CAPITAL FLOWS, THE EXCHANGE RATE AND AGRICULTURAL COMMODITY MARKETS: SOME EMPIRICAL EVIDENCE*

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Introduction

The relative influence on agriculture of sectoral shocks, shocks arising in other sectors, and shocks arising from macroeconomic policies is a controversial issue with important implications for the future of U.S. agriculture and the direction and efficacy of farm-policy options. Just over a decade ago, G. Edward Schuh first reasoned that the exchange rate was an important variable omitted from analysis of agricultural markets. Subsequent studies attempting to quantify the magnitude of the effects of exchange rates on agriculture have resulted in a wide range of estimates. These studies have suffered from one or more serious deficiencies: partial-equilibrium constraints that cannot be justified in the context of a more general model were imposed on exchange-rate effects, the exchange rate was the only macroeconomic variable considered, or the structural specification of the model did not facilitate comparison of the relative magnitude of the impacts attributable to sectoral versus macroeconomic factors.

The objective of this paper is to provide a more coherent analysis of the magnitude of trade-related macroeconomic, as opposed to more narrowly market-specific influences on the world corn market during the 1970s. Empirical results presented herein are derived from estimation of a 12-variable autoregressive model (VAR) using annual data from 1954 to 1980. The analysis is robust. Qualitatively similar results were

obtained from a more traditional simultaneous equation model in which U.S. corn price, domestic consumption, exports and end-of-period stocks were treated as endogenous variables. Characteristics of the VAR approach are that the analysis proceeds without a priori assumptions that relations between variable take a particular form, that effects of specific factors on selected agricultural variables are evaluated in light of contemporaneous and dynamic interactions among all variables, and that focus of the analysis is on the effects of unexpected shocks, given available information at a moment in time, on the expected future values of variables in the model.[1]

Relevant Economic Time-Series

Variables included in the analysis can be classified into two groups -- seven sectoral variables, and five macroeconomic and trade-related variables. In the first group, two variables -- the deflated dollar price of corn, p_c^{US}, and the aggregate quantity of U.S. corn exports, z_c^{ROW}, -- provide indicators of world corn-market developments that are crucial from a U.S. perspective. The characterization of corn demand is completed by including a measure of domestic U.S. consumption, x_{cc}^{US}, and of interactions with the livestock sector,

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[1]Space limitations preclude a thorough description of VAR econometric techniques. It is assumed that the reader is familiar with the concepts which underlie analysis in a VAR framework, particularly the autoregressive and moving average representations of a vector stochastic process, the computation of impulse response functions, and the orthogonalization of innovations when forecast errors are contemporaneously correlated. Similarly, the interpretation of VAR models, the merit of their use in economic analysis, and their relationship to more traditional econometric methods will not be discussed in further detail. These subjects have been considered in a related paper by the author. A useful reference is Sims, 1981.

represented by the deflated price of beef steers, p_b^{US}. Supply factors are measured by the quantity of corn produced in the U.S., y_c^{US}, the quantity of corn produced in the importing region, y_c^{ROW}, and the quantity of corn shipped by competing exporters, s_c^{*}.[2]

Nonagricultural variables included in the analysis are an index-measure of the real value of the U.S. dollar, ($e = \$^{rest\text{-}of\text{-}world}/\$^{US}$), the value of real income transfers (primarily from the U.S.) to the corn-importing region through trade and factor payment accounts, T^{ROW}, the value of real domestic-factor incomes in the U.S. and corn importing region, GNP^{US} and GNP^{ROW}, and the real cost of U.S. oil imports, OIL^{US}. The oil-sector variable, though not a perfect proxy, was included to measure the extent to which income transfers induced by the OPEC cartel, but not necessarily associated with trade imbalances, explain developments in U.S. corn exports, a possibility which does not seem implausible in light of stylized facts characterizing U.S. trade during the decade.

Choice of Orthogonal Order

A large number of orthogonal orders may be considered to account for contemporaneous correlations among errors in a 12-varible VAR model. In particular, inclusion in a VAR of both sector-specific and macroeconomic variables raises an issue with respect to choice of an

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[2]An end-of-period stocks variable often included in simultaneous equation models is not included in the VAR analysis. The identity that end-of-period stocks equal lagged stocks plus production minus consumption and exports implies innovations in stocks will be exact linear combinations of innovations in variables that are included in the VAR.

orthogonal order that might not arise in other applications. Placing sectoral variables high in the order conforms to the notion that close interactions among related variables defines a specific sector of the economy. But attributing large effects on macroeconomic variables to shocks to sectoral variables, as would tend to occur with such an order, contradicts a sense of scale that suggests specific sectors have relatively small causal effects on broad, across-economy variables. Placing macroeconomic variables before sectoral variables might be more appropriate in the latter respect, but may result in the effects of macroeconomic variables on the sector being overstated compared to interactions among sectoral variables themselves.

To determine the magnitude of these difficulties, several specifications of the 12-variable VAR model were considered as a basis for the analysis. Corn sector variables were placed below macroeconomic and other nonagricultural variables in the ordering reported in this paper. This imposes a presumption that contemporaneous correlations between macroeconomic and sectoral errors are attributable to macroeconomic shocks, and against effects of sectoral shocks on non-sectoral variables.

Interactions Among Variables: Some Impulse Response Functions

Some of the impulse response functions central to analysis of the source of shocks affecting developments in the world corn market are shown in Table 1. Responses of selected variables to shocks of one standard deviation are shown. Space limitations preclude presentation of a complete set of impulse response functions.

First, consider the effects of shocks to trade-related variable on

one another. An unexpected increase in the cost of oil imports causes expected income transfers to the corn-importing region to decline. The expected value of the U.S. dollar appreciates very slightly then depreciate. Depreciation caused by an oil-sector shock is less than ten percent of the value of an orthogonal shock to the exchange rate itself in all time-periods.

An unexpected increase in the income transfer through trade and factor payments accounts causes the expected value of the dollar to depreciate contemporaneously. The magnitude of this effect is one-third that of a direct orthogonal shock to the exchange rate. In subsequent periods the expected cost of U.S. oil imports rises. The expected value of the dollar remains weaker than would otherwise have been the case.

The effect on the exchange rate of a shock to income transfers is consistent with concepts drawn from a general equilibrium trade model. In such a model, relative price movements accommodating an increase in the transfer from one country to another are facilitated by depreciation of the currency of the former relative to the currency of the latter. Likewise, the estimated impact of an unexpected appreciation of the U.S. dollar on expected future values of income transfers to the corn-importing region is negative, as would be expected on the basis of the trade model. Appreciation of the U.S. dollar also causes the expected value of oil imports to fall. If so, unanticipated devaluations of the U.S. dollar in the early 1970s played a causal role inducing later increases in oil prices. Oil sales are usually denominated in dollars.

Table 1. Impulse Response Functions: The Effects of Orthogonal Shocks on Expected Contemporaneous and Future Values (One to Three Periods Ahead) of Selected Variables, 12-Variable VAR Model

	Variable							
Expected Value:	OIL^{US}	T^{ROW}	e	y_c^{US}	y_c^{ROW}	p_c^{US}	x_{cc}^{US}	z_c^{ROW}
contemporaneous	1.8	-1.5	.0003	-99.7	-942.6	.5	-655.8	-503.2
1	.5	-.3	-.0023	176.5	-538.7	-1.2	-560.7	289.3
2	.5	.01	-.0028	66.2	-353.1	-.4	83.4	555.0
3	.6	.2	-.0024	-32.1	-291.3	.2	18.3	543.0
contemporaneous	0	4.2	-.0098	-645.2	943.6	2.4	-2.3	1111.9
1	1.3	1.3	-.0069	-120.8	229.8	2.9	-738.9	473.8
2	1.1	.1	-.0054	362.1	-65.0	.3	-1298.4	518.2
3	.8	-.3	-.0041	471.7	-168.1	-1.1	-670.4	753.6
contemporaneous	0	0	.0289	-2665.2	1041.2	-2.7	410.2	-514.2
1	-.8	-.9	.0195	-781.5	110.1	-4.4	120.4	-833.2
2	-1.3	-.9	.0111	-245.4	-108.1	-3.7	990.0	-568.2
3	-1.2	-.3	.0046	-157.2	-108.9	-1.2	1316.1	-383.1
contemporaneous	0	0	0	9686.8	553.9	-2.1	232.7	-158.4
1	.3	-.1	.0025	2757.3	968.4	-2.3	2063.4	717.0
2	.5	.2	.0027	996.8	664.4	-1.4	1485.5	568.8
3	.5	.3	.0020	458.5	398.9	-1.2	823.1	404.5
contemporaneous	0	0	0	0	2888.2	-1.5	883.8	-166.3
1	-.02	.15	.0055	663.6	1412.2	-1.9	659.5	-1.9
2	-.01	.03	.0068	336.4	754.4	-1.8	761.3	-40.5
3	-.13	-.13	.0060	126.4	423.8	-1.7	691.4	-125.5

___: indicates initial shock

Second, consider the effects of selected shocks to agricultural variables. The estimated effects of shocks to agricultural variables on macroconomics and nonagricultural variables are generally small. Not surprisingly, this is not so for interactions among sectoral variables. An unexpected increase in corn production causes U.S. corn price to fall by over 50 percent of the value of an orthogonal corn price innovation (not shown in Table I). Expected U.S. corn exports and domestic consumption of corn both rise in the next period. The magnitude of the increase in U.S. consumption exceeds that of an orthogonal consumption innovation (not shown), while exports rise just less than would be caused by an orthogonal export shock (not shown). An unexpected increase in corn production in the corn-importing region also causes U.S. corn price to decline and U.S. consumption to rise, but has little net effect on U.S. corn exports. An orthogonal corn price innovation causes the expected value of U.S. consumption and exports to fall in the following period. Consumption falls by 50 percent of the value of an orthogonal innovation in consumption itself, while exports fall by one-quarter of an own-innovation.

Third, consider the estimated effects of shocks to macroeconomic and nonagricultural variables on agriculture. An unexpected increase in the cost of oil imports depresses expected U.S. corn consumption. Predicted exports of U.S. corn fall contemporaneously then rise. This is consistent with the reasoning that revenue earned by cartel oil-pricing was utilized in large part to purchase additional goods, including U.S. corn, but suggests a lag in this sequence of events. An oil-sector shock also lowers expected corn production in the

importing region. Effects on U.S. corn production are small.

A positive shock to income transfers causes an increase in the expected value of U.S. corn exports, an increase in expected corn price, and a decline in U.S. consumption. The magnitude of the contemporaneous effect on expected exports is the same as that of an orthogonal export shock. Unanticipated depreciation of the U.S. dollar has similar effects. The magnitude of the effect of a shock to the exchange rate on expected corn price one period later slightly exceeds that of an orthogonal price innovation.

An Historical Analysis of Factors Affecting the World Corn Market

Taken together the impulse response functions from the VAR model imply that the world corn market is affected to a considerable degree by shocks associated with trade-related macroeconomic variables, as well as by shocks that are more narrowly sector-specific. To conclude the analysis, the net effects of shocks from trade-related and sectoral sources on U.S. corn exports and price are shown in Figures 1 and 2, for the period 1970-1980.

Historical analysis of the relative magnitude of the impact of shocks from different sources is based on decomposition of the observed values of the corn export and price variables into the sum of a component that was predictable prior to 1970, and the cumulative effects of subsequent own-errors and errors in other variables. This decomposition depends on the magnitude of orthogonal shocks each year, estimated by the errors from the autregessive equations, and the contemporaneous and future effects of these errors, measured by the estimated impulse response functions. The cumulative effects of shocks

to the oil-sector, transfers through trade and factor payment accounts, and the exchange rate are considered separately. These effects are compared to the summed cumulative effects of all agricultural variables.

As shown in Figures 1 and 2, a surprisingly overvalued dollar lowers exports and price in 1970, 1971 and 1972, and unanticipated devaluations have large effects on exports and price in 1973, 1974 and 1975. Given these developments, and modest appreciation of the dollar in 1976 and 1977, an unexpected decline in the value of the dollar in 1978 has relatively greater effect on exports than price, compared to devaluations in the early 1970s.

Developments in the corn market also reflect large effects arising from agricultural shocks one year after unanticipated declines in U.S. corn production in 1970 and 1974. Agricultural shocks in 1977 and 1978 arise from diverse sources, while the unexpectedly large U.S. harvest in 1979 explains some of the unpredicted expansion of exports in 1980. Shocks to price attributed to sectoral variables are much larger in magnitude in 1972 than 1971, despite cumulative effects of sectoral variables on exports of similar magnitude (but opposite sign). Almost 50 percent of the effect of sectoral shocks on price in 1972 is attributable to a shock to price itself. In contrast, only a small fraction of the effects of sectoral variables on prices during the 1973-1975 period arises from own shocks. The cumulative effect on price of shocks to sectoral variables is quite small in 1980 compared to the effect of sectoral shocks on exports. The large sectoral effect on exports in 1980 includes a substantial own-prediction error.

The historical pattern of impacts on corn-market developments

Figure 1. Cummulative Effect on U.S. Corn Exports of Shocks to Oil Imports, Income Transfers, the Exchange Rate, and Agricultural Variables, 12-Equation VAR Model, 1970-1980

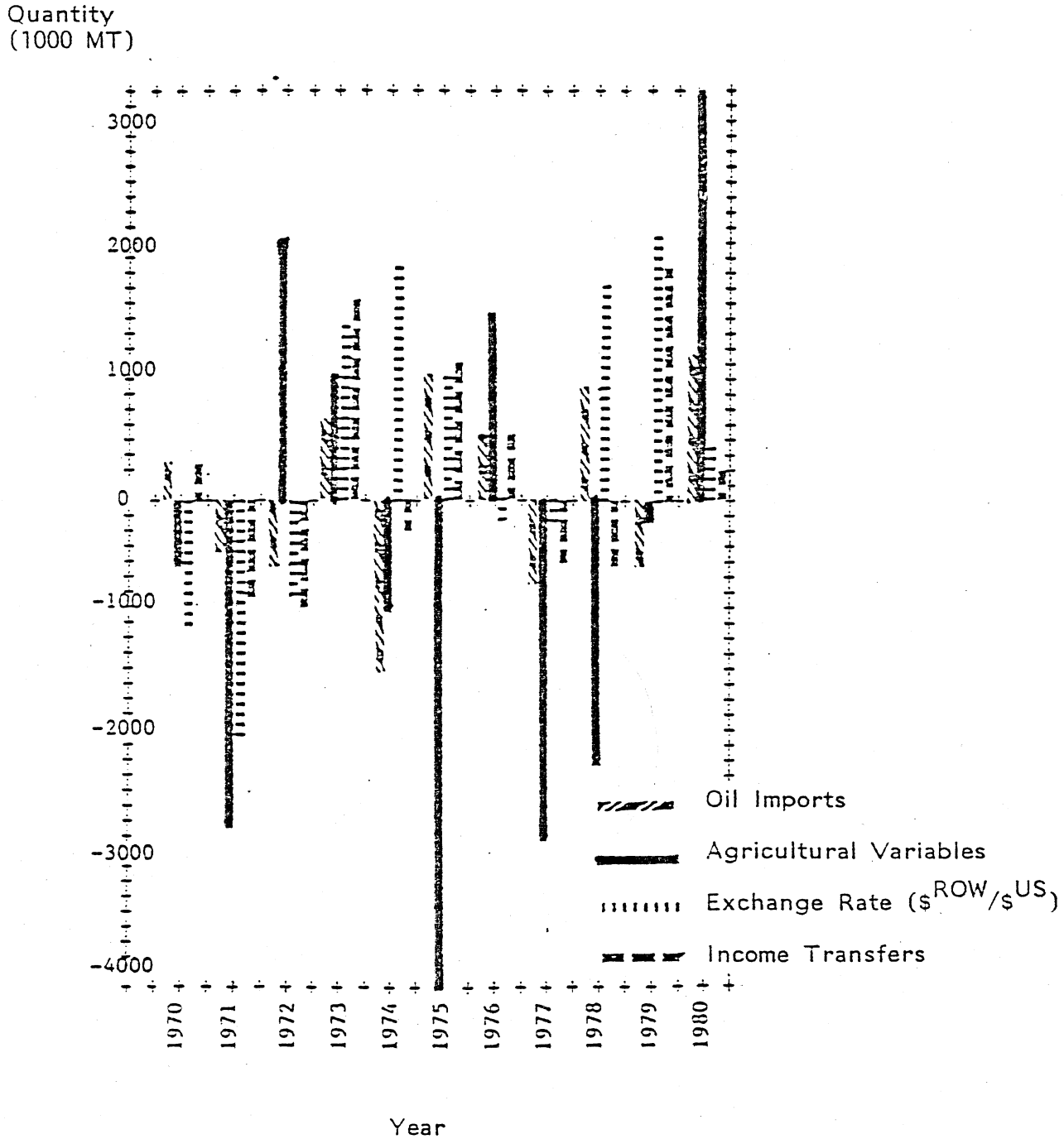
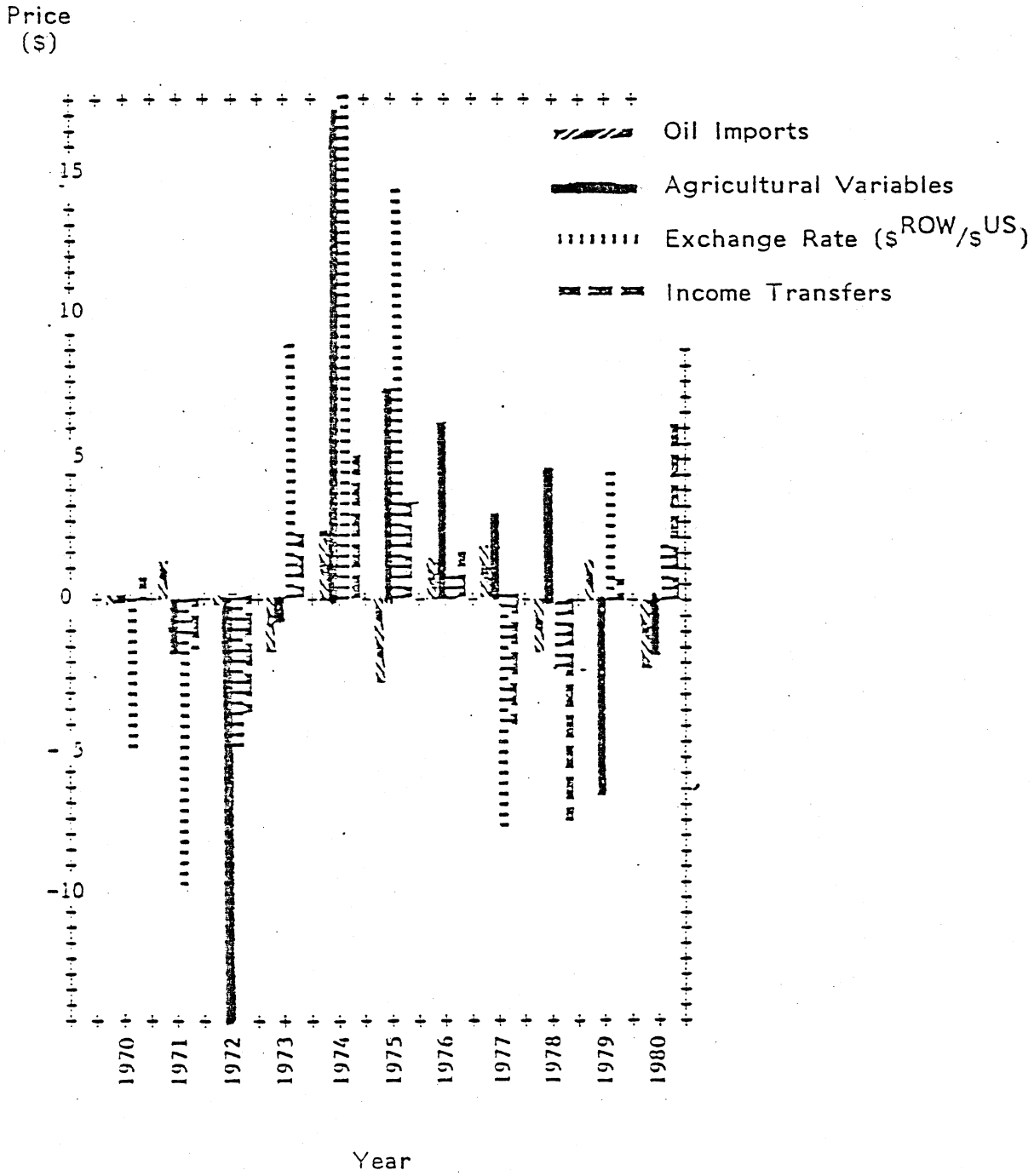


Figure 2. Cummulative Effect on Deflated U.S. Corn Price of Shocks to Oil Imports, Income Transfers, the Exchange Rate, and Agricultural Variables, 12-Equation VAR Model, 1970-1980



associated with oil-sector and transfer variables, also shown in Figures 1 and 2, imply that increases in the price of oil and the cost of oil imports between 1973 and 1974 had an immediate negative effect on exports, followed by lagged positive effects. Oil prices rose again in 1978 and 1979. Based on the estimated VAR model, the cost of US oil imports was unexpectedly low in 1978 and 1980, and unexpectedly high in 1977 and 1979. The pattern of forecast errors for oil import-value, together with the effect of earlier shocks, creates a negative effect of the oil-sector on corn exports in 1977 and 1979 and positive effects in 1978 and 1980. Effects of oil-sector shocks on price are estimated to be relatively small in magnitude.

Finally, relatively large cumulative effects of income transfers on corn exports in 1973 and 1979 reflect large orthogonal shocks with immediate positive impacts. Price impacts tend to emerge more strongly the following year. A decline in anticipated transfers lowers corn exports and price in 1977 and 1978.

Implications of the Analysis

The empirical results presented in Figures 1 and 2 have several interesting interpretations with respect to the issue of the magnitude of the effects of macroeconomic versus sectoral factors on agricultural markets. The historical impact analysis confirms Schuh's original contention that the exchange rate is an important variable that had previously been omitted from analysis of U.S. agriculture. The results presented in Figures 1 and 2 also suggest, however, that some studies that have focused on the early 1970s may overstate the relative importance of the exchange rate per se. Historical impacts on corn

exports attributable to orthogonal shocks to trade-related factors are broadly distributed among the oil-sector, income-transfer, and exchange-rate variables. Among these variables, the largest cumulative effects are attributed to the exchange rate, but effects of oil-shocks and transfer-shocks are each larger in magnitude than exchange-rate effects in three years. The cumulative effect on corn exports attributed to shocks to specific trade-related variables is exceeded by the effect of shocks to sectoral variables in seven of the eleven years.

The impacts attributed to shocks to the exchange rate are more dominant in explaining developments with respect to corn price. Effects of exchange-rate shocks exceed those of oil-sector and income-transfer shocks in eight of eleven years. The net effects of agricultural variables also exceeds the effect of the exchange rate in only three years.

Oil-sector shocks, income-transfer shocks and exchange-rate shocks are shown to be closely related by the VAR analysis. Estimated interactions among these variables are consistent with theoretical concepts based on a general equilibrium trade model. Evidence of separate effects of exchange-rate and income-transfer variables supports the reasoning that income effects are central to the impact of macroeconomic variables on agriculture. One implication is that effects of macroeconomic factors should be evaluated in a broader context than provided by a partial equilibrium model.

Perhaps it is most appropriate in assessing the relative influence on agriculture of sectoral versus nonsectoral factors to treat the effects attributed to exchange rates, income transfers, and oil-sector

developments as jointly measuring the impacts of a deeper and larger set of macroeconomic variables. Comparing the summed effect of shocks arising within the sector to the effect of any one of these variables may understate the total impact of non-sectoral factors. Year by year, the effects attributed to exchange rates, income-transfers, and the oil sector tend to be in the same direction. Associating transfer and oil-import effects would underscore the role of income transfers relative to the role of the exchange rate as perceived in a partial equilibrium context. Conversely, associating income-transfer and exchange-rate effects would underscore the role of macroeconomic policies as they arise conceptually in a general equilibrium trade model (and other macroeconomic models) relative to independent shocks to real sectors, such as the shock arising from cartel behavior of oil exporters. In either case the magnitude of nonsectoral impacts is enhanced relative to sectoral factors.

References

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