Long-Run Price Risk in U.S. Agricultural Markets*

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Abstract

The last three years have realized significant structural changes in the U.S. agricultural policy environment. These changes include nearly complete planting flexibility and the elimination of target-price-based income support for agricultural producers. Many have questioned the extent to which such policy changes may influence the variability of agricultural prices. This analysis uses price series dating from 1944 to develop a multivariate framework to evaluate the long-run (inter-season) determinants of endogenous variability for the prices of corn, wheat, and soybeans. An annual measure of price variability is calculated from monthly spot market cash prices for each of the three commodities. The generalized method of moments estimation technique is used to model the price variability measure as a function of several supply and demand variables hypothesized to be relevant. Several explicit policy variables are tested for their effect on output price variability as well as on the variable parameter estimates. Output price variability is found to be sensitive to stocks, demand shocks, yield shocks, input price variability, and policy factors. Results vary somewhat for corn, wheat, and soybeans. Implications for recent farm policy changes are offered.

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Introduction

The last three years have realized significant structural changes in the U.S. farm policy environment. The 1996 Federal Agricultural Improvement and Reform (FAIR) Act brought about numerous changes in farm policy, including nearly complete planting flexibility with the elimination of significant institutional restrictions (e.g., planting requirements for acreage base protection and acreage reduction program compliance) and economic barriers (e.g., large deficiency payment rates which encouraged the planting of the same crops over time). Although recent legislative events (including payments for low prices and production shortfalls) may lead one to question the extent of reforms, it is clear that production and marketing conditions will be subject to different policy constraints in the future.

Changes in farm policy have led some observers to argue that the volatility of long-run (i.e., inter-seasonal) prices is likely to increase. Using results from a large scale simulation model, Ray *et al.* (1998) recently argued that corn and wheat prices would be expected to be 82% and 40% more variable, respectively, over the next ten years than was the case over the preceding ten years. These results are especially startling in light of the significant price variability that characterized the 1980s and 1990s.

On the other hand, other market analysts predict that the increased planting flexibility will lead to greater acreage responsiveness to price change, thereby dampening price volatility. Recent work by Lin *et al.* (1999 and 1997) investigating supply responsiveness under the new policy environment suggests that supply response is moderately higher for corn, soybeans, and several other major field crops, although wheat supply response is basically unchanged. Wescott (1998b) argues that a higher supply response elasticity associated with policy shifts to full planting flexibility allows a larger response to market price movements, and can accelerate adjustments to shocks (particularly when starting from a period of low stocks) and mitigate longer run, annual price volatility.

The objective of this analysis is to develop a multivariate framework to evaluate the determinants of endogenous variability for the prices of corn, wheat, and soybeans. An annual measure of price variability is calculated from monthly spot market cash prices for each of the three commodities. The generalized method of moments (GMM) estimation technique is used to model the price variability measure as a function of several supply and demand variables hypothesized to be relevant. Several policy variables are tested for their effect on output price variability.

A brief history of price variability

Our data cover the period 1944-1997 and include monthly spot market cash prices for corn, "all wheat,? and soybeans obtained from the Bridge data base--wheat prices comprised a combination of Chicago (1944-1982) and St. Louis (1982-1997) soft red winter wheat, No. 2; corn prices were Chicago, No.2, yellow; and soybean prices comprised a combination of Chicago (1944-1982) and Central Illinois (1982-1997) soybeans, No. 2. All prices are expressed as dollars per bushel. The nominal price series were deflated using the U.S. monthly consumer price index (CPI), 1982-84 = 100, in order to avoid including inflationary spurts as commodity price instability. As an indicator of the long-term movements of "within-year" price variability, crop-year coefficients of variation (CV's)--the standard deviation of the 12 monthly deflated prices divided by the mean crop-year price--were constructed from the monthly average cash prices.

Historical evidence suggests that differences exist in price variability across both time periods and commodities (Heifner and Kinoshita; Sarris; Schnepf and Goodwin). An examination of price data reveals greater variability in the post-1970's period then during the two preceding decades. Prices exhibited dramatic increases in variability during the mid-1970's. Spikes in variability associated with droughts in 1983 and 1988, as well as the surge in commodity prices in 1995/96 were also evident. An examination of earlier data (1913-1997) reveals that prices were more variable during the four decades preceding WWII, than during any period since. Wheat prices tended to be less variable than prices for corn or soybeans.

Modeling Commodity Price Variability

An extensive body of research has evaluated determinants of price variability. Almost all of this research, however, has evaluated short-run, intra-season variability using weekly or monthly prices (see, for example, Goodwin and Schnepf; Hennessy and Wahl; and Streeter and Tomek). In contrast to existing research, this analysis utilizes annual data (1944-1997) to investigate determinants of variability for prices over the long run. Such variability is likely to be more relevant to questions involving changes in variance caused by acreage and output changes brought about by the increased planting flexibility.

In contrast to analyses of intra-season variability, which universally assume that determinants of variability are exogenous, our investigation requires that we recognize the potential for joint determination of variability of prices for commodities that compete for the same pool of acreage, as well as with factors related to variability. In light of the potential for cross-equation correlation and within equation simultaneity, we utilize a generalized method of moments (GMM) estimation framework. GMM estimation permits estimating the three variability equations (corn, wheat, and soybeans) as a system, thereby capturing potential cross-equation price variability inter-relationships.[1] GMM estimation also addresses the potential simultaneity bias of endogenous right-hand side variables.

Real marketing year CV?s for corn, wheat, and soybean spot market cash prices are defined as an exponential function of the rates of change of several types of aggregate supply and demand factors?yield, harvested acreage, domestic use, exports, and an index of producer input prices?as well as the natural logarithm of the marketing year ending stocks-to-use ratio from various USDA sources (table 1).[2]

$$CV_{i,\,t} \;=\; e^{(\,\beta_{0,i} \,+\, \beta_{1,\,i} \cdot x_{i,\,t} \,+\, \cdots \,+\, \beta_{k,\,i} \cdot x_{i,\,t}\,)} \,+\, \epsilon_{i,\,t}$$

$Cv_{i,t}$ represents the coefficients of variation for i=corn, wheat, and soybeans, $t=1944\ldots1997$; $x_{i,t}$ is a vector of

[1]See Greene (1997) for a detailed discussion of GMM estimation. A Parzen kernel is used in estimation to account for the correlation in the time function.

[2]This exponential representation was introduced by Harvey (1976) and is commonly used to model variance.

right-hand side exogenous and endogenous variables; β is a vector of parameters describing the association of the CV's with the vector of $x_{i,t;}$ and $g_{i,t}$ is a vector of error terms. To accommodate the exponential specification of the estimating equation, the supply and demand variables (yield, harvested acreage, domestic use, and exports) and the producer input price index are expressed as rates of change. The ending stocks-to-use ratio, loan rates, deficiency payments, and ARP's are expressed as natural logarithms. Because of the potential for cross-commodity price variability relationships, the covariance of the same-period and cross-period errors terms is not necessarily zero (i.e., $E(g_{i,t,}g_{j,s)} \neq 0,)$). GMM estimation accounts for these potential cross-equation and cross-period error relationships and endogeneity of explanatory variables in producing efficient and consistent estimators.

Following Gallant (1987), instruments include the exogenous variables (rates of change of acreage, the input price index, average farm prices received, and the CPI) and lagged values of the endogenous right-hand side variables (the stocks-to-use ratio, and rates of change of yields, domestic use, and exports). A general specification test frequently used to evaluate the GMM specification (consisting of the model and instrument choice) is the test of overidentifying restrictions. Under the null hypothesis that the specification is correct, the test statistic will be distributed as a chi-squared with degrees of freedom equal to the number of overidentifying restrictions (i.e., the number of instruments times the number of equations, less the number of parameters estimated). This test is presented with our estimates.

At the farm level, acreage is allocated among competing field crops in order to maximize planting time expected profit. However, acreage also has been a principal mechanism through which government agricultural policy has operated. Yields are included to control for random weather events. Acreage and yield changes are expected to have a negative, indirect effect on price variability through their influence on production. Increases in production tend to dampen both price levels and variability by contributing to an increase in total supply relative to market demand. Similarly, an abundance of stocks relative to use tends to make prices less sensitive to new market information; thus, increases in the stocks-to-use ratio can be expected to negatively impact price variability.

Domestic use includes food, feed, seed, residual, and industrial uses for corn and wheat, as well as crush and seed for soybeans. However, most variation in domestic use resonates from cyclical and near-term shifts in livestock and poultry feeding operations. For corn, increased feed use likely heightens price variability due to fairly stringent feed ration requirements and limited substitutes. The opposite effect holds for wheat where feed usage can actually dampen price volatility by increasing when wheat prices are low relative to coarse grains, but dropping off in favor of other grains when price relationships are less favorable. For soybeans, the influence of domestic use is less clear due to the nature of soybean crushing operations where plants have minimum capacities that must be maintained in spite of shifting price levels. This can aggravate variability when supplies are low, but may dampen volatility when supplies are more abundant.

Exports capture two conflicting effects on price variability-?international supply and demand shocks, and government export assistance programs. International shocks may result from the entry or exit of a major buyer or when an export competitor suffers a yield-reducing weather event. The strength of this effect should depend on the size of U.S. export market share and on the number of export competitors. The dominance of U.S. corn in international markets, suggest that any significant relationship between export variability and output price variability should appear most strongly in the corn equation.

A potential offset to the export-demand effect is the influence of government export-assistance programs, e.g., food donations, PL480 (long-term, low-interest sales), GSM credit guarantees, and EEP subsidies. Such programs increase U.S. grain exports during periods of excess supply and relatively lower prices, but are curtailed when supplies are tighter and prices higher and thus likely have a dampening effect on price variability. In that the preponderance of U.S. grain export programs have been directed at wheat, any offsetting effect should appear most strongly for the wheat price variability equation.

Lapp and Smith (1992) demonstrated the importance of macroeconomic phenomena to agricultural price variability. Macroeconomic effects are represented by three methods. First, the variability measures were constructed from deflated prices to avoid including inflationary spurts as commodity price instability. Second, the annual rate of change in the CPI (representing the general economy-wide rate of inflation) is included in the set of instruments. Finally, an indicator of the general level of major agricultural input prices--reflective of the importance of fuel and chemical input costs--is included in the model. Rising input prices tend to shift relative profit margins in favor of crops with lower input requirements. Higher cost crops, e.g., corn, will lose acreage (indirectly effecting production and total supply) which, in turn, should raise price variability. The converse should occur for lower cost crops, e.g., soybeans. In order to control for the acute period of price volatility generated by the unusual confluence of demand, supply, and macroeconomic shocks that occurred in the mid-1970's (Riley), a simple dummy variable for the years 1972-76 was included.

Government policy influences are inherent in all of the supply and demand variables, but manifest themselves most directly in the acreage, export, and ending stocks-to-use variables. The full variety of intervention in agriculture is described in detail elsewhere (Rasmussen and Baker; Green; Wescott, 1998b). Several explicit policy variables are included to directly measure the influence of loan rates, deficiency payments, and acreage restrictions on output price variability.

Wescott (1998a) has pointed out that changes in the price support program since the 1985 Farm Act have resulted in less interference with price determination. Price support levels were sharply reduced from the high levels of the late 1970's and early 1980's. Corn produced in 1986-90 was denied entry into the FOR which had accumulated huge stocks by the mid-1980's and corn in the reserve was made more accessible to the marketplace via generic certificates. This trend was continued with the 1990 Farm Act that initiated planting flexibility provisions, as well as marketing loans which allowed repayment of loans at less than the original loan rate (begun in 1993 for corn and wheat).[3] In his U.S. corn price model , Wescott multiplied a zero-one dummy variable for the "high policy intervention" years of 1979-1985 times the higher of the 9-month nonrecourse loan rate and the FOR loan rate to produce a policy variable that figured strongly in corn price formation. This same variable,

[3]Marketing loan programs for rice and cotton were begun under the 1985 Farm Act.

(DUM7985)*(loan rate), is considered here. A second policy variable combines the effects of the target price and loan rates by calculating the deficiency payment (equal to the target price minus the higher of the loan rate or the average market price over a specified period) times the zero-one target price year dummy variable, (DUM7495)*(deficiency payment) is also tested. Finally, a zero-one dummy for years when an ARP was in effect times the ARP percentage, (DUM_ARP)*(ARP), was included to test for government acreage restriction effects.

Soybean's development as a major crop in the 1950's post-dated the development of many of the major features of government program interventions. As a result, soybean production has managed to avoid coming directly under most Federal supply control programs, and instead has been affected only indirectly via cross-commodity planting and price effects. A Federal loan program has existed for soybeans to provide price support. Therefore, only the loan rate variable is directly applicable to the soybean estimating equation. The deficiency payments and ARPs for corn are substituted in the soybean equation to reflect the strong competition for acreage between corn and soybeans and the likely cross-commodity effect of government programs.

Results

Table 2 reports results for several specifications including two models that omit any explicit government policy variables (I-II), followed by several models (III-VI) that include explicit government policy variables. Predictions of the marketing year coefficients of variation for corn, wheat, and soybean cash prices under all specifications follow the general pattern of volatility movements, but fail to capture the more dramatic upward and downward swings.

In line with expectations, results indicate that output price variability is negatively related to the level of stocks relative to total disappearance across all model specifications. Corn price variability is also positively related to increasing variability in domestic use and exports. For wheat, price variability is negatively related to increases in export variability and generally shows no relationship with changes in domestic use. The negative effect of wheat export variability tends to confirm the importance of government export assistance programs, and suggests that U.S. wheat exports act as a residual source of supply to world markets at the margin. The lack of statistical significance for domestic wheat use likely reflects the offsetting roles that food and feed usage have with wheat price volatility--positive for widespread increases in the variability of domestic use for milling and other food and industrial uses, but negative (and partially offsetting) when acting as a residual outlet to feed markets.

Yield variability (representing weather effects) has a strong negative relationship with corn price variability. Yield variability results were weaker for soybeans and were not significant for wheat. Wheat?s dual seasons (winter vs. spring) within a single crop year and different geographic locations (Southern vs. Northern Plains) likely diminish the influence of yield variability on the aggregate wheat market.

No significant relationship was found between rates of change in harvested acres and price variability, in the absence of any specific controls for government policy. This likely reflects the counter-balancing effect of government acreage controls inherent in the acreage variable. Input price variability appears positively related to changes in for all three commodities, though this variable loses its significance for corn and wheat when the 1972-76 dummy variable is added. For soybean price variability, the relationship with variability in producer input prices actually switches signs from positive to negative and is now suggestive of soybean production as lower cost relative to corn and wheat. As input prices rise, producers favor soybeans, resulting in a greater acreage, more production, and lower price variability.

Government Policy Variables

The explicit government policy variables hint at the effects of acreage constraints and price support programs on commodity price variability. In the majority of cases, explicit government policy variables had no significant effect on commodity price variability. However, in those cases of a statistically significant relationship, the policy variables consistently have a surprising positive relationship with price variability. The deficiency payment variable, (DUM7495)*(Deficiency), shows a positive relationship with wheat output price variability. A similar positive relationship was found between soybean price variability and the corn deficiency payment. This outcome suggests that Federal income support activities had a price destabilizing effect on those two commodities.

The loan rate variable, (DUM7985)*(loan rate) which proved important in Wescott?s (1998a) corn price model failed to show any relationship with corn or wheat price variability. However, soybean price variability was positively related to its own loan rate. Wheat price variability showed a similar unexpected positive relationship with ARP levels. When ARPs and deficiency payments were included simultaneously, wheat price variability showed a positive relationship with ARP levels while soybean price variability was positively related to both the ARP and deficiency payment rates for corn.

While far from conclusive, these results suggest that government programs had a tendency to produce higher levels of price variability. Thus, although these programs may have enhanced and stabilized producer incomes, market prices may actually have been more variable as producers responded to the distorted incentives provided by the program. For example, had deficiency payments been in place in 1997 and 1998 as under previous legislation, corn price CV would have been 4.3 and 4.9 percent higher in each of those years; the wheat price CV would have been 7.9 and 9.3 percent higher; and the soybean price CV would have been 20.2 and 25.4 percent higher.

Concluding Remarks

This analysis considers determinants of long-run price variability in U.S. corn, wheat, and soybean markets. We find that stocks have a significant negative influence on price variability. Yields are negatively related to variance, though this effect is significant only for corn. Finally, several policy variables are found to actually increase commodity price variability. At first glance, this effect may seem surprising. However, policies, which are intended to stabilize producer incomes, are likely to increase the volatility of market prices if they distort production and marketing arrangements. Decreases in acreage are shown to evoke modest increases in variability, though when policy variables are added to the equation acreage is no longer significant. This likely suggests that acreage changes since 1944 have been largely driven by policies. Changes in corn exports have a variance-increasing influence on corn prices while the opposite effect is realized for wheat prices.

Table 1--Variable Description for Generalized Method of Moments (GMM) Estimation of the Coefficient of Variation for Commodity Cash Prices, marketing years 1944-97.

Variable		Description	Mean	Std. Dev.
Corn price	-nominal -real	Chicago, No. 2, yellow corn, mo. ave. cash price: $/bu. (Source: Bridge data base.)	$2.02 4.06	$0.75 1.88
Corn CV[1]		Crop year ratio of st. dev. over mean of real price: %.	7.67	5.11
Soybean price	-nominal -real	Chicago (1944-82) and Central Illinois (1982-97), mo. ave. cash price: $/bu. (Source: Bridge data base.)	$4.47 8.43	$1.92 3.03
Soybean CV[1]		Crop year ratio of st. dev. over mean of real price: %.	7.74	6.33
Wheat price	-nominal -real	Soft red winter wheat, No.2, Chicago (1944-82) and St. Louis (1982-97), mo. ave. cash price: $/bu. (Source: Bridge data base.)	$2.72 5.67	$0.94 2.69
Wheat CV[1]		Crop year ratio of st. dev. over mean of real price: %.	7.08	4.19
Yield	-all wheat -corn -soybeans	National average yield, bushels per acre; USDA.	28.44 79.25 26.95	7.68 31.36 5.83
Stocks/use	-all wheat -corn -soybeans	Ratio of total stocks to total disappearance (domestic and international), USDA.	0.551 0.267 0.104	0.345 0.155 0.069
Dom. use	-all wheat -corn -soybeans	Total domestic disappearance, million bu; USDA.	853.04 4,271.06 793.58	226.51 1,420.77 447.81
Harv. acres	-all wheat -corn -soybeans	Total harvested acreage, million acres; USDA.	59.61 67.11 41.07	9.44 7.52 20.48
Input price index		USDA producer input price index, 1991=100.	51.30	34.33
Exports	-all wheat -corn -soybeans	Total exports (commercial and government-assisted), million bu. (Source: Bureau of the Census.)	865.91 1,010.75 410.92	422.83 803.08 315.72
Loan rate	-all wheat -corn -soybeans	USDA?s loan rate for 9-month nonrecourse loan: $/bu.[2]	$4.54 3.37 6.34	2.42 1.69 2.23
Target price	-all wheat -corn	USDA?s target price used to determine deficiency payments: $/bu.[3]	$3.49 2.35	1.28 0.84
Deficiency payment	-all wheat -corn	Target price minus the higher of the loan rate or the average farm price received. [3]	$0.20 0.09	0.41 0.21
ARP	-all wheat -corn	Acreage restriction program as a percent of base acres; USDA.	10.74 8.19	19.55 9.36

[1]CV = coefficient of variation calculated from deflated prices. [2]Average of deflated loan rates for the 1979-85 crop years. [3] Average of deflated target prices for the 1974-95 crop years.

Table 2- Generalized Method of Moments (GMM) Parameter Estimates of the Marketing Year Coefficients of Variation for Deflated Monthly Commodity Cash Prices, 1944-1997.[1]

	Model					
Equations/Parameters	**I**	**II**	**III**	**IV**	**V**	**VI**
Corn price CV equation						
Intercept	1.040***	1.200***	1.110***	1.297***	1.333***	1.226***
$Ln(yield_t/yield_{t-1})$	-2.943***	-2.813***	-1.530*	-2.639**	-2.099*	-2.231**
Ln(stocks/use)	-0.492***	-0.434***	-0.497***	-0.291	-0.379***	-0.408
$Ln(dom.\ use_t/dom.use_{t-1})$	4.528***	4.083**	2.581*	3.446**	1.992	3.804*
$Ln(harv.ac._t/harv.ac._{t-1})$	-0.586	-0.004	-0.456	-0.534	-0.771	-1.263
$Ln(Inp.indx_t/inp.indx_{t-1})$	2.258***	-1.043	0.209	1.630	-0.671	0.292
$Ln(exports_t/exports_{t-1})$	0.625***	0.672***	0.396**	0.657***	0.586***	0.602***
Dum7276	-.--	0.499***	0.507***	0.423**	0.414*	0.520**
$Dum7985*Ln(loan\ rate_t)$	-.--	-.--	0.030	-.--	-.--	-.--
$Ln(Expected\ Deficiency_t)$	-.--	-.--	-.--	0..33	-.--	0.072
$Ln(ARP_t)$	-.--	-.--	-.--	-.--	-0.011	-0.081
Adjusted R2	0.074	0.094	0.230	0.081	0.067	0.070
Wheat price CV equation						
Intercept	1.592***	1.464***	1.505***	1.430***	1.429***	1.382***
$Ln(yield_t/yield_{t-1})$	-0.742	-0.612	-0.268	-0.830	-0.605	-0.565
Ln(stocks/use)	-0.222***	-0.344***	-0.371***	-0.347***	-0.410***	-0.422***
$Ln(dom.\ use_t/dom.use_{t-1})$	0.668	0.543	1.101*	1.026	0.274	0.574
$Ln(harv.ac._t/harv.ac._{t-1})$	-0.429	-1.163***	-0.901**	-0.876**	-1.459***	-1.075**
$Ln(Inp.indx_t/inp.indx_{t-1})$	4.137***	1.183	0.300	0.979	-1.228	-1.540
$Ln(exports_t/exports_{t-1})$	-0.423**	-0.505*	-0.255*	-0.231	-0.556**	-0.306
Dum7276	-.--	0.914***	1.014***	0.851***	1.107***	1.119***
$Dum7985*Ln(loan\ rate_t)$	-.--	-.--	-0.002	-.--	-.--	-.--
$Ln(Expected\ Deficiency_t)$	-.--	-.--	-.--	0.051**	-.--	0.030
$Ln(ARP_t)$	-.--	-.--	-.--	-.--	0.068***	0.059**
Adjusted R2	0.180	0.498	0.571	0.513	0.535	0.549
Soybean price CV equation						
Intercept	1.504***	1.011***	0.658***	0.394	0.829***	0.258
$Ln(yield_t/yield_{t-1})$	-1.649*	0.009	0.166	1.575	-0.193	0.315
Ln(stocks/use)	-0.177**	-0.340***	-0.465***	-0.513***	-0.395***	-0.525***
$Ln(dom.\ use_t/dom.use_{t-1})$	-2.148	-0.962	-1.623	-2.247	-0.423	-0.132
$Ln(harv.ac._t/harv.ac._{t-1})$	0.304	0.444	1.165	1.741*	-0.145	-0.187
$Ln(Inp.indx_t/inp.indx_{t-1})$	1.726***	-2.139**	-3.210**	-2.425**	-2.657**	-2.992
$Ln(exports_t/exports_{t-1})$	0.312	-0.066	-0.030	-0.180	-0.102	-0.080
Dum7276	-.--	1.400***	1.594***	1.672***	1.438***	1.701***
$Dum7985*Ln(loan\ rate_t)$	-.--	-.--	0.401***	-.--	-.--	-.--
$Ln(Expected\ Deficiency_t)$	-.--	-.--	-.--	0.174***	-.--	0.127**
$Ln(ARP_t)$	-.--	-.--	-.--	-.--	0.069	0.085**
Adjusted R2	-0.102	0.490	0.534	0.571	0.525	0.560
Test of Overidentifying Restrictions[1,2]	23.02(42)	18.26(42)	19.39(48)	20.04(57)	17.80(48)	17.43(60)

[1] Asterisks indicate statistical significance: *** is at the α=0.01 or smaller level; ** is at α=0.05; and * is at α=0.1.
[2]Tests the null hypothesis that the equation is correctly specified. Distributed as a Chi squared random variable (degrees of freedom). The null hypothesis is not rejected for any equation.

References:

Collins, Keith J. And Joseph W. Glauber. 1998. "Will Policy Changes Usher in a New Era of Increased Agricultural Market Variability?? *Choices*, second quarter 1998, pp 26-29.

Gallant, A. R. 1987. *Nonlinear Regression.* New York: John Wiley and Sons.

Goodwin, Barry K. and Randy Schnepf. 1998. "Determinants of Endogenous Price Risk in Agricultural Markets.? Paper presented in Organized Symposium on Price Risk at the 1998 AAEA Summer Meetings in Salt Lake City.

Green, Robert C. 1990. *Program Provisions for Program Crops*, (March), Staff Report No. AGES 9010, Economic Research Service, USDA.

Greene, William H. 1997. *Econometric Analysis*, 3rd edition, Prentice-Hall, Inc.

Harvey, A. 1976. "Estimating Regression Models with Multiplicative Heteroscedasticity,? *Econometrica* 44:461-65.

Heifner, Richard. 1997. "Can Options Traders Forecast Crop Price Volatility Over the Growing Season?? Selected paper presented at the 1997 AAEA summer meetings in Toronto.

Heifner, Richard and Randal Kinoshita. 1994. "Differences Among Commodities in Real Price Variability and Drift,? *Journal of Agricultural Economics Research*, Vol. 45, No.3, (Fall), pp. 10-20.

Lin, William. 1999a. "Analyzing U.S. Wheat Acreage Response Under the 1996 Farm Act,? *Wheat Yearbook*, WHS-1999 (March), Economic Research Service, USDA, pp. 21-26.

Lin, William, Bob Skinner, Scott Sanford, and Daniel G. De La Torre Ugarte. 1999b. "The Impact of Planting Flexibility Under the 1996 Farm Act on the U.S. Major Field Crops Sector,? Selected paper to be presented at the 1999 AAEA summer meetings in Nashville, TN.

Rasmussen, Wayne D. And Gladys L. Baker. 1979. *Price-Support and Adjustment Programs From 1933*

13

to 1978: A Short History, AIB 424, Economics, Statistics, and Cooperatives Service, USDA.

Ray, Daryll E., James W. Richardson, Daniel G. De La Torre Ugarte, and Kelly H. Tiller. 1998. "Estimating Price Variability in Agriculture: Implications for Decision Makers,? *Journal of Agricultural and Applied Economics*, Vol. 30, No. 1 (July), pp. 21-33.

Sarris, A.H. 1998. "World Cereal Price Instability and a Market Based Scheme for Managing the Risk of Developing Country Cereal Imports,? Paper presented at the symposium *Policy Reform, Market Stability, and Food Security,* Alexandria, VA, June 26-27, 1998.

Schnepf, Randall D. and Barry K. Goodwin. Forthcoming 1999. "Wheat Price Volatality,? Wheat Industry Base Book, Economic Research Service, USDA.

Wescott, Paul C. 1998a. "Market Factors and Government Programs Affecting U.S. Corn Prices,? *Feed Yearbook*, FDS-1998 (April), Economic Research Service, USDA, pp. 46-51.

Wescott, Paul C. 1998b. "Implications of U.S. Policy Changes for Corn Price Variability,? *Review of Agricultural Economics*, Volume 20, No. 2, pp. 422-434.

14