GRAIN EXPORTS AS A SOURCE OF AGRICULTURAL INSTABILITY*

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Numerous recent articles have dealt with causes and implications of domestic agricultural market instability [2, 3, 4, 7]. In these articles large, unexpected and erratic grain exports since 1972 are hypothesized to be a primary contributor to recent agricultural market instability. More specifically, Seevers [4] and others have stated that recent severe instability in agriculture markets began in late 1972 with a combination of increased export demand and strong domestic economic expansion. These analyses have largely based their conclusions upon intuition rather than a thorough empirical investigation.

This paper reports results of an empirical analysis of the dynamic effects of increased grain exports in 1972 using a simulation model of the agricultural sector. The percentage of 1972 grain price increases caused by the increment in 1972 grain exports above the 1971 level is estimated. Estimates of length of time agricultural prices and production continued to adjust in response to the 1972 increase in grain exports are also made. These estimates provide an empirical basis for analyzing instability of the period and for testing the hypothesis that exports were a major source of agricultural sector instability during and after 1972.

THE ANALYTICAL MODEL

The econometric-simulation model used in this analysis was developed to assess effects of changing domestic and international market conditions on the grain, livestock and oilseed sectors of U.S. agriculture. The model consists of 249 equations estimated by ordinary least squares and two stage least squares. Data used in estimating the model cover the time period 1952 to 1971.

In the following sections a brief overview of the model's structure and forecasting ability will be given. In addition, a table of key elasticities embodied in the model's structure is presented in Appendix I.

Due to the model's size, it is impossible to fully describe and validate within this paper. A complete model description (listing of equations, elasticities, discussion of theoretical underpinnings, etc.) together with simulation runs to crop year 1976 are available in Trapp's dissertation entitled "An Econometric Simulation Model of the United States Agricultural Sector" [5]. An abbreviated description of the model will also be available in a forthcoming Michigan State University research bulletin [6].

Model Structure

The model is divided into three major model components: (1) a domestic supply component for food grains, feed grains, oilseeds, low grade beef, high grade beef, pork, poultry and dairy products; (2) a domestic demand component for each of the above commodities and; (3) an international trade component to account for U.S. exports of food grains and oilseeds, as well as imports of low grade beef.

Figure 1 depicts the structure of the model with blocks and circles representing supply, demand and price formation activities; arrows relating cause and effect flows; and comb-like configurations pointing

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into various activity blocks indicating entry points of exogenous variables. Major exogenous variables include foreign population, income and agricultural production growth and competing export prices. U.S. grain exports to communist countries are determined exogenously but exports to other countries can be determined endogenously. In this analysis, however, changes in total export levels are the specific variable under study. Therefore, changes in exports are exogenously controlled in simulations for this analysis. Prices of non-agriculturally produced inputs such as fertilizer, wages, capital, etc. are exogenous as also are a number of U.S. macroeconomic variables including population, income levels and inflation rates. Exogenous policy variables include diversion rates, loan rates and P.L. 480 export levels. Government stock operations are endogenous and are basically determined as a nonlinear function of the spread between market price and support price.

As depicted in Figure 1, analysis of the livestock market begins with an estimation of breeding stock production which leads to an estimate of domestic production of livestock products, which in turn interacts with demand to determine a price. Price is fed into the supply analysis for succeeding years to generate a recursive mechanism for estimating quantities of livestock supplied through time.

The upper portion of Figure 1 depicts the food grain market, which contains both foreign and domestic components. After domestic supply and

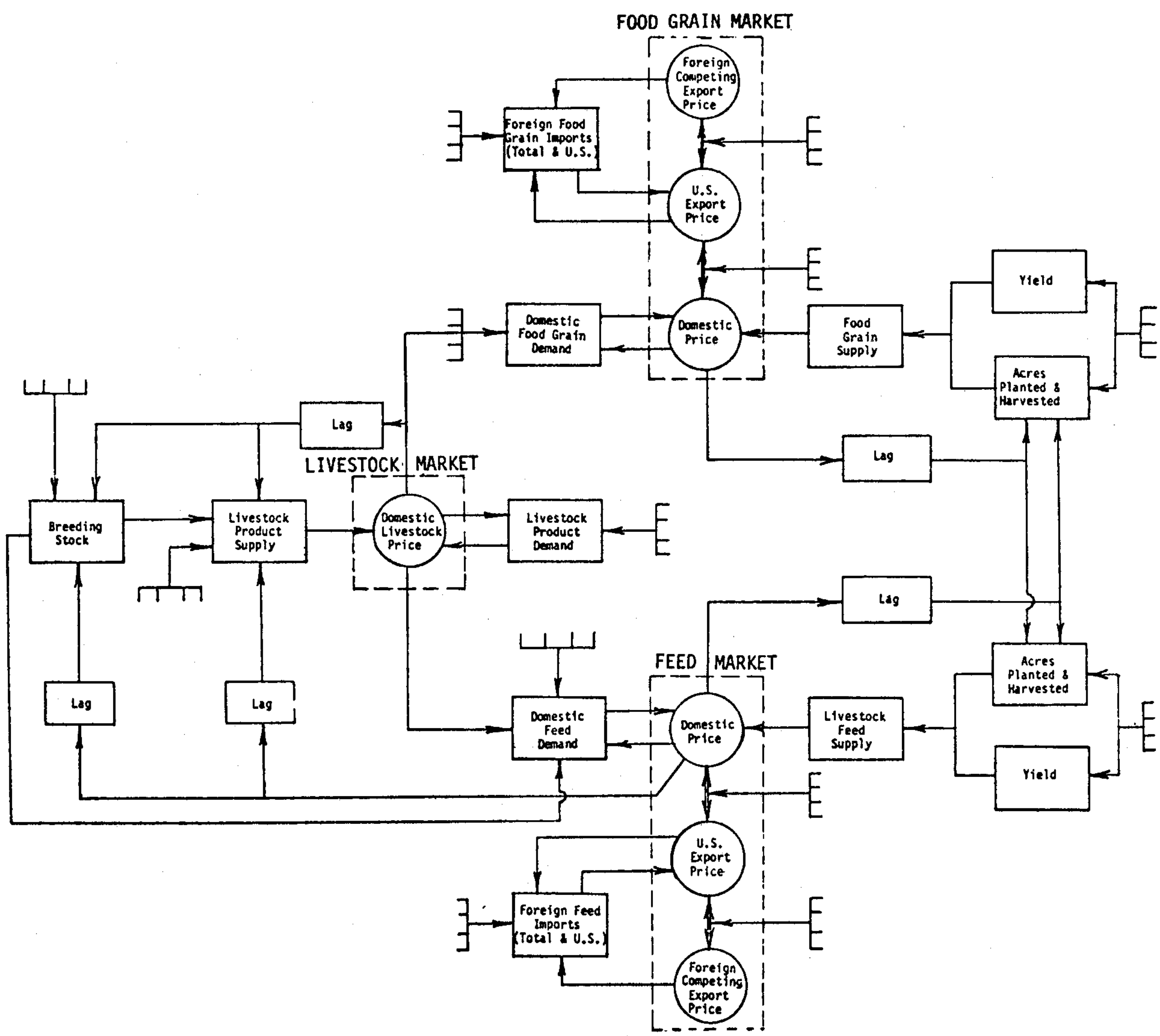


FIGURE 1. NATIONAL AGRICULTURE SECTOR STUDY (NASS): MAJOR SUBSECTOR LINKAGE STRUCTURE

demand conditions for food grains are established, they are linked to the foreign market for U.S. food grain. Foreign and domestic demand interact to simultaneously determine prices and allocation of grain between these markets. The same general format is indicated for feed grains in the lower section of the diagram, but in this case *vis a vis* food grains, domestic demand maintains a stronger link to the livestock market.

The analytical model is capable of generating estimates of the following endogenous price and quantity variables: fed beef, non-fed beef, pork, dairy, chicken, eggs, turkey, feed grains (corn, barley, oats and sorghum), food grains (wheat), oilseeds and cotton.[1] Finally the international component interacts with domestic supply and demand components to enable projection of U.S. exports of food grains, feed grains and oilseeds. Import projections of non-fed or low grade beef into the U.S. can also be obtained.

Model Performance

For the sample period (1952-1971) predicted values of endogenous variables were compared to their actual values. For this *ex post* evaluation, grain price and quantity variables had an average correlation coefficient (r) of .938. Livestock price and quantity variables had an average correlation coefficient of .902.

In Table 1, forecasts of selected endogenous variables are compared to actual values for the years 1970-1974. Forecasts for 1972-1974 are for years outside the sample period. All were made using actual values of exogenous variables, with the exception that all lagged endogenous variables used after 1972 are those predicted by the model. The average percent of absolute error of forecasting, in this manner, the fourteen crop and livestock price and quantity variables listed in Table 1 (excluding food and feedgrain stocks) over the years 1972, 1973 and

TABLE 1. FORECAST AND ACTUAL VALUES OF SELECTED ENDOGENOUS VARIABLES

	1970		1971		1972		1973		1974	
	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated
Crops										
Prices:[c]										
Wheat ($/bu.)	1.14	1.26	1.10	1.06	1.40	1.44	2.98	1.39	2.74	3.21
Corn ($/bu.)	1.14	1.25	.89	.85	1.25	1.11	1.92	1.07	2.00	1.29
Soybeans ($/bu.)	2.45	2.65	2.50	2.45	3.49	3.60	4.27	2.85	4.23	1.92
Quantity:										
Wheat (Bil. bu.)	1.351	1.371	1.618	1.619	1.545	1.680	1.705	1.792	1.793	1.457
Corn (Bil. bu.)	4.152	4.115[a]	5.641	5.699	5.573	5.437	5.647	5.759	4.651	4.922
Soybeans (Bil. bu.)	1.127	1.136	1.176	1.204	1.207	1.276	1.547	1.448	1.233	1.302
Livestock										
Prices:[c]										
Fed Beef ($/cwt.)	25.70	24.67	28.59	28.74	34.41	30.98	30.75	34.65	26.80	29.83
Pork ($/cwt.)	14.52	17.11	18.81	20.91	28.45	25.06	26.17	26.07	29.13	18.85
Milk ($/cwt.)	5.02	5.01	4.94	5.07	5.30	5.21	5.39	5.33	5.62	5.26
Chicken ($/cwt.)	11.69	10.26	11.29	11.48	11.25	12.06	18.18	17.87	14.57	8.00
Quantity:										
Fed Beef (Bil. lbs.)	30.479	30.895	30.454	30.614	29.336	30.614[b]	30.927	30.454	31.484	31.954
Pork (Bil. lbs.)	22.815	21.240	20.886	20.404	18.805	19.330	19.902	20.707	17.457	20.321
Milk (Bil. lbs.)	118.086	118.336	120.069	119.539	116.505	119.340	114.752	115.632	115.076	111.076
Chicken (Bil. lbs.)	8.463	8.284	8.503	8.504	8.889	8.718	8.750	8.341	8.919	9.447
Government Stocks										
Food Grain (Mil. tons)	17.088	16.693	21.432	23.417	6.345	9.062	4.323	5.076	.567	2.598
Feed Grains (Mil. tons)	1.105	1.154	1.964	2.225	1.344	1.089	.952	1.342	.093	1.009

[a]Dummy variable included in 1970 corn yield function for the corn blight.

[b]The naive model of no change was assumed for beef due to various exogenous shocks occuring to beef in the 1972 crop year not considered by the model, i.e., termination of the price freeze.

[c]Prices are deflated by the Consumer Price Index where CPI=100 in 1967.

[1]While demand for meat products is not subdivided, demand for grain is broken into the following five sources: (1) direct demand for human consumption; (2) derived demand for use as livestock feeds by category of livestock; (3) public stock demands; (4) private stock demands; and (5) seed demand.

1974, was 13.38 percent. Forecasting these same variables over a period within the data sample period yielded a comparable absolute percentage error of 6.55 percent. In light of the unusualness of the 1972-1974 period, relative accuracy of the model's forecasts for this period is felt to be quite acceptable.

Of particular interest in this analysis is the model's ability to realistically predict market conditions for 1972. With the exception of wheat quantities and chicken prices, all turning points in 1972 are predicted correctly. Inability of the model to precisely forecast wheat quantity can be traced to a failure to predict a decline in wheat yields in 1972. The reason for missing the chicken price turning point is less clear but a likely factor is underestimation of turkey meat, a strong substitute for chicken. The average absolute percentage error of predicting the 1972 values of the fourteen price and quantity variables in Table 1 is 5.46 percent. The ability demonstrated by the model to realistically predict 1972 market conditions despite substantial changes in exogenous conditions for 1972 lends validity to use of the model in analyzing the impact of changes in exogenous conditions during 1972.

SIMULATION OF DYNAMIC EXPORT EFFECTS

To examine the dynamic impact of a change in grain export demand in 1972 from its 1971 level, the effect of this change must be isolated from effect of all other changes in 1972 and subsequent years. The previously described simulation model was used to accomplish this as follows. First, a base run was made in which all exogenous variables, including grain exports, are projected as constant values equal to their 1971 levels. Endogenous variable values simulated in the base run for 1972 and subsequent years differ from 1971 values due to lagged effects of previous economic conditions (Figures 2 and 3). Lagged endogenous and exogenous values are passed backward through the model's estimated lag structures as the model iterates through time. They continue to influence simulated values until they have passed through the total length of the lag structures.[2] Lag structures contained in the model are those estimated to be most realistic and consistent with past lagged response. The composite nature of the distributed lags in the model causes cyclical tendencies. These cyclical tendencies cause simulated values for 1972 and subsequent years to differ from 1971 levels. In a second run, a *single period*[3] export shock was imputed into the model for the year 1972 using actual 1972 export increases. The increases were 16 million tons of wheat, 16 million tons of feed grains and 9 million tons of soybeans (where soybean exports are measured in meal equivalents). The difference between the dynamic paths of key endogenous variables of the model are compared for these two runs to determine the effect of increased grain exports upon domestic agricultural markets.

Figures 2 and 3 display several comparisons of the dyanmic paths generated by the base run and "export shock" run. Table 2 presents calculated differences between the time paths for key endogenous variables of the base run and export shock run.

Crop Sector Response

Simulated price increases for wheat, feed grains (represented by corn price) and soybeans, due to increased exports, were 44.6 cents, 6.7 cents and 149 cents respectively (Table 2). By way of comparison, price increases estimated for 1972 in the validation run which used actual 1972 values for all exogenous variables (not just exports), were 38 cents, 26 cents and 115 cents for wheat, corn and soybeans respectively (Table 1).

Major exogenous conditions changing between crop years 1971 and 1972, other than export conditions include: (1) alteration of crop price supports and acreage diversion levels which favored wheat and soybean production relative to corn production; (2) removal of "price controls" in the latter part of the 1972 crop year which prolonged livestock and pork feedings periods, thus stimulating feed demands; and (3) continued upward trends in income and population growth creating more demand, especially for meat. These exogenous factors explain the difference between predictions for 1972 where all exogenous changes are considered (including the above), versus predictions where only changes in exogenous export conditions are considered. The net effect of these factors was to: (1) further contribute to "tightening" the feed grains market and thus reinforce the upward price pressure created by increased feed grain exports; and (2) "loosen" market conditions for wheat and soybeans and thereby partially offset the effects of increases of wheat and soybean exports. Hence, the

[2] Lagged responses of livestock production to input and output prices are described by third degree polynomially distributed lags ranging in length from 2-6 years. Crop production relations either do not contain distributed lag models or have geometrically declining distributed lags.

[3] After one period of simulation the exogenous shock variables are returned to their original level, i.e., the base run level which in this case is the recorded 1971 level.

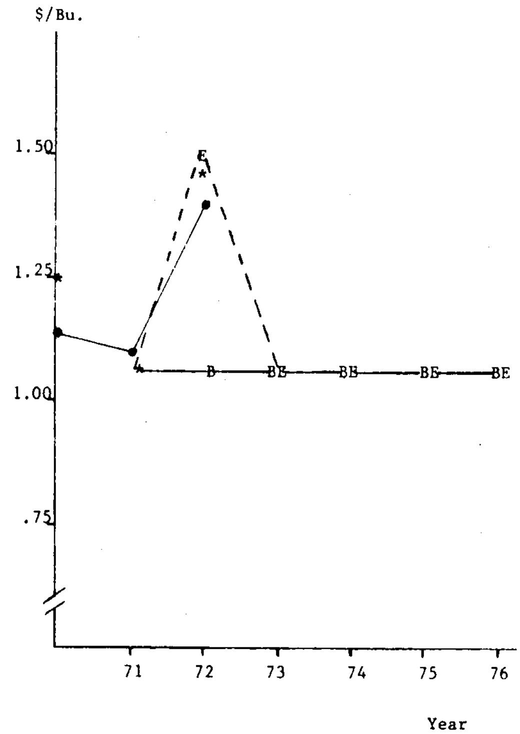


FIGURE 2A. WHEAT PRICES

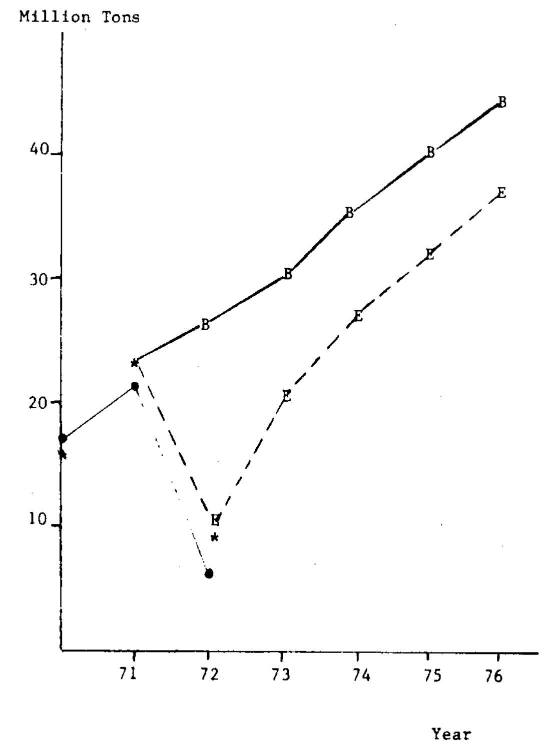


FIGURE 2B. GOVERNMENT WHEAT STOCKS

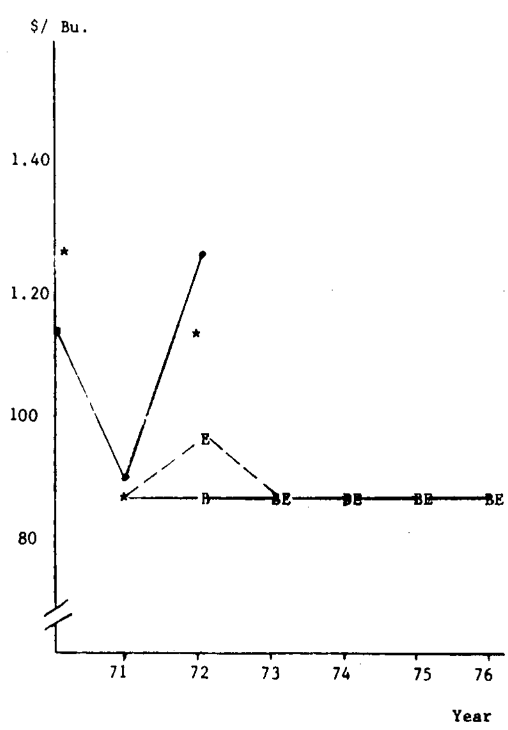


FIGURE 2C. CORN PRICE

NOTE: Prices are deflated by the Consumer Price Index value for 1971 where CPI = 100 in 1967.
- • Actual Value
- * Predicted Value
- E Export Shock Run Value
- B Base Run Value

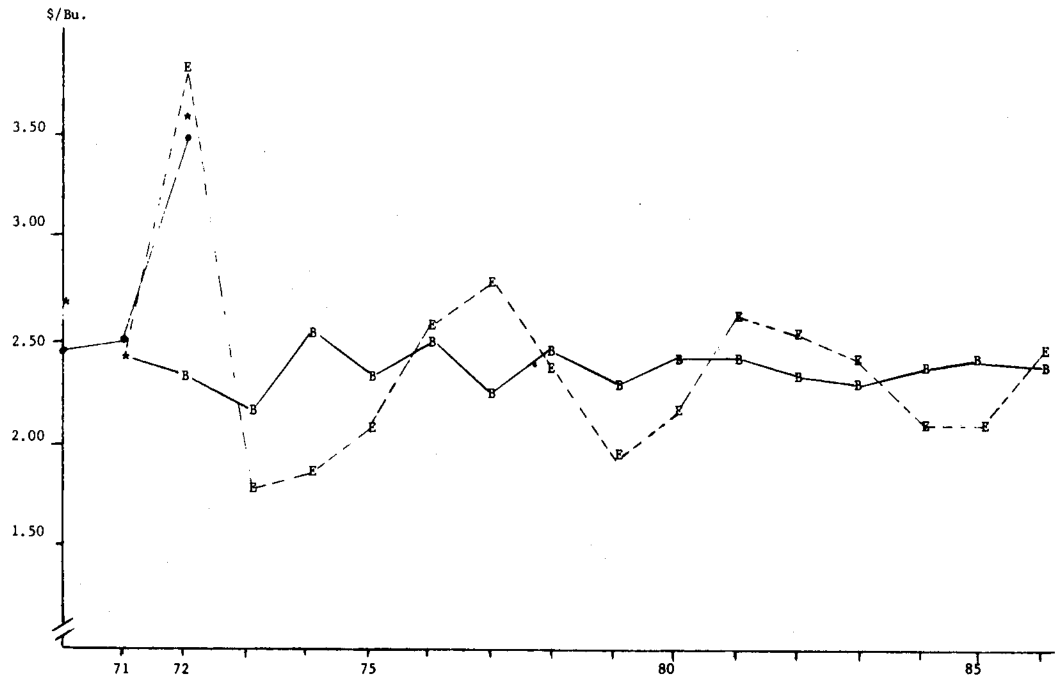
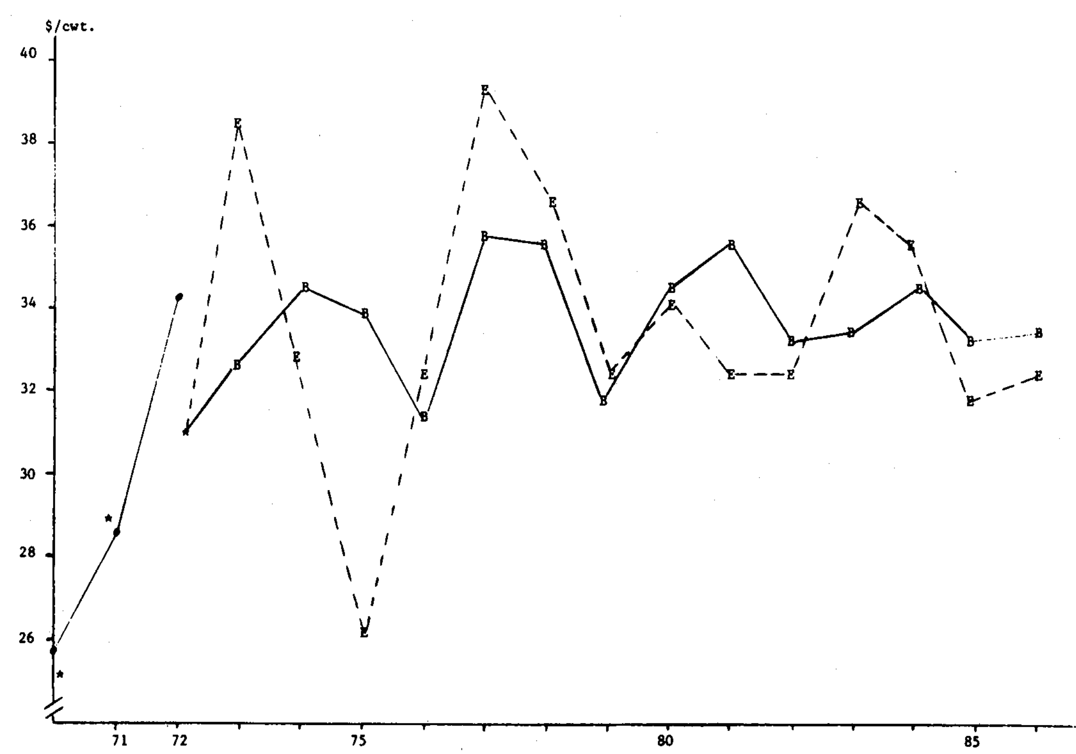


FIGURE 3A. SOYBEAN PRICES



NOTE: Prices are deflated by the Consumer Price Index value for 1971 where CPI = 100 in 1967.

- • Actual Value
- * Predicted Value
- E Export Shock Run Value
- B Base Run Value

FIGURE 3B. FED BEEF PRICE

TABLE 2. CALCULATED DIFFERENCES BETWEEN BASE AND EXPORT SHOCK SIMULATION RUNS

	Differences For Current and Intermediate Periods						Cummulative Net 15 Year Difference
	0	1	2	3	4	5	
Crops							
Prices:							
Wheat ($/bu.)	.446	.000	.000	.000	.000	.000	.446
Corn ($/bu.)	.067	.000	.000	.000	.000	.000	.067
Soybean ($/bu.)	1.490	-.342	-.697	-.264	.075	.583	.374
Quantity c/							
Wheat (Bil. bu.)	.0	.231	.0	-.012	.0	.004	.271
Corn (Bil. bu.)	.0	-.476	.058	.104	.292	-.014	-3.450
Soybean (Bil. bu.)	.0	.363	.177	-.580	-.115	-.063	.357
Gross Crop Value a/ (Bil. $)	3.143	-.146	-.432	-.207	.357	.614	2.047
Livestock							
Prices: c/							
Fed Beef ($/cwt.)	0	5.960	-1.270	-7.860	.980	3.493	1.010
Pork ($/cwt.)	0	4.330	- .710	1.740	5.210	-1.207	8.760
Milk ($/cwt.)	0	.082	- .038	.038	.118	- .144	.123
Chicken ($/cwt.)	0	8.907	-5.244	-4.891	2.569	1.393	.871
Quantity c/							
Fed Beef (Bil. lbs)	0	-3.051	.234	3.762	- .207	-1.978	- .311
Pork (Bil. lbs)	0	.407	- .227	-3.556	-2.335	.746	-4.196
Milk (Bil. lbs)	0	- .399	-1.547	-1.976	- .414	1.075	-1.574
Chicken (Bil. lbs)	0	-1.024	.674	.250	- .225	.112	- .455
Gross Livestock Value b/ (Bil. $)	0	3.491	-1.214	-3.588	1.478	- .798	-2.061
Government Reserves							
Food Grain (Mil tons)	-15.925	-10.665	-8.531	-8.006	-7.112	-6.921	-84.057
Feed Grains (Mil tons)	-25.238	-36.353	-21.673	-3.069	.141	-1.868	-171.348

[a]Gross value includes gross revenues from wheat, corn, soybeans, corn, oats, barley, sorghum and cotton.
[b]Gross value includes gross revenues from pork, fed beef, non-fed beef, milk, chicken, turkey and eggs.
[c]No response occurs for these categories during the first period by definition of the recursive model.

grain export shock of 1972 accounted for nearly all the simulated 1972 price change for wheat and soybeans, but for only about one-fourth of the predicted rise in 1972 feed grain prices (Figures 2a, 2b, 3a).

Several responses endogenous to the model can be observed which help "cushion" the export shock. First, the base run simulation indicates that stocks of corn and wheat would be increased in the absence of any exogenous changes in 1972. This excess production was of a magnitude adequate to have filled approximately 20 percent of the increase in export demand (7 percent in the case of feed grains and 42 percent in the case of wheat). In addition, the government liquidated 10.2 million tons of wheat stocks (Figure 2b), and its entire estimated feed grain stock holdings (6.1 million tons). Simulation results also indicate the private sector would have liquidated approximately 20 percent of its wheat and feed grain stocks and well over half of its relatively small quantity of soybean stocks.

The effect of the simulated 1972 export shock does not extend beyond 1972 in the case of corn and wheat prices because of government policies in effect for these crops. Government policy incentives for producing wheat and corn in 1971 were conducive to excess production. These policies are held constant throughout the simulation runs, hence corn and wheat prices in the export shock run return to their respective support price levels following the shock period.[4] Government stock purchases are required after the shock period to maintain support prices for corn and wheat (Figure 2b).[5]

[4]While corn and wheat prices return to base run levels, corn and wheat production do not because of intercrop competition between soybeans, corn and wheat, i.e., increased soybean acreage reduces corn acreage, but not enough to raise the market price of corn above the support price.

[5]In reality government food grain and feed grain production policies were sharply revised in 1973 and demand continued to increase for grains after 1972. These changes resulted in the complete liquidation of all government grain stocks and continued high prices for corn and wheat. The shock and base runs simulated here do not impute these changes and hence do not simulate their effects, but rather simulate a synthetic situation designed to analyze the impact of the 1972 grain exports increases. Synthetic simulations indicate corn and wheat stock would have accumulated rapidly under 1971 supply and demand conditions.

No excess production existed for soybeans (soybean stocks were not increasing), nor did the government have soybean stocks to cushion the 1972 shock; hence, there is a sharp initial price response simulated for soybeans. Soybean price declines in subsequent periods are attributed to over-reaction by producers to shock period price increases (Figure 3a). Soybean prices eventually rise again and begin to converge on the base run level in an oscillatory fashion.[6] Hence the 15 year net cumulative difference between the export shock run and base run of 37.4 cents is less than the initial or shock period difference (Table 2).

Gross Value of Crops and Livestock

Responses of gross livestock and crop revenues to the 1972 export shock are presented in Table 2. The simulated initial gross revenue response to increased exports is a rise in crop gross income and a fall in livestock gross income. Response patterns of gross livestock and crop revenue are very similar to those depicted in Figures 3a and 3b for soybean and beef prices, i.e. the shock run values fall above and below the base run values in an oscillating pattern. This results in the 15-year cumulative differences being smaller than the initial differences between the shock and base runs. The positive cumulative difference in gross crop revenue is nearly equal to the cumulative negative difference in gross livestock revenue, indicating that in the long-run an export shock produces very little net effect upon total agricultural sector gross revenue.

CONCLUSION

The empirical analysis presented supports the hypothesis that a major portion of the U.S. domestic agricultural market instability occurring since 1972 has been due to variations in grain export demand. Applications of the economic agricultural sector model used in this analysis indicated that the 1972 export increases accounted for nearly all of the 1972 price change for wheat and soybeans but only one-fourth of the change in corn price.

Government and private stocks of feed grains and wheat carried into 1972 "cushioned" the severity and duration of the price impact from the 1972 export shock for the commodities. Simulated price response to the export shock in the soybean market was more severe and longer lasting than in the feed grain and wheat markets. Simulated price and quantity responses in livestock markets were observed to persist for approximately seven years.

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[6] A similar oscillatory convergence pattern is observed for all commodities for which the government does not hold stocks.

APPENDIX I. KEY SUPPLY AND DEMAND ELASTICITIES AND FLEXIBILITIES

Commodity	Supply			Demand	
	Acres Planted			Domestic Food and Feed	
Crops	Effective[a] Support Price		Lagged Own Price	Own Price	Major Substitute Price
Wheat	.693		.472	-.068	--
Corn	.132		.037	-.236	.165 (Corn)
Soybeans	--		.260	-.261	.046 (Soybean Meal)
	Lbs. of Production			Per Capita Demand (Price Dependent)	
	Own Price				
Livestock	Short-Run	Long-Run	Corn Price	Own Quantity	Major Substitute Quantity
Fed Beef	.45	1.31	-.40	-1.70	- .65 (Non-fed Beef)
Pork	.17	.44	-.15	-2.09	-1.65 (Fed Beef)
Milk	.06	.58	-.06	- .63	-2.53 (All Red Meats)
Chicken	.39	.80	-.36	-1.58	-1.58 (Turkey)

[a]The "effective price support" variable referred to here was developed by Houck and Ryan [1]. It is calculated by adjusting the announced support price by a factor reflecting planting restrictions required for a producer to be eligible for a given price support.