The Soybean Sector in the 1970's: An Analysis of Price Variability

by

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Abstract

Price variability in the 1970's is analyzed for the soybean sector using structural and time series models. The impact of changes in predetermined variables on the price level is analyzed with the structural model. Supply factors, trade factors and domestic demand factors are evaluated over the period 1971 to 1977.

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It is well known that the period of the 1970's has been one of higher and more volatile commodity prices when compared to the previous 2 decades. There is wide if not unanimous agreement among analysts that the increased level and uncertainty of export markets is a major factor in this new market situation. This export growth has been associated with world income growth, exchange rate changes, trade policies and a declining rate of growth in agricultural productivity (Cochrane, Johnson, Robinson, Schuh).

The purpose of our study is to go into a more detailed analysis of the sources of price variability in the 1970's. We focus on the soybean sector which has been one of the most volatile markets, and we look at domestic as well as foreign factors affecting prices. A better understanding of these factors and their relative importance is important in looking at future market prospects and in evaluating the need for price stabilization. A farmer-owned reserve program similar to that currently operating in wheat and feed grain markets could be extended to soybeans in future legislation.

The dramatic change in both the level and variance of soybean prices between the periods 1960-70 and 1971-78 is shown in Figure 1. The average level is nearly double in the later period and the variance is much greater. Table 1 provides more evidence of this for soybean and soybean meal and oil prices. The mean level more than doubled in all cases. The standard deviations increased even more than the means. The coefficient of variation (CV) nearly tripled for soybean and meal prices. Oil prices which had a relatively greater variability than the others in the 1960's, continued to have a higher CV in the 1970's and it more than doubled over the 1960's level.

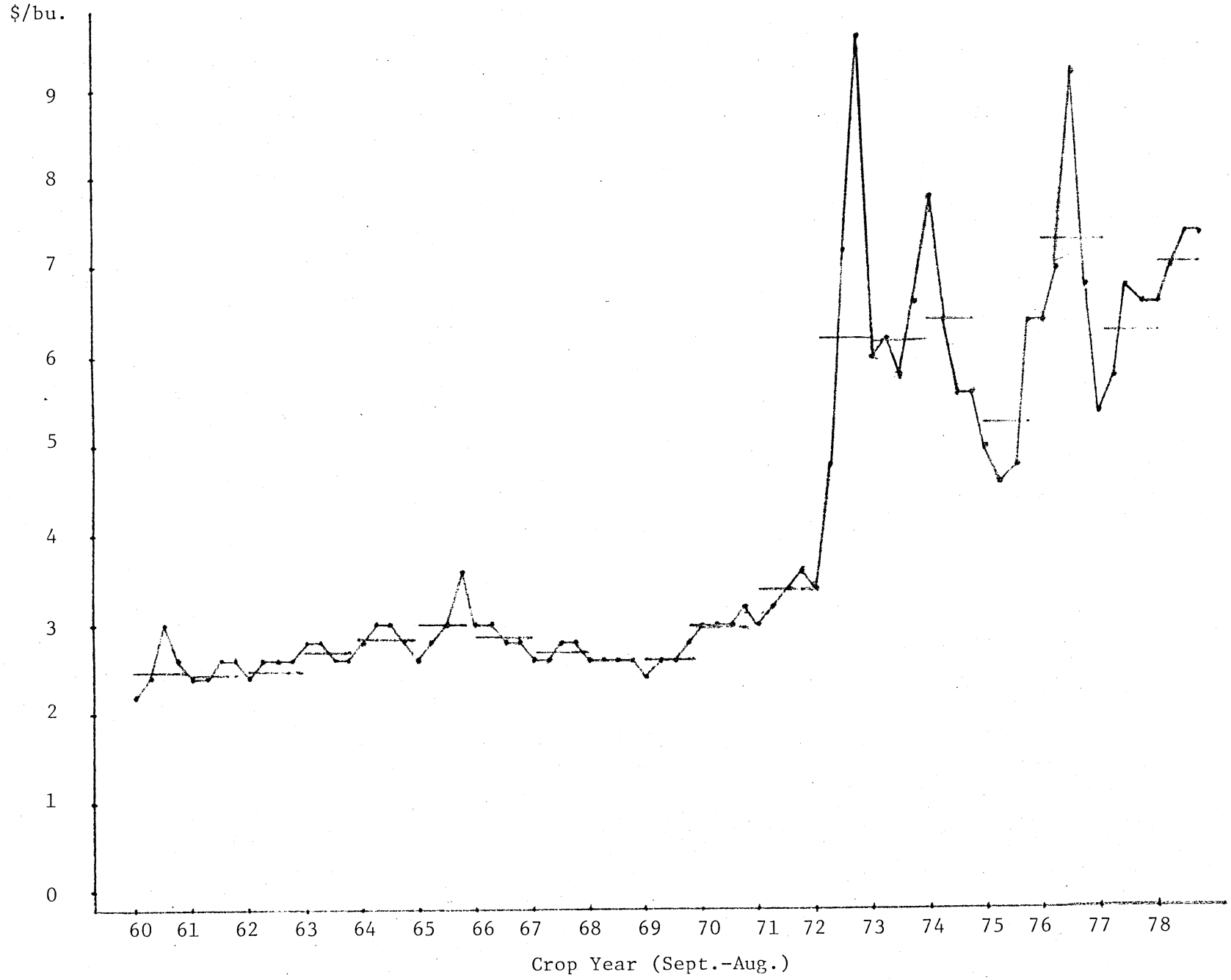

Figure 1. Soybean: Average price, #1 yellow, Chicago (quarterly and annual average)

Table 1. Comparison of changes in the means, standard deviations and coefficients of variation of soybean, meal and oil prices from 1960-70 to 1971-78.

	Mean		Standard deviation		Coefficient of variation	
	60-70	71-78	60-70	71-78	60-70	71-78
Soybean price ($/bu)	2.74	5.97	0.25	1.59	9.2	26.6
Meal price ($/ton)	78.18	161.75	7.89	49.14	10.8	30.4
Oil price (¢/lb)	10.21	22.98	1.65	8.05	16.1	35.0

We analyze the annual soybean price variability of the 1970's by means of a structural model of the soybean sector. We then explore the use of time series analysis to study monthly price variability for both periods.

Methodology

An econometric model is an appropriate tool for analyzing the effect of changes in predetermined factors on endogenous variables in a simultaneous framework. We employ such a structural model of the soybean industry to measure the impact of changes in individual predetermined variables on the price of soybeans. This is a static year-to-year analysis in which acreage harvested and yield are among the predetermined variables.

The model is of the form

$$(1) \qquad By_t + \Gamma x_t = u_t$$

where B is a matrix of structural coefficients on the vector of endogenous variables y_t, Γ is a matrix of structural coefficients on the vector of predetermined variables x_t, and u_t is a vector of residuals. The model has 9 estimated equations, 3 identities and 4 technical relationships which link the soybean, meal and oil components and impose supply and demand equilibrium on the system.[1/]

The reduced form of this model is

$$(2) \qquad y_t = \Pi x_t + v_t$$

where Π is a matrix of "derived" reduced-form coefficients on the endogenous variables and v_t is a vector of reduced form residuals. The endogenous

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1/ A more detailed description of the model is presented by Meyers and Hacklander.

variables of interest in this study are the prices of soybeans, soybean meal and soybean oil. For the sake of brevity we will focus on the price of soybeans, the basic commodity, though the procedure would also be applicable to the other prices.

Let y_{1t} be the soybean price with the reduced form equation

$$y_{1t} = \sum_{i=1}^{n} \pi_{1i} x_{it} + v_{1t} \tag{3}$$

The analytical approach is represented by the equation

$$\Delta y_{1t} = \sum_{i=1}^{n} \pi_{1i} \Delta x_{it} + \Delta v_{1t} \tag{4}$$

We computed the contribution of each predetermined variable (x_i) to the total change in soybean price from year t-1 to year t. The unexplained portion of the change is represented by Δv_{1t}.

An illustration of the model and the impact analysis is presented in Figure 2. All quantities are expressed in soybean equivalents to simplify the diagram. The equilibrium in t-1 is represented by solid lines. A decline in Brazil's soymeal exports in year t, ceteris paribus, increases foreign demand for U.S. meal and beans and the domestic crush. The prices of meal and beans increase and the price of oil declines.

Analysis of Annual Price Variation

The performance of the model in estimating prices over the crop years 1971/72 to 1977/78 with soybean production predetermined is shown in Figure 3. This indicates that our procedure should provide a good accounting of the sources of change in soybean prices. Meal and oil price estimates do less

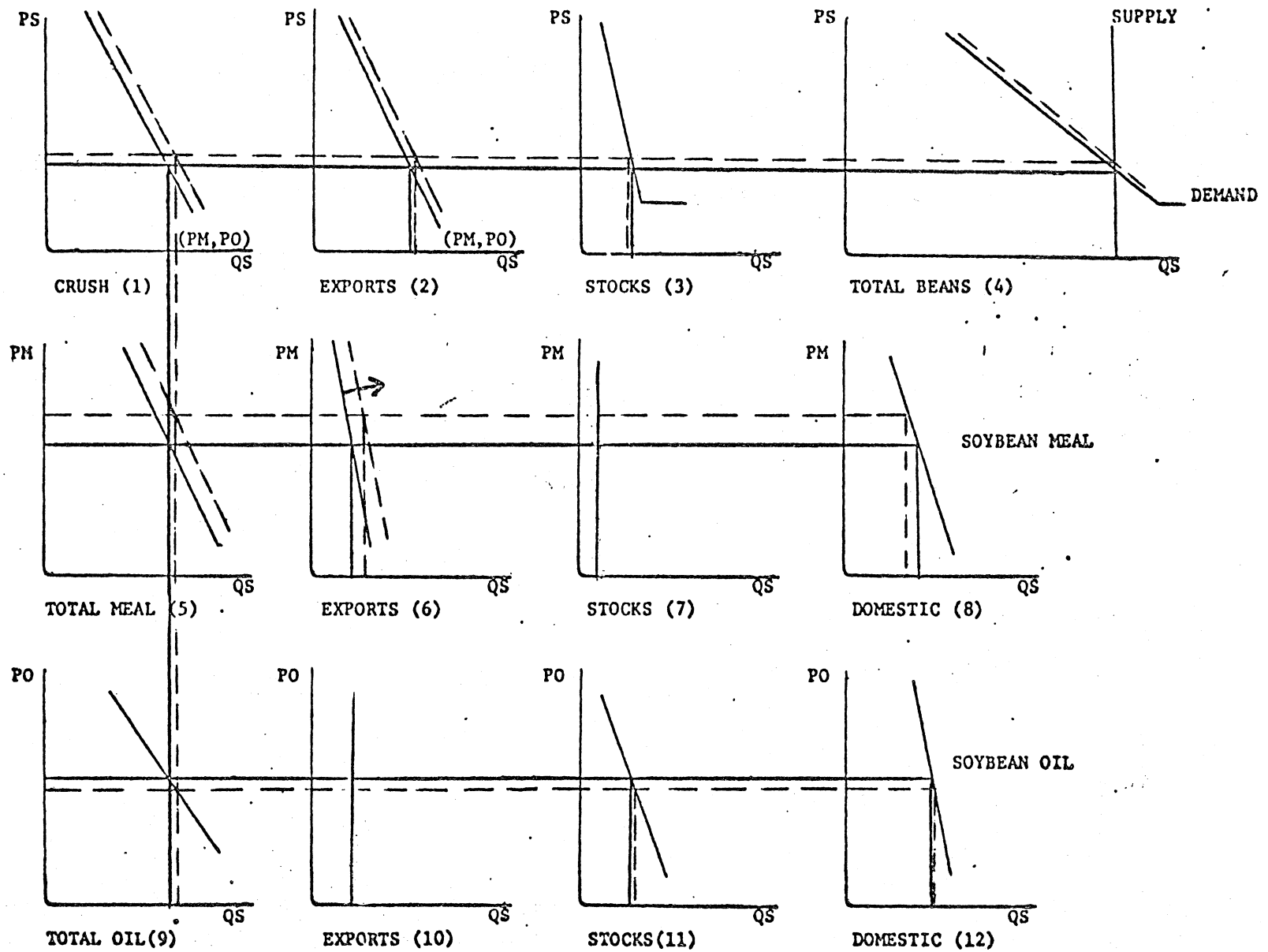

Figure 2. Impact of decline in Brazil's soymeal exports on U.S. soybean industry.

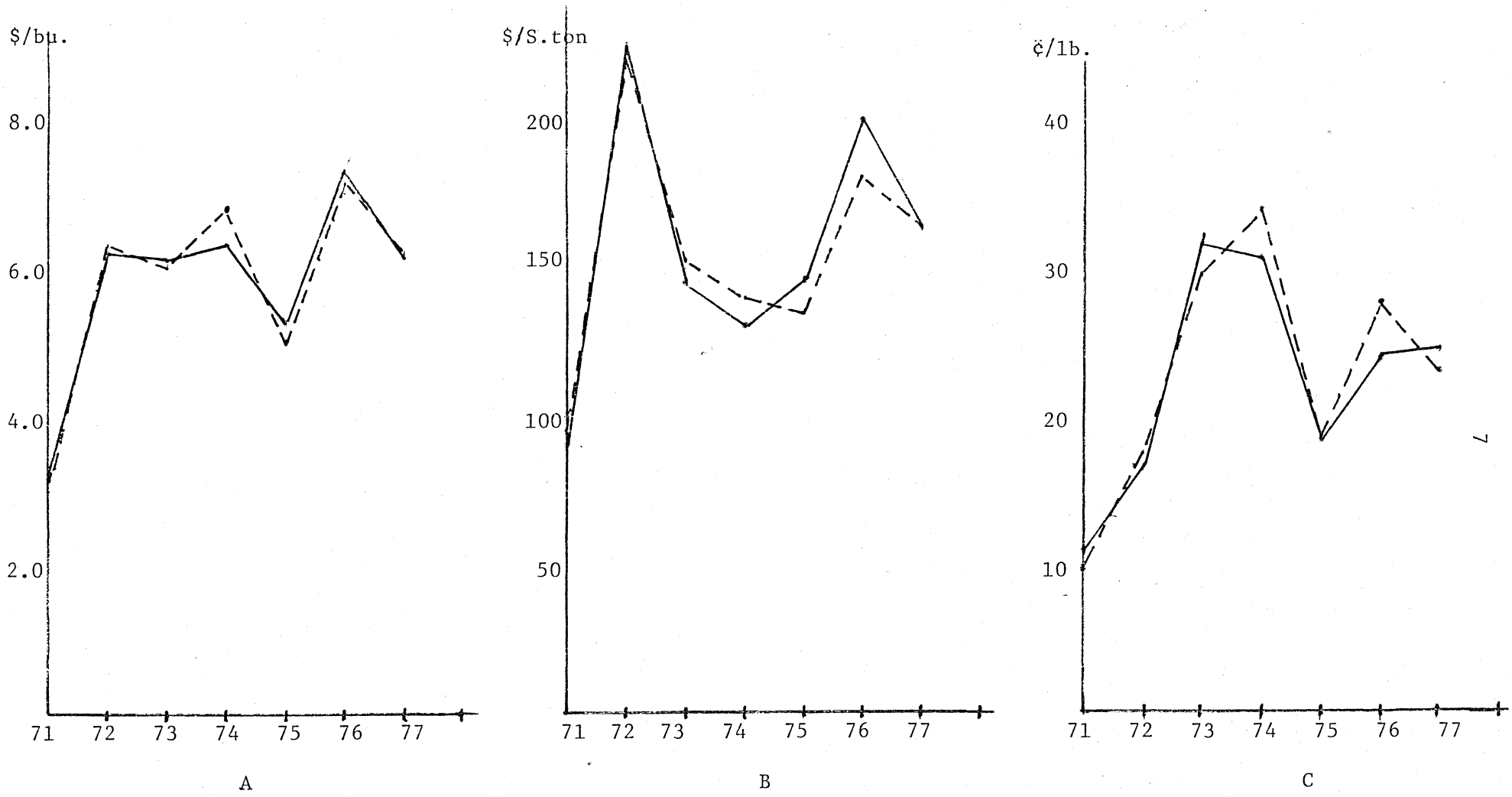

Figure 3. Actual (-) and estimated (--) prices of soybeans (A), soybean meal (B) and soybean oil (C) from 1971-77 with soybean production predetermined.

well on average and there's one turning point error for meal (1975) and two for oil (1974, 1977). Since, we do not report on the effects of all predetermined variables, the unexplained portion of the year-to-year price change in Table 2 is sometimes larger than that in Figure 3A.

The presentation of our results in Table 2 is divided into 4 parts: supply factors, trade factors, domestic (oil and meal) demand factors and corn price. The supply factors reported are acreage, yield and beginning stocks of soybeans and beginning stocks of oil. Meal stocks are small and not very variable, because of perishability. Supply factors as a whole are more destabilizing than any other group of factors, with impacts varying from \$1.56/bushel in 1974 to -\$2.28/bushel in 1975. This is a classic illustration of the cobweb effect with both acreage and yield contributing substantially in most years. Over the 6 year period supply factors had a net impact of -\$3.49/bushel on average soybean prices. The impact of beginning soybean stocks is, with one minor exception, countercyclical to production effects. This is to be expected since low prices in year t-1 are associated with high beginning stocks and low production in t. Beginning oil stocks have the same countercyclical behavior but the impacts are generally small.

The trade factors reported include exchange rates, USSR imports, Brazil exports, fish meal, oil trade and EEC demand and policy factors. The model confirms the general belief that trade factors have had a large impact on price levels and price variability. In 1972 trade was the dominant factor in the sudden price surge. The impact was negative in the following 2 years but strongly positive from 1975 to 1977. The net impact over the 6 year period was \$3.68. The particulars of the trade results are worthy of more attention. The dollar value of SDR's, a measure of exchange rate effects,

Table 2. The effect of major supply and demand factors on year-to-year changes in average wholesale price of soybeans, 1971 to 1977.[a/]

	1972	1973	1974	1975	1976	1977	Total
				$/bu.			
Supply Factors							
Soybeans							
Acreage	-0.50	-1.68	0.71	-0.36	0.80	-1.53	-2.56
Yield	-0.01	0.0	1.51	-1.87	0.93	-1.46	-0.90
Beg. Stocks	0.14	0.07	-0.62	-0.10	-0.31	0.78	-0.04
Soybean Oil							
Beg. Stocks	-0.01	0.05	-0.04	0.05	-0.11	0.07	0.01
Sub Total	-0.38	-1.56	1.56	-2.28	1.31	-2.14	-3.49
Trade Factors							
SDR	0.33	0.15	0.06	-0.24	0.0	0.25	0.55
USSR	0.21	-0.03	-0.08	0.30	0.05	-0.16	0.29
Brazil	-0.20	-0.31	-0.31	-0.24	0.17	0.59	-0.30
Fish meal	0.61	-0.28	-0.21	0.21	0.13	0.01	0.47
Oil Trade	-0.06	0.23	-0.35	-0.17	0.35	0.32	0.32
Soy oil Exports	-0.06	0.20	-0.17	-0.05	0.20	0.22	0.34
Palm oil Imports	0.0	0.03	-0.18	-0.12	0.14	0.10	-0.03
EEC	0.33	0.22	0.24	0.61	0.47	0.48	2.35
Livestock	0.25	0.19	0.03	0.34	0.27	0.35	1.43
EEC Corn Price	0.08	0.03	0.21	0.27	0.20	0.13	0.92
Sub Total	1.22	-0.02	-0.65	0.47	1.17	1.49	3.68
Domestic Demand Factors							
Oil Market	0.26	0.44	0.04	0.79	0.02	-0.08	1.47
Substitute, F & O	0.14	0.25	-0.01	0.65	-0.15	-0.20	0.68
Real Income	0.12	0.19	0.05	0.14	0.17	0.12	0.79
Meal Market	0.33	-0.25	-0.19	0.29	0.14	0.40	0.72
Livestock Price	0.51	-0.16	0.20	-0.10	-0.02	0.30	0.73
Animal Units	-0.18	-0.09	-0.39	0.39	0.16	0.10	-0.01
Sub Total	0.59	0.19	-0.15	1.08	0.16	0.32	2.19
Corn Price	0.48	0.97	0.43	-0.46	-0.37	-0.13	0.92
All Factors Above	1.91	-0.42	1.19	-1.19	2.27	-0.46	3.30
Actual Price Change	2.97	-0.09	0.20	-1.06	2.07	-1.19	2.90

[a/] 1972 refers to change from 1971/72 crop year to 1972/73 crop year.

had an important positive impact on price in 1972 and 1977, a negative impact in 1975 and a net impact of $0.55 for the period. This is important, but it is not the dominant factor by any means.

Substantially more important was the steady growth in EEC demand brought about by increased livestock production and, after 1973, increases in the threshold price of corn. Because soybean and meal imports are not subject to tariffs, the higher EEC corn prices benefited the soybean market. The EEC demand factors account for over 60 percent of the net trade impact for the period. Soybean imports by the USSR did not have a large net impact but the year to year fluctuations had a destabilizing effect. Brazil's growing production and exports of soybeans and meal had a 20 to 30 cent negative impact every year until the poor crops of 1977 and 1978. The effect of these crop failures in the Southern hemisphere was to raise U.S. soybean prices in crop years 1976 and 1977. The fish meal crisis of 1972 had a major impact that year but its net impact since then has been small. Soybean oil exports and domestic consumption of palm oil are exogenous in the model and their effects are reinforcing. Increasing palm oil imports in 1974 and 1975 coincided with declining soybean oil exports. The next two years the pattern reversed and strengthened soybean prices substantially. The net effect of palm oil imports for the period was negligible, while soybean oil exports had a net positive impact of $0.34.

The domestic demand factors have been an important source of growth in soybean price levels over this period, but the net impact of $2.19 is less than for trade factors. These market factors have not been a stable source of growth with price effects ranging from -$.15 in 1974 to $1.08 in 1975.

Both oil and meal factors contributed to the 1972 great leap upward in soybean price; but over the 6 year period, soybean oil demand factors had twice the impact of the livestock variables.

The price of corn receives special treatment because it affects both domestic (meal) and export (bean and meal) markets and is itself greatly influenced by the interaction of corn and soybean markets. Nevertheless it is exogenous in this model and its impact is important. It has a large positive impact on soybean prices from 1972-74 and a negative but declining impact from 1975-77. This reflects the rapid rise in corn prices the first three years and the rapid subsequent decline. The net effect is strongly positive ($0.92) for the period.

The factors included in the analysis explain a large part of the actual change in price most years. The discrepancy of approximately $1.00 in 1972 is largely explained by a structural shift in the inventory demand for soybeans. The discrepancy in 1974 may be largely explained by the effect of the price freeze on the livestock industry which reduced meal demand.

With regard to factors included in Table 2 there is little reason to believe that the next decade will differ greatly from the 1973 to 1977 period. The confluence of events that occurred in 1972 is less likely to be repeated, because it was the reinforcing effects of many factors rather than any single factor which explain the outcome. The moderating effects of the grain reserve program on the price of corn is likely to have a stabilizing effect on the soybean market and may also serve to dampen the cobweb fluctuations in production.

Implications for Further Research

The analysis of variation in annual prices can be extended by performing a dynamic analysis in which the effect of a change in x_{it} is traced across all succeeding years. By this means the supply effects in Table 2 would be explained by previous changes in exogenous variables.

The change in average annual prices explains one aspect of the price variability but producers and buyers of soybeans are also affected by within year price variation (Figure 1). One approach to the analysis of short-run (quarterly or monthly) price variability is to use the information already available in the annual model in combination with a time series model.

Box-Jenkins methodology has been applied to soybean monthly cash price during 1960-1978. In the identification stage, searching for the working series, we have found that the natural log form is required due to the changing underlying structure of the commodity in the 1970's. The autocorrelation function of the natural log series, however, does not die down rapidly which indicates that the series is a non-stationary time series.

The working series we have used for the analysis is the first seasonal differencing of the natural log series, or it can be written as:

$$W_t = (1 - B)^0(1 - B^{12})Z_t \tag{5}$$

where

$B \equiv$ lagged operator

$Z_t \equiv \ln(Y_t)$

$Y_t \equiv$ monthly cash price of soybean at time t

The conclusion from the identification stage has confirmed that the underlying structure of the series has changed during the study period. Besides the year-to-year variation, we have found that the seasonal fluctuation within the year has greatly influenced the price of the commodity.

The final result from estimation, diagnostic checking and forecasting of Box-Jenkins methodology is:

$$(6) \qquad W_t = \underset{(20.0374)}{1.2928}\, W_{t-1} - \underset{(-5.4553)}{0.3519} W_{t-2} - \underset{(23.2473)}{0.9299} U_{t-12}$$

$$S = 0.2396 \qquad \bar{R}^2 = 0.9780$$

$$Q = 30.182$$

where

$W_t = \ln(Y_t) - \ln(Y_{t-12})$

U_t = error term

S = standard deviation

Q = Box-Pierce statistic

The figures in the parenthesis are t-statistics. The table value of χ^2 at 5% level of significant is 32.67 which is greater than the Q-statistic we obtained. It is the best model among those that we have tried. The result suggests that seasonal fluctuation is very significant in soybean price series.

Further research will be directed toward building a short-run (quarterly or monthly) model which explains the behavior of the soybean market within a crop year. Price variations will have an effect on the allocation of stocks of beans from period-to-period within a year and also will have an effect on the production decision which is initiated during the third quarter of the

crop year (March-May). Production, which is a once-a-year phenomenon, is realized in the first quarter of the crop year (Sept.-Nov.). Therefore, the linkage of the short-run model to the annual model will indicate how within-year price variation affects the annual production and price behavior in the soybean complex.

Price expectations in the soybean market are important factors. The rational expectations, adaptive expectations and cash-futures price expectations would be tested. The decision rules on inventory holding and production can be derived from a model of dynamic optimization under uncertainty.

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