

Estimating Price Variability in Agriculture: Implications for Decision-Makers

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ABSTRACT

Using a stochastic version of the POLYSYS modeling framework, an examination of projected variability in agricultural prices, supply, demand, stocks, and incomes is conducted. Random yield and export shocks are introduced in each of 100 iterations of a ten-year simulation and planted acreage, production, total use, ending stock, stock-to-use, season average price, and net return results are presented for corn, wheat, soybeans, and cotton during the 1998-2006 period. Increased planting flexibility introduced in the 1996 farm bill results in projections of significantly higher planted acreage variability compared to recent historical levels. Ending stocks and stock-to-use ratios are projected to be higher for corn and soybeans and lower for wheat and cotton compared to the 1986-96 period. Significantly higher variability is projected for corn prices, with wheat and soybeans prices also more variable. No significant change in cotton price variability is projected. Compared to the 1986-96 period, net returns are projected to be more variable for corn, wheat, and soybeans, but less variable for cotton.

Key Words: POLYSYS model, price variability, stochastic simulation

The economic well-being of production agriculture and agribusiness is influenced by a number of forces beyond the influence of economic agents in agriculture. Producers and analysts can formulate reasonable expectations about the influences of some of these exogenous factors, such as population, per capita incomes, technology, and current government policies and programs when making production plans. Other exogenous factors cannot be expressly incorporated in decision making – including random effects of weather, biological phenomenon, changes in institutional structures among trading partners, and natural phenomenon – but strongly influence domestic and global agricultural supplies.

A large portion of the historical variability in agricultural prices, supplies, exports, and returns can be attributed to factors over which individual producers have neither control nor reliable predictive ability. For more than a half century, various government programs specifically designed in part to reduce the variability of agricultural prices, supplies, exports, and farm incomes have affected U.S. agriculture. Since passage of the Federal Agriculture Improvement and Reform (FAIR) Act in 1996, a dismantling of government supply controls and price stabilizing programs has begun with movement toward freer agricultural production and markets. Now that government supply controls and price stabilizing tools are no longer available, it has

become even more critical that producers, policy makers, and other agricultural decision makers are cognizant of the sources and magnitude of variability around agricultural yields and exports and on decision making variables such as prices and net returns. Also of considerable interest is whether price and net return variability is less or greater in the South than for the U.S. as a whole.

A number of deterministic, large-scale models of the U.S. agricultural sector have proven to be useful tools for projecting prices and incomes with an “average state” of weather, unchanged international institutional structures, and other exogenous conditions.¹ But producers, policy makers, agricultural lenders, agribusinesses, and others are increasingly interested in the range and relative frequencies of prices given the variability associated with yields and exports. Stochastic simulation techniques allow estimation of probability distributions for endogenous variables such as prices and net returns, given probability distributions for uncertain variables in the system. Uncertainty in the agricultural system may be in the form of probability distributions on the random variables, such as yields and exports, or on the disturbance terms for particular equations. Stochastic simulation of such a model results in an estimate of the probability distributions on the endogenous variables and, thus, provides an important dimension to the information base for decision makers.

This added dimension of variability around key indicators of agricultural performance will be especially important for examining agricultural sector impacts of the FAIR Act. This paper represents an initial examination of supply, demand, price, and income variability using a stochastic simulation model of the U.S. agricultural sector, based on the Policy Analysis System (POLYSYS) national simulation model (Ray et al., 1997). A ten-year stochastic baseline simulation is performed using the November 1997 FAPRI agriculture baseline. All of the baseline assumptions regarding agricultural policies, domestic and global economic conditions, weather, technological change, and other influences also characterize the stochastic baseline simulation, except that stochastic yield and export shocks are introduced. Examination of the results focuses on crops of primary importance to Southern agriculture, including corn, soybeans, cotton, and wheat. For selected commodities, statistics on variability are presented for harvested acreage, yield, supply, feed use, export use, ending stocks, season average price, and net returns per acre. The probability distributions associated with the ten-year simulation are compared to the historical variation of crop prices, supplies, demands, and returns to allow an examination of the change in projected variability in agriculture compared to observed variability in recent years.

¹ Examples of large-scale deterministic structural models that are often used for policy analysis include models such as AGMOD (Ferris, 1993), COMGEM (Penson et al., 1993), FAPRI (Devadoss et al., 1993), AGSIM (Taylor, 1993), and CARD LP (English et al., 1993).

Methodology

The POLYSYS national agriculture simulation model is anchored to a national baseline of projections for agriculture. Baseline projections for crop acreages, prices, and expenditures are retailored for 305 production regions corresponding to Agricultural Statistic Districts (ASDs). Changes to the baseline are then introduced exogenously, and the model estimates the impacts of changes to the baseline for regional crop supply, national crop prices and demand, livestock supply and demand, and agricultural income. Endogenous model crops include corn, soybeans, cotton, grain sorghum, barley, oats, wheat, and rice. Seven livestock commodities are also included as a complement to the feed demand component of the crop sector. The calculation of most national variables in POLYSYS is driven by deviations from a baseline and elasticity parameters. POLYSYS incorporates 305 regional linear programming crop supply models and a crop demand and price simultaneous block in the estimation of endogenous crop variables. The regional crop supply models are designed to allocate marginal changes in acreage over the baseline crop acreage within each region, subject to a 15 percent acreage shift constraint in any simulation year. Thus, a POLYSYS simulation yields a dynamic performance path for crop and livestock supply, demand, price, and agricultural income variables.

An implicit assumption characterizing results from deterministic simulation models like POLYSYS is that simulation results differ from the baseline only to the extent that changes are introduced to define a simulation. Thus, deterministic models are generally limited to providing point estimates of endogenous variables. It is possible to use a deterministic model to examine the impacts of changes from the baseline for model variables characterized by high levels of uncertainty. For example, the sensitivity of agricultural variables to baseline export projections has been the subject of several POLYSYS simulation analyses (e.g., Ray and Tiller, 1997; Ray, 1996; Ray et al., 1995). But unless specific changes to the baseline export projections are simulated, the endogenous variables are estimated under the assumption that there is no range of values associated with baseline export projections. While a deterministic model could be used to perform multiple simulations that introduce randomness to desired variables, stochastic techniques provide a statistical framework to perform a series of simulations in an efficient and systematic manner (Taylor, 1994; is '86 FLIPSIM ref. the stochastic version?; others?).

A POLYSYS stochastic baseline simulation is developed by introducing variability in (a) national crop export projections and (b) yield estimates for each of the 305 regions into the POLYSYS baseline simulation. Stochastic exports for eight crops were simulated from a multivariate empirical (MVE) distribution of deviations from a trend. The MVE distribution for exports was estimated using data for 1982-1996. Historical values of crop exports over the 1982-

1996 period were regressed on a time trend for each of the eight model crops to obtain the error terms (variability) from historical trend expectations.² The percentage deviations from the trend for each crop were used to specify empirical probability distributions for crop export deviations. A correlation matrix of crop export deviations for eight crops was calculated and used in conjunction with the historical percentage deviations from trend to simulate correlated random deviates to the annual baseline export values in the stochastic simulation.

A multivariate empirical distribution for crop yields was not used to generate random yields due to the sheer size of the correlation matrix for simulating eight crops in each of 305 regions. The historical variability of regional crop yields, 1972-1996, was used to develop empirical distributions for production for each crop in each region. Percentage deviation structures are preserved by year to reflect correlation across crops and regions. Correlated yields were simply simulated by randomly selecting rows from the matrix of annual percentage yield deviations for the 305 regions and eight crops. Once a row in the matrix (year) was selected randomly, the deviations were applied to their respective baseline value to calculate the stochastic yield.³

In the first year of a POLYSYS simulation, the model randomly selects a percentage deviations for initial export shocks for each crop and applies it to the baseline value for crop exports in that year. Similarly, a random year is chosen from 1972 to 1996, and the yield percentage deviations for each of eight crops in each of 305 regions for that year are applied to the baseline yield projections. Similar random draws of export shocks and yield percentage deviations are made in each successive year of the simulation. In a ten-year simulation, ten random annual draws of export shocks and yield percentage deviations are made and applied to their respective baseline values. The model solves the ten-year horizon in a recursive fashion using the random yields and exports as the changes from the baseline that lead to changes in quantities supplied, prices, quantities demanded, ending stocks, and expected prices in the next year that lead to acreage changes.

A ten-year simulation of the model with random annual export shocks and yield deviations comprises one iteration of the model. The ten-year simulation sequence is repeated 100 times to allow estimation of a probability distribution for endogenous model variables for each of the ten simulation years. Figure 1 illustrates the interaction of variability in exports and yields over the simulation period and across iterations. In the first year of the first iteration, the model draws an

² Export data are available prior to 1982, but evidence of a structural change in U.S. exports around 1982 exists. An alternative to truncating historical exports at 1982 would be inclusion of additional historical export data with an estimation of structural change included in the regression of historical exports on a time trend.

export percentage deviation for each crop and applies it to the baseline export value to introduce one realization of a stochastic shock to exports. The model also draws a year and applies the corresponding percentage yield deviations for all eight crops in all 305 regions to introduce one realization of stochastic yields. The stochastic yields directly influence crop supplies, which in turn influence agricultural prices, incomes, stocks, and demands. The random export shocks influence crop demands, which are reflected in total demand and, thus, the determination of crop prices. Thus, the variability of both yields and exports contribute to the determination of agricultural prices.

Effects of the export and yield deviations from the baseline projection are transferred to subsequent simulation years through their initial influence on prices, which are used to form price expectations for future production decisions, and through their influence on crop demands and ending stocks. In the second simulation year, another set of random yield and export deviations is applied to baseline yield and export values, and the simulation is repeated. The same process follows in each of the remaining eight simulation years until a ten-year simulation sequence is completed. This ten-year simulation sequence comprises one iteration of the stochastic model. One hundred iterations are performed, drawing random export and yield percentage deviations in each of the ten simulation years that comprise one iteration. The resulting stochastic baseline provides 100 estimates of each variable in each simulation year, providing an estimate of the probability distribution for each variable. The stochastic baseline represents a ten-year forecast of supply and demand and income variables, with probability distributions around each endogenous variable.

Results

The simulated summary statistic values for key output variables in POLYSYS – such as planted acres, production, total use, ending stocks, and prices – are summarized in table 1 for crops of major importance to Southeastern agriculture, including corn, wheat, soybeans, and cotton. Historical means for the 1986-1996 period are also reported. The eleven years of historical data were then detrended and standard deviations from the historical trend are reported in table 1 to avoid overstating the variation in these data. The coefficients of variation for the historical data are reported in table 1 using standard deviations based on deviations from trend. Thus, the first column for each crop in table 1 reports the historical mean, the standard deviation from the trend, and this deviation as a percentage of the historical mean, as a proxy for the coefficient of variation.

³ Historical crop yields were regressed on a time trend to calculate the annual percentage deviations from trend. The regional nature of the crop supply sector of the model requires complete historical yield data at the county level,

The second column reports similar descriptions of the data over the ten-year simulation period, 1997-2006, where the means for each variable are means over all ten simulation years and all 100 ten-year iterations, the standard deviations are the average deviations from the detrended simulation data, and the coefficients of variation are the detrended standard deviations as a percentage of the overall simulation mean. For each crop, the two columns provide one way to compare variable performance in the historical period to variable performance in the simulation period. It should be noted that while these measures provide one method of inter-period comparison (1986-96 compared to 1997-2006), they remain a comparison of one observed path (among the numerous paths that could have occurred during that time) to 100 potential paths of outcomes for the simulation period.

Planted Acreage

The 1996 farm bill provides farmers with nearly complete flexibility in determining their crop mixes, leading to the expectation that planted acreage after 1996 will be more variable than prior to 1996. Planted corn acreage over the 1997-2006 simulation period is projected to be more than 8 million acres greater than the 1986-96 average (table 1). Planting flexibility is projected to increase the relative variability of planted corn acres from 0.053 during 1986-96 to 0.094, an increase of 77.4 percent.

Wheat planted acreage declines slightly from the historical average of 71.5 million acres (table 1). The coefficient of variation for wheat acreage rises from 0.053 during 1986-96 to 0.089 (68 percent higher) during the 1997-2006 period. For soybeans, 1997-2006 planted acreage projections are 7.7 million acres greater than the historical average. Variability over the simulation period rises 296 percent from the historical coefficient of variation of 0.023. Cotton planted acreage is projected to increase by one million acres during the 1997-2006 period, with average variability over the entire simulation period projected to be six percent lower than over the historical period, as farmers in marginal cotton areas switch to other crops.

Production

Average annual production for the four crops increases throughout the projection period, largely in response to acreage gains and trend-adjusted mean crop yields (table 1). The coefficient of variation for corn production actually declines from its respective historical measure by 13 percent. Some portion of this apparent decline in variability for corn may stem from a significantly higher mean level of production reported for the projected years. If the standard deviations are used to compare variability, then table 1 shows a higher standard deviation (and, thus, higher nominal

which were not available electronically prior to 1972. Thus, historical data available for estimation of yield deviations from a trend are limited to 25 years.

variability) for projected corn production during the 1997-2006 simulation period, compared with the historical deviation. Variability in wheat production rises by nearly two percent from the historical period, while variability in soybean production rises by more than 33 percent. Cotton variability is slightly more than 20 percent above the 1986-96 level (0.107) for the 1997-2006 period.

Total Use

As with production, total use of the four crops is projected to be higher during the simulation period, compared to the historical average. Corn use, in particular, rises 26.1 percent during the simulation period from the historical level of 8.1 billion bushels. This increase in corn use is a direct reflection of the FAPRI baseline, which assumes significant increases in grain exports over the simulation period.

Variability in total use for the projection years is greater than the historical variability for corn and wheat, but lower for soybeans and cotton. Wheat total use shows the greatest increase in variability while soybeans total use shows the greatest decrease in variability. Wheat variability is 33.3 percent above the historical coefficient of 0.060 in the simulation, while corn variability is 17 percent higher. Soybean total use variability declines by 7.3 percent during the simulation period, compared to the historical period. Cotton total use experiences similar variability results, with lower variability over the 1997-2006 period.

Stocks

Average ending stock levels generally are projected to decrease in absolute terms for corn and wheat and as a percent of total use for all four crops over the 1997-2006 period (table 1). The coefficients of variation for corn and soybeans ending stocks and stocks-to-use ratios increase during the simulation period compared to the historical period, while they decrease for wheat and cotton. Variability in soybean stocks, a reflection of the variability in soybean acreage, increases by more than 75 percent in the simulation, compared to the historical period, as it becomes the preferred flex crop under the 1996 farm bill. Variability in cotton stocks as measured by the simulation coefficient of variation 0.282 is lower than the historical coefficient of variation 0.316.

The probability of experiencing various levels of ending stocks is summarized in table 2. Averaged over the entire projection period, there is a 38 percent chance that corn ending stocks will be below one billion bushels, a 45 percent chance that stocks will fall between one billion and two billion bushels, and an 18 percent chance that corn stocks will be above two billion bushels. Table 2 also shows that, averaged over 1998-2006, there is a 42 percent chance that wheat ending stocks will fall below 600 million bushels, a 33 percent chance that soybean ending stocks will fall below 200 million bushels, and a 13 percent chance that cotton ending stocks will fall below three

million bales. The probability of achieving very high stock levels averaged over the simulation period is 17 percent for soybeans (stocks over 500 million bushels), 16 percent for cotton (stocks greater than six million bales), and 9.4 percent for wheat (stocks over one billion bushels). In looking at intertemporal changes in ending stocks, the probability of experiencing very low stocks increases considerably over the simulation period for wheat, cotton, and corn, with the probability distribution for soybeans ending stocks remaining relatively constant over time.

Season Average Price

Season average annual prices during the 1997-2006 period are projected to increase over the historical period for all four crops (table 1). Corn prices are projected to average \$2.65 per bushel over the 1997-2006 period with a coefficient of variation of 0.242, indicating that season average corn prices are projected to be 82 percent more variable over the ten-year study horizon than during the historical period. The coefficient of variation for wheat prices over the 1997-2006 period indicates that wheat prices will be 40 percent more variable than during the 1986-96 period. Soybean prices are projected to have 25.8 percent more relative variability than during the historical period. By contrast, cotton prices have the lowest average comparative increase in variability (one percent) during the simulation period versus the 1986-96 period.

Annual summary statistics and probabilities for crop prices are provided in table 3. There is a 10 percent chance that the 1998 corn price will be less than \$1.79 per bushel, and a 25 percent chance that the 1998 price will be below \$1.96 per bushel. On the other end of the distribution, the 1998 corn price has only a 10 percent chance of exceeding \$3.38 per bushel (table 3). Generally, the distribution of crop prices within each simulation year is skewed leftward, as indicated by an annual mean price greater than the median price (*'50% Probability ≤:'* in table 3). Thus, producers have a higher probability of experiencing prices below the expected value of price and are less likely to experience prices at or above the expected value of price.

Histograms of crop price coefficients of variation averaged over the ten-year simulation period show the probabilities of experiencing alternative levels of price variability during the simulation period, as presented in figure 2.⁴ Comparing the historical period to the simulation period, figure 2 shows that corn price experiences the most dramatic increase in variability during 1997-2006. The probability of achieving a level of variability greater than the historical level (mean historical coefficient of variation of 0.133) is greater than 95 percent. Simulation period corn prices were less variable than historical period prices in fewer than five of the 100 iterations. Soybean prices

⁴ Note that the coefficients of variation presented in figure 2 are calculated as the percentage of the residuals from trend to the period expected value, an analogous calculation to the coefficients of variation presented in table 1. The annual coefficients of variation presented in table 3, however, are the sample standard deviation as a percentage of the mean.

were more variable in the simulation period in more than 76 percent of the iterations, and wheat prices were more variable in more than 86 percent of the iterations. Average cotton price variability during the simulation period was approximately equal to variability during the historical period. A statistical test was performed to test the hypothesis that the mean of the simulation coefficient of variation for price is greater than or equal to the coefficient of variation of actual prices experienced from 1986 to 1996. The simulation mean coefficient of variation for corn price, 0.242, was significantly different from the coefficient of variation of corn price over 1986-96, 0.133, at the 0.01 significance level ($t = 4.52$). In the case of wheat, the simulation coefficient of variation, 0.20, was significantly different from the historical coefficient of variation, 0.146, at the 0.05 significance level ($t = 1.79$). The simulation coefficients of variation for soybeans and cotton were not significantly different from their respective historical coefficients of variation.

Income Measures

Average net returns (value of production less variable expenses) over the simulation period for all four of the crops are greater than their respective 1986-96 averages (table 1). Net returns are more variable for wheat, corn, and soybeans, while cotton net returns experience a marked decline in variability. Variability in cotton returns falls by 38 percent during the ten-year simulation period, compared to the eleven-year historical period.

Wheat returns experience the greatest increase in variability, rising 138.8 percent in the simulation from their historical coefficient of 0.183. Variability of corn net returns is about 60 percent higher than the historical coefficient, and the soybeans net returns coefficient is nearly five percent higher than the historical coefficient of variation 0.152.

Historical and projected net returns (value of production less variable expenses) to the eight major crops (corn, grain sorghum, oats, barley, wheat, soybeans, cotton, and rice) are provided in table 4. Mean returns rise significantly over the projection period – from \$24.7 billion in 1998 to \$34.0 billion in 2007. Compared to the historical variability (coefficient of 0.134), the relative coefficient of variation for this income measure ranges between 25.6 percent and 52.1 percent greater during the simulation period.

Summary and Conclusions

This research used a stochastic version of the POLYSYS national agriculture simulation model to compare the variability of agricultural variables projected for the 1997-2006 period to variability observed prior to 1996. As expected, increased planting flexibility introduced in the 1996 farm bill results in significant increases in planted acreage variability compared to historical levels of variability for major Southern crops. The coefficients of variation for corn, wheat and soybean

planted acreage are more than 68% higher over the 1997-2006 period compared to the 1986-1996 period. Variability in cotton planted acreage declines during the simulation period as producers in marginal cotton areas switch to other crops. Increases are experienced in the absolute level of total use for all four crops over the projection years compared to historical levels, while total use variability increases for corn and wheat, but decreases for soybeans and cotton. Average ending stocks decline for corn and wheat while stocks-to-use ratios decline for all crops during the simulation period. Ending stocks and stocks-to-use variability for corn and soybeans are projected to increase over their historical levels while variability for wheat and cotton are projected to decrease over their historical levels.

The levels and variability of supply, demand and stock variables for each crop are reflected in projections of season average prices. Steady increases are projected for all crop prices over the period, with the exception of an early downturn in wheat price followed by recovery and gains. Comparing the average coefficient of variation for the historical period with that for the simulation period (calculated as deviations from a trend as a percentage of the period expected value), corn prices average 82 percent more variable during the 1997-2006 period than during the historical period. Variability of wheat and soybean prices is 40 and 25.8 percent higher, respectively, than variability observed during the 1986-96 period. In contrast, cotton prices are only one percent more variable during the simulation period. The increases in price variability and production variability are also transmitted to increases in the variability associated with net returns to each crop.

While price variability is clearly projected to increase over the period, it is not possible to use the data presented to determine precisely what portion of increased price variability may be attributed to government program and policy changes instituted in the 1996 farm bill. Average stocks tended to be relatively low at the outset of the 1996 farm bill period and are projected to remain low. Definitive statements regarding price variability since the 1996 farm bill should be tempered with recognition that low stocks are generally manifest in greater price variability, irrespective of policy settings. For example, had corn stocks not been above four billion bushels in 1988 when average corn yield fell from 120 bushels per acre to 85 bushels per acre, a very different corn price path may have been observed during the historical period. Further assessment of price variability attributable to the 1996 farm bill will await times of higher stock-to-use ratios. Among the crops considered, cotton is most unique to the South and experiences the least variability during the simulation period, with price variability very near recent historical levels and a decrease in variability of net returns compared to the 1986-96 period. In the case of soybeans, another important crop in the South, price variability is not significantly different from the historical period but net return variability is approximately five percent higher than during the

historical period. Hence price and net return variability for Midwestern corn and Great Plains wheat may be larger than for Southern cotton.

Table 1. Summary Statistics of Historical Average (1986-96), 1998, and 2002 Results for Crop Variables

Item	Corn			Wheat		
	1986-96 ¹	1998	2002	1986-96 ¹	1998	2002
Planted Acreage						
Mean (Mil. Ac.)	74.1	83.1	83.0	71.5	70.2	70.4
Standard Deviation	3.9	7.0	8.5	3.8	6.1	5.7
Coefficient of Variation	0.053	0.084	0.102	0.053	0.087	0.081
Production						
Mean (Mil. Bu., Bales for Cotton)	7,800	9,860	10,315	2,220	2,466	2,515
Standard Deviation	1,332	1,413	1,617	238	249	258
Coefficient of Variation	0.171	0.143	0.157	0.107	0.101	0.103
Total Use						
Mean (Mil. Bu., Bales for Cotton)	8,096	9,597	10,273	2,220	2,482	2,574
Standard Deviation	425	626	705	134	241	247
Coefficient of Variation	0.053	0.065	0.069	0.060	0.097	0.096
Ending Stocks						
Mean (Mil. Bu., Bales for Cotton)	1,897	1,329	1,296	735	779	679
Standard Deviation	877	722	778	276	223	264
Coefficient of Variation	0.462	0.543	0.600	0.375	0.286	0.389
Stocks-to-Total Use Ratio						
Mean (Ratio)	0.24	0.14	0.12	0.36	0.32	0.27
Standard Deviation	0.11	0.07	0.07	0.13	0.12	0.13
Coefficient of Variation	0.468	0.521	0.576	0.353	0.375	0.490
Season Average Price						
Mean (\$/Bu, /# for Cotton)	2.34	2.48	2.65	3.35	3.05	3.71
Standard Deviation	0.31	0.65	0.70	0.49	0.65	0.95
Coefficient of Variation	0.133	0.261	0.266	0.146	0.214	0.258
Net Returns (Value of Production – Variable Expenses)						
Mean (Mil. \$)	7,825	9,459	11,310	3,533	2,575	4,131
Standard Deviation	1,461	3,284	3,846	648	1,441	2,111
Coefficient of Variation	0.187	0.347	0.340	0.183	0.560	0.511

¹ For the historical period, the mean is the historical mean; the standard deviation is the deviation of residuals from detrended historical data; and the coefficient of variation is calculated using that deviation from trend and the historical mean.

Table 1. Summary Statistics of Historical Average (1986-96), 1998, and 2002 Results for Crop Variables, Continued

Item	Soybeans			Cotton ²		
	1986-96 ¹	1998	2002	1986-96 ¹	1998	2002
Planted Acreage						
Mean (Mil. Ac.)	60.3	67.7	66.3	12.7	13.9	13.7
Standard Deviation	1.4	5.9	6.5	1.0	1.2	1.2
Coefficient of Variation	0.023	0.087	0.097	0.080	0.087	0.086
Production						
Mean (Mil. Bu., Bales for Cotton)	2,037	2,541	2,621	15	18	19
Standard Deviation	188	329	359	1.7	2	2
Coefficient of Variation	0.092	0.130	0.137	0.107	0.129	0.130
Total Use						
Mean (Mil. Bu., Bales for Cotton)	2,077	2,528	2,674	16	18	19
Standard Deviation	171	244	244	1.1	1	1
Coefficient of Variation	0.082	0.097	0.091	0.068	0.078	0.071
Ending Stocks						
Mean (Mil. Bu., Bales for Cotton)	265	305	283	4	5	5
Standard Deviation	72	177	164	1.2	2	2
Coefficient of Variation	0.270	0.579	0.580	0.316	0.314	0.339
Stocks-to-Total Use Ratio						
Mean (Ratio)	0.13	0.12	0.10	0.26	0.27	0.25
Standard Deviation	0.03	0.06	0.05	0.10	0.09	0.09
Coefficient of Variation	0.231	0.528	0.528	0.375	0.346	0.379
Season Average Price						
Mean (\$/Bu, /# for Cotton)	6.06	6.30	6.48	0.64	0.67	0.69
Standard Deviation	0.75	1.22	1.11	0.06	0.07	0.08
Coefficient of Variation	0.124	0.193	0.172	0.101	0.108	0.119
Net Returns (Value of Production – Variable Expenses)						
Mean (Mil. \$)	7,412	9,229	10,009	1,317	1,395	1,501
Standard Deviation	1,130	1,713	1,681	551	417	398
Coefficient of Variation	0.152	0.186	0.168	0.418	0.233	0.260

¹ For the historical period, the mean is the historical mean; the standard deviation is the deviation of residuals from detrended historical data; and the coefficient of variation is calculated using that deviation from trend and the historical mean.

² For prices and returns, 1986 was removed from the historical period to avoid an extreme price impact resulting from the first year of the cotton marketing loan program in 1986.

Table 2. Probability of Experiencing Crop Ending Stock Levels, 1998-2006

Crop/Range	1998	1999	2000	2001	2002	2003	2004	2005	2006
Corn (Mil. Bu.)									
Less than 1,000	0.34	0.30	0.36	0.41	0.41	0.38	0.38	0.41	0.41
1,000 to 2,000	0.46	0.49	0.43	0.47	0.39	0.50	0.44	0.44	0.40
More than 2,000	0.20	0.21	0.21	0.12	0.20	0.12	0.18	0.15	0.19
Wheat (Mil. Bu.)									
Less than 600	0.21	0.39	0.42	0.45	0.47	0.44	0.46	0.46	0.51
600 to 1,000	0.66	0.51	0.48	0.48	0.39	0.47	0.46	0.47	0.42
More than 1,000	0.13	0.10	0.10	0.07	0.14	0.09	0.08	0.07	0.07
Soybeans (Mil. Bu.)									
Less than 200	0.34	0.34	0.32	0.28	0.42	0.32	0.27	0.29	0.38
200 to 500	0.49	0.39	0.53	0.54	0.45	0.55	0.56	0.53	0.49
More than 500	0.17	0.27	0.15	0.18	0.13	0.13	0.17	0.18	0.13
Cotton (Mil. Bales)									
Less than 3	0.06	0.09	0.11	0.09	0.11	0.21	0.16	0.13	0.21
3 to 6	0.73	0.71	0.72	0.77	0.73	0.64	0.71	0.77	0.65
More than 6	0.21	0.20	0.17	0.14	0.16	0.15	0.13	0.10	0.14

Table 3. Summary Statistics and Probability Distributions of Season Average Prices for Corn, Wheat, Soybeans, and Cotton, 1998-2005

Variable	1998	1999	2000	2001	2002	2003	2004	2005	2006
Corn Season Ave Price (\$/Bu)									
Mean	\$2.48	\$2.42	\$2.48	\$2.59	\$2.65	\$2.71	\$2.65	\$2.92	\$2.86
Standard Deviation	0.65	0.57	0.66	0.58	0.70	0.66	0.66	0.80	0.82
Coefficient of Variation	0.261	0.236	0.265	0.222	0.266	0.243	0.249	0.273	0.287
Minimum Observation	\$1.35	\$1.29	\$1.46	\$1.38	\$1.46	\$1.49	\$1.51	\$1.67	\$1.61
Maximum Observation	\$3.99	\$4.26	\$4.76	\$4.07	\$4.47	\$4.42	\$4.50	\$5.08	\$5.52
<i>Probability:</i>									
10 Percent < or = to:	\$1.79	\$1.76	\$1.68	\$1.92	\$1.86	\$1.94	\$1.85	\$2.01	\$2.00
25 Percent < or = to:	\$1.96	\$1.99	\$1.97	\$2.14	\$2.08	\$2.25	\$2.13	\$2.38	\$2.19
33 Percent < or = to:	\$2.05	\$2.14	\$2.10	\$2.18	\$2.13	\$2.34	\$2.21	\$2.52	\$2.27
50 Percent < or = to:	\$2.30	\$2.29	\$2.32	\$2.45	\$2.52	\$2.59	\$2.55	\$2.72	\$2.67
66 Percent < or = to:	\$2.59	\$2.54	\$2.70	\$2.84	\$2.89	\$2.85	\$2.90	\$3.01	\$3.02
75 Percent < or = to:	\$2.95	\$2.76	\$2.93	\$2.98	\$3.18	\$3.18	\$3.06	\$3.30	\$3.37
90 Percent < or = to:	\$3.38	\$3.11	\$3.30	\$3.30	\$3.47	\$3.64	\$3.49	\$4.13	\$4.06
Wheat Season Ave Price (\$/Bu)									
Mean	\$3.05	\$3.41	\$3.52	\$3.60	\$3.71	\$3.57	\$3.72	\$3.65	\$3.67
Standard Deviation	0.65	0.76	0.81	0.76	0.95	0.83	0.88	0.82	0.84
Coefficient of Variation	21.37	22.36	22.97	21.14	25.75	23.36	23.52	22.54	22.90
Minimum Observation	\$1.52	\$1.91	\$1.61	\$2.04	\$1.62	\$1.61	\$1.56	\$1.96	\$2.03
Maximum Observation	\$5.15	\$5.19	\$5.83	\$5.72	\$6.06	\$5.79	\$6.12	\$5.95	\$5.91
<i>Probability:</i>									
10 Percent < or = to:	\$2.27	\$2.39	\$2.51	\$2.63	\$2.49	\$2.58	\$2.52	\$2.61	\$2.55
25 Percent < or = to:	\$2.68	\$2.92	\$2.95	\$3.04	\$3.01	\$3.04	\$3.19	\$3.13	\$2.99
33 Percent < or = to:	\$2.76	\$3.03	\$3.12	\$3.18	\$3.32	\$3.15	\$3.35	\$3.33	\$3.28
50 Percent < or = to:	\$2.90	\$3.33	\$3.47	\$3.57	\$3.67	\$3.54	\$3.60	\$3.60	\$3.71
66 Percent < or = to:	\$3.22	\$3.65	\$3.74	\$3.89	\$4.01	\$3.82	\$4.02	\$3.85	\$4.02
75 Percent < or = to:	\$3.36	\$3.89	\$4.07	\$4.07	\$4.29	\$4.02	\$4.20	\$4.02	\$4.14
90 Percent < or = to:	\$3.79	\$4.42	\$4.41	\$4.43	\$4.93	\$4.62	\$4.77	\$4.63	\$4.40

Table 3. Summary Statistics and Probability Distributions of Season Average Prices for Corn, Wheat, Soybeans, and Cotton, 1998-2005, Continued

Variable	1998	1999	2000	2001	2002	2003	2004	2005	2006
Soybean Season Ave Price (\$/Bu)									
Mean	\$6.30	\$6.04	\$6.18	\$6.20	\$6.48	\$6.47	\$6.45	\$6.61	\$6.92
Standard Deviation	1.22	1.21	1.11	1.15	1.11	1.06	1.19	1.10	1.23
Coefficient of Variation	19.32	19.99	17.93	18.52	17.20	16.34	18.41	16.63	17.78
Minimum Observation	\$4.18	\$4.27	\$3.88	\$4.21	\$4.24	\$4.31	\$4.49	\$4.26	\$4.77
Maximum Observation	\$9.98	\$9.25	\$9.82	\$9.41	\$9.87	\$9.42	\$10.52	\$10.74	\$10.43
<i>Probability:</i>									
10 Percent < or = to:	\$4.86	\$4.76	\$4.91	\$4.90	\$5.11	\$5.21	\$5.19	\$5.33	\$5.40
25 Percent < or = to:	\$5.37	\$5.03	\$5.39	\$5.34	\$5.77	\$5.64	\$5.59	\$5.75	\$6.03
33 Percent < or = to:	\$5.65	\$5.29	\$5.58	\$5.56	\$5.89	\$5.85	\$5.84	\$5.97	\$6.25
50 Percent < or = to:	\$6.16	\$5.63	\$6.02	\$6.03	\$6.38	\$6.35	\$6.11	\$6.54	\$6.73
66 Percent < or = to:	\$6.63	\$6.50	\$6.44	\$6.51	\$6.82	\$6.87	\$6.64	\$6.91	\$7.29
75 Percent < or = to:	\$6.95	\$6.75	\$6.84	\$6.86	\$7.03	\$7.22	\$6.94	\$7.28	\$7.54
90 Percent < or = to:	\$7.82	\$7.80	\$7.38	\$7.66	\$7.92	\$7.78	\$7.88	\$7.73	\$8.44
Cotton Season Ave Price (\$/Lb)									
Mean	\$0.67	\$0.67	\$0.68	\$0.70	\$0.69	\$0.71	\$0.70	\$0.70	\$0.71
Standard Deviation	0.07	0.08	0.08	0.08	0.08	0.09	0.07	0.08	0.09
Coefficient of Variation	0.108	0.121	0.117	0.108	0.119	0.129	0.106	0.118	0.133
Minimum Observation	\$0.47	\$0.50	\$0.53	\$0.48	\$0.51	\$0.56	\$0.54	\$0.53	\$0.51
Maximum Observation	\$0.83	\$0.89	\$0.94	\$0.91	\$0.97	\$0.99	\$0.88	\$1.04	\$1.02
<i>Probability:</i>									
10 Percent < or = to:	\$0.58	\$0.58	\$0.57	\$0.60	\$0.58	\$0.60	\$0.60	\$0.61	\$0.60
25 Percent < or = to:	\$0.62	\$0.61	\$0.62	\$0.65	\$0.64	\$0.63	\$0.64	\$0.65	\$0.65
33 Percent < or = to:	\$0.64	\$0.63	\$0.64	\$0.67	\$0.66	\$0.66	\$0.66	\$0.67	\$0.66
50 Percent < or = to:	\$0.67	\$0.66	\$0.66	\$0.70	\$0.70	\$0.70	\$0.71	\$0.70	\$0.69
66 Percent < or = to:	\$0.70	\$0.70	\$0.70	\$0.73	\$0.72	\$0.75	\$0.74	\$0.74	\$0.75
75 Percent < or = to:	\$0.72	\$0.72	\$0.72	\$0.74	\$0.74	\$0.76	\$0.76	\$0.75	\$0.76
90 Percent < or = to:	\$0.76	\$0.78	\$0.78	\$0.78	\$0.78	\$0.82	\$0.79	\$0.79	\$0.83

Table 4. Summary Statistics of the 1986-96 and Project Periods for Value of Production Plus Contract Payments Minus Variable Expenses for the Eight Major Crops

	'86-96 ¹	1998	1999	2000	2001	2002	2003	2004	2005	2006
Eight-Crop Value of Production + Payments - Variable Expenses										
Mean (Mil. \$)	21,240	24,745	24,993	25,725	27,874	29,211	30,337	30,812	33,096	33,983
Stand. Deviation	2,846	4,866	4,860	5,741	5,074	6,057	5,590	6,170	6,330	6,587
Coeff. of Vartn.	0.134	0.197	0.195	0.223	0.182	0.207	0.184	0.200	0.191	0.194

¹ For the historical period, the mean is the historical mean; the standard deviation is the deviation of residuals from detrended historical data; and the coefficient of variation is calculated using that deviation from trend and the historical mean

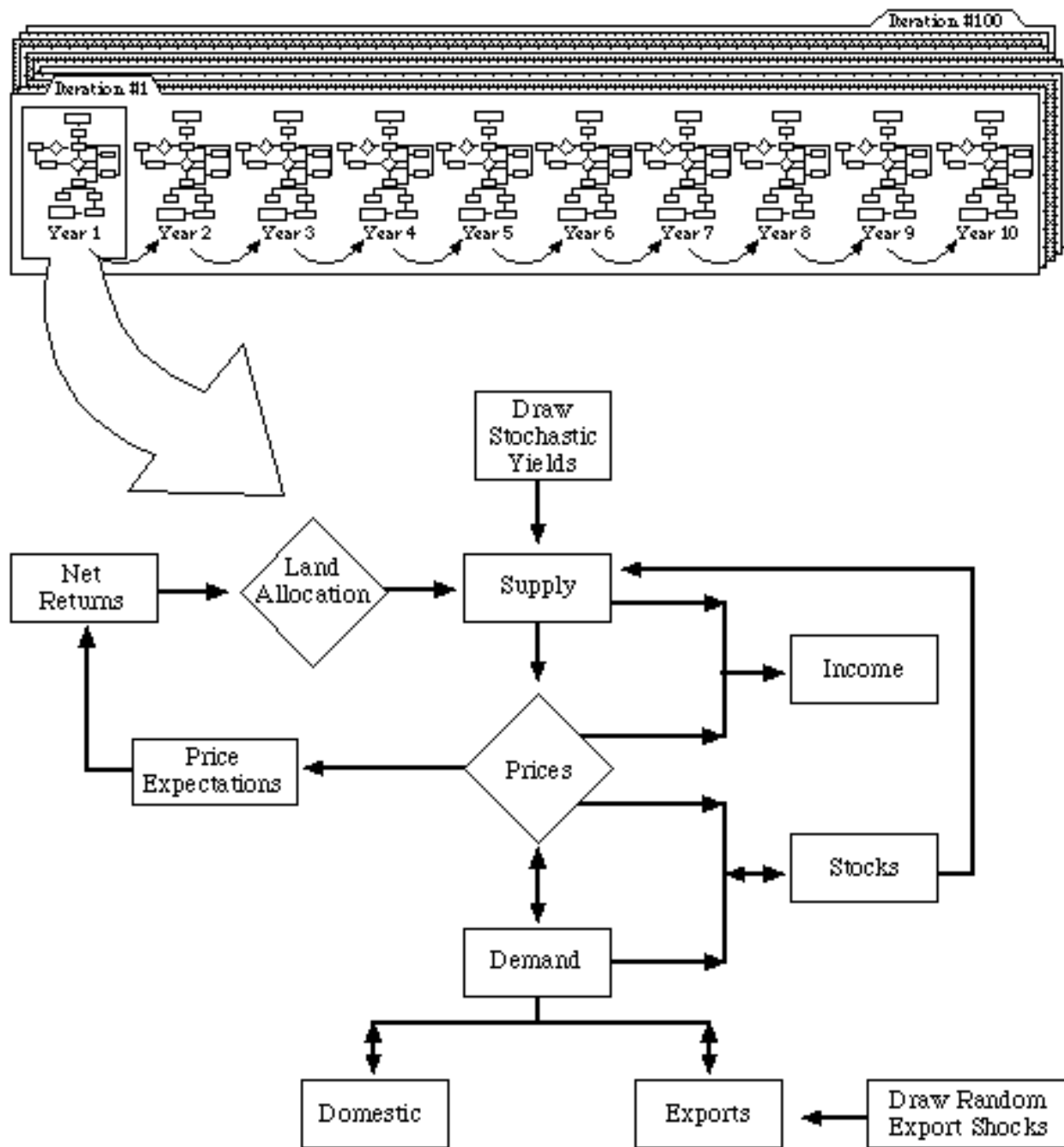


Figure 1. Schematic diagram of stochastic POLYSYS methodology.

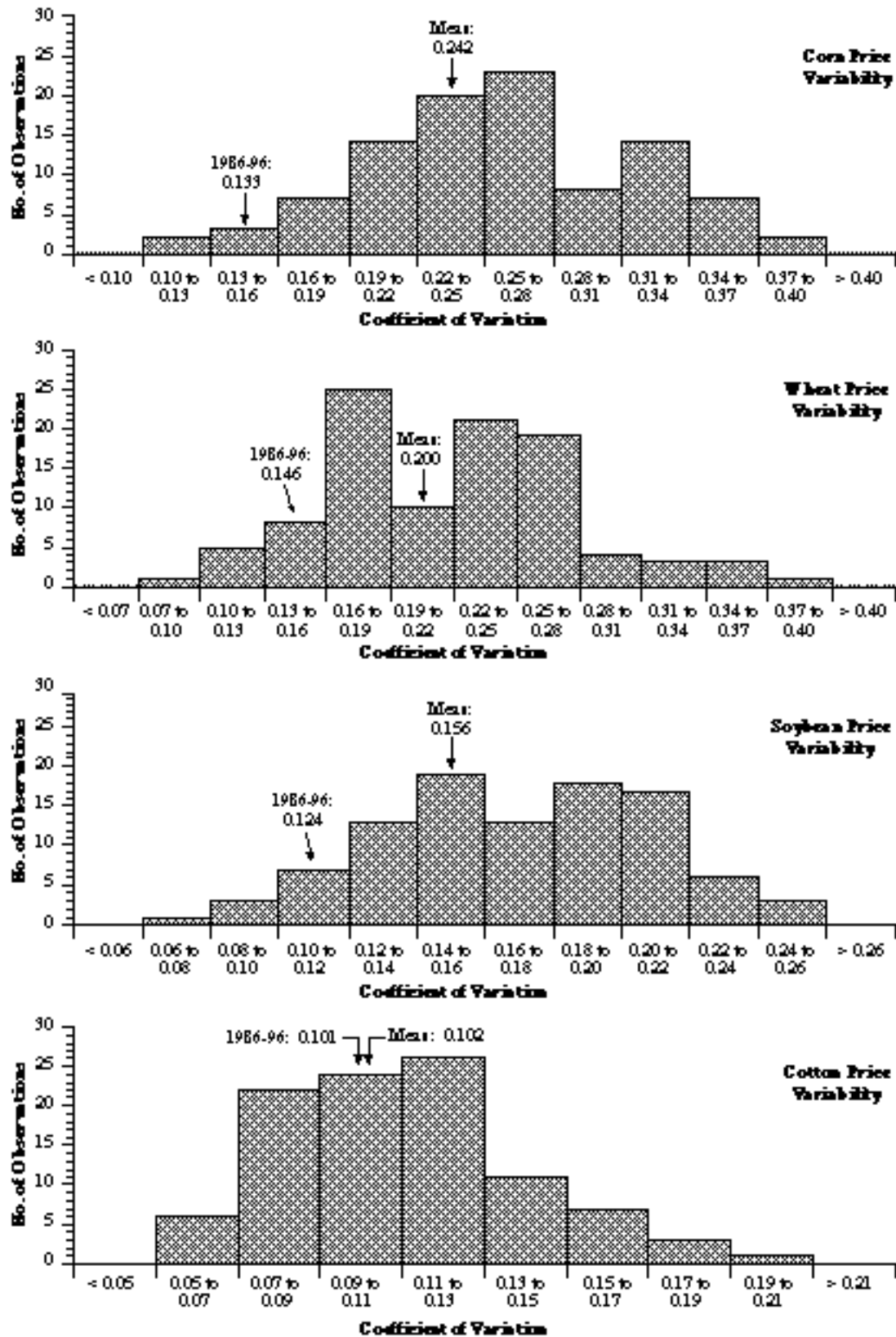


Figure 2. Histograms of simulation period price coefficients of variation.

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