles of food and feed usage in wheat price volatility—positive for widespread changes in domestic use for milling and other food and industrial uses, but negative (and offsetting) when acting as a residual outlet to feed markets—result in a net neutral effect.

Similarly, changes in the general level of input prices are expected to have positive associations with price variability indirectly via their negative influences on production and total supply. For example, rising input prices tend to dampen production and, in turn, may raise price variability. However, no relationship was found with corn and wheat price CV's. Instead, soybean price variability showed a negative association with changes in input prices, suggesting that soybean cost savings relative to corn and wheat played a role (*AO* May 1999). As input prices rise, producers favor soybeans because net returns are higher, resulting in greater acreage, more production, and lower soybean price variability.

Government policy influences are inherent in nearly all related supply and demand variables. Several government program initiatives (including some that preceded the 1996 Farm Act) were studied to directly measure the influence of loan rates (which tend to act as support prices), expected deficiency payments (which were intended to stabilize income but often had the unintended consequence of limiting substitution in production because of associated acreage restrictions), and acreage reduction programs (which were designed to reduce supply by removing acreage from production). Results hint at some effects on commodity price variability for wheat and soybeans from acreage constraints and price support programs, but no government policy variable was found to influence corn price variability.

While far from conclusive, these results suggest that past government programs had a tendency to produce higher levels of price variability, at least for wheat and soybeans. In every case where a government policy variable was found to be important, it had a positive association with price variability. At first glance, this effect may seem surprising. However, policies that are intended to stabilize producer incomes—a central goal of past policy—are apparently likely to increase the volatility of market prices if they distort production and marketing arrangements.

Since the 1996 Farm Act, government policy has shifted away from potentially price-destabilizing direct intervention in agricultural production processes and markets. Instead, USDA's Risk Management Agency has been working to provide the necessary tools and information for farm operators and other participants in agricultural markets to better understand and manage risks associated with producing and selling agricultural commodities. Although effective techniques for managing inter-year price risk remain elusive, a variety of management tools—e.g., futures and options contracts, and various crop and revenue insurance products (*AO* April 1999)—exist for managing within-year price risk. AO

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