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GOVERNMENT INTERVENTION AND FOOD PRICE INFLATION

by

John Freebairn, Gordon C. Rausser, and Harry de Gorter

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1. INTRODUCTION

During the past decade, the U. S. agricultural sector became increasingly integrated with both the domestic and international economies. The dramatic integration with world markets resulted, in part, from the introduction of flexible exchange rates and the significant increases in agricultural exports. Although governmental intervention continues to be pervasive, an increased dependency on market forces within the U. S. agriculture and food system has occurred, particularly in labor, credit, and capital markets.

The increased integration that has been witnessed during the last decade has raised a number of important issues regarding (1) the effects of shocks sourced in agriculture, those sourced in the domestic general economy, and those sourced in the international economy; (2) the comparative effectiveness of sector versus general economy policies on the U. S. agricultural sector; and (3) the weight that should be given to the effects of agricultural and food sector policies on the general economy as well as the agricultural sector. A serious evaluation of these issues requires an understanding of the interrelationships between the U. S. agricultural sector, the balance of the U. S. economy, and the international economy. Such interrelationships are crucial in the assessment of direct and indirect effects of various policies--sectoral as well as fiscal and monetary. The ultimate effects of monetary, fiscal, and exchange-rate policies as well as of direct agricultural price

support, acreage diversion, and reserve-stock holding policies and trade restrictions on food price inflation and general price inflation obviously depends on the nature and extent of the direct and indirect causal links between the agricultural sector, the general economy, and the international economy. Available evidence strongly suggests that the effects of these policies on prices, quantities, and employment entail complex time paths involving feedback relationships and that much can be gained by an integrated treatment of agricultural sector and economy-wide policies.

Agriculture in the United States is an important sector; it plays a major role in determining the most sensitive component of the price level, it is a major supporting factor in our net trade position, and it is important for regional politico-economic reasons. Food products contribute 18 percent of the weight of the consumer price index which, in turn, enters the wage bargaining process. The volatility of food prices, and especially the jump in grain prices in 1972-73, appears to have had significant effects on the paths of general economy wages and prices. The dependence of U. S. agriculture on exports increased to about 50 percent of sales in 1978-79, and agricultural exports represent approximately 20 percent of total U. S. exports. Domestic agricultural prices have become more directly linked to world prices with the elimination of the two-tier sector price policies of the U. S. government and the move to flexible exchange rates. Beginning in 1973, the Food and Agricultural Act eliminated the wedge between domestic agricultural prices and world prices.

In the current economic environment, developments overseas and in exchange rates have significant implications for agricultural product prices and input costs and for farm income and asset values. The growing dependence of U. S.

agriculture on other sectors for inputs and for farm production as well as for the processing, storage, transport, and distribution of farm products has meant that general economy prices (including wage rates) directly influence returns to agriculture. Approximately 60 percent of the consumer's food dollar goes to nonfarm activities. In turn, the agricultural farming component spends 30 percent to 50 percent of its gross receipts on nonfarm inputs. To be sure, these costs are directly linked to wages and capital costs in the balance of the U. S. economy. These facts, in combination with the stronger labor- and capital-market links which occurred in the 1970s with the steadily decreasing information and regulatory barriers, have effectively eliminated the isolated economic environment the agricultural sector experienced during the 1950s and 1960s (Schuh, 1980). The resulting price links between agriculture, the domestic economy, and the international economy are in addition to the real resource-flow links and economic growth developments that have been the focus of some important analyses of the agricultural economy [Schultz; Tyrchniewicz and Schuh; and Gardner (1976)].

In this setting, the purpose of this paper is to report a preliminary framework for assessing the effects of policy changes and of noninstrument shocks on the performance of the agricultural sector and on the general economy. Policies include macroeconomic measures emanating from fiscal, monetary, and exchange-rate spheres as well as agricultural sector policies such as acreage diversions, price supports, storage subsidies, and trade import quotas. Examples of noninstrument shocks include droughts and surges in Soviet grain-import requirements. The framework is designed to generate an assessment of a number of performance measures including general economic inflation, national income, and agricultural sector returns and asset

values. The framework assumes the form of a three-sector quantitative model--agriculture, the balance of the U. S. economy, and the international economy. Special emphasis is placed on the interrelationships among the three sectors (e.g., price, income, and foreign accounts) and on the explicit inclusion of sector as well as general economic policy instruments. The model is constructed explicitly for policy analysis; it is not intended to serve as a forecasting tool. At this juncture, the model reported is only a preliminary attempt to assess the effects of policy changes and of other exogenous shocks in one sector on each of the three sectoral components. The sequence is to determine (1) the effect of sectorial policies on agriculture; (2) the effect of the resulting endogenous variables in the agricultural sector on the general economy; (3) the effect of fiscal and monetary policies on the general economy; and (4) the effect of the resulting general economy endogenous variables on the agricultural sector. This is accomplished by treating the links between U. S. agriculture, the U. S. general economy, and the international economy endogenously. In essence, the purpose of the model is to determine quantitatively the forward and feedback links between the agricultural and general economies.

The remainder of the paper is organized as follows. Section 2 presents a review of the relevant literature that relates to the specified model. Section 3 presents the specific questions that we hope to analyze after the model-construction process is complete. These questions provide the basis for the specification and structure of the model. The major contributions offered by the model structure <u>vis-a-vis</u> models currently available are outlined. An explanation of the framework of the model is presented in section 4 along with selected results; section 5 presents a few selected policy simulations; and

section 6 sketches the additional work that must be accomplished to capture answers to the questions presented in section 3.

2. LITERATURE REVIEW

Marshaling the literature regarding the three sectors under examination is, indeed, a difficult task. In the early 1970s, however, this task would have been relatively straightforward. At that juncture, the agricultural sector was modeled generally as a closed system with only exogenous influences from the general and international economies. Since U. S. agriculture policy effectively isolated agriculture from domestic and international market forces, such a structure was a reasonable approximation. In addition, most macroeconomic models treated the agricultural sector exogenously prior to the food price explosion in 1972-1974.

Since the mid-1970s, a number of models have been constructed which recognize the linkages among the three sectors. Nevertheless, we typically find the agricultural sector being modeled as a satellite system with forward linkages to the nonagricultural base of the economy and only a minimal degree of feedback.[1] Hence, the literature can be examined from three perspectives: from a macroeconomic perspective; from an agricultural sector perspective; and from the perspective of both forward and backward linkages among the international, domestic, and agricultural economies. From the macroeconomic perspective, agriculture is treated largely as being predetermined with only

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[1]There are, of course, numerous modeling efforts in which agriculture is treated as one of several distinctive sectors in a large, multisector system that is held together by various devices--e.g., an input-output system.

important forward links; from an agricultural sector perspective, the macroeconomy is treated largely as being predetermined with important causal influences on the agricultural sector; and, finally, the integration of the three sectors begins to recognize the interactions and joint determinations of the performance in each of the three major sectors.

2.1. From a Macroeconomic Perspective

During the 1950s and 1960s, the relative stability of the prices of agricultural and other raw materials allowed most macroeconomic modelers and policymakers to dismiss the importance of the agriculture and food system. Most studies treated this sector as exogenous. The original Brookings model included an agriculture sector constructed by Fox, but this effort was not incorporated into subsequent extensions of the Brookings model. In the early 1970s the perspective was altered significantly. Owing to the substantial increases in the price of grains from 1971 to 1974, it was inevitable that conventional macroeconomic models would significantly underestimate the course of inflation. During this period, of course, oil price increases were an added disturbance.

In the mid-1970s the commercial forecasting macroeconomic models constructed by DRI, Wharton, and Chase Econometrics began the construction process for agricultural sector submodels. These models have now been extended to include other countries and an international sector. These efforts include the development of the Wharton link models and models of various international components under construction by Chase Econometrics and DRI as well as other commercial vendors. In each instance, during the last decade the models have been expanded to the point where they contain endogenous sectoral detail

rather than simple representations of aggregate national accounts. Nevertheless, U. S. agriculture is generally modeled as a satellite system with linkages to the nonagriculture base of the economy but with only minimal feedback.

The surge in food and energy prices during the early 1970s and their implications for economic performance led a number of academic researchers to turn their attention to the effects of rises in food and energy prices. A series of studies appeared in the Brookings Papers on Economic Activity, including Okun, Gordon, and Gramlich. Other such studies include those by Kaldor, Phelps, Schlagenkauf and Shupp, van Duyne (1979), Lawrence (1980), and Blinder. The general characteristics of the conceptual base for such models focus on the wage-markup price equation that reflects Hicks' fixed price or Okun's customer goods concept with an allowance for food and material prices and a Phillips curve wage equation.

Much of this literature experiments with adaptive and rational price expectations in the wage equation. The agricultural sector in these models is treated either as a flex-price (auction) market or as exogenous. Food price increases are generally analyzed in terms of their time pattern of effects on an aggregate price index and on employment under different assumptions regarding price expectations and varying degrees of accommodating monetary or fiscal policy. The wage-price equation relationship in these models operates by magnifying the price effects of initial disturbances. One of the few models that includes assets explicitly has been advanced by van Duyne (1979), who was able to capture additional dynamic effects following a temporary drop in agricultural output. Similar to the other studies, his results strongly suggest that higher agricultural and energy prices worsen the unemployment/inflation possibility set.

2.2. From an Agricultural Sector Perspective

In initial modeling efforts on agriculture, this sector was treated as a separate entity. This was justified, in large part, by governmental policies which created a closed agriculture and food system in the United States. In these models, agriculture was affected by a few general economic variables such as consumer disposable income, interest rates, and the level of agricultural exports. Disturbances in agriculture were assumed to have no impact on the rest of the economy. These modeling efforts may be found in Cromarty, Egbert, Quance and Tweeten, and Lamm (1981a) and in the national programming models built by Earl Heady and associates.

The second generation of agricultural models develops forecasts in a recursive framework. General macroeconomic models are first used to forecast a set of relevant variables that are used to solve the agricultural system. The solution values for these variables are then transmitted back to the general economy through a set of definitional linkages. Examples of these linkages include definition of the consumer price index and of the gross national product. Adjustments are allowed in order to enforce accounting constraints. This work includes that of Chen on the Wharton agricultural sector model and of Roop and Zeitner. The Wharton agricultural model, for example, contains 249 equations of the agricultural sector that are to be used in conjunction with the Wharton macroeconomic model. In principle, the two models can be solved simultaneously. Operationally, they are solved iteratively. The representation of these two models contains most of the intersectoral relationships and policy instrument variables that are of importance. However, there is no allowance for the direct effects of interest rates and of liquidity variables on supply or, more particularly, for inventory demand

behavior. In addition, the effects of nonfarm costs are attributed entirely to fertilizer costs even when, for example, the labor costs are more important and follow different time paths. Roop and Zeitner propose a much smaller, nine-equation model of the agricultural sector for iterative solution with the Wharton macroeconometric model. An agricultural sector model constructed by DRI that is similar in size to the Wharton agricultural model has been linked with the DRI macroeconometric model in an evaluation of the 1972-73 agricultural price explosion (Eckstein).

All of these second-generation agricultural sector models (as well as other models of similar vintage) have the required demand-related linkages with the nonagriculture macroeconomic variables of domestic and foreign economies. Despite the fact that production is an explicit component of these models, none deal with the specific input markets to agriculture that stem from the nonagricultural sectors. Supplies of inputs specific to agriculture are treated implicitly as infinitely elastic, and no financial constraints are imposed on the agricultural sector. Moreover, in the farm-account components of these models, there are neither feedbacks to other subcomponents nor links with other financial sectors of the macroeconomy.

Another major shortcoming of the second-generation agricultural sector models is their failure to include explicit variables to represent sector policies. Such policy instruments as acreage diversion or set-asides, deficiency or diversion payments, loan rates, storage or input-cost subsidies, and public storage are neglected. Moreover, these modeling efforts generally treat exogenously the international sector, i.e., export demand for agricultural commodities. Of course, many of these features are incorporated explicitly into individual commodity models. In the case of wheat, for example,

Gardner (1980) has drawn the distinction between public and private storage and has obtained some interesting implications for optimal public storage policy.

In terms of individual commodity models, a number of other studies by agricultural economists provide building blocks for analyzing the effects of sector production policies and their implications for the general economy. Commodity supply studies, initiated by Houck and his colleagues, describe and quantify the influence of loan rate, acreage diversion, and acreage allotment policies on crop supply response. Estimates of beef import control program effects by Freebairn and Rausser and Arzac and Wilkeson, of the dairy industry program by Salath et al. and Novakovic and Thompson, and of the sugar program by Gemmill suggest that these governmental interventions relative to free-trade policy do not lead to large increases in retail food prices. Further work along these lines including the effects of such governmental programs on the variability of prices would be desirable. In general, these individual commodity models ignore any feedback effects of changes in agricultural prices on general prices, the exchange rate, employment, and the like; and, in turn, the implications of these changes for the agricultural sector.

Concern with the predetermined treatment of (or, at most, the weak linkages between) the domestic macroeconomy and the international economy on the agricultural sector has led to a third generation of agricultural sector models. Among the first of these models is the thesis study by Shei. This third-generation model representation includes 24 equations and uses an annual time period. It was constructed primarily to study the effects of devaluation and to analyze an exogenous increase in commodity export demand. In addition, various simulations were conducted to assess the implications of exogenous

increases in the money supply. The model has significant price and trade linkages between agriculture, the rest of the economy, and the balance of the trading world. Despite a number of estimation problems--in particular, key parameters in the commodity supply, commodity export demand, and livestock supply equations that had to be specified from nonsample information--the model performed reasonably well. The annual time dimension did not allow an assessment of the implications of interest rates on private storage or the interactions between private and public storage. Moreover, many agricultural sector policy instrument variables were not included in the model specification.

A second, even more aggregate, model representation has been presented by Lamm (1981a). In this model specification, only three inputs to agricultural production are specified: the real annual flow of capital into the agricultural sector, the agricultural labor force, and time. In light of the changes in relative input prices, this model is unable to capture the input substitution that has been underway for almost a decade. Furthermore, this model, as well as the Shei model fails to account for the accumulation of wealth by different sectors.

Another third-generation model, recently developed by Prentice, consists of more than 100 equations and provides greater detail regarding many parts of the economy than is available in the models developed by Shei and Lamm (1981a). However, it fails to include credit markets; thus, it ignores the increasingly important financial linkages between agriculture and the rest of the economy.

Still another third-generation model is based on a massive data collection effort by Hughes and Penson. This model captures many important linkages

including interactions between (1) agricultural producers and suppliers of input; (2) agricultural output, wholesale purchase of food items, and the final consumption of agricultural goods at the retail level; (3) agriculture and the U. S. balance of trade and exchange rates; (4) agriculture and the government sector; and (5) agriculture and national financial markets. It emphasizes the effects of financial links and uses a framework of a supply of and a demand for loanable funds for linking balance sheet data from the agricultural sector with the balance of the economy and various arms of monetary policy. The interface of farm accounts and demand for input is used as the basis for a loanable fund demand function which, while interacting with the supply of funds loanable to agriculture, solves for the equilibrium credit to this sector. This impressive modeling effort is based on annual data interpolation from annual U. S. census and farm accounts. Among other potential deficiencies, the principal limitation is that the model is based on a "flex/flex" framework. With such a framework, it is not possible to assess the potential macroexternalities of food price increases.

2.3. An Integrative Perspective

A review of the models presented above strongly suggests that what is missing is an integrative focus on the role of (1) inflation, (2) exchange rates, and (3) the effect of sector versus general economic policies. None of the previously mentioned modeling efforts concentrate on this integrative focus. Various separable elements are available and will be discussed here briefly prior to moving on to the model representation advanced below.

2.3.1. Inflation Focus

Among the first serious evaluations of food prices and inflation was that published by Hathaway. He argued that food price inflation in the early 1970s

was largely the result of increased demand plus production shortfalls. D. Gale Johnson argued, by contrast, that the large price increases in international markets occurred primarily because consumers and producers were prevented from reacting to price changes that resulted from governmental policies designed to stabilize domestic prices. In his view, all of the adjustment to the production shortfalls and demand increases was imposed upon a rather limited segment of the worldwide market for feeds and grains. In support, he offered the classic example of sugar prices from early 1974 through early 1975.

An additional explanation by Lawrence (1980) emphasized the role of speculators in this price explosion. Commodities were treated as assets as well as inputs into consumption. They argue against the view that a rise in primary commodity prices represents solely a change in relative prices.

Some have argued that the rapid accumulation of international monetary reserves is a source of the disturbances. However, the transition mechanism between reserves and commodity prices has not been modeled adequately. Recently, Lawrence (1980) has argued that their consequences in commodity market behavior can be appreciated fully only when these markets are embedded in a general equilibrium model of a dualistic economy which has both auction and customer markets. A formal model of a dualistic economy is developed which includes three markets: a money market, a primary commodity market that clears in the short run by price adjustments, and a manufactured goods market that clears in the short run by quantity adjustments. Because expectations are presumed to be rational, in the long run nominal changes are neutral; but, in the short run, unanticipated monetary disturbances affect relative primary commodity prices. Commodity booms may stem from monetary factors in addition to changes in the conventional determinants of supply and demand. Monetary

Empirical analysis on the effects of exchange rates on agriculture includes that by Chambers and Just (1979, 1981). The second study constructed a dynamic quarterly model to analyze the time path of effects of the exchange rate on prices received; quantities produced; consumption; exports; and inventory stocks for wheat, corn, and soybeans. Johnson et al. have reported a similar analysis for the wheat commodity system. These empirical studies suggest that the exchange rate elasticity of price is greater than unity, that there is a complex time pattern of adjustment, and that the pattern differs across commodities. However, these empirical investigations are very partial in their perspective They ignore any effects of exchange rate changes on domestic price inflation and incomes which, in turn, impact on agricultural input costs and output demand. However, Shei analyzes the effects of the devaluation on the general economy and supports the view that the partial equilibrium approach overestimates the domestic price effect of a devaluation on agricultural prices by a substantial margin.

Considerable controversy has arisen on whether exchange rates have real as well as nominal effects. In large part, the resolution of this controversy depends on rigidities in the economy, expectation formations on prices and further exchange rate changes, and whether the initial state is one of equilibrium or disequilibrium. In any event, the principal factors and causal mechanisms determining exchange rates, now that market forces rather than governmental decree play a dominant role, have been subject to considerable debate. Focusing on the capital component of the balance of payments, there is a growing body of theory and empirical studies supporting the view that monetary and fiscal policies affect capital flows; and this component, in turn, is an important causal force explaining short-term movements of exchange

rates. Both Frankel and Driskill provide supporting empirical studies for the monetary approach. These efforts, along with other studies on the traded goods and services component, suggest that the exchange rate and agriculture must be imbedded in the model which recognizes economywide behavior along with monetary, fiscal, and official foreign reserves policies.

The specification of exchange rate determination is intimately tied to the export demand relationships facing U. S. agricultural commodities. In most empirical studies to date, the exchange rate is treated as exogenous in the latter relationships. Most efforts to date operate with net export demand functions along the lines of Houthakker and Magee and, thus, omit potential causal factors that are likely to bias estimates of export price elasticities downward. Bredahl et al. have specified a framework which allows for partial responses of domestic to world prices resulting from policy intrusions, transport cost, and product heterogeneity. Work along similar lines in an empirical setting may be found in Abbott as well as P. Johnson. This work is motivated, in large part, by the controversy surrounding the price transmission elasticity for different countries due to national agriculture and trade policies, including the sensitivity of these policies to market conditions. For these reasons, empirical estimates of the export demand elasticities for particular commodities vary widely. For aggregate net export demand in the United States, these estimates range from less than unity up to approximately 10. Operationally, it is indeed likely that the time path of adjustment will depend upon short-run inventories, lagged supply response, and eventual policy reactions to market prices. Hillman, Johnson, and Bale and Lutz have discussed these issues. Zwart and Meilke have investigated these issues for wheat and argue, based on their results, that overseas policies

have exaggerated the instability of world excess demand for U. S. agricultural commodities. This empirical work supports the views of D. Gale Johnson.

2.3.3. Focus on General Economic versus Sector Policies

The studies surveyed in this section strongly suggest that output prices and input costs of the agricultural sector are significantly influenced by economic events in the rest of the economy and the trading world. The studies provide building blocks of an integrative framework which attempts to capture the interrelationships between agriculture, the domestic economy, and the international economy. These interrelationships establish a dynamic pattern of feedback effects among prices, outputs, and incomes among the different sectors. A general equilibrium representation of these interrelationships allows analysis of the full effects of the agricultural sector, general economy, and trade policies. The traditional sector or commodity policies pursued by the U. S. government are currently viewed by much of the profession as inadequate for dealing with the new instability affecting U. S. agriculture (Schuh). Over the last three years, this instability has been magnified by U. S. monetary policy and the resulting volatility of interest rates and exchange rates.

Unfortunately, there has been no quantitative analysis on the effectiveness of general economic policies versus sector policies on the performance of the U. S. agricultural sector. In general, there remains a dearth of analysis on the indirect and feedback effects resulting from these two general types of policy interventions. Schnittker, Hathaway, Cooper and Lawrence, and Prentice and Schertz have investigated policy options for ameliorating the effects of volatility in the agricultural sector on general economy prices and macroeconomic performance. However, to our knowledge, no studies have attempted to

quantify the effects of such policies in a fashion which recognizes the price and quantity interlinks between commodity policies, general inflation indices, the exchange rate, and aggregate economic activity. The only empirical investigation pointing in this direction is based on the Wharton macro and agricultural sector econometric models (Chen). In this study, the "parity price" values for 19 commodities were introduced into the Wharton agricultural model using inputs from the Wharton macroeconometric model. The resulting simulations of the Wharton agricultural model were fed into the Wharton macroeconometric model to generate revised general inflation levels, national income levels, world trade, and related magnitudes. These revised values were, in turn, fed into the agricultural model, and the effects were evaluated. The simulation indicated large increases in farm income, the consumer price index, and treasury costs with significant reductions in domestic and export demand.

3. IMPORTANT ISSUES

The purpose for undertaking the model construction presented in this paper is to provide answers to the following questions:

i. What are the effects of alternative exogenous shocks on the agricultural sector and the general economy?

ii. Should sector policies in agriculture be designed to deal with specific shocks on the agricultural sector?

iii. In analyzing various policies and their effects on the agricultural sector, are sector policies more or less important than macroeconomic policies?

iv. In evaluations of agricultural sector policies, what is the relative magnitude of effect on the general economy as well as the agricultural sector?

The last two questions are largely self-explanatory, while (i) and (ii) may require some elaboration. Analysis conducted to date on the macroeconomy investigates only the effects of agricultural droughts or production shortfalls (Gordon). In quantitative models of the general economy, export demand booms have not been analyzed. Proper identification on the source of shocks is imperative in evaluating the optimal design of accommodating monetary and fiscal policies as well as sectoral policies. To be sure, an export boom versus a domestic drought or governmental supply restrictions implies far different levels of export receipts and national income. If export demand for agricultural grains is elastic, a drought or supply control will result in a fall in export income. By contrast, an outward export demand shift would have the opposite effect. Given agriculture's 20 percent contribution to U. S. export receipts, these two alternative sources of shocks can have opposite and significantly different implications for optimal exchange rate and monetary policies. Policy reactions to these forces will have secondary repercussions on the agricultural sector and on the balance of the domestic economy.

To respond adequately to each of the issues (i-iv), a quantitative model must be constructed to determine the effects of the following shocks:

1. A dramatic shift in grain export demand.
2. A dramatic environmental induced change in agricultural crop production.
3. A change in agricultural policy such as price-support schemes, land-use controls, and public holding of stocks.
4. A change in fiscal policy.

5. Changes in monetary policy, including sterilization or no sterilization of changes in foreign account and in government deficit; and accommodation or not, for real shocks in the agricultural sector and the balance of the international economy.
6. Changes in exchange rate policy couched in terms of fixed, flexible, and government-managed floating exchange rate regimes.

To assess the effects of these shocks, key features must be incorporated into the model representation. The key features of the model constructed in this paper, which distinguish it from those reviewed in section 2, include: explicit treatment of public versus private grain storage, detailed agricultural sector policies, and policy reaction functions for both monetary and agricultural sector instruments; a flex price specification for the agricultural sector and a fixed price specification for the domestic economy; explicit links with the international economy and endogenous determination of the exchange rate; and explicit links between the domestic economy and the agricultural sector through agricultural input markets; inventory investment equations for agriculture and the balance of the economy along with fixed investment relationships for breeding stocks in the livestock sectors; and margin relationships between farm and retail prices. The special features integrated in one model distinguish the representation presented here from what is available in the literature. To be sure, many of the building blocks are available in the current literature; but, as yet, the integration of these particular features have not appeared in any of the academic or commercially constructed models.

4. THE MODEL

The model is defined in terms of the performance variables, the policy and other exogenous variables to be manipulated, and the key underlying causal relationships and identities. As previously noted, the model focuses primarily on policy analyses rather than forecasting. It is designed to assess the time path of direct and indirect effects of a changed policy or other exogenous variable in one sector of the economy on itself as well as the other sectors.

4.1. Performance Variables

The effects of alternative values of exogenous variables are analyzed by their time pattern of effects on related performance variables. For the general economy, these variables are aggregate inflation (measured by the consumer price index) and real income (measured by the gross national product). Performance variables from the agricultural sector include commodity-level measures of prices and quantities produced, domestically consumed, exported or imported, and held for stock. More aggregate measures include net income to crop producers (wheat, coarse grains, and soybeans); net income to livestock producers (beef, hog, poultry, egg, and dairy); and the value of agricultural land. The effects on the relative importance of trade and private capital flows and effects on the exchange rate or change in official reserves are analyzed. Initially, the study will consider the expected changes in the performance variables; but, at a later stage, assessments of the relative variability of key performance variables under alternative scenarios will be assessed.

4.2. Exogenous Variables

We are interested in analyzing the effects of two sets of exogenous variables. For the noncontrollable exogenous variables, they are a weather-induced fall in domestic crop production and a boom in overseas demand for U. S. crop products. Both variables were attributed some of the blame for the stagflation experience of the 1970s. The model can also be used to assess the effects of exogenous changes in rest-of-world prices including oil.

A second set of exogenous variables is the policy variables. At the general economy level, these include fiscal policy either as a change in government expenditure and/or in taxation collections and monetary policy via the purchase of government securities and/or changes in bank reserve requirements. Future studies could also consider changes in fiscal policies as they affect investment and depreciation components of the user cost of capital variables. The level of the exchange rate can be set directly or indirectly by changes in the holdings of net official reserves. The model constructed, however, will focus largely on experimentation with a diversity of agricultural instrument variables. These include crop acreage set-aside provisions and diversion rates; loan rates; direct income grants and deficiency payments; direct government storage purchases and subsidies on private storage; government food purchases and disposals; and, in the case of livestock products, regulations on allowable import levels and domestic milk prices.

In practice, many of the policy instruments will be adjusted as a policy set. For example, an expansionary policy package could involve expansion of the money supply, expansionary fiscal policy, and devaluation. A farm income support package might entail a policy mix of acreage restrictions, government storage expansion, deficiency payments, and lower livestock imports.

Moreover, policies which help quell inflation and thus exert downward pressure on farm input costs could be considered part of a farm income support package.

All policy instrument variables will not be regarded as strictly exogenous. For particular scenarios, some of them will be treated as endogenous policy reaction functions. An accommodating monetary policy and an acreage diversion rate positively related to accumulated grain stocks are two examples.

At the conceptual level, the model is specified in such a manner that a diversity of potential policy variables can be manipulated. However, in practice only some of these instruments will be varied for particular dynamic path assessments. Other variables can be held constant or they can be modeled by endogenous policy reaction functions.

4.3. Model Structure

The model provides links, both direct and indirect, between the exogenous variables and the performance variables. It is based on behavioral relationships and identities. A quarterly time period is used. This degree of temporal disaggregation permits an understanding of the dynamic interrelationships between different prices in the models which would be glossed over with an annual model. On the whole, the agricultural sector is specified as a flex price model and the rest of the economy as a fixed price model.

The agricultural sector is specified as a series of supply and demand equations with price playing the key equilibrating role. Agricultural crop production is disaggregated into wheat, coarse grains, and soybeans; cotton, tobacco, fruits, vegetables, and other crops are not included. Demand equations are specified for domestic food demand, export demand, private storage demand, government storage demand, and government export disposal. Planted

acreage equations representing planned supply are expressed as functions of expected market prices, government policies regarding loan rates and diversion payments, and input costs. The planted acreage equations are related to general economy movements in wages, interest rates, and material costs. Actual supply is explained by planted acreage, seasonal conditions, technology, and current output prices. Livestock products are disaggregated into beef, pork, poultry, eggs, fluid milk, and manufactured milk products. Domestic supply is influenced by expected and past output prices, by feed costs, and by costs of nonfarm purchased inputs. Particularly in the cattle and hog subsectors, allowance is made for cyclical response behavior. Domestic supply plus government-determined import volumes are equated with domestic demand to determine prices. Retail-to-farm-price link equations are influenced by the costs of nonfarm labor and materials. A set of identities determine income to the crop and livestock activities. The income measure is defined as gross receipts less expenditure on nonfarm inputs and, in the case of livestock, less expenditure on livestock feed.

The rest of the economy is modeled along the lines of the new classical economics framework. Aggregate demand is broken down into private consumption expenditure, private fixed capital investment, change in inventories (which, in turn, is segregated into nonfarm and crop commodity inventories), government expenditure, and exports less imports (which also are broken down into agriculture and nonagriculture components). Aggregate supply is represented by price and wage equations. Nonfarm price is determined as a markup over wages (adjusted for productivity) and material costs. Wages are explained by a price expectations-augmented Phillips framework. These equations together provide the key relationships explaining nonfarm prices, wages, and real

income. The general price level is a weighted average of nonfarm prices and food prices.

A conventional money-demand equation is equated to the money supply to determine interest rates. Changes in the money supply result from the government budget deficit plus the net surplus of foreign transactions plus the net change in the Fed holdings of government securities. The interest rate, together with price expectations, enters the consumption, investment, and inventory equations of aggregate real demand, the supply and inventory demand equations in the agricultural sector, and net foreign capital movements.

A balance-of-payments identity ties the international accounts together. Only for agricultural exports is the large-country assumption imposed. For simplicity, the world demand for other exports and the world supply of livestock foods and other imports are assumed to be perfectly elastic. International trade in goods and services is influenced by world price movements and the exchange rate. Net changes in private overseas and foreign capital stocks are influenced by relative domestic to overseas interest rates and by expected movements of the exchange rate. The exchange rate is either predetermined, as was the case before 1973, or set to balance the supply of and demand for foreign currency with an inclusion of exogenous changes in net official revenues. The latter is zero in the case of flexible exchange rates—the 1981 reference—and nonzero for a managed or dirty float—the 1973-1979 experience.

Expected prices play key roles at several points including agricultural supply, the wage equation, and in the aggregate expenditure equations. Initially, adaptive price expectation models will be assumed, in part because they appear to have as much empirical support as alternative models (for example, Feige and Pearce and Stein). Given the interest in, and appeal of, the rational expectations model, the effect of rational and other expectation

models will be evaluated in future specifications of the model. Needless to say, clearly the type of expectations model can have a dramatic effect on the policy analyses. As a simple example, a drought-induced reduction in agricultural output and exports would have a greater effect on the exchange rate and wages with an adaptive expectations model than with a rational expectations model. The latter would treat the disturbance as a temporary and reversible aberration, while the former would regard it as the start of a new trend.

A number of crucial intersectional links should be highlighted. Changes in agricultural prices, due to seasonal factors and overseas demand or government policies, feed directly into food prices and, more importantly, indirectly into animal-based food prices because of changed livestock production costs. The latter will involve complex lags. Higher food prices lead to higher wages and, in turn, by the markup equations to higher nonfood prices. These prices, in turn, raise costs to agricultural producers, which affect their production decisions, and the cycle of cause and effect develops. Changes in monetary and fiscal policies influence the money supply and interest rates which alter aggregate demand and prices. They also affect international capital flows, commodity inventory demand, and agricultural input costs. Changes in aggregate consumption alter the domestic demand for agricultural products. Exchange rate movements, which are, themselves, influenced by changes in domestic demand, domestic and overseas prices, and directly by policy, affect foreign demand for exports, supply of imports, and the money supply. These changes set in force pressures for further changes in prices, wages, incomes, and production decisions. Other sectoral interdependencies are represented in the model, but the above discussion outlines some of the more important links.

4.4. Estimation

The complete model contains 51 behavioral equations and 36 identities. Quarterly data for the period 1966(1) to 1980(4) are used to estimate the equations except for the overseas capital flows and exchange rate equations where 1973(2) to 1980(4) data are used. Data series was obtained from the Federal Reserve Model data file, Department of Commerce reports, and U. S. Department of Agriculture reports and personal communication.

The model is essentially a simultaneous equation block with the exception of the agricultural acreage equations which form a block of recursive equations. Initially, the equations are estimated by ordinary least squares (OLS) procedures; but, ultimately, it is proposed to use a consistent estimator. Because of the many nonlinearities of the system, it is solved using the Gauss-Seidel method.

4.5. Distinguishing Features of the Model

In the remainder of this section, we report the distinguishing features of the model. These features are not generally available in previously constructed models. They include the direct effects of agriculture sector policies, meat-breeding stock and production relationships, policy reaction functions, domestic price linkages for farm-retail margins and farm purchased input costs, explicit links with the international economy including endogenous exchange rates; and an asset-market framework for the monetary sector. The complete estimated model will soon be available in a Department of Agricultural and Resource Economics Report.

4.5.1. Direct Effect of Sector Policies

The following discussion centers on the preliminary empirical results of agricultural sectoral policy impacts. Table 1 displays the crop acreage

response elasticities for the effective support rate, diversion payments, market price, and variable costs. The results are consistent with prior expectations and significant. Note, in particular, that the variable cost elasticities are relatively large and governmental policies significantly affecting acreage decisions. The impact of variable costs and market prices on yields are given in Table 2. The elasticities in the coarse-grain and soybean equations are almost equal while the corresponding elasticities are small for wheat.

The number of cows milked (CMK) in the dairy sector is affected by the lagged average price of milk (PM) and the price of feed (PF) as shown in the follwing equation (with standard errors in parentheses and elasticities in brackets):

$$CMK = 3.8 - .13\ D1 - .12\ D2 - .07\ D3$$

$$+\underset{\substack{(.004)\\[.17]}}{.071}\ PM(-2) - \underset{\substack{(.0013)\\[.06]}}{.0023}\ PF(-2) - \underset{(.006)}{.02T}$$

where D represents a dummy variable to reflect quarterly seasonal effects. The prices for fluid milk are set by the federal government in relation to the minimum support price for milk used in processed products. The blend price received by farmers is a weighted average of the two prices set by the government.

Since government stocks and exports of crops frequently represent 50 percent of total stocks and exports, explicit representation of the interaction between private and public stockholding is modeled. Briefly, the federal government sets target prices, storage and interest rate subsidies, and diversion payments. Private economic agents respond by deciding on the

TABLE 1

Estimates of U. S. Crop Acreage Response Elasticities, 1954-1980

	Wheat		Coarse grains		Soybeans	
	Short run	Long run	Short run	Long run	Short run	Long run
Effective support rate						
Wheat	.27 (.06)[a/]	.57				
Coarse grains			.08 (.05)	.19		
Soybeans					.15 (.06)	.57
Effective division payment						
Wheat	-.02 (.01)	-.05				
Coarse grains			-.04 (.01)	-.09		
Market price of previous year						
Wheat	.15 (.06)	.32				
Coarse grains			.12 (.06)	.29	-.29 (.07)	1.11
Soybeans			-.12 (.06)	-.29	.50 (.07)	1.97
Variable costs of off-farm inputs of previous year						
Wheat	-.15 (.06)	-.32				
Coarse grains			-.16 (.08)	-.38		
Soybeans					-.22 (.04)	- .85

a/ Estimated standard errors given in parentheses.

b/ Costs of purchased materials, hired labor, and interest payments.

Source: Computed.

TABLE 2

Estimates of U. S. Crop Yield Response Elasticities, 1954-1980

	Wheat		Coarse grains		Soybeans	
	Short run	Long run	Short run	Long run	Short run	Long run
Farm price						
Wheat	.09 (.07)[a/]	.09				
Coarse grains			.27 (.11)	.55		
Soybeans					.29 (.10)	.41
Variable costs of off-farm inputs[b/]						
Wheat	-.11 (.07)	-.11				
Coarse grains			-.39 (.11)	-.78		
Soybeans					-.35 (.13)	-.50

a/ Estimated standard errors given in parentheses.

b/ Costs of purchased materials, hired labor, and interest payments.

Source: Computed.

appropriate levels of private stocks, production, marketings, and the net amount of grain placed under the government loan and Farmer Held Reserve programs. Net of direct government purchases and sales, governmental inventories are then determined. Table 3 gives the results of the equations explaining net placements. Changes in beginning public stocks, interest rates, target prices, and market prices consistently and significantly affect net placements for both wheat and feed grains. The level of grain production and beginning private stocks also significantly and positively affect net placements but are not reported in Table 3. Private stock demand equations are given in Table 4. Private stocks are affected by production; government controlled stocks; interest rates—current and expected; target and market prices; and incoming private stocks.

4.5.2. Livestock Inventory and Output Decisions

An example of the opposite effects between the short- and long-run changes in meat and feed prices in the livestock industry is shown below for the hog sector. The inventory investment of breeding stock (IH) is affected positively by lagged hog prices (PH) and negatively by feed prices (PF) and interest rates (IR):

$$IH = 331.1 + 250.1\ D1 - 268.8\ D2 - 22.5\ D3 + \underset{\substack{(.11)\\ [.11;\ 3.5]}}{23.1}\ PH(-1)$$

$$- \underset{\substack{(-.08)\\ [-.08;\ -2.4]}}{8.3}\ PF(-1) - \underset{(34.7)}{18.4}\ IR(-4) + \underset{(.07)}{.96}\ IH(-1).$$

In contrast, hog production (QH) is negatively related to changes in hog prices and positively related to feed prices and off-farm costs of production (C):

TABLE 3

Elasticity Estimates for Selected Variables on Net Quantities of Grain Placed Under Government Storage Programs Quarterly, 1966-1980

	Wheat		Coarse grains	
	Short run	Long run	Short run	Long run
Target price				
Wheat	13.4 (3.1)[a/]	18.4		
Coarse grains			16.4 (3.2)	23.4
Market price				
Wheat	-13.4 (3.1)	-18.4		
Coarse grains			-16.4 (3.2)	-23.4
Government stocks				
Wheat	- 5.8 (1.7)	- 8.0		
Coarse grains			- 7.6 (1.5)	-10.8
Interest rate				
Wheat	.06 (2.1)	.08		
Coarse grains			6.34 (2.01)	9.1

a/ Standard errors given in parentheses.

Source: Computed.

TABLE 4

Elasticity Estimates for Variables Affecting
Private Industry Demand for Grains
Quarterly, 1966-1980

	Wheat		Coarse grains	
	Short run	Long run	Short run	Long run
Target price				
Wheat	.16 (.07)[a/]	.42		
Coarse grains			.06 (.047)	.16
Government stocks				
Wheat	-.07 (.02)	- .18		
Coarse grains			-.05 (.024)	- .14
Interest rate				
Wheat	-.10 (.07)	- .26		
Coarse grains			-.02 (.036)	- .05
Grain production				
Wheat	.46 (.04)	1.21		
Coarse grains			.47 (.02)	1.27
Market price				
Wheat	-.06 (.057)	- .16		
Coarse grains			-.06 (.047)	- .16

a/ Standard errors given in parentheses.

Source: Computed.

$$QH = 1218.9 - 11.5\ D1 - 137.7\ D2 + 282.8\ D3$$

$$+ \underset{(.037)}{.21}\ IH(-3) - \underset{\substack{(3.63)\\[.303]}}{24.4}\ PH + \underset{\substack{(1.46)\\[.07]}}{2.4}\ PF + \underset{\substack{(11.2)\\[.33]}}{80.7C}$$

Any shock to the economy leading to increased feed prices will exacerbate hog-meat prices in the short run through liquidation of hog inventories and increased hog supply. However, hog prices will be higher in the long run compared to initial levels since hog supply will decrease due to depleted breeding stocks. Similar patterns of cyclical response to price changes were found for cattle and beef.

4.5.3. Policy Reaction Functions

In general terms, policy decisions with respect to import quotas on livestock and dairy products, minimum support prices for grains and dairy products, government stocks, and government purchases and sales of grain and dairy products represent a political balance between higher prices sought by producers, lower food costs sought by consumers, and small and nonvisible budget outlays. A formal optimization model analysis of U. S. beef import quotas by Rausser and Freebairn in which the import level was positively related to prices and negatively related to the inventory of animals had good explanatory properties for the 1970s. A similar approach can be taken here for the other sectors and policies noted above since the entire constraint structure is estimated for each sector influenced by governmental policies and linked to general economy price, expenditure, and public budget levels. The response of private economic agents to governmental program instruments is modeled explictly and, hence, allows for the direct derivation policy-reaction functions on the part of government. Certain preliminary reduced-form,

policy-reaction functions were estimated in this model for government target prices, wheat and coarse grains, and milk support prices. This allows for the direct feedback effect of economic conditions on governmental behavior.

4.5.4. Domestic Price Linkages

The degree of interdependence between farm prices, P^f, retail food prices, P^r, nonfarm (product and services) prices, P^n, raw material (principally energy) prices, P^e, general wages, W, and costs of nonfarm inputs (which enter farm-supply functions), C^f, in the model is represented by the following set of equations:

(1) retail-farm price equations:

$$P^r = f(P^f, W, P^e),$$

(2) nonfarm price mark-up equation

$$P^n = f(W, P^e),$$

(3) general price index identity

$$P = \theta P^r + (1 - \theta) P^n,$$

(4) Phillips curve wage equation

$$W = f(EP, Y - YP),$$

and

(5) farm purchased input cost identity

$$C^f = \phi_1 W + \phi_2 P^n + \phi_3 P^e + \phi_4 r,$$

where EP denotes expected price, Y - YP denotes the difference between realized and potential GNP, r denotes nominal interest rate, and all other terms are as defined above. Similar to the results reported by Hein and by Larnm and Westcott, our estimates of the retail-farm price equations indicate that changes in farm prices take two quarters before being fully reflected in

changes in retail prices. Also, we find no evidence of significant non-symmetries of response to price rises and falls. Our estimates of the nonfarm price and wage equations yield similar results to previous studies of Gordon, Wachter, and others; as with these studies, it is difficult to distinguish between different lag structures. There seems to be some instability of parameters, and some specifications imply an accelerationist relationship. In total, the five equations describe a highly interrelated process of cause and effect between farm and nonfarm prices.

4.5.5. Explicit Links With the International Economy and Endogenous Determination of the Exchange Rate

The general specification of the identity for U. S. transactions with the rest of the world is given by

$$CX * PC + OX * \frac{PW}{E} - LM * PPL - OM * PW * E + PNCF + COR = 0$$

where

CX = real quantity of crop exports

PC = index of crop prices in $U.S.

OX = real quantity of other exports

PW = index of world prices (using same weights as for exchange rate)

E = index of exchange rate (defined as number of $U.S. required to purchase a unit of foreign currency given by the Federal Reserve Board's bilateral 10-country weighted index)

LM = real quantity of livestock imports

PPL = index of livestock import prices in $U.S.

OM = real quantity of other imports

PNCF = net change in private capital assets (defined as change in U.S. private assets abroad plus change in foreign private assets in the United States less discrepancy)

and

COR = a balancing item representing net change in official assets (by both U. S. and foreign country authorities).

Crop exports, CX, and crop price, PC, are derived from a price clearing model which has equations for crop production, domestic demand for food, domestic demand for feed, private inventory demand, government inventory demand, and a supply equals demand identity. Rather than estimate simplified export demand elasticities and risk the many biases associated with this procedure (see Orcutt and Thompson), we used Yntema's formulae to calculate the export demand elasticities as a weighted sum of domestic demand and supply elasticities in the principal export-competing and import-competing countries. We have extended the procedure used by Bredahl et al. to allow for time lags in response and for cross-price effects. Specifically, for the export demand elasticity in a particular period, we use the formulae:

$$E_{ij} = \sum_r \left\{ \frac{Q^d_{ir}}{Q^e_i} E^d_{jr} E^d_{ijr} - \frac{Q^s_{ir}}{Q^e_i} E^s_{jr} E^s_{ijr} \right\} + \sum_t \frac{Q^m_{it}}{Q^e_i} E^m_{ijt}$$

where

E_{ij} = elasticity of export demand for i with respect to price

E^d_{ijr}, E^s_{ijr} = elasticity of demand and supply, respectively, for i with respect to price j in country r

E^d_{jr}, E^s_{jr} = elasticity of response of domestic demand price and supply price, respectively, to exporter's price

E^m_{ijt} = elasticity of excess demand in country t (distinct from country r) for imports of i with respect to exporter's price j

Q^e_i = U. S. exports of i

Q^d_{ir}, Q^s_{ir} = quantity of i demanded and supplied, respectively, in country r

and

Q^m_{it} = net import of i by country t.

The preferred strategy was to treat all countries in the first right-hand term; however, limited data forced the treatment of the centrally planned economies by the second right-hand term.

The implementation of the above relationships required data from several sources. Briefly, the country breakdown follows that of the USDA Grain, Oilseeds and Livestock Model (GOL) described by Rojko et al. (a total of 26 country groupings). Quantity data came from USDA publications. The price elasticities refer to three periods: (1) where there is is no supply response (one quarter); (2) where short-term supply response is allowed (one year); and (3) the long run. The price elasticities of demand, long-run supply, and of import demand of the centrally planned economies elasticities are essentially those of the GOL model (where available) updated by recent estimates reported in the literature. The short-run supply elasticities are based either on available studies or set at half the long-run supply elasticity. Values for the price transmission elasticities (with extreme values of zero for completely insulating domestic policies and unity for free trade) are determined arbitrarily after consideration of information on national agricultural policies compiled by FAO, country yearbooks, annual reports of marketing

authorities, and professional journal articles. For example, in the case of wheat, the price transmission elasticities for the EC are set at 0 for the short run and 0.1 in the long run; for Canada, at 1.0; and for Australia, at 0 in the case of consumption and 0.75 in the case of production. Clearly, some approximations are invoked. The derived direct and cross-price elasticities of demand for U. S. exports of wheat, coarse grains, and soybeans are given in Table 5.

Comparing the long-run direct price elasticities of export demand with those of other studies, they are much greater than those obtained by Chambers and Just who use a simplified net export demand function (-.25 for wheat, -.62 for corn, and -.29 for soybeans) and are less than those estimated by Johnson (-6.7 for wheat and -10.2 for feedgrains) although slightly above the preferred estimates of Bredahl et al. (-1.67 for wheat, -1.31 for corn, -2.36 for sorghum, and -0.47 for soybeans). Of course, the cross-price elasticities reduce the value of our total elasticities below the direct price effect. A single variable representing the net effects of supply and demand factors for U. S. effects was estimated as a residual item. Since the model is designed only for policy analysis, this is not considered a weakness.

For livestock imports, principally beef and manufactured dairy products, policy factors are dominant. Our initial specification assumes that the import quantity, LM, is determined by a quota and that the domestic price, PM, is paid for these imports. The domestic U. S. price is determined from a solution of domestic demand equals domestic production plus imports of livestock products. It is assumed that this price exceeds the world price, that exporting countries receive the rent between the United States and world price, and that the United States can purchase LM without driving the world

TABLE 5

Estimated Direct and Cross Price Elasticities
of Export Demand for U. S. Crops

	Elasticity with respect to price of:		
	Wheat	Coarse grains	Soybeans
<u>One quarter</u>			
Wheat	- .57	.21	0
Coarse grains	.16	-1.00	.45
Soybeans	.02	.08	- .61
<u>One year</u>			
Wheat	-1.34	.47	0
Coarse grains	.40	-1.54	.48
Soybeans	.02	.16	- .94
<u>Long run</u>			
Wheat	-3.80	1.19	0
Coarse grains	1.19	-3.97	.70
Soybeans	.05	.54	-1.76

Source: Computed.

price above PM. These assumptions are in accord with the facts for most of the 1970s. An alternative specification replaces the exogenous import quota with a policy reaction function.

Turning to the exports of noncrop products, OX (mainly of a manufacturing source) and imports of nonlivestock products, OM (mainly raw materials and manufactured products), we assume that the United States can be regarded as a small country. This simplifying assumption is based on quasi-free trade in these products and the fact that U. S. foreign trade represents less than 10 percent of the rest of world production. As a result, world prices, PW, are treated as exogenous. The demand for other imports and the supply of other exports are described by the functions:

$$OX_t = -15.06 - \underset{\substack{(30.81)\\[-0.71]}}{64.69} \sum_{i=0}^{7} w_i \left(\frac{P}{WP^*E}\right)_{t-i} + \underset{(.0199)}{0.1396Y} + \underset{(6.5315)}{7.1529D}$$

$$w_0 = -.87,\ w_1 = -.21,\ w_2 = .26,\ w_3 = .54,\ w_4 = .64,\ w_5 = .55,$$

$$w_6 = .28,\ w_7 = -.19$$

$$OM = -164.1 + \underset{\substack{(6.70)\\[0.59]}}{46.53} \sum_{i=0}^{7} w_i \left(\frac{P}{WP^*E}\right)_{t-i} + \underset{(.0074)}{0.1566Y}$$

$$w_0 = .54,\ w_1 = .19,\ w_2 = -.04,\ w_3 = -.16,\ w_4 = -.16,$$

$$w_5 = -.05,\ w_6 = .17,\ w_7 = .50$$

where

OX = real noncrop exports

OM = real nonlivestock imports

P = U. S. nonfood price index

WP = world price index

E = index of exchange rate

Y = real U. S. GNP

and

D = dummy variable for pre-1973.

The long-run import demand elasticity of 0.59 is similar to that obtained by Goldstein et al. and Murray and Ginman when they impose the homogeneity constraint (estimates of 0.68 and 1.23, respectively); but the results of these and other papers question forcing this constraint. Our estimated export supply elasticity 0.71 is less than the estimate of between 3 and 6 obtained by Goldstein and Khan. We found no significant response of either import demand or export supply to the gap between actual and potential GDP. Thus, income has a linear effect in both equations.

To explain the net change in private capital assets held by U. S. residents and foreigners, PNCF, we used a simplified portfolio capital model and followed the empirical work by Kreicher. Our equation estimated over the period 1973 to 1980 is:

$$PNCF = -6.98 + \underset{(1.2106)}{3.7914}\ (R_d - EP) - \underset{(1.0275)}{3.3355}\ (R_w - EPW)$$

where

PNCF = net private capital flow,

R_d = domestic short-term interest rate (three-month Treasury bill rate),

R_w = foreign short-term interest rate (using Federal Reserve Board bilateral weighted series),

EP = expected domestic inflation (using adaptive expectations model

$$EP_t = 0.2\ P_t + 0.8\ EP_{t-1}),$$

and

EWP = expected world inflation (using adaptive expectations model

$$EWP_t = 0.2\ WP_t + 0.8\ EWP_{t-1}).$$

The estimates indicate that changes in domestic and world real interest rates and expected inflation rates are significant causal variables.

Given the above determinants of the demand for and supply of foreign currency (in terms of $U.S.), the balance of payments equation can be used to reflect three scenarios for the determination of exchange rates. First, the exchange rate is set exogenously; thus, the change in official reserves, COR, is treated as a residual endogenous variable. Second, a scenario of fully flexible exchange rates is obtained by setting COR = 0, and solving the balance of payments equation for the exchange rate, E. Third, a scenario of a managed float (the 1973-1980 story) can be used. This can be achieved by setting COR exogenously and solving the balance of payments for E. Alternatively, changes in the exchange rate can be modeled by a policy reaction function. We estimated such a function:

$$e = .69 - \underset{(.0431)}{.1146} \sum_{i=0}^{7} w_i (PFUND)_{t-i}$$

$$w_0 = .42,\ w_1 = .24,\ w_2 = .11,\ w_3 = .03,\ w_4 = -.01$$

$$w_5 = -.00,\ w_6 = .05,\ w_7 = .15$$

where e denotes percentage change in exchange rate (at annual rate), and PFUND is the balance of payments on private account. This equation indicates that,

as the private balance of payments goes into debt, the authorities devalue the $U.S. but with some adjustment and/or expectation lags. Adjustments can be initiated by changes in the individual components of PFUND which include domestic prices of crop, livestock and nonfood products, and world prices; domestic and foreign interest rates; and expected domestic and foreign inflation rates.

4.5.6. The Monetary Sector

The formulation of the monetary sector follows the current literature rather closely. The demand for real money balances is estimated as a function of real income (positive and significant); the nominal interest rate (negative and significant); and the lagged real money balances (stable, positive, and significant). Money supply is treated as an identity; it equals the previous stock of high-powered money plus governmental deficits, the change in official reserves of foreign assets (balance of trade from the real sector plus net short-run capital inflows), and the change in the Fed's holdings of bonds all times the money multiplier. The interest rate is determined endogenously by equating money demand and supply.

The above (partial) financial asset portfolio view forms the basis for the simulation analysis reported in the following section. A second version of a monetary sector is under development. This second version emphasizes not only commodity assets but other nonfinancial assets such as land, gold, consumer durables, and residential and commercial real estate. In total value terms, these tangible assets are approximately equal to public holdings of financial assets. This second version leads to a generalized "asset market" approach where increases in the real rate of interest causes public holdings to shift from tangible assets to financial assets and vice versa for decreases. Tax

policy (ordinary and capital gain tax rates) over the sample period magnify the effects of decreases in the real rate of interest. No simulation results are reported here for this generalized asset market view. We hope to provide such results in the near future.

5. SIMULATION RESULTS

At this juncture, only a few simulations have been conducted with the estimated model. Further revisions of the model specification will be made prior to any additional simulation experiments. In any event, the results of four experiments are reported here: (1) a permanent increase in crop export demand; (2) a temporary increase in crop export demand; (3) restrictive monetary policy; and (4) a bountiful harvest in the current crop year, 1981.

5.1. A Permanent Increase in Crop Exports Demand

The model is used to assess the impact of a permanent increase in grain export demand due to world shortfalls in crop production, changes in agricultural policies, or other exogenous shocks in the rest of the world. The effects of the export boom on the time paths of U. S. crop and livestock prices and quantities, real income, inflation, nominal wages, international transactions, and the exchange rate are evaluated.

The initial effect of the export shift is to raise domestic and world prices of grain and reduce domestic feed and food demand for grain. The extent of the price increase is conditional on the initial level of inventories and the time required by stockholders to realize that the demand shift is not temporary but long term. Prices will increase approximately 40 percent assuming no inventories. Domestic food demand is 20 percent of total sales with a price elasticity of 0.2; feed demand is 30 percent of total sales with

short-run and long-run price elasticities of 0.2 and 0.4, respectively; and short-run and long-run export demand elasticities of 1.0 and 3.0, respectively. The initial impact will be moderated over time as supply and feed demand respond. As a result, prices will increase by 10 percent with total output improving by 8 percent (assuming a long-run supply elasticity of 0.8). In addition, these direct effects will be modified by indirect effects on the exchange rate, nonfarm input costs, and national income.

The higher costs of grain will significantly affect the poultry, egg, and dairy industries by inducing a contraction in supply causing their prices to increase by 8 percent and 10 percent in the short- and long-run, respectively (assuming short- and long-run supply elasticities with respect to feed costs of 0.2 and 1.0, respectively). For the cattle and hog industries, the response will be more complicated due to cyclical behavior. Indeed, their prices will fall in the short run as breeding herds are liquidated in response to the decline in expected profits. After two and three years for hogs and cattle, respectively, the decline in breeding inventory and feeding rates (rate of gain and animal weights) will result in higher meat prices.

Via the consumption multiplier and investment accelerator processes, the crop export boom induces an increase over time in national income, exceeding that of the increase in farm income. The sooner the crop boom is recognized as permanent, the faster this phenomenon will occur.

An important indirect effect of the export boom is the induced rise in general inflation and wages. This process is more complicated in its time dynamics than described by Okun (1975), Gramlich (1979), and others. The high domestic grain prices flow through to higher retail prices for cereal products and products based on oilseeds. These products, however, have a less than

5 percent weight in the CPI. By the end of the year, prices of dairy products, poultry, and eggs will be higher. Importantly, for the reasons discussed above, prices of the important beef and pigmeat products which contribute over 6 percent of the weight of the CPI will not contribute to inflation in the short run. By the end of three years, their prices will rise significantly as a result of the higher grain prices.

In turn, wage rates will rise, in part because the higher consumer price index raises both current and expected inflation rates and, in part, because the increase in real income leads to less resistance to wage increases via the Phillips curve relationship. Here the way in which the food price increases influence expectations about inflation is important.

Given the initial increase in wages, there will be rises in nonagricultural prices via the cost markup rules for pricing these products. The higher wage and nonagricultural product prices will influence farm as well as nonfarm production and investment decision making. The interaction between wage increases and nonagricultural product prices works to magnify the original effects. In the accelerationist models, this process can proceed for many quarters and beyond. This aspect of the model forms the basis of most macroeconomic frameworks.

Looking at the balance of trade, the initial favorable effects of the crop export boom will be partly offset by the rise in imports caused by the increase in real income. While the induced rise in domestic price levels will, ceteris paribus, work against a favorable trade balance, it is likely that this will be matched by similar price rises in other trading countries. Almost certainly the net effects will be positive.

A number of alternative scenarios can be drawn for the money supply. The favorable balance of trade will increase the money supply if it is not sterilized by the authorities. Whether the increased nominal money supply causes a rise or fall in interest rates depends on the combined offsetting effects of the increases in real income and in nominal prices. A fall (rise) in interest rates will cause a flow of funds out of (into) the country and increase (reduce) real investment and inventory holding activity. If the increased money supply is sterilized, it is clear that interest rates will have to increase and that this will lead to increases in foreign capital inflow and place a depressing effect on domestic real income.

Assuming there is no marked increase in capital outflow, the favorable trade balance will exert pressure for a currency revaluation. A revaluation will help to restrain inflationary forces as well as influence industry structure. In the very long run, a sustained crop export boom will call for some contraction of competing export and import industries.

The many interrelationships and feedback effects present a complicated picture which is sensitive to numerous paremeters, expectation formation patterns, and policy reactions. Nonetheless, some general effects on the agricultural sector and general economy performance variables can be drawn. The boom in crop export demand will increase crop income; reduce livestock income; and, in net, increase aggregate agricultural income. The net gains will increase with time because of greater adjustment possibilities. An isolated agricultural sector model analysis would overestimate the income gains by ignoring the impacts of the induced rise in labor and nonfarm input costs on farm supply and demand, the currency revaluation, and by underestimating the induced increase in livestock product prices. Higher general economy prices,

wages, and real income will flow from the export boom. The long lags before higher livestock product prices enter the general economy were not captured by previous macroeconomic analyses and nor were the impacts on the exchange rate.

5.2. A Temporary Increase in Crop Export Demand

The effects of a temporary shift in export demand is critically dependent on the expectation formation patterns of agricultural producers, wage bargainers, price setters, and policymakers. In the rational expectations formulation, agents will view the boom as a temporary reversible aberration and so induce minimal short- and long-term effects will be induced. Changes in inventories will absorb much of the market requirements and, hence, dampen short-run price movements. Producers will not alter planned crop acreages and livestock inventories. Wage negotiators will place little weight on any temporary food price inflations, while government authorities will use monetary and exchange rate policies to counteract any potential short-run food price inflation.

In a world of adaptive or extrapolative price expectations, there will be important short-term effects but few long-term effects. With the anticipation that changes in forces will continue into the future, the observed effects for the short and intermediate term will be similar to those described in 5.1. When the export demand contracts, these very same forces will be set in reverse. Other than the observation that money wages do not contract, there is little evidence of asymmetrical responses by decision-makers as between price rises and price falls.

5.3. Restrictive Monetary Policy

Suppose the monetary authorities effectively reduce the rate of growth of the money supply by selling government securities to the public. What happens in our model to the key performance variables in the general economy, the agricultural sector, and the interface with the rest of the world

The story for the general economy is essentially that of the new classical economics model in an open economy. A reduction of the money supply leads to a fall in real money balances and a rise of interest rates (or a fall in the rate of money growth causes a fall in the rate of growth of real monetary balances and a rise in interest rates). The higher interest rates adversely affect inventory and investment levels but with a long pattern of lags which, in turn, shift the aggregate demand curve to the left. This has the effect of reducing aggregate real output and the rate of inflation. However, the fall in inflation in time shifts the aggregate supply curve to the right, and these shifts increase real output while reducing the inflation rate. Under the simple rational expectations model of Lucas, Sargent and Wallace, and others, the supply curve shifts at the same rate as the demand curve so that real output differs from potential output only by a white noise random variable. When allowance is made for lagged inventory and investment responses to interest rate changes, the situation revealed by econometric studies, including our model and Blinder and Fischer, reveal the resulting cyclical responses. Under adaptive price expectations in the wage equation, the monetary contraction will cause a fall in real income in the short run; however, there is a longer run tendency to return to full employment. The latter result stems in no small part from the fact that adaptive expectations are asymptotically rational. There is a growing body of empirical evidence supporting some element of adaptive expectations.

The inclusion of international trade complicates the model in two ways. First, a lowering of the inflation rate relative to that in other countries improves the competitive position of the traded goods industries. Again, the response to changing relative prices takes two years to fully adjust in our model. The improved trade balance leads to a rightward shift of the aggregate demand curve. Second, higher interest rates will increase net capital inflow on the foreign account. The induced improvement of the balance of payments on both the trade and capital accounts will add to the money supply, and here we assume this effect is sterilized as part of the restrictive monetary package. Also, it will create pressures for revaluation of the exchange rate.

Combining these effects, we can draw the following picture. The short-run effects of a tighter monetary policy is to reduce the rate of inflation, reduce the level of real income, and improve the balance of payments. There is a longer run tendency for real income to return to its potential level. A long-run equilibrium situation requires full employment, an inflation rate equal to the rate of growth of the nominal money supply, and the exchange rate to change as the difference between the domestic and world inflation rates (the purchasing power parity doctrine in a world of no real changes).

These macroeconomic effects have important implications for the agricultural sector. The fall in real income in the short run reduces demand for the meat and dairy products (income elasticities around 0.3) but has only small effects on demand for cereal products and eggs (income elasticities less than 0.05). These responses will take some time because of lagged responses of real income to higher interest rates and because of lagged response of consumption expenditure to changed income. In the livestock industries, the fall in consumer demand could initiate a phase of liquidation of the breeding

herd. The decline of the livestock industries, together with reductions in the direct crop product demand, will result in reduced domestic demand for crops, a fall in their prices, and increased export sales. Over the longer run, the return of real income to full employment levels will reverse these short-term effects.

By reducing the rate of inflation, the tight monetary policy will improve farm incomes. Costs of purchasing off-farm labor, goods, and services and costs of off-farm marketing activities will be less than they otherwise would, although some of this will be offset by the higher interest costs. Lower production costs will facilitate higher farm incomes and increased supply response. However, should domestic inflation fall significantly below inflation in overseas countries, there will be pressures for revaluation of the currency. This, in turn has adverse effect on export demand for crop products and leads to falling crop prices.

Then, as for the general economy, tight monetary policy will have no effects in the long term on agriculture, since it affects only nominal and not real terms. However, it may have important short- and intermediate-term effects. Because of longer lags between the fall in income and its effects on food demand and on lower general prices and wages, it is likely that farm incomes will increase during the short run. This will be more so in the case of the crops where there are further lags in the livestock derived demand, and there are the cushioning effects of an elastic export demand. In time, currency revaluation associated with the relatively low level of domestic inflation will cause the rate of change of prices received to fall back into line with the rate of change of prices paid. Our results support the view that the long run will be approached not in a monotonic fashion but via a dampened cyclical path.

5.4 A Bountiful Harvest, 1981

It is interesting to use our model to describe the likely path of general prices, wages, and income and of agricultural prices, inventories, and income over the next year or so. Specifically, consider the case of a bountiful harvest, tight monetary policy, no changes in fiscal policy, a flexible exchange rate policy, and no changes in agricultural sector programs.

The initial price-depressing effect of the bountiful harvest will be exaggerated by secondary effects. The tight monetary policy causes a rise in real interest rates. These, in turn, depress nonfarm inventory investment and fixed investment. After a period of steady adjustment, there will be reductions in real income, employment, and consumption expenditure including that on food—more so for the income-elastic meats. At the same time, the high interest rates will encourage greater capital inflow which, together with the fall in imports caused by the slowdown of real income growth, will cause some appreciation of the exchange rate. In addition, the higher interest rates induce the private sector to hold less crop inventories.

Effects on the livestock sector are more complex. The fall in crop prices, by reducing animal feed costs, will raise expectations about the future profitability of animal production. While this will mean greater supplies of poultry, eggs, and dairy products in the next quarter, its initial effect for beef and pork will be the reverse since animals are retained for breeding rather than being sent for slaughter although those animals slaughtered will be fed to heavier weights. However, the fall in income associated with the tight monetary policy will, in due course, cause a shift to the left of the food-demand curves. After some quarters, the meat price decline may exceed the effect of the feed-cost decline on expected livestock profitability.

The longer run and, perhaps, the intermediate run (after a year) effect will be for livestock prices to fall.

Developments stemming from the tight monetary policy and the fall of agricultural commodity prices will be deflationary. Low commodity prices work through to lower food prices but with the full effect taking up to two quarters which, in turn, reduces expected prices used in the wage-bargaining process. Slower real income growth will also exert a downward force on the rate of wage expansion. In turn, lower wage increases mean lower rates of growth of nonfarm prices. The reduced rates of wages and nonfarm prices will offer some relief to nonfarm costs but, of course, they will still have to incur the high interest-rate costs.

6. CONCLUDING REMARKS

The dynamic econometric model presented in this paper adequately incorporates the interactive and feedback effects of macroeconomic policies, sectoral policies, and noninstrument shocks on key performance variables in agriculture and the general economy. Previous frameworks focusing on agriculture are viewed as too partial (Ekstein and Heien, Hathaway, D. Gale Johnson) or too simplistic in their evaluation of various sources and types of shocks. Moreover, the perspective offered by macroeconomists has failed to treat the agricultural and food system adequately and to identify the appropriate source of the shock in evaluating macropolicies. To correct the narrow focus and partial treatments of inflation, exchange rates, and dichotomous sectorial and macropolicies, the current model representation is integrative in scope and distinguishes key features of public versus private decisions, policy reaction functions, and fix/flex prices.

The results indicate that policy and noninstrument shocks (1) have different short-run and long-run effects in terms of both magnitudes and direction on key performance measures, (2) have effects that result in sectoral policies which are substitutable or complementary with macroeconomic policies in either the short or long run with some reversals occurring due to the dynamics of the meat sector, and (3) are either exacerbated for some policies or ameliorated for others by including the endogenous policy reaction functions.

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