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MACROECONOMIC ENVIRONMENT FOR U. S. AGRICULTURAL POLICY

by

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June 1985

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Chapter 1

Introduction

Thus far in the 1980s, the course and path of the U. S. agricultural sector have been dramatically influenced by external events in the domestic and international economies. Many of these events can be traced to the change in U. S. Federal Reserve policy in October of 1979 and focus of the Reagan Administration on fiscal policy. In October of 1979, the Federal Reserve adopted a policy of attempting to control money supply directly, rejecting their previous policy of targeting interest rates. The Reagan Administration adopted a policy of reducing federal taxes and expenditures with significantly more success achieved in reducing revenues. Huge federal government deficits have resulted which the Federal Reserve has, on the whole, consciously avoided monetizing.

The U. S. fiscal and monetary policies have driven real interest rates to all-time highs. The management of money supply in the United States and the relatively high interest rates in this country have reversed the decline of the U. S. dollar that occurred throughout the 1970s. Interest rates have played a major role in enhancing the value of the U. S. dollar against other major currencies to a point that very recently exceeded the level of the dollar prior to the introduction of flexible exchange rates. Given the dominant role of the Federal Reserve and the rapid appreciation in the value of the dollar, other central banks also maintained a tight rein on their money supply. They also attempted to manage the value of their currency vis-à-vis the dollar by selling dollars and buying their currencies. As a result, they indirectly contracted their own respective money supplies. These monetary

phenomena, along with the following factors, combined to cause significant decreases in the real prices and, in fact, deflation in agricultural commodity markets over the period of the 1980s.

1. A steady increase in the value of the dollar which has increased import competition for a number of economic sectors including elements of U. S. agriculture and has had the additional effect of decreasing the inflation rate.
2. The reduction of some barriers to trade which enhanced supply response and increased the liquidity of international markets for a number of commodities.
3. A significant decline in the rate of export growth that faces the United States (from the less-developed, the industrialized, and the Communist countries), in part, due to the rapid increase in competitive supplies available from other agricultural exporting countries, for example, Brazil and Argentina.
4. The record crops that occurred in 1981 and 1982 which brought significant pressure on spot markets and led to market prices that enhanced the attractiveness of the farmer-held reserve that was established by the Food and Agriculture Act of 1977 and continued under the Act of 1981.^{1/}

With the deflation in agricultural commodity markets and the increasing attractiveness of financial assets, the value of some agricultural asset values, particularly land, has dropped sharply. Due to the role of land resources as collateral for agricultural loans and credit lines, the apparent

debt-absorption capacity of U. S. agriculture has fallen markedly. This is evidenced by the increased frequency of bankruptcies in the agricultural production sector and by what has come to be called the agricultural financial crisis of 1984.

In the decade of the 1970s, the implications of economic linkages with the U. S. general economy and the international economy on the agricultural sector are almost the exact opposite of the conditions that exist in much of the 1980s. In 1972-73, the magnitude of increases in farm product and food prices surprised even the most informed people within the public and private sectors. The move to flexible exchange rates, the rapid expansion of international markets, the emergence of a well-integrated international capital market, and the decreasing barriers between the agricultural economy and other domestic economic sectors all resulted in significant changes in the agricultural sector. During this period, the Federal Reserve expanded the U. S. money supply with the effective objective of holding the real price of energy at basically the same level; other countries attempted to "inflate their way out" of the energy price shocks by increasing their money supplies. They also attempted to manage their exchange rates with the U. S. dollar by selling their currencies and buying dollars and, thus, indirectly increasing their money supplies even more. These monetary phenomena, combined with the following factors, pointed in the same direction of rapidly increasing agricultural commodity prices:

1. The value of the U. S. dollar on international currency markets steadily declining.
2. The barriers to trade which insulated many countries from the price-formation process on international markets and, thus, eliminated potential supply responses to the

favorable prices and made international markets "thinner" than they otherwise would have been.

3. The "real" export demand growth in a number of less-developed countries (LDC) along with industrialized and communist countries improving or upgrading the diet of their consuming populations.
4. The elimination of the huge governmental stocks that had accumulated during the 1960s^{2/} motivated by the U. S. Treasury exposure of carrying public stocks.

The increases in commodity prices, along with the rapid rate of inflation experienced in 1972-1974 and again in 1978-1980, resulted in a dramatic move in the valuation of the major resource input in agricultural production, namely, land. The price increases in land values indeed increased more than almost all other assets in the U. S. economy. Due to the distinction between tax rates on earned income and on capital gain income, U. S. agricultural land prices increased at a more rapid rate than the rate of inflation during much of the 1970s. Once again, due to the role of this resource input in agricultural credit markets, namely, its use as collateral for agricultural loans and credit lines, the total absorption capacity of U. S. agriculture for debt appeared to be augmented by leaps and bonds during the decade of the 1970s.

Hence, beginning in the early 1970s, the U. S. agricultural sector has been subjected to a vicious roller-coaster ride, the valleys and peaks of which have been defined largely by the external linkages to the U. S. macro-economy and the international economy. To be sure, the external linkages with the domestic economy and with the international economy have made it crystal clear that timing, in terms of entry and exit from U. S. agricultural

production, is indeed critical. New entrants into agricultural production, prior to 1972, are doing quite nicely even in the face of the rapid declines that have occurred in asset values and in income levels during the 1980s. In fact, on the basis of asset values alone, such owners of agricultural land could be totally incompetent at farming and still have benefited substantially from their investment. Currently, anyone entering agricultural production during the period of 1978 through 1980 is either on the verge of bankruptcy or has an independent source of wealth and income, independently of how effective he or she might be as a farming entrepreneur or manager.

In addition to the external linkages with the domestic and international economies, government commodity policies continue to play a major role in determining the course and path of the U. S. agricultural sector. Numerous surveys and evaluations of U. S. agricultural policy have been conducted,^{3/} and many views exist on the formal justification for governmental intervention. As argued at some length in Just and Raussers,^{4/} the only market failure justification for governmental intervention is excessive uncertainty or unanticipated instability.^{5/}

Prior to 1972, the common explanations for this instability were the inelastic nature of aggregate food demand; the low income elasticity of demand; and, on the supply side, weather patterns, rapid technological change, atomistic behavior (and in some treatments, naive price expectations), and asset fixity.^{6/} These characteristics were viewed as existing in a closed, insulated representation of the U. S. agricultural sector. Without governmental intervention, the inherent and unanticipated instability resulting from these characteristics was regarded by many to be unacceptable to all actors in the food and agricultural system: input suppliers, producers, assemblers, processors, distributors, and consumers.

Long ago, Keynes^{7/} argued that the inherent instability in storable commodity markets would lead to insufficient private stockholding. Risks associated with price volatility coupled with uncertainty about the ultimate "normal price" and the length of time that stocks would have to be held were viewed as the three major contributing factors for this outcome. Keynes argued, as Houthakker^{8/} did some years later, that government intervention was needed because of divergence between social and private risks. Bosworth and Lawrence^{9/} consider this perspective along with a number of other justifications for government interventions to stabilize the prices of volatile commodities and come to the conclusion that the divergence between social and private benefits provides the best justification. In particular, private stockholders will not store for extreme contingencies because they do not expect to receive the true scarcity value of their stocks during such periods.

Since 1972, the conventional wisdom has placed increasingly less emphasis on the inherent instability in commodity markets and more emphasis on external linkages with other markets. During this period, the deregulation of the credit and banking system resulted in a greater exposure of agriculture to conditions in the domestic money markets. Also, because of the shift from fixed exchange rates to flexible rates, commodity markets have become more exposed to international money markets and real trade among countries. Moreover, the emergence during this period of a well-integrated international capital market meant that agriculture, through domestic money and exchange rate markets, has become increasingly more dependent on capital flows among countries.^{10/}

Government behavior has also played an important role in commodity market instability. After the Soviet grain deal, the absence of government-held

stocks contributed to the large price increases. With the Food and Agriculture Act of 1977, changes in the commodity programs were introduced which permitted a wider fluctuation in prices. The export embargo in 1980, variations on the rules of the Farmer Owned Reserve program since 1980, and the Payment-In-Kind (PIK) program of 1983, to name but a few major changes in government agricultural programs, make it clear that policy uncertainty can be a major contributor to private commodity market instability. In addition, the mere existence of governments is a major reason why private stockholders may not store for extreme contingencies and, thus, provide needed price stabilization. History reveals that it is difficult for governments to resist taking actions that interfere with the market system during periods of shortage.^{11/}

Since 1972, the greater dependence on trade has exposed U. S. agriculture to more shocks from foreign markets. Consistent with increased dependence on trade for the world economy as a whole, U. S. agriculture is heavily dependent on exports. In the late 1970s, U. S. agricultural exports accounted for almost 40 percent of total output. In addition, agricultural exports represent approximately 20 percent of the total U. S. exports. Net agricultural exports consistently make a positive contribution to the balance of payments, while the nonagricultural sector is a net importer. To be sure, this increased dependence has made U. S. agriculture less stable due, in part, to the emergence of the Soviet Union, with its unstable agriculture, as a major importer and due to barriers to trade which cause changes in foreign markets to be borne by the United States and other exporting countries who practice relatively free trade.

The linkages of commodity markets with U. S. money markets are indeed pervasive. Since farming is extremely capital intensive^{12/} and debt-to-asset

ratios have risen dramatically over the last ten years, movements in real interest rates have significant effects on the cost structure facing agricultural production. Stock carrying in storable commodity systems is sensitive to changes in interest rates; and for nonstorable commodities (for example, live cattle and live hogs), breeding stocks are interest-rate sensitive. These effects, combined with the influence of interest rates on the value of the dollar, press grain products from both the demand side (for example, export demand, domestic livestock grain demand, and stockholding demand) and the cost side. The especially sensitive nature of agriculture to interest rates suggests that this sector is vulnerable to unanticipated monetary and fiscal policy changes. It has been argued that, since 1972 but particularly since 1980, the instabilities in monetary and fiscal policies have contributed importantly to the instabilities of commodity markets.^{13/}

There is ample evidence that the U. S. agricultural sector has become more closely linked, due to deregulation and the introduction of completely flexible exchange and interest rates, with the rest of the domestic and international economies. The instability in monetary and fiscal policies is thought to have imposed sizable shocks on commodity markets. If agricultural commodity markets behave as "flex price" markets while others behave as "fixed price" markets, "macroexternalities" will be imposed upon the agricultural sector. That is to say, overshooting will occur in agricultural sector markets even if expectations are formed rationally because of the spillover effects of monetary and fiscal policy on commodity markets.

Overshooting can introduce further instabilities into a sector that is already inherently unstable. These overshooting externalities can assume the form of implicit taxes or subsidies. In the United States, for example, high

and volatile interest and exchange rates work together with corresponding contractions in world income and agricultural export demand to draw resources out of agricultural production. Only in this fashion will the agricultural sector reach an equilibrium with the balance of the U. S. economy. Without governmental intervention, however, farmers are faced with a painful adjustment tax because of agriculture's capital intensity and its dependence on international trade. Over the period from 1980 to 1983, this tax took the form of higher interest payments and lower commodity prices in cases where the supply of goods was not shrinking fast enough. An additional tax was imposed in the form of a significant drop in farmers' stock of wealth. Precisely the opposite situation occurred from 1973 to 1975. The externalities during this period assumed the form of subsidies which led to the accumulation of wealth through large increases in land values.

Given the above perspective, a number of questions arise: (1) What are the major linkages between and among the macroeconomy, international economy, and agricultural economy and how can they be quantified? (2) What is the order of magnitude of effects of policy changes originating in agriculture, the macroeconomy, and the international economy on the three sectors after consideration of the direct, indirect, and feedback effects? (3) Given the importance of agriculture in the U. S. economy [food products contribute approximately 20 percent to the weight of the consumer price index (CPI)], what quantifiable role have commodity markets had on the path (inflationary or deflationary) of general economy wages and prices? (4) What is the differential impact of macroeconomic policies (fiscal and monetary) versus agricultural sector policies on the performance of the U. S. agricultural sector? (5) Should agricultural sector policies be conditional on shocks to macroeconomy and international economy emanating from U. S. fiscal and monetary policies?

The present study will provide preliminary answers to the above questions. A principal constraint facing any empirical attempt to address these questions is the lack of sample data on flexible exchange rates and interest rates facing the U. S. agricultural sector. In the case of flexible exchange rates, approximately ten years of data are available; and in the case of truly flexible interest rates facing agriculture, only four years of data are available. In any event, an attempt to answer these questions begins with a literature review in Chapter 2 followed by specification of the macroeconomy, the international economy, and the agricultural sector economy in Chapter 3. Appendix A provides a complete listing of all variables, endogenous and exogenous, appearing in the specification of each of the three components. Chapter 4 presents the estimated equations. Chapter 5 reports some simulation experiments followed by concluding remarks in Chapter 6.

Chapter 2

Literature Review

Marshaling the literature regarding the three components under examination is a difficult task. In the early 1970s, however, this task would have been relatively straightforward; the agricultural sector was modeled generally as a closed system with only exogenous influences forming the general and international economies. Since U. S. agricultural policy effectively isolated agriculture from domestic and international market forces, such a structure was a reasonable approximation. In addition, most larger 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 a few linkages to the nonagricultural base of the economy with only a minimal degree of feedback.^{1/} Hence, the literature can be examined from three perspectives: a macroeconomic perspective, an agricultural sector perspective, and an integrative perspective. From the macroeconomic perspective, agriculture is treated largely as being predetermined with some backward links; from an agricultural sector perspective, the macroeconomy is treated largely as 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 performances in each of the three major sectors.

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 policy-makers to dismiss the importance of the agriculture and food system. Most studies treated this sector as exogenous. The original Brookings model included an agricultural sector constructed by Fox,^{2/} 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 vendors, such as Data Resources, Inc. (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 with 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 those by Okun; Gordon; and Gramlich.^{3/} Other such studies include those by Kaldor; Phelps; Schlangenhaut and Shupp; Van Duijne; Lawrence; and Blinder.^{4/} 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.

Prior to the early 1970s, standard macroeconomic theory ignored instability problems associated with agricultural production and, instead, concentrated on output versus price adjustments. Moreover, in analyzing the dynamics of wealth, most work focused exclusively on the financial sector ignoring commodity stocks. However, with the flourish of theoretical developments in macroeconomic theory that accompanied the stagflation of the 1970s, agriculture began to receive attention. The major conceptual developments incorporating agriculture are the fixed-price/flex-price formulation emphasized by Hicks^{5/} and Okun^{6/} and the implied "overshooting" popularized by Dornbusch.^{7/}

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,^{8/} 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. His model incorporates money, foreign exchange, and commodity markets along with goods markets. Asset markets adjust instantaneously following a shock, while goods market prices adjust in response to the inflationary gap. In this model, commodity market disruptions have strong and persistent effects on the rest of the economy (that is, prices, exchange rates, trade flows, and capital flows). These shocks are transmitted through substitutions among the three assets. Van Duyne recognizes the significance of the feedback effects from commodity markets to the rest of the economy and makes the separation between fixed- and flex-price sectors. His model also stresses the role of commodities both as investment goods (stockholding and speculation) and as consumption goods. It assumes a stock equilibrium for the commodity markets making commodity prices respond to shocks instantaneously.

From an Agricultural Sector Perspective

In initial modeling efforts in agriculture, this sector was treated as a separate entity. This was justified, in large part, by governmental policies that 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 influence on the rest of the economy. These modeling efforts may be found in Cromarty; Egbert;

Quance and Tweeten; and Lamm^{9/} and in the national programming models built by Earl Heady and his 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 defined linkages. Examples of these linkages include definition of the CPI and of the gross national product (GNP). Adjustments are allowed in order to enforce accounting constraints. This work includes that of Chen^{10/} on the Wharton agricultural sector model and of Roop and Zeitner.^{11/} 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 importantly, 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 interactive solution with the Wharton macroeconometric model in an evaluation of the 1972-73 agricultural price explosion.^{12/}

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 production as 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 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 representing sectoral policies. Policy instruments, such as acreage diversion or set-asides, efficiency 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, that is, 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^{13/} 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 policies and their implications for the general economy. Commodity supply studies initiated by Houck and his colleagues^{14/} 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,^{15/} of the dairy industry program,^{16/} and of the sugar program^{17/} 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, is desirable. In general, 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, ignore 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.^{18/} This third-generation model representation includes twenty-four equations and uses an annual time period. It is 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 among 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 specified from nonsample information--the model performed reasonably well.

A second, even more aggregated, model representation has been presented by Lamm.^{19/} In this model specification, only two major inputs to agricultural production are specified: the real annual flow of capital into the agricultural sector and the agricultural labor force. 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 and the Shei model fail to account for the accumulation of wealth by different sectors.

Another third-generation model, recently developed by Prentice,^{20/} 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 or

Lamm.^{21/} It fails, however, 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.^{22/} This model captures many important linkages including interactions among (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 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 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 or overshooting noted in Chapter 1.

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) the general price level (inflation or deflation), (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 structure specified in Chapter 3.

General Price Level and the Nonneutrality of Money

Among the first evaluations of food prices and inflation were those published by Hathaway.^{23/} He argued that food price inflation in the early 1970s was largely the result of increased demand and production shortfalls. D. Gale Johnson^{24/} 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 commodities. In support, he offered the classic example of sugar prices from early 1974 through early 1975.

An additional explanation by Bosworth and Lawrence^{25/} 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.

Lawrence and Lawrence^{26/} have noted that the consequences of international monetary reserves on 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 (flex) and customer (fixed) 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 commodity prices. Commodity booms may stem from monetary factors in addition to changes in the conventional determinants of supply and demand. Monetary changes are allowed to operate through channels other than those of interest rates and the level of aggregate demand. For such a dualistic economy representation, macroeconomic externalities associated with commodity price fluctuations provide a rationale for direct governmental intervention.

In a frictionless classical framework with complete price flexibility, one-shot monetary disturbances will be neutral. Such frameworks have been referred to as monetarist-new classical models.^{27/} Other frameworks, however, imply different adjustment speeds in nominal variables and departures from money neutrality. In fact, investigations of the money neutrality proposition have empirically addressed the "stickiness" of prices in various markets. If prices are sticky, quite obviously the strict monetarist proposition that money supply growth in excess of the growth in money demand instantly translates into rapid inflation does not hold.

The underlying forces that make some prices sticky do not, of course, hold to the same extent in all markets. Okun^{28/} has emphasized the distinction between manufactured goods and services, which he has referred to as customer markets, and basic commodity markets which he has referred to as auction markets. In this descriptive analysis, customer markets are characterized by

imperfect competition, noninstantaneous arbitrage, and differentiated products which make the adjustments of prices to economic demand and supply forces sluggish. On the other hand, homogeneity and the ease of arbitrage make prices in auction markets instantaneously adjust to demand and supply forces. Perhaps more importantly, it has been demonstrated by Dornbusch^{29/} that, in an economy with both sticky prices and flexible prices, a monetary shock that leaves sticky prices unchanged in the short run causes the flexible price markets to overshoot their long-run equilibrium until all prices reach an equilibrium reflecting the initial monetary shock. As Frankel and Hardouvelis^{30/} point out, "This overshooting phenomenon can be thought of as a macroeconomic example of the Le Chatelier principle. Because one variable in the system (manufactured good prices) is not free to adjust, the other variables in the system (commodity prices) must jump correspondingly further in order to compensate" (page 4).

Conceptual and empirical validation of the fixed/flex price distinction, along with the overshooting phenomenon, has been addressed by a number of authors. Generally, the question that is investigated is not whether commodity prices respond instantaneously while manufactured prices do not but, rather, whether commodity prices adjust at a faster rate than do manufactured or noncommodity prices. As early as 1975, Gordon^{31/} investigated the effect of aggregate excess demand on price movements and concluded that, while nonfood prices are responsive to changes in the ratio of actual to potential income (defined as the inflationary gap), food prices were not found to be so affected. The conclusion drawn by Gordon^{32/} was that food prices adjust quickly to excess demand, while nonfood prices adjust very slowly.

In a subsequent investigation, Gordon^{33/} empirically investigated the Sargent-Wallace-Lucas (SWL) policy effectiveness argument. Here, Gordon^{34/}

attempts to isolate those forces that dictate price stickiness. In particular, he focuses on adjustment costs, long-term contracts, and the decentralization of decision making. In the empirical analysis presented in this paper, price changes are related to changes in the inflationary gap, lag prices, and various forces representing supply shocks. Gordon^{35/} concludes that the empirical results obtained unambiguously reject the SWL proposition in favor of the notion of fixed-price markets. In particular, prices are found to respond slowly to changes in the ratio of current to natural output and respond only partially to expected money growth.

Bordo^{36/} has also investigated the differential rates of adjustments of sectoral prices to monetary changes. In essence, Bordo explains the pattern of industry and sectoral price response to monetary changes by implicit contract lengths. His framework implies that the degree of price flexibility across sectors can be represented by price variability in that sector. On the basis of this proposition, commodities respond more rapidly than manufactured goods to monetary changes. His empirical results validate the distinction between the behavior of auction markets that are characterized by price flexibility and customer markets characterized by the use of long-term contracts and price inflexibility.

On the conceptual front, Mussa^{37/} has recognized the internal inconsistencies that arise when imposing rational expectations on models with sticky prices. To achieve consistency, Mussa has developed a price adjustment rule that " . . . circumvents these theoretical difficulties and analyzes the essential characteristics of this rule" (page 1021). The rule is derived from a microeconomic model in which there is an implicit cost in continuously changing prices; thus, it is optimal to adjust individual prices only at discrete intervals and by finite amounts. In essence, the rule provides for

price changes at such frequencies so as to equate the marginal gains of reducing the losses from disequilibrium to the marginal costs of continuous price changes.

Along similar but more formal lines, Rotemberg^{38/} has developed a formal theoretical model from which fixed-price markets naturally emerge. Specifically, he constructs a dynamic model in which perceived costs of adjustments by firms play a dominant role. Empirical representations are derived that correspond to the fixed-price hypothesis. Empirical estimation of the theoretically derived price paths satisfy all the relevant theoretical constraints and appear to be robust. In other words, the empirical results support the fixed-price hypothesis. Moreover, a nested hypothesis of a "Walrasian adjustment" (instantaneous price adjustment to contemporaneous changes of money balances) is rejected by the data. The principal reasons for these results appear to be the small response of aggregate demand to changes in money balances and the high cost of changing prices. Among the more important results obtained by Rotemberg is the significance that is obtained when food prices and fuel prices are removed from the price indices (gross domestic product price deflator). This result further supports the fixed-price/flex-price separation and differential responses to monetary growth.

In theoretical models which incorporate price stickiness, overshooting of flex-price markets is an obvious result. Very few direct tests of overshooting have, however, been conducted. To be sure, overshooting can only be tested in conjunction with a particular model specification. Thus, the results obtained depend, in part, upon the assumptions therein imposed. Several models of exchange rate determination have been advanced which lend indirect support for the price stickiness hypothesis as well as exchange rate overshooting.^{39/} A direct test of whether overshooting can be validated for

exchange rates has been conducted by Meese.^{40/} His results show that domestic and foreign prices for the United States, Germany, Japan, and the United Kingdom are predetermined with respect to the exchange rate. These results are also consistent with exchange rate overshooting.

Another model of the fixed-price/flex-price variety of the inflation process has been presented by Van Duyne.^{41/} In the long run, output in this model is supply determined; and the inflation rate depends solely on the rate of growth of the nominal money stock. In the short run, however, shocks to food prices can induce substantial and persistent bursts of inflation even if the rate of growth of the money supply is fixed. This framework is used to test the hypothesis that consumers' expectations are biased in the sense of their placing too much weight on the recent behavior of food prices. An acceptance of this hypothesis suggests that shocks to food prices may have magnified effects on subsequent rates of inflation. The empirical results obtained do not support this hypothesis; thus, Van Duyne argues that sectoral anti-inflation policies, such as agricultural export controls and meat price ceilings, are less effective and, hence, less justifiable than is generally presumed.

Still other studies have emphasized the effect of inflation on the performance of the agricultural sector. Tweeten and Griffin^{42/} have investigated prices paid to, and received by, farmers relative to the general price level. This and other related studies incur possible specification errors by omitting other real factors determining prices received and paid. Several studies have investigated the effects of inflation on agricultural finance^{43/} and on farm assets and values.^{44/} In general, these studies support the view that inflation has real effects on the structure and performance of the agricultural production component and on income distribution.

The direct effects of monetary policy on agricultural prices has been evaluated by Belongia and King.^{45/} In their empirical work, the percentage change in the food-price index is regressed on a distributed lag of money growth rates, personal income growth, and relative postsale food-price growth. Their results suggest that, for monthly data, the sum of all dynamic effects of money growth does not differ significantly from one suggesting long-run money neutrality. Belongia^{46/} has also examined the effects of unanticipated monetary shocks on agricultural prices. In this empirical work, deviations from mean-money growth rates are defined as unexpected money growth, and it is related to deviations of relative agricultural prices from their sample means. The results indicate long-run neutrality of agricultural prices to unexpected money growth or surprises. To be sure, these measures of unexpected money and agricultural prices are indeed ad hoc.

Tweeten^{47/} has claimed that inflation is actually harmful to U. S. agricultural producers. In essence, his work argues that the rate of change in agricultural prices diverges from the rate of change in the general price level resulting in reductions in real-farm income. On the other hand, Starleaf et al.^{48/} has claimed that U. S. agricultural producers benefit from inflation. This result is based on regressions of the rate of change in prices received by farmers on the rate of change of prices paid. These regression specifications admit structural factors such as changes in real output, real aggregate demand, and so on.

Gardner^{49/} presents some ad hoc relationships for agriculture during recessions and inflations over the period 1976-1978. Not surprisingly, with only five years of data under a less-regulated agricultural sector, the major variables that possessed explanatory power are recessions and the exchange

rate. More recently, Lombra and Mehra^{50/} investigated the dynamic relationship between an index of food prices and proxies representing monetary and fiscal policies. They found that money stock has a statistically significant cumulative effect on food prices, and this effect increases quantitatively as we move from the farm to the retail level.

Focus on Exchange Rates

The theory of exchange-rate determination has evolved from the traditional Keynesian^{51/} model to the modern asset-market portfolio balance approach--a framework better suited to the analysis of inflation, expectations, and portfolio substitution. The role of the current account in influencing exchange rates has been integrated in the portfolio balance models of Branson; Kouri and Porter; and Rodriguez^{52/} and empirically tested by Hooper and Morton.^{53/}

The shift to flexible exchange rates adds a new dimension to the interdependence between the agricultural and nonagricultural sectors. In a regime of floating exchange rates, the equilibrium rate of exchange is not a price that equilibrates one particular market, such as the market for foreign exchange, or a price that assures flow equilibrium (balance of payments), or the price of relative monies determined in the asset markets (stock equilibrium). Rather, as Fair^{54/} notes:

The exchange rate is not in any rigorous sense determined either in a stock market or in the flow market. The exchange rate has an effect on many of the decisions of the economic agents in the model, decisions regarding both the stock and flow variables, and these decisions in turn affect a number of different markets.

The effects of exchange rates on U. S. agriculture were highlighted by Schuh.^{55/} He argued that the exchange rate was overvalued during the 1960s. This exacerbated the adjustment problems facing U. S. agriculture, and the devaluations and movement to flexible exchange rates during the 1970s led to significant structural changes. The movement away from the fixed exchange rate scheme made U. S. agriculture more vulnerable to international economic events and policies while, at the same time, freeing U. S. agriculture from the implicit export tax burden of the overvalued dollar in the latter days of the Bretton Woods Agreement.

Empirical analyses on the effects of exchange rates on agriculture include works by Chambers and Just.^{56/} The 1981 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, Grennes, and Thursby^{57/} 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, ignoring any effects of exchange rate changes on domestic price inflation and incomes that, in turn, affect agricultural input costs and output demand. Shei^{58/} 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.

Chambers and Just^{59/} continued their effort to examine the effects of exchange rates on U. S. agriculture by investigating the effects of monetary

policy through its influence on the exchange rate. They augmented their model with an endogenous determination of exchange rates. This empirical framework allows the monetary effects to work their way exclusively through the exchange rate. However, the effects of changes in the monetary stock on interest rates, inventories, production costs, etc., are ignored.

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. This component, in turn, is an important causal force explaining short-term movements of exchange rates. Both Frankel and Driskill^{60/} 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. Most operate with net export demand functions along the lines of Houthakker and Magee^{61/} and, thus, omit potential causal factors that are likely to bias

estimates of export price elasticities downward. Bredahl, Meyers, and Collins^{62/} have specified a framework that 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. R. Johnson.)^{63/} This work is motivated 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 ten. Operationally, it is indeed likely that the time path of adjustment will depend upon short-run inventories, lagged supply responses, and eventual policy reactions to market prices. Zwart and Mielke^{64/} have investigated these issues for wheat and argue, based on their results, that foreign policies have exaggerated the instability of world excess demand for U. S. agricultural commodities. This empirical work supports the views of D. Gale Johnson.^{65/}

All of the theoretical and empirical evidence in a literature certainly supports the view that real exchange rates have important and significant effects on the prices of agricultural commodities. For example, Longmir and Morey^{66/} find that a 10 percent change in the real exchange rate results in a 6 percent change in the price of corn and soybeans. These and numerous other studies, however, have not been entirely clear on how the exchange rate should enter export demand equations. In particular, "does the exchange rate have a separate effect on export demand, or should it be used only to adjust domestic prices to translate these prices into their foreign currency equivalent?" Nishiyama and Rausser^{67/} have examined this issue theoretically and

empirically in terms of U. S. agricultural trade with Japan. Their work traces a dynamic path of exchange rate effects on import demands through owned price, cross prices, and the policy distortion effects. Each of these effects are first-round or direct effects of changes in exchange rates and can be analyzed within a traditional partial equilibrium model. In a general equilibrium framework, a number of secondary effects are isolated by Nishiyama and Rausser. Four such effects are identified: (1) capital flow effect, (2) the unsterilized intervention effect, (3) trade balance effect, and (4) the foreign income effect. Of the direct effects, two can be theoretically signed, namely, owned price and policy distortion; and, of the secondary effects, two can be signed, namely, unsterilized intervention and foreign income. The remaining effects are ambiguous and can only be determined by empirical analysis.

Focus on General Economic Versus Sector Policies

Unfortunately, there has been little 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. The first empirical investigation points in the direction of the price and quantity interlinks among commodity policies, general inflation indices, the exchange rate, and aggregate economic activity; aggregate economic activity is based on the Wharton macro and agricultural sector econometric models.^{68/} In this study, the "parity price" values for nineteen 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 models, and the effects were evaluated. The simulation indicated large increases in farm income, the CPI, and U. S. Treasury costs with significant reductions in domestic and export demand.

A short-run theoretical model of the interaction between the financial and agricultural sectors has been developed by Chambers.^{69/} The model is used to examine the effects of monetary policy on the agricultural sector. The short-run effects are not neutral since agricultural prices are more flexible than nonagricultural prices. In order to capture the interrelationships between financial markets and agricultural markets, Chambers specified a theoretical model that contains an asset market with money, domestic and foreign bonds, and an agricultural sector with domestic and foreign demand supply and stockholding equations. This theoretical model determines the exchange rate, interest rate, agricultural and nonagricultural prices, and quantities simultaneously. In this framework, comparative static analysis is conducted to determine the qualitative effects of monetary policy. Unfortunately, the results are ambiguous unless a rather detailed set of additional assumptions are introduced concerning the signs and magnitudes of various parameters.^{70/} The theoretical results are explained by the effect of a restrictive monetary policy on commodity stockholding behavior and the decreased competitiveness of agriculture in world markets due to an increase in the exchange rate.

McCalla^{71/} has described the relationship between commodity markets and international liquidity, exchange rates, and money interventions using

McKinnon's^{72/} basic results on currency substitution. Commodity price declines, according to McKinnon, were caused by a combination of tight monetary policy causing dollar revaluation and export demand reduction and also international portfolio substitutions away from commodities. In the currency substitution framework of McKinnon, monetary policy in the United States has magnified effects on world liquidity. This is because of the high substitutability among currencies and the responses of other governments to the strength or weaknesses of the value of the dollar. In effect, attempts on the part of other governments to preserve the value of their currencies results in the simultaneous contraction or expansion in world-wide money supply. Such global liquidity upheavals have asset market effects on storable commodities and also income effects that affect foreign demands and, thus, exports of U. S. agricultural commodities.^{73/}

Shei and Thomson,^{74/} following the earlier work of Shei,^{75/} advanced a model centered on the analysis of the relationship between inflation and agriculture by combining both structuralist and monetarist characteristics in the model. They consider as structural characteristics the differential path of adjustment among sectors--agriculture being the flex-price part and manufacturing and services being the fixed-price part. As monetarist characteristics, they consider the "autonomous" increases in prices caused by monetary increases. While this model has a number of the intersectoral linkages included, it omits the effects of interest rates on private and public grain storage, most forms of agricultural policy instruments, and the dynamics of adjustment in the livestock component. Moreover, their model and simulations treat the exchange rate as fixed.

A recent effort at conceptualizing and empiricizing the interlinkages among agriculture, the general economy, and the exchange rate is the work of

Freebairn, Rausser, and de Gorter.^{76/} They report that a detailed agricultural sector (crops, livestock, dairy, and poultry) and a small demand-side macromodel were specified and individual equations were estimated. Their improvements over previous studies include endogenizing the international sector (exchange rates) and including direct links from the macroeconomy to agriculture (for example, interest rates on inventories and price/wage inflation on agricultural supply through variable costs) and the influence of certain key agricultural policies.

The agricultural sector representation advanced in the present study is a condensed and improved version of the agricultural component appearing in the Freebairn et al. study.^{77/} The international and macroeconomic components of Freebairn, Rausser, and de Gorter have been altered substantially. A behavioral determination of exchange rates has been introduced, and a more detailed monetary sector subcomponent has been constructed.

Chapter 3

Model Structure

The questions posed at the end of Chapter 1 dictate a model structure which concentrates upon the effects of macroeconomic and agricultural sector policies. For this reason, the model specification is largely determined by the desire to use the model for policy analysis. The constructed model is not designed to serve as a forecasting framework. At this juncture, the model is only a preliminary attempt to assess the effects of policy changes and of other exogenous shocks on each of the three model components. In particular, the model structure must be able to assess the effect of (1) sectoral policies on agriculture, (2) the resulting endogenous variables in the agricultural sector on the general economy, (3) fiscal and monetary policies on the general economy, and (4) the resulting general economy endogenous variables on the agricultural sector. This is accomplished by endogenizing the links among U. S. agriculture, the U. S. general economy, and the international economy.

The studies surveyed in Chapter 2 strongly suggest that output prices and input costs of the agricultural sector are significantly influenced by economic events in the domestic and international economies. The studies provide building blocks for an integrative framework. The framework attempts to capture the interrelationships among agriculture, the domestic economy, and the international economy. These interrelationships establish a dynamic pattern of feedback effects among prices, outputs, and incomes across the different sectors. Only a general equilibrium representation of these interrelationships allows analysis of the full effects of the agricultural sector, general economy, and trade policies. In what follows, the specified structure of each component (macro, international, and agriculture) is briefly described.

Structure of the Macroeconomy

There are at least three major specifications that could be advanced for the macroeconomy component: (1) new classical monetarist, (2) Keynesian, and (3) neo-Keynesian. In (1) price determination occurs in flex-price or "auction" markets, and the general price level is set by the rate of monetary expansion. Expectations are rational, the Phillips curve is vertical, and a monetary approach is taken to explain the balance of payments. The Keynesian framework (2) is well known and need not be repeated here except to note that it does admit some administered prices; in particular, wages are presumed to be sticky downward and flexible upward. The third framework (3) follows the fixed-flex price determination advanced by Hicks^{1/} and elaborated upon by Okun.^{2/} The macroeconomic representation of (3) contains a number of "customer" markets. In these markets prices are sticky due to contracts which set prices (based upon economic forces in some previous period); thus, disequilibrium output adjustments are required. For such markets, prices are sticky in the short run but flexible in the long run. The inflation rate over the long run equals the rate of monetary expansion.

Macroexternalities can be imposed upon the agricultural sector under (2) and (3), but no externalities are admitted by (2) aside from the short-run effects of unanticipated money. The model advanced in the present study for the macroeconomy component can be described as a neo-Keynesian, sticky-price framework. Its fixed-price character comes from the specification that prices adjust slowly to changes in excess demand through an expectations-augmented Phillips curve. The major subcomponents of the specified structure are aggregate consumption, aggregate domestic investment, domestic monetary sector, Phillips curve relationship, domestic income sector, and a government finance

sector. A complete listing of the endogenous variables for each of these subcomponents is provided in section 1 of Appendix A. Aggregate domestic demand is composed of equations for private consumption expenditure, private fixed-capital investment, change in inventories, and government expenditure. Interest rates influence private expenditures. Aggregate supply is represented by price and wage equations. Nonagricultural prices are determined as a markup over wages (adjusted for productivity) and material costs. A price expectations-augmented Phillips framework explains wages. These equations provide the key relationships determining prices, wages, and real income. The general price level, which also enters the wage equation, is a weighted average of nonfarm prices and food prices. The monetary financial component consists of a money demand equation, a money supply process, and interest rate determination equations for both the short and long term.

In specifying the macroeconomy component, particular attention was paid to a framework that easily handles fiscal and monetary policies as well as agricultural policies. As a result, the framework incorporates a series of links with the agricultural sector and a series of important policy instruments. The model specification admits the possibility of conducting combinations of policy experiments, both monetary and fiscal.

As revealed in Figure 1, much interaction exists between the subcomponents of the macromodel. For linkages within the income-determining subcomponent, aggregate income and its elements (consumption and investment) are linked such that changes in any of the elements bring about changes in income through the GNP identity and through multiplier effects appearing in the individual equations of consumption and investment. An increase in aggregate income flows into the monetary sector through an increase in aggregate demand. It leads

to an increase in the total demand for money and an increase in the yield on bonds as demand for credit increases for new investment. As the gap between current and potential income closes, employment tends to rise as do wages and prices. Linkages with the international economy component, revealed in Figure 1, lead to an increase in imports and appreciation in the exchange rate as the domestic demand for money rises provided that domestic money supply remains fixed. For the financial sector of the model, an increase in nonborrowed reserves tends to reduce short-term interest rates and, consequently, long-term interest rates. These lower rates feed into the aggregate demand through consumption of durables and aggregate fixed domestic investment.

The government finance sector includes an equation determining total tax collections by the federal government which is affected by changes in nominal GNP. Increases in tax collections help finance government expenditure and, also, reduce disposable income which is endogenously determined by income and taxes. The model preserves the Federal Reserve's independence in conducting monetary policy. In the case of government deficits, the Federal Reserve decides what portion it will finance by purchasing government securities.

Because of the importance of monetary policy, the change in policy regimes from controlling interest rates to controlling the money stock is reflected in the specification of the monetary-financial sector. A monetary policy shock has a number of effects. For example, if the shock assumes the form of an increase in money growth rates, short-run interest rates will decrease because of increases in nonborrowed reserves of commercial banks and relative credit availability. The decrease has spillover effects to the long end of the yield curve and tends to drive the long-term bond rate down. This tends to increase investment, GNP, etc. As argued in the following section, it also affects the

exchange rate directly and indirectly (through changes in short-run interest rates). It creates inflationary expectations to the extent that part of the shock is considered permanent. Those expectations feed directly into the price level through the expectations-augmented Phillips curve and also tend to drive the long-term interest rate higher, thus, counteracting the liquidity effects.

The monetary sector of the macroeconomy component and the associated actions of the Federal Reserves' accommodation-nonaccommodation of the government deficit/surplus (or sterilization-nonsterilization of foreign reserves) may be represented in many different forms. In the specification advanced here, three identities will form the basis for the role of the Federal Reserve and the interaction among money creation, deficit spending, and government debt holding. These identities are:

$$\begin{aligned} G - T &= \Delta B_d + \Delta B_{cb} + \Delta B_f && \text{(government deficits)} \\ CA + KA + ORT &= 0 && \text{(current account)} \\ \Delta B_{cb} - ORT &= \Delta MB && \text{(monetary base)} \end{aligned}$$

assuming for simplicity that treasury cash reserves remain constant and where G = government expenditures, T = taxes (net transfers to public sector), ΔB_d = net change in domestic holdings of government bonds, ΔB_{cb} = net change in the Federal Reserve Bank holdings of government bonds, ΔB_f = net change in foreign holdings of government bonds, CA = current account, KA = capital account, ORT = official foreign reservation transactions, and ΔMB = change in the monetary base (high-powered money). Note that G and T are part of the demand model of the macroeconomy model. The government deficit equation is defined to be the government budget constraint, and the budget surplus/deficit

is financed through bond purchases/sales by the U. S. Treasury. The current account equation represents the foreign account or balance-of-payments equilibrium under either fixed or flexible exchange rates.

Two extreme cases illustrate the workings of the government deficit identity. If the entire deficit is publicly financed, then the change in Federal Reserve bond holdings is zero; investors finance the deficit by accepting additional government securities. On the other hand, complete monetization of the deficit occurs if the Federal Reserve engages in open-market operations by buying bonds. This increases the stock of high-powered money and Federal Reserve holdings of government securities. Thus, the money supply, rather than the supply of bonds held by the public, is increased; and the deficit is financed by money supply creation.

At the same time, there is also a constraint on the operations of the central bank which holds under fixed or flexible exchange rates. This is a condition on the international transactions of the United States, reflected by the current account identity. Under fixed exchange rates, official reserve transactions are dictated by the other two balances and are necessary to offset excess demand or supply for dollars without exchange rate movements. Under freely floating rates, the exchange rate adjusts in a manner consistent with this identity; and there is no need for official reserve transactions.

The final identity relates to the creation of a high-powered money or monetary base. The difference between the change in bond holdings by the Federal Reserve and the official reserve transactions is the change in high-powered money. The first term, representing the monetization of the debt, creates money since the Federal Reserve open-market operations involve the purchase of bonds which are paid for by increasing its liabilities to the

banking sector. However, to the extent that bonds are acquired through official reserve transactions and then sold to the general public through the opposite open-market operation, the change in the monetary base is offset.

The money supply is represented by

$$MS = m \cdot MB$$

where MS is the money supply, m is the money multiplier, and MB is as defined above. Changes in the money multiplier can result from Federal Reserve Bank actions (for example, changes in commercial bank reserve requirements or in the federal fund rate); commercial bank behavior (for example, changes in lending decisions or in reserves); and the public behavior (for example, change in currency demand or in demand deposits). For simplicity, m is regarded as fixed in the current model specification. Changes in the monetary base result from Federal Reserve Bank behavior outlined above. The monetary equilibrium can be summarized by two equations,

$$G - T - ORT = \Delta B_d + \Delta B_f + \Delta MB$$

and the equilibrium condition in the money market. The interest rate is determined by the money market equilibrium condition. Changes in the interest rate directly affect private expenditure decisions in the rest of the domestic economy and a number of relationships in the international and agricultural economy components.

Note that the government deficit equation can be decomposed to permit the endogenous variables of the agricultural sector to be jointly determined with the government finance sector. When particular conditions in agricultural markets make necessary some expenditures as part of agricultural policies,

that portion of government spending is no longer exogenous. Thus, agricultural markets have a feedback directly to the domestic macroeconomy, one which does not exist under either exogenous government spending or under the typical "satellite" model approach to the agricultural sector.

Structure of the International Economy

For reasons of simplicity and variable parsimony, the structure of the international economy was specified to involve six endogenous variables and a large number of exogenous variables (see section 2 of Appendix A). Tradables are disaggregated into agricultural and nonagricultural components. Private capital transactions are influenced by relative interest rates--expected rates of inflation in the United States and in the rest of the trading world. Prior to 1973, a fixed exchange rate is specified. Since then, exchange rates are determined by the supply and demand for foreign currency with an inclusion of exogenous changes in net official reserves.

The detailed specification of the identity for U. S. transactions with the rest of the world in terms of U. S. dollars is given by

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

where CX = real quantity of crop exports, PC = index of crop prices in U. S. dollars, OX = real quantity of other exports, PW = index of world prices (using the same weights as for exchange rate), E = index of exchange rate (defined as number of U. S. dollars required to purchase a unit of foreign currency) given by the Federal Reserve Board bilateral ten-country weighted index, LM = real quantity of livestock imports, PPL = index of livestock import prices in U. S. dollars, OM = quantity of other imports, and KA and ORT are as defined in the section on structure of the macroeconomy.

Crop exports, CX, and crop price, PC, are aggregates of the export quantities and prices of wheat and feed grains. Similarly, livestock imports and prices, LM and PPL, refer to aggregates for beef. Livestock imports are treated exogenously, but wheat and feed grain exports are determined endogenously. The demand portion of this endogenous determination is specified as a net rest-of-world excess demand function. The key price variable is the relative U. S. farm price adjusted for any export subsidy divided by the world price. The exchange rate measured as dollars (U. S.) per unit of foreign currency enters the specifications as a separate explanatory variable. Because there are substitution possibilities in both the production and the consumption of those grains in other countries, the export demand will have cross-price as well as own-price arguments. The effects of shifts in foreign income, of production shifts in other countries, and of seasonal conditions are included in the specification.

The import demand of nonagricultural products implicitly assumes that the supply of imports to the United States is nearly infinitely elastic. The export equation is regarded as a reduced-form equation of a supply of and demand for U. S. exports described in Goldstein and Khan.^{3/} While the response to income changes is considered to be fairly immediate, the specification allows for delayed adjustments in the case of price changes.

The exchange rate determination is based on an asset market framework.^{4/} The basic assumptions underlying this framework are rational expectations, sticky prices, and uncovered interest parity. The model bridges the gap between monetarist theories of exchange rate determination and "sticky price" models; namely, the effects of a change in the interest rate on the exchange rate are different depending on whether or not the change represents a real

change or a change due to a rise in inflation expectations. Thus, a rise in the U. S. nominal interest rate due to a rise in the real interest rate will cause the dollar price of foreign currency to fall (appreciation) since demand for U. S. assets increases. On the other hand, a rise in the nominal interest rate due to a rise in inflationary expectations will cause the exchange rate to depreciate since demand for foreign assets relative to the United States will rise.

An increase in U. S. real growth causes demand for U. S. money to rise, and a given money supply causes the dollar to appreciate. The opposite happens with a rise in foreign real economic growth. Finally, a rise in inflationary expectations in the United States will depreciate the exchange rate while the opposite happens with inflationary expectations in the rest of the world. As the causal flows revealed in Figure 1 show, the international sector real part (imports and exports) feeds directly into the income determination sector (with opposite signs). The exchange rate affects both imports and exports, and its effect spreads throughout the model via aggregate demand changes. Note, also, that changes in the wage-price combinations affect the international sector via the changes in the U. S. wholesale price index that enter both export demand and import demand equations.

Structure of the Agricultural Economy

The agricultural sector is specified as a series of supply and demand equations with price playing the key equilibrating role; hence, aside from government intervention, this sector is specified as a series of flex-price markets. Agricultural crop production is disaggregated into wheat and coarse grains (soybeans, cotton, tobacco, fruits, vegetables, and other crops are not

included in the model). Demand equations are specified for domestic food demand; domestic feed demand; other domestic uses (seed, alcoholic beverages, industrial, etc.); private storage demand; government storage demand; the farmer-owned reserve; and export demand for both wheat and feed grains. Planted acreage equations representing planned supply are expressed as functions of expected market prices, government policies regarding target and loan rates and acreage set-asides and diversion payments, and input costs. The input costs are related to general economy movements in wages, interest rates, and material costs. Yields are explained by seasonal conditions, technology, expected output prices, and current input costs.

The structure of the agricultural sector represented is decomposed into two major blocks of grain equations and three blocks of livestock equations. As shown in Figure 1, these blocks are related to the international and macro-economy sectors through forward and backward linkages. Each grain block includes behavioral equations for acreage planted, yield per planted acre, domestic utilization, and inventories. Production is computed as the product of acreage and yield. Domestic utilization is divided into two components: (1) livestock and residual demand and (2) industry or food demand.

Inventories are either publicly controlled (government-owned stocks, inventories tied to outstanding Commodity Credit Corporation (CCC) loans, and stocks in the farmer-owned reserve) or privately owned. The privately held stocks and CCC inventories are aggregated into a single inventory position, while farmer-owned reserve and government-owned stocks are each modeled separately. This specification allows different rules governing control and substitutions of the various types of stocks to be incorporated in policy experiments.

Since the planting decision is inextricably tied to the discrete choice of participation in farm programs, an appropriate specification must incorporate the trade-off between compliance or noncompliance with government programs as well as the trade-off between expected returns of all potential crop choices. Traditional acreage response equations included in past models do not fully incorporate these trade-offs. Acreage planted of each crop is presumed to depend on expected returns from noncompliance and compliance with acreage programs for the crop under consideration, acreage that can be planted under full program compliance, and the expected profitabilities from competing crops.

Crop production costs depend on inputs purchased from the nonfarm sector. Costs are a function of wage rate paid for hired labor; market interest rate paid for financing working capital, machinery, and buildings; raw material prices paid for energy and fertilizer; and an index of nonfood prices paid for services and materials not included above and equipment. This cost measure provides a direct link with performance of the general economy, and increases have adverse effects on expected profitability of agricultural products.

Domestic wheat consumption is divided into food consumption and other uses with separate demand equations for each component. Feed demand for wheat depends on own price and corn price, each relative to the price of broilers and the number of broilers on feed. Domestic feed demand for feed grains is specified to be a function of the inventories of cattle on feed, pigs on feed, and broilers on feed. Feed grain consumption increases with the number of animals on feed. As suggested by the theory of consumption, domestic per capita food demand for wheat is a function of the real price of wheat, an index of real food prices, and real per capita income. Other uses are modeled as a function of real prices and real income.

Inventory equations are used to complete the grain blocks and determine the price of each crop. As noted above, inventories are separated into three components. In general, it is expected that a measure of the expected profitability of holding stocks will be the main determinant of private stockholding. The different specifications for the various public inventory positions reflect constraints imposed on release and entry in the publicly controlled stocks plus by other causal influences.

Quantity demanded by the private sector for stocks by both the producers and the users is motivated by transactions and precautionary motives. A large part is also due to the seasonality of production and to speculative motives. All motives are conditioned by the cost of holding stocks. Speculative demand is influenced by the farm price relative to expected farm price. It is also presumed that the relative farm price to loan price and stocks held by the government have an influence.

Interest rates enter the stockholding equations both as real interest rates and as a government interest rate subsidy. In the private stock equations, it is expected that increased interest rates should have a negative effect due to the increased opportunity cost of holding idle inventories. The portfolio effect of the interest rates on stockholding is reflected in the price equation. As real interest rates rise, prices of wheat and feed grains tend to fall to make investors willing to hold grain inventories and, thus, achieve asset market equilibrium.

Stocks demanded by the government sector include government-owned stocks or the farmer-owned reserve. To a large extent, government stocks are a residual with the government playing a passive role. Farmers place stocks with the government when the farm price is close to the loan price, and they redeem

loans only as the farm price moves above the loan price. Again, the government is loath to release its own supplies until prices rise above the loan price. In the case of the farmer-owned reserve, such prices are prespecified and are well above the loan price.

The livestock sector includes blocks of equations for beef, pork, and broilers. The structure of each block in the meat sector is the same. The meats are disaggregated to reflect different consumption patterns over time, different income elasticities, and different production processes (for example, length of time on feed). Per capita meat demand is modeled in price-dependent form as a function of own quantity, the price of substitute meats, and income. Prices and income are measured in constant dollars, and income is per capita. A nonagricultural price index representing the price of substitute nonfood items is also included in the meat demand equations.

Supply behavior in the cattle sector is disaggregated into equations explaining the closing inventory of beef cows, the gross number of placements of cattle on feed, and the production of beef. Disaggregation of the cattle sector admits the dynamics associated with biological production lags and interactions between cattle and feed prices. Our model follows that described by Jarvis; Freebairn and Rausser; and by Arzac and Wilkinson⁵ except that, for simplicity, we have only one cattle price. The cattle breeder and fed-cattle activities are treated as distinct operations with different decision-makers.

Because of the biological lags involved, a change in the current cow inventory reflects a history of decisions to (1) retain or slaughter cows and (2) sell heifers to feeder operators or retain them for breeding over a period of three years. These decisions are related to current and past beef prices relative to feed costs (reflecting profitability) and current and past real interest rates (reflecting holding costs).

The gross number of placements of cattle on feed is expressed as a function of lagged cow inventories to reflect the availability of feeder calves and the expected profitability of cattle feeding. Profitability is influenced by the price of beef relative to feed costs. Feed costs for beef cows depend on the cost of feed grains as measured by the farm price of corn. Production of beef comes from gross number of placements of cattle on feed in previous periods, cull cows, and other nonfed cattle slaughter. The farm price of beef and the feed cost for beef may have two effects; on the one hand, they encourage feeding of animals to heavier weights and, on the other, they encourage withholding of breeding stock. The latter effect stems directly from the dynamics of beef cow inventory.

As with the cattle sector, the representation of the hog sector is highly aggregated. It is specified to allow for cyclical responses of pork production to changes in the final product price and costs. Equations are given for the closing inventory of breeding sows, pig crop, production of pork, and the demand for pork. The decision to retain breeding sows or send them for slaughter is based on a comparison of their current sale value and the expected returns from the sale of hogs in the future. The closing inventory of breeding sows is positively related to the price of hogs, negatively related to feed costs, and negatively related to the interest cost of holding inventories. The pig crop is specified as a function of lagged breeding hog inventory and anticipated profitability from producing pork. Production of pork depends on previous pig crops and liquidation of breeding inventories.

Production of broilers is modeled as a profit-maximizing activity. Similarly to the beef and pork subcomponents, equations presuming the same type of causal influences are specified for poultry production, broiler chicks hatched, and broiler hatchery supply flocks.

Real interest rates enter the livestock equations as a measure of the opportunity cost of holding livestock inventories. A rise in real interest rates tends to decrease current breeding inventories and increase current slaughter and production of meat and push prices down. The longer run effects of an increase in the real interest rate will be a rise in meat prices due to smaller herds.

Major Linkages

A number of linkages are admitted by the model specification. Some represent causal influences running from the macroeconomic sector to the agricultural sector, and some run from the international component to the agricultural sector. Both of these causal influences are defined as forward linkages. The opposite effects, that is, those that run from the agricultural component to the macroeconomic or the international economic component, are defined as backward linkages. In addition to forward and backward linkages, there are potentially important linkages between U. S. monetary policy and foreign monetary policies. As suggested in Chapter 1, this linkage could have important implications for exchange rates and worldwide recessions. Each of these linkages is examined in this subsection.

Forward Linkages. Macroeconomic variables are integrated into the agricultural sector wherever they are theoretically relevant. The most important linkages are observed in the grain equations representing acreage, yield, demand, and inventory behavior and in the livestock equations representing breeding inventory decisions. The macroeconomic variables included in these linkages are interest rates, personal income, nonfood and general inflation rates, and energy costs.

An increase in interest rates will have several direct effects on the agricultural sector. The most immediate impact will be on inventory behavior. Within the grain sector, rising interest rates will result in the movement of grain from private positions into government positions including the farmer-owned reserve and CCC inventories or the selling of grain on spot markets. Moving grain into government positions allows farmers to gain the benefit of subsidized interest rates offered by the CCC, while selling grain reduces interest costs to zero. Since some farmers may not be eligible for the benefits of the farmer-owned reserve or CCC nonrecourse loans, their only alternative may be to sell grain on the spot market.

Within the livestock sector, rising interest rates make it more costly for livestock producers to hold breeding animals. Therefore, in the short term, higher interest rates will lead to slaughter of breeding inventories. Other short-term effects include reduced feed demand since it becomes more costly to hold livestock to heavier weights; reduced acreage since, all else constant, an increase in interest rates both increases production costs and increases the implicit interest subsidy offered by the CCC and, therefore, increases the incentive to participate in any acreage reduction programs that may be offered; and increased yield per planted acre since increased participation in acreage reduction programs allows farmers to take their least productive land out of production.

The short-term impacts of these changes include movement of grain into the farmer-owned reserve which "insulates" that grain from the market so that it has a less-depressing effect on price; pressure for lower grain prices because higher interest rates may lead to more grain being sold by farmers who are not eligible for the government storage programs; and pressure for lower meat

prices because increased slaughter of breeding animals will lead to higher meat supply and a lower price. Which of these effects is dominant depends on the current levels of all the variables and on the magnitude of the change in the interest rate. The crop production effect will probably be small; and, in most cases, the pressures for lower prices will outweigh the pressures for higher prices. All else constant, a sudden rise in interest rates will result in a fall in meat prices.

The longer term impacts of these changes will lead to pressure for higher grain prices. This will occur in the intermediate run because there will be less grain stored in private inventory positions than in the case with lower interest rates and less grain will be in total inventories because larger quantities will have been consumed after the rise in interest rates. Pressure for higher meat prices will be felt in the longer run because there will be fewer breeding animals and, therefore, fewer placements of animals on feed and a smaller meat supply.

An increase in the CPI will primarily affect the consumer market for agricultural commodities. In the short term, an increase in the CPI can have two possible effects depending on the behavior of wages. If wages increase at the same rate as the general price level and no monetary illusion exists, then an increase in the CPI will have no impact on the demand for agricultural commodities. If wages increase at a slower rate than the CPI, then the demand for agricultural commodities, in particular beef, will fall. In general, only changes in relative prices will affect demand for agricultural commodities over both the short and long runs.

If demand for beef does fall as a result of a decrease in real wages, this will result in a decline in beef prices and a possible decline in pork and

broiler prices because these are substitutable commodities. However, previous studies suggest that for pork and broilers a decrease in real income may cause a greater expansion in demand for these goods than the increase in demand caused by the substitution effect away from beef. Therefore, the price of pork and broilers may fall or rise from an increase in prices where wages do not keep up. These ambiguous results hold for both the short and long run.

An increase in the nonfood CPI results in increased costs of producing crops and changes in relative prices associated with meat demands and food demand for wheat. Increased production costs will result in reduced crop production and, perhaps, some substitution among competing crop enterprises. In general, increases in the nonfood CPI will result in only small changes in food consumption. In the short run, increases in the nonfood CPI will have little impact on prices. However, in the longer run, higher crop prices should result.

Crop production requires both direct energy inputs (for example, fuel for tractors) and indirect energy inputs (for example, fertilizer). Thus, higher energy costs are associated with increased crop production costs. As with increases in the nonfood CPI, increases in energy costs will result in reduced crop production and higher long-term crop prices.

Backward Linkages. Agriculture is fully integrated into the macroeconomic model rather than appearing as a satellite or independent sector. There are three main influences in the macroeconomy which reflect backward linkages from the agricultural sector. The three linkages are reflected in the CPI, endogenous deficits, and the effects on the balance of trade.

Food prices represented by grain and livestock prices are determined endogenously within the agricultural sector. Grain prices are determined at the

farm level; and these influence the production of livestock and, hence, retail livestock prices. The set of prices is then converted into an index of food prices--one component of the overall CPI.

The food CPI linkage is important everywhere that the CPI enters the macroeconomic model. These linkages occur in any equation for which variables, such as income, are deflated by the CPI as well as equations with the CPI entering as a separate explanatory variable. Examples of the latter include money growth, wage inflation, and the demand for imports. While the latter equation actually is estimated with the wholesale price index, that index is determined from the CPI in a separate reduced-form equation.

A second linkage from the agricultural sector to the macroeconomy is through agricultural program expenditures. Operation of government storage programs and the deficiency payments are examples of legislated expenditures that are fixed in contrast to much of the nonfarm components of the budget which are likely to be fixed in dollar terms. The outcome for prices, production, private storage, and other variables endogenous to the agricultural sector thus determines the level of government spending on agriculture and its contribution to deficits. As government expenditures rise, the GNP increases; and this factor enters into consumption, investment, etc. There are multiplier effects leading to further increases in the GNP and in taxes.

Finally, the level of agricultural exports is a third linkage. *Ceteris paribus*, an increase in agricultural exports would be expected to increase the value of the dollar (decrease the rest-of-world dollar exchange rate). Since the increase in exports leads to an increase in GNP, it is captured by the inclusion of GNP in the exchange rate equation.

International Monetary Linkages. In addition to the above linkages between the agricultural and domestic macroeconomic sectors, there are possibly important linkages between U. S. monetary policy and policies of foreign banks. To the extent that such interdependence exists, it represents another linkage between the domestic macroeconomic sector and agriculture. As U. S. monetary policy changes, if there are responses in the rest of the world which affect foreign GNP, exchange rates, or prices, this will translate into shifts in the export demand curve faced by U. S. agricultural producers. Monetary interdependence is generally recognized to exist in fixed exchange rate regimes, while one of the arguments advanced by proponents of flexible exchange rates includes "monetary independence." The presence of currency substitution, however, suggests that this basis for flexible exchange rates is invalid.

Under fixed rate regimes, such as the monetary system set up by the Bretton Woods agreement, central banks are compelled to engage in interventions in currency markets to maintain a fixed exchange value of their domestic vis-à-vis foreign currencies. This is in contrast to the case of flexible rates where no such intervention is necessary; while monetary authorities may still engage in intervention to affect the foreign exchange value of domestic money, such actions become discretionary. The monetary independence result follows from the observation that, under fixed rate regimes, when one country follows a particular monetary policy, say, an expansionary one, if that policy creates pressure on the rate of exchange with another currency, a response is called for by central banks abroad. For the present example, foreign monetary authorities are compelled to engage in a similar expansionary monetary policy when they observe a tendency for their currency to appreciate. Thus, the country beginning the process is said to have "exported" its inflation. When

exchange rates are flexible, no such obligation exists on the part of central banks; only if they act to maintain exchange rates within a certain band (for example, by following the U. S. lead and inflating their currency) in a "managed float" can inflation be exported by other countries.

McKinnon^{6/} and others have argued in recent years that the monetary independence argument for flexible exchange rates involves an untested assumption about the portfolios of moneyholders. In order for monetary independence to hold, it must be assumed that the country in question is an "insular" economy, at least as far as money demand is concerned. Moneyholders must not substitute foreign currency holdings when the domestic currency becomes less desirable nor vice versa. If this does not hold, currency substitution implies that the effects of domestic monetary policy are exported even under perfectly flexible rates.

This exporting of monetary policy and resulting loss of independence can occur in two ways. Each scenario follows an essentially monetarist treatment of the effects of monetary policy with short-run effects on real variables such as income. First, foreign monetary authorities target a growth rate for foreign currency consistent with objectives for unemployment, interest rates, or some other variable or mix of variables based on their expectations of the demand for that currency. In the case of substitution between currencies, such a targeted growth rate is also conditional on expected money growth abroad. If the United States engages in some unanticipated monetary policy, say, expansion, there will be an increase in the demand for the foreign currency if expansionary policies in the United States are expected to depreciate the value of the dollar. The upshot is that the foreign monetary authorities will have under anticipated money demand, and their monetary policy will then

be more restrictive than was desired. Independence from U. S. policies of the operation of foreign monetary policy is lost.

A second possibility is that the foreign authorities are able to recognize the unanticipated shift in U. S. monetary policy quickly. In that case, they may act so as to maintain the value of their currency rather than allow it to appreciate. They accommodate the U. S. money growth by responding with the same policy. Money is no longer as tight in the foreign country, but the result is an even greater increase in the world money supply. This is exactly the phenomenon McKinnon^{7/} has claimed is responsible for the rapid worldwide inflation of the 1970s.

Currency substitution has interesting implications for the structure given to our agricultural, domestic macroeconomic, and international sectors. In particular, a new linkage of agricultural and nonagricultural variables is introduced. The direct effect of monetary policy on agriculture through exchange rates and interest rates is straightforward. However, domestic monetary policy also affects money growth abroad under currency substitution and real variables such as income. These feedback effects from U. S. money supply to foreign currencies work in addition to direct effects through financial markets--the changes in the growth rates of foreign currency will affect foreign income. Foreign income, in turn, is an important variable in the demand for U. S. agricultural exports as increased income abroad will lead to greater consumption through an income effect. Either of the currency substitution scenarios described above can cause this income effect.

Note that, depending on whether the result is for foreign monetary policy to be more or less restrictive than originally intended, U. S. agricultural exports can either fall or rise relative to the monetary independence outcome. The magnitude of foreign income effects and the resulting change in

export demand will depend on the extent to which economic agents abroad failed to anticipate the change in monetary policy following the U. S. policy change. As long as any part of the change in money growth is unanticipated, real effects on income and other variables result.

The offsetting changes in money growth rates required in the presence of currency substitution and monetary interdependence can be thought of as sterilization of the effects of the unanticipated money shocks from abroad. In this context, it is important to clarify the conventional sterilization of reserve flows. The usual interpretation involves the central bank intervening in the currency market, say, to prevent its currency from depreciation. Since this involves buying its currency for either bonds or foreign exchange, there is a reduction in the money stock. Sterilization would involve an offsetting expansion of domestic money so as to maintain previous growth targets. However, there is no clear reason for such an operation; as long as capital is mobile, the sterilization operation will restore the currency to a situation of excess supply. The so-called sterilization of the effects of intervention in exchange markets does, indeed, leave the total money stock unchanged; but the situation of excess currency supply is also unchanged.

It is presumed here that the central bank targets the growth rate of some monetary aggregate, based on desired levels of unemployment, interest rates, etc. This will involve some forecast of money demand by both domestic resident and foreign holders of the currency. The foreign demand, in the presence of currency substitution, will be a function of foreign bank policies, requiring that these, also, be forecast. When there is some unanticipated shift in monetary policy abroad, then there will be a shift in money demand which leaves the original target either too restrictive or too easy in comparison with the levels of money growth consistent with original goals.

It will, therefore, be necessary to adjust monetary growth to accommodate or sterilize the unanticipated change in money demand. To the extent that monetary authorities are able to make this adjustment and to the extent that moneyholders do not perceive this as a shift in policy but merely a response to other central banks' policies, there will be no real effects. More likely, there will be shocks in real variables, such as income and the real rate of interest, as the unanticipated money growth is discovered by moneyholders. To incorporate this effect in the most general way, a set of reaction functions measuring monetary interdependence could be added to the model. This would complete the linkage between U. S. monetary policy and domestic agriculture operating through effects on foreign income. As interdependence becomes important, foreign GNP and other variables become endogenous to the model.

While theoretically satisfying, the empirical significance of currency substitution has yet to be either demonstrated or rejected conclusively. McKinnon^{8/} presented some evidence in support, while a recent study by Batten and Hafer^{9/} finds that changes in the rate of return to holding foreign currencies seem to have little effect on the demand for domestic money. Related empirical work by Grilli and Yang^{10/} illustrates the role of increases in worldwide liquidity in explaining the inflation of primary commodity prices. Currency substitution exacerbates this growth in liquidity, and, therefore, in commodity prices. While empirical determination of the real effects of currency substitution remains an open question, its presence introduces another linkage between monetary policies and agricultural markets.

Chapter 4

The Estimated Model

In this section the estimated equations are reported for the model representation outlined in Chapter 3. For each equation, a brief description is presented along with the typical summary statistics. Standard errors appear in parentheses below each estimated coefficient. The following sections pertain to the domestic macroeconomy component, to the international economy component, and to the agricultural sector component. For each component, quarterly data spanning the period 1966 (first quarter) through 1982 (fourth quarter) were utilized.

Macroeconomy Component

Aggregate Consumption. Real consumption expenditures are disaggregated to three categories-- nondurables (CN), durables (CD), and services (CS)--and estimated in per capita terms. The explanatory variables for consumption are per capita income and lagged consumption reflecting the persistence of consumption patterns, business-cycle effects, etc. Theoretical considerations lead to the selection of variables, while choice of variable form was determined in a manner consistent with the Houthakker and Taylor^{1/} "habit formation" approach to consumption. A real interest rate variable is included in the equation for the consumption of durables to reflect intertemporal substitution possibilities. High real interest rates are presumed to delay replacement of automobiles, refrigerators, etc. To the extent that this variable reflects wealth effects, it would be expected to enter with a positive sign. However, the disposable income variable is expected to reflect the major wealth effects. The negative sign on the interest rate on three-month U. S. Treasury

bills is, therefore, consistent with expectations. This is also the case with the other variables; all marginal propensities to consume are between zero and one, with acceptable coefficients on the lagged dependent variables:

Nondurable Goods

$$\begin{aligned} \left(\frac{CN}{N}\right)_t &= .088096 + .85044 * \left(\frac{CN}{N}\right)_{t-1} + .03250 * \left(\frac{YD}{N}\right)_{t-1} \\ &\quad + .13946 * \left(\frac{DYD}{N}\right)_t \\ &\quad (.04493) \quad (.07528) \quad (.01653) \end{aligned}$$

$$D.W. = 1.81$$

$$R^2 = .988$$

Durable Goods

$$\begin{aligned} \left(\frac{CD}{N}\right)_t &= -0.0780 + 0.0515 * \left(\frac{YD}{N}\right)_{t-1} + 0.406 * \left(\frac{DYD}{N}\right)_t \\ &\quad + 0.761 * \left(\frac{CD}{N}\right)_{t-1} - 0.002452 * RRATE \\ &\quad (0.0348) \quad (0.0155) \quad (0.0684) \quad (0.0647) \quad (0.00105) \end{aligned}$$

$$\hat{p} = -0.410.$$

$$R^2 = .9176$$

Services

$$\begin{aligned} \left(\frac{CS}{N}\right)_t &= .000335 + .9800 * \left(\frac{CS}{N}\right)_{t-1} + .01051 * \left(\frac{YD}{N}\right)_{t-1} \\ &\quad + .06186 * \left(\frac{DYD}{N}\right)_t \\ &\quad (.01451) \quad (.02521) \quad (.0136) \quad (.01999) \end{aligned}$$

$$D.W. = 2.16$$

$$R^2 = .99931.$$

Aggregate Domestic Investment. The investment component of the GNP is broken into three parts: residential investment, investment in plant and equipment, and changes in real business inventories. Important specification issues

arise concerning the proper definition of capital stock, proper lag structure, and cost of capital variables. In any case, the important variables dominating the investment decision are hypothesized to be aggregate demand, cost of capital, and profitability. Accordingly, the explanatory variables chosen were first differences of disposable income following the pattern in the consumption equations and the first differences of bond yields. Also, lagged dependent variables are introduced to reflect the distributed lag effects of the causal explanatory variables. Note also that, while total aggregate demand changes are likely to affect nonresidential investment, disposable personal income seems to be the relevant variable for residential investment demand:

Residential Investment

$$\begin{aligned} \text{IFIXR}_t = & \begin{matrix} .12962 \\ (2.4) \end{matrix} + \begin{matrix} .71087 \\ (.0752) \end{matrix} * \text{IFIXR}_{t-1} + \begin{matrix} .033162 \\ (.01017) \end{matrix} * \text{YD}_{t-1} \\ & + \begin{matrix} .03110 \\ (.03110) \end{matrix} * \left(\frac{\text{DYD}}{\text{N}} \right)_t - \begin{matrix} 1.6681 \\ (0.5429) \end{matrix} * \text{BONDY}_t \end{aligned}$$

$$\hat{p} = .3801$$

$$\bar{R}^2 = .989$$

Nonresidential Investment

$$\begin{aligned} \text{IFIXNR}_t = & \begin{matrix} .10414 \\ (2.360) \end{matrix} + \begin{matrix} .97536 \\ (.0317) \end{matrix} * \text{IFIXNR}_{t-1} + \begin{matrix} .12764 \\ (.0243) \end{matrix} * (\text{GNP}_t - \text{GNP}_{t-1}) \\ & - \begin{matrix} .5598 \\ (.329) \end{matrix} * \text{BONDY}_{t-1} + \begin{matrix} .08176 \\ (.02460) \end{matrix} * (\text{GNP}_{t-1} - \text{GNP}_{t-2}) \\ & + \begin{matrix} 1.8095 \\ (.76085) \end{matrix} * \text{AV23DIV} \end{aligned}$$

$$\text{D.W.} = 2.11$$

$$\bar{R}^2 = .990$$

Inventory Investment

$$\text{INVCH}_t = 4.1125 + 0.6551 * \text{INVCH}_{t-1} - 0.24172 * \text{COMPR}_t$$

(2.5035) (0.09102) (0.29446)

D.W. = 1.65
 $\bar{R}^2 = 0.449.$

Residential and nonresidential investment demands are a function of changes in income (disposable and aggregate, respectively) and a cost of capital variable approximated by the average yield on AAA rated 15-year corporate bonds. Inventory investment is extremely volatile, presenting great swings from quarter to quarter. This makes it extremely hard to estimate. Our equation is a simple one--modeling inventory investment as a function of its past value--and the opportunity cost of funds for inventory holding approximated by the short-run interest rate.

Domestic Monetary Financial Sector. The goal in constructing this sector was to capture, in a simplified manner, the interaction of financial decisions by the nonbank public, the financial institutions, and the monetary and fiscal authorities. The framework of the monetary financial sector takes into account the changes that occurred in the financial markets, especially the changes in policy directions by the Federal Reserve Board and the increasing deregulation of the financial markets since the early 1980s. Three major groups are admitted by the specified structure for the monetary financial sector of the U. S. economy. These groups are: nonbank investors, the commercial banks, and the monetary authorities. They interact in the two major markets--the market for bank reserves and the market for deposits.

Under a policy of targeting the level of nonborrowed reserves, the Federal Reserve calculates the relationship between nonborrowed reserves and some

monetary aggregate(s) which it targets and adjusts its assets by conducting open-market operations. A decision by the Federal Reserve to tighten monetary policy can be achieved through selling of some of its government securities and, as a result, reducing banks' nonborrowed reserves. Given reserve requirements and with an unchanged discount window policy, a shortage is created in the market for reserves that drives the federal funds rate up. Under a post-October, 1979, regime, the Federal Reserve's open-market operations through purchases and sales of securities affects one to one the banks' nonborrowed reserves. Movements in the nonborrowed reserves are translated into changes in rates of return through the interaction between the two separate albeit interdependence markets: the market for reserves and the market for deposits.

For empirical purposes, a reduced form representation was selected for short-run interest rate determination, specifically, an equation designed to directly capture the effects of monetary policy changes by the Federal Reserve in terms of reserve adjustments and the Federal Reserve's discount rate (RMFRBNY). Since the model is quarterly, movements in the federal funds rate following a change in nonborrowed reserves (RESFRBN) are considered to have been fully transmitted to other short-run rates within the period of one quarter. Thus, the short-run nominal interest rate (represented by the commercial paper rate) is directly a function of nonborrowed reserves and required reserves (RESFRBR) of the banking system.

Short-term nominal interest rates are also modeled to reflect the pressure on capital markets and real interest rates caused by economic growth in the private sector and by the U. S. Treasury Department's sale of government securities to the private sector. During each quarter, the federal government's

deficit is financed by either borrowing from the public or by selling treasury bonds to the Federal Reserve. A sale of government securities to the public puts pressure on the price of securities to fall which, in turn, increases the rate of return on these instruments. Arbitrage in the financial markets drives other rates of return (including the rate on commercial paper) upwards. The amount of deficits (DEF) relative to nonborrowed reserves (RESFRBN) is a proxy for the excess credit demand arising from the public sector. The ratio of these two variables is defined as RDEFRES. Similarly, a proxy for the excess credit demand arising from the private sector is a ratio of disposable income (YD) to nonborrowed reserves; this variable is defined as RYDRES. The remainder is an approximation to Treasury's borrowing from the private sector. We scale this variable by dividing by the nominal GNP and define the resulting variable by the symbol $RDGNP_t$.

Apart from monetary policy variables and capital market pressure variables, an inflationary expectations proxy variable is also included in the interest rate equation. Expected inflation increases nominal interest rates (for given real interest rates) since both borrowers and lenders expect a "less valuable" dollar when the loan is paid back if inflation is present. The inflationary expectations proxy is defined as MFIT. The resulting estimated equation is:

Commercial Paper Rate

$$\begin{aligned} \text{COMPR}_t = & -1.3710 + 0.40366 \text{ RDEFRES} + 0.2303 \text{ MFIT} \\ & (5.401) \quad (0.302) \quad (0.2874) \\ & + 1.9897 \text{ RESFRBR}_t + 0.1312 \text{ RYDRES}_t - 1.9347 \text{ RESFRBN}_t \\ & (0.349) \quad (0.0494) \quad (0.342) \end{aligned}$$

$$\text{D.W.} = 1.738$$

$$\bar{R}^2 = 0.820.$$

The real balances held by the public are hypothesized to depend on prices and income just as the demand for any other good. Real money balances can be thought of as a good producing a flow of services, e.g., serving as a means of making payments and as a component of the investment portfolio. Therefore, income is included to reflect the normal demand influence, while interest rates indicate the opportunity cost of storing wealth in the form of money balances as opposed to another investment. Income is expected to enter with a positive sign as long as money balances have a positive income elasticity. Interest rates, on the other hand, will have a negative relationship with money holdings; as interest rates rise, alternative investments become more attractive relative to money as a form of storing wealth:

$$\begin{aligned}
 & \text{Money Demand} \\
 \log\left(\frac{\text{MNYIA}}{\text{CPIU}}\right)_t &= \frac{.966}{(.01733)} * \log\left(\frac{\text{MNYIA}}{\text{CPIU}}\right)_{t-1} + \frac{.03109}{(.01409)} * \log \text{GNP}_t \\
 & \quad - \frac{.02555}{(.00806)} * \log \text{COMPR}_t \\
 \hat{p} &= .197 \\
 \bar{R}^2 &= .99
 \end{aligned}$$

where MNYIA is money stock defined as currency plus demand deposits plus traveler's checks, CPIU measures the consumer price index, and the remaining variables are as defined previously.

Turning to the term structure of interest rates, the 15-year AAA rated corporate bond (BONDY) was chosen to represent long-term interest rates. Following the expectations hypothesis, long-term interest rates were modeled as a distributed lag of short-term interest rates. The MFIT variable was also included to capture the effects of inflationary expectations on the long-run interest rate. The resulting equation is

Long-Run Interest Rate (Term Structure Equation)

$$\text{BONDY}_t = \frac{0.31285}{(0.2376)} + \frac{0.7695}{(0.04180)} * \text{BONDY}_{t-1} + \sum_{j=0}^2 a_j * \text{COMPR}_{t-j} \\ + \frac{0.2006}{(0.0974)} * \text{MFIT}_t$$

$$\hat{p} = 0.121$$

$$R^2 = 0.9669$$

where

$$a_0 = \frac{0.0937}{(0.0162)}, \quad a_1 = \frac{0.0625}{(0.0108)}, \quad a_2 = \frac{0.0312}{(0.005)}, \quad \sum_{j=0}^2 a_j = \frac{0.187}{(0.0324)}$$

The coefficients on all variables have the expected sign and are statistically significant. The coefficient on inflationary expectations is positive (as expected) and significant, indicating that a positive inflationary premium is demanded by investors in response to a rise in expected inflation. The length of adjustment implied by the coefficient on the lagged dependent variable (approximately four quarters) seems somewhat long given the competitive nature of the financial markets.

Following Barro,^{2/} expected money growth is used to generate inflationary expectations. An ad hoc mechanism is presumed in which expected money growth is estimated by past money growth rates and some variables likely to be related to Federal Reserve policy responses to current economic conditions. The resulting predicted variable can be thought of as anticipated money growth, and deviations of actual from predicted values have been interpreted as unanticipated changes in the growth rate of money.^{3/}

The formulation assumes that the Federal Reserve follows a policy according to which money growth rates are adjusted each quarter in response to

changes in real income, interest rates, and the inflation rate. Changes in these money growth rates cause revisions by economic agents of their expectations about future inflation rates. Using fitted money growth rates as a proxy for expected inflation allows for the endogenous generation of inflationary expectations within the model. The estimated equation for inflationary expectations is

Inflationary Expectations

$$\begin{aligned}
 \text{MFIT}_t = & -0.06935 + 0.9582 * Q_1 - 0.3310 * Q_2 + 0.6777 * Q_3 \\
 & (1.0128) \quad (1.054) \quad (0.3185) \quad (1.058) \\
 & + 0.8059 * \text{MONGRTH}_{t-1} - 0.73487 * \text{MONGRTH}_{t-2} \\
 & (0.138) \quad (0.179) \\
 & + 0.25013 * \text{MONGRTH}_{t-3} - 0.2315 * \text{MONGRTH}_{t-4} \\
 & (0.175) \quad (0.139) \\
 & - 0.1445 * \text{COMPR}_{t-1} + 0.00113 * \text{GNP}_{t-1} - 0.2489 * \text{CPIUINF}_{t-1} \\
 & (0.209) \quad (0.000804) \quad (0.118) \\
 & \hat{p} = -0.75 \\
 & \bar{R}^2 = 0.604
 \end{aligned}$$

where Q_i refers to quarterly dummies for the i th quarter, MONGRTH_{t-i} refers to past values of money growth rates, and CPIUINF refers to the rate of change in the nonfood CPI. The results for the equation indicate that monetary growth accommodates changes in GNP and the Federal Reserve follows a policy of "leaning against the wind" in response to inflation and interest rates.

Phillips Curve Relationships. The supply side of the macromodel is composed of Phillips curve relationships or, equivalently, the nonfarm price and wage determination. The general theoretical basis is that nonfarm prices are "sticky" due to the existence of long-term contracts, information lags,

uncertainty, lags in deliveries, etc. Following Gordon,^{4/} prices and wages are specified to adjust gradually to the gap between income and its full employment level (INCGAP) or, equivalently, between unemployment and its natural level. The equation to generate values for nonfarm price inflation (CPINFINF) expresses the annual percentage change in prices also as a function of contemporaneous and lagged values of oil-price inflation (OILINFL) and a variable to reflect wage-productivity differentials (WPRODIF). The latter explanatory variable captures the role of labor costs in the so-called "inflationary spiral." Finally, inflationary expectations were incorporated in this equation as represented by MFIT. The estimated equation is:

Nonfood Price Inflation

$$\text{CPINFINF}_t = 0.011704 + 0.03655 * \text{CPINFINF}_{t-1} + 0.3297 * \text{MFIT}$$

$$+ \sum_{j=0}^3 \beta_j * \text{WPRODIF}_{t-j} + \sum_{k=0}^2 k_j * \text{OILINFL}_{t-j} \\ + \sum_{j=0}^2 \delta_j * \text{INCGAP}_{t-j}$$

$$\beta_1 = 0.0280 \\ (0.0176)$$

$$k_1 = 0.0057 \\ (0.0019)$$

$$\delta_1 = 0.0015 \\ (0.0007)$$

$$\beta_2 = 0.0210 \\ (0.0132)$$

$$k_2 = 0.0038 \\ (0.0013)$$

$$\delta_2 = 0.0010 \\ (0.0005)$$

$$\beta_3 = 0.0140 \\ (0.0088)$$

$$k_3 = 0.0019 \\ (0.0006)$$

$$\delta_3 = 0.0005 \\ (0.0002)$$

$$\sum_{j=0}^2 \beta_j = 0.0699 \\ (0.041)$$

$$\sum_{j=0}^2 k_j = 0.0115 \\ (0.004)$$

$$\sum_{j=0}^2 \delta_j = 0.00298 \\ (0.152)$$

$$\text{D.W.} = 1.71$$

$$R^2 = 0.620.$$

The annual percentage change in wages (WINFL) is related to deviations of the unemployment rate (RU) from a "natural" rate (RUADJ), current and lagged values of inflation represented by the CPI, and changes in the minimum wage level (MINWAG). The last two variables can be expected to lead to increases in wage growth, while the first variable would be negatively related to wages. The minimum wage is a floor on wage rates; as it grows, so do wages, while higher rates of inflation are expected to lead to greater wage inflation as workers attempt to maintain real wage levels. The deviation of the current unemployment rate from the natural rate is a measure of labor market pressure on the demand side; a large value for this variable corresponds to slackness in the demand for labor, and wage rates would then be expected to decrease. The difference between unemployment and its natural level enters nonlinearly in the equation to reflect the differential response of unemployment to different movements in the business cycle; large values of the reciprocal correspond to reduced demand in labor markets, so the positive sign on this coefficient is expected. Each of the other coefficients is positive, thus, confirming theoretical expectations:

Wage Inflation

$$\begin{aligned} \text{WINFL} = & 3.50078 + \sum_{j=0}^6 \pi_j * \text{CPIUINF}_{t-j} + \sum_{j=0}^3 q_j * \text{MINWAG}_{t-j} \\ & (.87616) \\ & + \sum_{j=0}^3 s_j * \frac{1}{(\text{RU} - \text{RUADJ})_{t-j}} \end{aligned}$$

$$\hat{p} = .72953$$

$$R^2 = .546$$

where

$$\begin{array}{lll}
 \pi_0 = \begin{array}{c} 0.0982 \\ (0.0184) \end{array} & q_0 = \begin{array}{c} 0.0190 \\ (0.0093) \end{array} & s_0 = \begin{array}{c} 1.4785 \\ (0.0043) \end{array} \\
 \pi_1 = \begin{array}{c} 0.0842 \\ (0.0157) \end{array} & q_1 = \begin{array}{c} 0.0142 \\ (0.0069) \end{array} & s_1 = \begin{array}{c} 0.8745 \\ (0.8697) \end{array} \\
 \pi_2 = \begin{array}{c} 0.0702 \\ (0.0131) \end{array} & q_2 = \begin{array}{c} 0.0095 \\ (0.0046) \end{array} & s_2 = \begin{array}{c} 0.4268 \\ (1.9762) \end{array} \\
 \pi_3 = \begin{array}{c} 0.0561 \\ (0.0105) \end{array} & q_3 = \begin{array}{c} 0.0043 \\ (0.0023) \end{array} & s_3 = \begin{array}{c} 0.1353 \\ (0.9181) \end{array} \\
 \pi_4 = \begin{array}{c} 0.0421 \\ (0.0079) \end{array} & & \\
 \pi_5 = \begin{array}{c} 0.0281 \\ (0.0052) \end{array} & & \\
 \pi_6 = \begin{array}{c} 0.0140. \\ (0.0026) \end{array} & &
 \end{array}$$

An unemployment rate (RU) is included in the model to transmit to the wage equation the influence of the inflationary gap. It will be of interest to determine the effects of alternative policies on this variable, and it is likely that short-run policies are influenced in part by unemployment levels. In the model, the unemployment equation constitutes an indirect mechanism that transmits changes in the "inflationary gap" to the price-wage determination sector of the model.

Unemployment is explained by a distributed lag on the difference between actual and potential income with the expectation that the greater these differences, the less would be the rate of unemployment. This difference is an endogenous variable as current real GNP is generated in the income-determination sector of the model. The full employment level of output is assumed to be exogenous--determined by demographics, technological change, etc.

The current level of wage inflation is incorporated to reflect the effects of short-run trade-offs between inflation and unemployment. In the long run,

only real wage changes should affect labor demand. But there can be short-run effects on employment if firms are unable to determine whether the wage change is real or nominal. Two reasons for such an effect in the short run are hypothesized. First, to the extent that this growth in wages includes a real wage increase, there will be a reduction in employment. Second, even if wage growth is solely due to price-level inflation, it may be some time before employers are able to determine that no real wage growth is occurring. Either hypothesis is consistent with the estimated positive relationship between nominal wage inflation and unemployment.

The estimated equation is

Unemployment

$$RU_t = 3.7629 + \sum_{j=1}^4 t_j * INCGAP_{t-j} + .1414 * WINFL_t$$

$\hat{p} = 0.786$
 $\bar{R}^2 = 0.682$

where

$$t_1 = \frac{-0.0111}{(0.0009)} \quad t_2 = \frac{-0.0083}{(0.0006)} \quad t_3 = \frac{-0.0056}{(0.0004)} \quad t_4 = \frac{-0.0028}{(0.0002)}$$

This result indicates that an increase in the wage rate causes unemployment to increase suggesting that unemployment is mostly involuntary.

Transmission of Price Effects. The wholesale price index (WPI) is a reduced-form equation which is based on the CPI. Causality is not implied, but this equation is needed to transmit changes in the U. S. price level to the international sector of the model. It was hypothesized that the WPI would better

represent the prices of exported goods, and this was confirmed when the equations of the international sector were estimated:

$$\begin{aligned} WPI_t = & .02280 + 0.4142 * CPIU_t + 0.3107 * CPIU_{t-1} \\ & (.11672) \quad (0.0186) \quad (0.0139) \\ & + 0.2071 * CPIU_{t-2} + 0.1036 * CPIU_{t-3} \\ & (0.0039) \quad (0.0046) \end{aligned}$$

$$\hat{p} = .972$$

$$\bar{R}^2 = .765.$$

The CPI is generated from its two components--the food component of CPI, defined as CPIF, and the nonfood component, defined as CPINF:

$$\begin{aligned} CPIU_t - CPIU_{t-1} = & 0.2616 * (CPIF_t - CPIF_{t-1}) \\ & (0.0796) \\ & + 0.7384 * (CPINF_t - CPINF_{t-1}) \\ & (0.0796) \end{aligned}$$

$$D.W. = 1.43$$

$$\bar{R}^2 = 0.6689.$$

The food component of the CPI is based upon the price of meats and the various factor prices which influence the margins between the retail and farm level.

The estimated relationship is:

$$\begin{aligned} \Delta(CPIF) = & .0348 - 0.0055 * Q_1 - 0.0056 * Q_2 - 0.0129 * Q_3 \\ & (.00714) \quad (0.00678) \quad (0.00749) \quad (0.00643) \\ & + 0.0003 * \Delta PBEEF_t + 0.0005 * \Delta PPORK_t + 0.0009 * \Delta PBR_t \\ & (0.00032) \quad (0.00042) \quad (0.000638) \\ & + 0.0007 * \Delta PAFC_t + 0.0002 * \Delta PAFW_t + 0.0022 * \Delta PAFS_t \\ & (0.0158) \quad (0.0080) \quad (0.0034) \\ & + 0.8572 * \Delta WAGE_t + 0.00012 * OILINFL_t \\ & (0.0451) \quad (0.00008) \end{aligned}$$

$$\hat{p} = 0.945$$

$$\bar{R}^2 = 0.849$$

where Q_i represents quarterly dummies; $\Delta PBEEF$, the change in the farm price of beef; $\Delta PPORK$, the change in the farm price of pork; ΔPBR , the change in the farm price of broilers; $\Delta PAFC$, the change in the farm price of corn; $\Delta PAFW$, the change in the farm price of wheat; $\Delta PAFS$, the change in the farm price of soybeans; $WAGE$ defines the nonfarm wage index; and $OILINFL$ defines the price of oil.

This is also a "transmission" equation to endogenize the export price index for nonfarm products (PEXNAG). A simple specification is advanced which allows this index to respond to changes in the domestic price level. Specifically, the nonfood price index (CPINF) is used to represent the domestic price level. The resulting equation is

$$PEXNAG_t = -0.37039 - \frac{0.466}{(0.1198)} CPINF_t + \frac{0.7814}{(0.2466)} CPINF_{t-1}.$$

$$\hat{p} = 0.940$$

$$\bar{R}^2 = .7893.$$

Domestic Income Determination Sector. Real GNP is determined as the sum of all domestic demand components plus the demand for domestic product by foreigners minus the domestic demand for foreign products. The various components of GNP are summed according to the definition:

$$GNP = CS + CN + IFIXR + IFIXNR + INVCH + G + EXAG + EXNAG - EMNP.$$

Each of these components is determined within the macrosector with the exception of G (total government expenditures is exogenous), $EXAG$ (farm exports which is jointly determined by macroeconomic variables such as the exchange

rate), and other variables endogenous to the agricultural sector (such as the price of farm products).

Personal disposable income is obtained from the level of GNP incorporating the effects of taxation. An equation to generate disposable income permits the effects of changes in tax rates to be analyzed. As long as the policies of interest do not involve alternative methods of taxation, it is sufficient to consider a single proportional tax rate chosen to give the same tax revenues as does the set of tax rates. This constructed tax rate is defined as PTAX. Increases or decreases in this tax rate can be used to analyze the effects of changes in tax revenues on the deficit; aggregate demand; the level of disposable income; and the demand for farm products, exports, etc. Because the model is quarterly, a distributed lag of GNP by quarter is used to explain total tax payments. Since taxes are incorporated to complete the government budget constraint, such a specification will suffice. The estimated equation is:

$$YD = 363.664 + .6794 * GNP_t + 0.53687 * GNP_{t-1} - 1,079.599 * PTAXR \\ (34.527) \quad (.04387) \quad (0.43746) \quad (74.05) \\ - 273.0770 * PTAXR_{t-1} \\ (79.28)$$

$$\hat{p} = .646$$

$$\bar{R}^2 = .993.$$

Government Finance Sector. This sector consists of identities corresponding to the government's budget constraint and an endogenously determined deficit. The first equation of this sector--the government's budget constraint--is an identity which explains the financing of the federal government's deficit. As already mentioned, the Treasury can finance the federal deficit by either

selling government instruments to the public (bonds) or to the Federal Reserve. Monetary policy in the United States places the initiative on the Federal Reserve as to what part of the federal deficit is to be monetized, i.e., the amount of government securities the Federal Reserve is willing to absorb. A decision by the Federal Reserve to buy or sell government securities has an immediate impact on the monetary base through a change in the commercial banks' reserves held with the Federal Reserve. Thus, a decision by the Federal Reserve to increase its stock of government securities constitute a "monetization" of part of the deficit. Such an act constitutes an increase in the money supply due to the increase in the monetary base.

The way government deficits and discretionary Federal Reserve actions interact to determine interest rates can be summarized in the following identities along with the interest rate determination equation:

$$\begin{aligned}
 (I_1) \quad & \text{GEXPEND} - \text{GTAXES} = \text{DEFIC} \\
 (I_2) \quad & \text{DEFIC} = \Delta \text{BRIV} + \Delta \text{BFED} + \Delta \text{TRCASH} \\
 (I_3) \quad & \Delta \text{BFED} = \Delta \text{MONBASE} \\
 (I_4) \quad & \Delta M = m * \Delta \text{MONBASE}.
 \end{aligned}$$

Equation (I_1) defines the deficit as the difference between government expenditures (GEXPEND) and government receipts (GTAXES) that include both tax and nontax receipts. A positive number signifies a deficit. Equation (I_2) shows how the deficit is financed, through sales of government securities to the public (ΔBRIV) or to the Federal Reserve (ΔBFED) and movements in the U. S. Treasury Department's cash reserves (ΔTRCASH), in the tax and loan accounts. Equation (I_3) simply expresses the fact that movements in the

Federal Reserve's assets (ΔBFED) will have to be accompanied by an offsetting change in its liabilities to the banking sector ($\Delta \text{MONBASE}$). Finally, equation (I_4) is a reduced form expressing the fact that an increase in the base increases money supply through the process described in the monetary financial sector.

For fixed exchange rate intervention, balance-of-payments imbalances have to be financed and thus the needed identities are:

$$\text{CA} + \text{KA} + \text{ORT} = 0$$

$$\Delta \text{BFED} - \text{ORT} = \Delta \text{MB}.$$

For a given deficit, alternative combinations of financing between borrowing from the public and borrowing from the Federal Reserve can produce quite different results for the endogenous variables in the model. Monetary policies can be characterized as more or less "strict" or "tight" as more (less) of the deficit is financed by private borrowing. A realistic scenario that would reflect the institutional realities in conducting monetary policy in the United States would put private borrowing financing of the deficit to be the dependent variable in the government budget constraint identity. The experience of the late 1970s and early 1980s shows that the Federal Reserve paid little attention to the treasury's demands for funds, especially under the new requirement of reserve targeting.

While government expenditures are exogenously given, the deficit is endogenously generated. With a given tax rate, changes in GNP increase the government's tax revenues, and the deficit becomes lower for a given level of expenditures. To explain total tax and nontax collections, a variable representing tax and nontax receipts of the federal government was regressed on a

distributed lag of nominal GNP and the average tax rate variable. Quarterly dummies were also added to capture seasonal pattern in tax collections.

The tax equation is employed to complete the government budget constraint generating government tax and nontax receipts (GTAXES). The estimated equation is

Tax Collections

$$\begin{aligned}
 \text{GTAXES}_t = & -110.3513 + 304.4669 * \text{PTAXR}_t + 0.0216 * \text{GNP}_t \\
 & \quad (32.283) \quad (100.93) \quad (0.0007) \\
 & + 0.162 * \text{GNP}_{t-1} + 0.0108 * \text{GNP}_{t-2} + 0.0054 * \text{GNP}_{t-3} \\
 & \quad (0.0005) \quad (0.0004) \quad (0.0002) \\
 & - 1.3585 * Q_1 + 26.5269 * Q_2 + 8.1987 * Q_3 \\
 & \quad (2.076) \quad (2.260) \quad (2.037)
 \end{aligned}$$

$\hat{p} = 0.315$
 $R^2 = 0.9579.$

The equation fits the data quite well with positive coefficients on GNP and PTAXR according to expectations.

Finally, the construction of the implicit average tax rate is accomplished simply as

$$\text{PTAXP} = \text{GTAXES}/\text{GNP}$$

or total tax collections relative to nominal GNP is the computed average tax rate.

International Economy Component

The international component of the model consists of five equations that explain nonfarm exports, nonfarm imports, feed grain exports, wheat exports, and the exchange rate. All equations are functions of endogenously determined

domestic variables and of foreign variables that are considered exogenous in this version of the model.

The increasing sensitivity of the U. S. economy to international events demands an accurate modeling of the international sector components. On the other hand, export and import equations for the United States have been found to be very unstable over time. For the exchange rate, no specification enjoys general acceptance; and all of the empirical studies seem to explain exchange rate movements for only a short period of time past the last data point in the sample.

Nonfarm Exports. Demand for U. S. nonfarm exports was modeled as a demand equation for U. S. goods and services by foreigners; and, as such, it includes foreign real income and relative U. S. versus rest of world (ROW) prices as the determinants of export flows. The specification presumes foreign importers respond to changes in U. S. price (converted to their own currency) vis-à-vis their own price. Foreign income changes also affect U. S. exports. The data used to construct the export equation variables reflect prices and trade volumes between the United States and ten major trade partners. The U. S. price was represented by the U. S. price deflator for exportables adjusted by a trade-weighted exchange rate index using the same countries and weights. A ten-country trade weighted WPI (using again same countries and weights) was used to capture import substitution effects for the foreign country. As prices of import substitutes change in the foreign country, U. S. exports are expected to change in the same direction. Due to the level of aggregation, and to the extent that changes in the foreign WPI may not accurately reflect movements in the price of import substitutes, the U. S.

price and the foreign price were separately included in the equation. Foreign real income (an index of real incomes for the same ten countries) was also included to capture shifts in the export demand facing the United States. A second-degree, 8-quarter polynomial distributed lag was found to best capture responses of exports to U. S. and foreign prices. It is well known that trade flows respond slowly to price changes, and long lags on these variables are very common in the literature.^{5/}

The form that the export sector is estimated assumes an underlying theoretical structure in which the export supply curve is infinitely elastic. Violation of this assumption is very likely to occur at least for nonfarm exports unless excess capacity exists that prevents prices of exportables to rise when an increase in export demand occurs. It is well known that such an omission can cause a downward bias in the estimated parameters of the price elasticities of export demand.^{6/}

The estimated equation is

$$\begin{aligned} \log(\text{EXNAG})_t = & -3.390342 + \sum_{j=1}^8 d_j * \log(\text{PEXNAG}_t / \text{EXCHFRB}_t) \\ & + \sum_{j=1}^8 e_j * \log(\text{FORWPI})_{t-j} + \sum_{j=0}^2 h_j \log(\text{FORGNP}) \end{aligned}$$

$$\begin{aligned} \hat{p} &= .4831 \\ R^2 &= .721 \end{aligned}$$

where

$d_1 = 0.0291$ (0.1091)	$d_2 = -0.0661$ (0.0622)	$d_3 = -0.1351$ (0.0332)
$d_4 = -0.1780$ (0.0320)	$d_5 = -0.1947$ (0.0420)	$d_6 = -0.1853$ (0.0463)
$d_7 = -0.1497$ (0.0412)	$d_8 = -0.0879$ (0.0259)	

$$\begin{array}{lll}
 e_1 = -0.0405 & e_2 = 0.0623 & e_3 = 0.1372 \\
 (0.1892) & (0.0972) & (0.0409) \\
 e_4 = 0.1842 & e_5 = 0.2032 & e_6 = 0.1943 \\
 (0.0547) & (0.0813) & (0.0913) \\
 e_7 = 0.1575 & e_8 = 0.0927 & \\
 (0.0814) & (0.0511) & \\
 h_0 = 0.7009 & h_1 = 0.4673 & h_2 = 0.2336 \\
 (0.0985) & (0.0656) & (0.0328)
 \end{array}$$

This result shows that the equation fits the sample data well, but a sample split revealed parameter instability for the equation. This is a very common problem in the literature associated with aggregate export and import equations.

Import Demand for the United States (Nonfarm). Specification of the import demand equation follows the same logic as the export supply equation; namely, import demand depends on the prices of imported goods and import substitutes as well as domestic real income of the United States. The problem of downward bias in import demand elasticities is also less serious since the supply of importables can be safely considered fixed when the rest of the world is taken to be the "second country" involved in trade.

Import demand for the United States is well known to be very unstable, even more unstable than export demand. The instability seems to be mostly due to changes in foreign supply conditions.^{7/} In the import equation specified in this work, the U. S. WPI is used to represent the price of import substitutes. Own price is obtained by multiplying the foreign WPI by the exchange rate. The income variable is represented by the U. S. real GNP. As in the export demand sector, import demand was estimated by imposing a second-degree polynomial distributed lag on the price variables. The estimated equation is

$$\begin{aligned} \log(\text{EMNP})_t = & -7.52573 + \sum_{j=1}^8 k_j * \text{WPI}_{t-j} \\ & + \sum_{j=1}^8 l_j * \log(\text{DOLFORP})_{t-j} + 1.6699 * \log(\text{GNP}_t) \\ & \quad \quad \quad \hat{p} = .6048 \\ & \quad \quad \quad R^2 = .664 \end{aligned}$$

where

$k_1 = 0.0661$ (0.0199)	$k_2 = 0.1157$ (0.0348)	$k_3 = 0.1488$ (0.0448)
$k_4 = 0.1653$ (0.0498)	$k_5 = 0.1653$ (0.0498)	$k_6 = 0.1488$ (0.0498)
$k_7 = 0.1157$ (0.0448)	$k_8 = 0.0661$ (0.0199)	
$l_1 = -0.0385$ (0.0108)	$l_2 = -0.0674$ (0.0190)	$l_3 = -0.0866$ (0.0244)
$l_4 = -0.0962$ (0.0271)	$l_5 = -0.0962$ (0.0271)	$l_6 = -0.0866$ (0.0244)
$l_7 = -0.0674$ (0.0190)	$l_8 = -0.0385$ (0.0108)	

As in the case of the export demand equation, the parameter stability evaluation revealed significant instability over different time periods for the above equation.

Wheat Exports. The world demand for U. S. wheat was modeled as a standard reduced-form excess demand equation. The explanatory variables in the equation are (1) farm price of wheat relative to the product of the U. S. price level and the trade-weighted exchange rate, (2) the exchange rate as a separate variable to capture foreign income movements following a move in the value of

the dollar and a subsequent monetary policy reaction by foreign governments,^{8/} (3) the ROW production of wheat, (4) an index representing real world GNP, (5) lagged wheat exports, and (6) quarterly dummy variables. The resulting estimated equation is

$$\begin{aligned}
 XW_t = & 178.412 + 73.006 * Q_1 + 17.544 * Q_2 + 264.394 \\
 & (247.28) \quad (34.59) \quad (41.31) \quad (54.02) \\
 & + 13.204 * [PAFW_{t-1}/(CPIU_{t-1} * EXCHFRB_{t-1})] \\
 & \quad (34.72) \\
 & - 105.395 * [PAFW_{t-2}/(CPIU_{t-2} * EXCHFRB_{t-2})] \\
 & \quad (40.30) \\
 & + 35.085 * [PAFW_{t-3}/(CPIU_{t-3} * EXCHFRB_{t-3})] + .024 * GGNP_t \\
 & \quad (32.65) \quad (1.34) \\
 & + 64.041 * EXCHFRB_t + .513 * XW_{t-1} + .314 * XW_{t-4} \\
 & \quad (138.018) \quad (0.15) \quad (0.17) \\
 & - .515 * RWPRDW_t \\
 & \quad (0.43)
 \end{aligned}$$

$$D.W. = 2.137$$

$$R^2 = .816.$$

All variables have the correct sign, but certain important variable coefficients are not significantly different from zero at the 5 percent significance level (real world GNP and the exchange rate).

Feed Grain Exports. The feed grain exports equation follows a similar specification as the equation for wheat exports. The estimated equation is:

$$\begin{aligned}
 XFG_t = & -20.340 + 0.343 * Q_1 - 3.077 * Q_2 + 2.950 * Q_3 \\
 & (9.762) \quad (0.87) \quad (0.99) \quad (1.379) \\
 & + 5.152 * [PAFC_{t-1}/(CPIU_{t-1} * EXCHFRB_{t-1})] \\
 & \quad (2.02)
 \end{aligned}$$

$$\begin{aligned}
& - \frac{1.907}{(2.51)} * [PAFC_{t-2} / (CPIU_{t-2} * EXCHFRB_{t-2})] \\
& - \frac{1.852}{(1.76)} * [PAFC_{t-3} / (CPIU_{t-3} * EXCHFRB_{t-3})] \\
& + \frac{.208}{(0.06)} * WGNP_t + \frac{7.204}{(3.850)} * EXCHFRB_t + \frac{.180}{(0.13)} * XFG_{t-1} \\
& + \frac{.320}{(0.13)} * XFG_{t-4} - \frac{0.058}{(0.02)} * RWPRDFG_t
\end{aligned}$$

$$D.W. = 1.851$$

$$\bar{R}^2 = .854.$$

Note that the sum of the coefficients on the feed grain export equation indicates that the total response on exports to a change in price is positive, not the expected relationship.

Unfortunately, the literature on farm exports does not present any better alternatives to the current specification which could be used for the purposes of this study. Further research is needed to establish credible answers as to the real magnitudes of export price elasticities.

Exchange Rate Determination. The exchange rate equation is estimated for the 1973-1983 period. Hence, the sample includes only the period of flexible exchange rates. The explanatory variables entering the exchange rate equation are RNMDRES, the ratio of nonmonetized deficit to nonborrowed reserves (RESFRBN); MNY1A, the U. S. M1; FORM1_t, the index of foreign M1s; DINCOME_t, the U. S. real GNP minus foreign GNP index; DPRICES, the inflation rate differentials (CPIUINF - FPISTAR_t) where FPISTAR_t is the ex post foreign inflation rate (percentage change in FORWPI); and DUM8083, dummy variable that takes on unit values for the period 1980-1983 and 0 otherwise.

The ratio RNMDRES is introduced as a proxy for real interest rates. The numerator represents government demand for credit from the public and the denominator is directly related to available credit. Hence, an increase in this ratio (as an increase in U. S. real interest rate) is expected to appreciate the dollar. We unsuccessfully tried to incorporate the foreign real interest rate in the equation; thus, it was excluded from the estimation. Domestic and foreign money supplies are expected to have a positive and negative effect, respectively, on the exchange rate. As MNY1A increases, *ceteris paribus*, interest rate in the United States tends to fall relative to ROW interest rate causing the exchange rate to depreciate. The opposite occurs as foreign money rises.

An increase in GNP causes demand for U. S. money to rise which (given money supply) increases the price of U. S. currency relative to the ROW currency (i.e., the dollar tends to appreciate). The opposite happens with a rise in foreign real GNP (FORGNP). Finally, a rise in inflation expectations in the United States will depreciate the exchange rate, while the opposite happens with inflationary expectations in the rest of the world. Using *ex post* inflation to approximate inflationary expectations is a result of our inability to get any meaningful results when MFIT, our proxy for inflationary expectations, was included.

Since the early 1980s are characterized by a persistent appreciation of the dollar and at the same time large capital inflows in the United States and high real interest rates, a dummy variable was included in the equation DUM8083 to capture possible shifts in the exchange rate equation. The negative and significant coefficient on that variable is in accordance with the high value of the dollar for that period. The resulting estimated equation is

$$\begin{aligned}
\text{EXCHFRB}_t = & -0.5404 + 0.9197 * \log(\text{EXCHFRB}_{t-1}) \\
& (0.7045) \\
& + 0.2324 * \log(\text{MIUS}) - 0.1195 * \log(\text{FORM1}) \\
& (0.1953) \quad (0.1176) \\
& - 0.011032 * \text{RNMDRES}_t - 0.09864 * [\log(\text{GNP}_t) - \log(\text{FORGNP})_t] \\
& (0.01304) \quad (0.3318) \\
& + 0.00494 * (\text{CPIUINF}_t - \text{FPISTAR}_t) - 0.0566 * \text{DUM8083}_t \\
& (0.00308) \quad (0.0237) \\
& \text{D.W.} = 1.898 \\
& R^2 = 0.899.
\end{aligned}$$

Agricultural Sector Component

The agricultural sector is composed of wheat, feed grains, and three livestock products--beef, pork, and poultry. For both wheat and feed grains, the major equations cover acreage planted, yields, total production, domestic utilization, inventories (public and private), and price determination representations. For the three meats, the representations cover the demand for meats, meat production, animal placements, animals on feed, and breeding inventories. In what follows each of these equations is briefly discussed, and the empirical results are reported.

Acreage Planted. Since the planting decision is tied to the choice of participation in farm programs, the acreage equations for wheat and feed grains contain most of the policy instruments used in agricultural programs for controlling crop production.^{9/} Acreage planted for each set of crops is hypothesized to depend on the expected real returns from the various alternatives faced by the farmer. This requires that measures of the expected real returns from compliance and noncompliance with government programs be included in each acreage equation. Expected real returns from noncompliance are

specified as the product of expected price and expected yield less per acre variable cost of production. All terms are put into real terms by dividing by the CPIU. For instance, for feed grains, a variable NPFGN (net profits from nonparticipation, feed grains) is specified as:

$$\text{NPFGN} = (1/\text{CPIU}) * (\text{FPC} * \text{EYLD CGS} - \text{CCGS})$$

where CPIU is the consumer price index; FPC is the expected price of corn (approximated by the futures price); EYLD CGS is the expected yield for corn and grain sorghum; and CCGS is the nominal costs of production for corn and grain sorghum.

Expected real return from program compliance (NPFGP) is specified as the sum of expected per acre deficiency payments, expected additional CCC payments due to default on nonrecourse loans, and expected interest subsidies received on CCC loans all divided by the CPI. From this amount, we subtract per acre real variable cost of production and add any additional per acre real diversion payments offered by the government. Again, taking the feed grains variable as an example, the real per acre return from program compliance is given by

$$\begin{aligned} \text{NPFGP} = (1/\text{CPIU}) * \{ & (1 - \text{DRFG}) * [\text{TPC} * \text{YLDFGP} + \text{SPC} * (\text{EYLD CGS} - \text{YLDFGP}) \\ & + (\text{COMPR} - \text{ICCC}) * \text{SPC} * \text{YLDFGP} - \text{COSTFG}] + \text{DPC} * \text{DRFG} \} \end{aligned}$$

where DRFG is the diversion rate for feed grains; TPC is the target price for corn; YLDFGP is the program yield for feed grains; SPC is the support price for corn; COMPR is the market interest rate; ICCG is the subsidized CCC interest rate; and DPC is the diversion payment for corn (per acre). To incorporate the possibility of substituting from one crop to another, analogous

expected returns variables for competing crops are included in each acreage equation.

In addition to these variables for expected returns, each equation also includes variables for real per acre additional voluntary acreage diversion payments, e.g., DVDFG for feed grains. Lagged acreage is included to represent lags in adjustment of planted acreage due to fixed factors and crop rotation plans.

Corn and Grain Sorghum Acreage

$$\begin{aligned}
 ACGS_t = & 76.945 + .145 * (NPFNG_t/CPIU_t) \\
 & (11.17) \quad (0.10) \\
 & - .078 * (NPFGP_t/CPIU_t) - .132 * NPWN_t/CPIU_t \\
 & (0.14) \quad (0.11) \\
 & + .244 * NPWP_t/CPIU_t + .004 + NPSN_t/CPIU_t \\
 & (0.12) \quad (.001) \\
 & + .153 * ACGS_{t-4} - .450 * DVDFG_t \\
 & (0.10) \quad (0.07)
 \end{aligned}$$

$$D.W. = 1.817$$

$$R^2 = .826.$$

Wheat Acreage

$$\begin{aligned}
 AW_t = & 12.430 + .119 * (NPFNG_t/CPIU_t) + .018 * NPFGP_t/CPIU_t \\
 & (12.62) \quad (0.18) \quad (0.23) \\
 & + .134 * NPWN_t/CPIU_t - .196 * NPWP_t/CPIU_t - .093 * NPSN_t/CPIU_t \\
 & (0.21) \quad (0.18) \quad (0.14) \\
 & + .853 * AW_{t-4} - .189 * DVDW_t \\
 & (0.13) \quad (0.14)
 \end{aligned}$$

$$D.W. = 1.724$$

$$R^2 = .789.$$

Yield Per Acre. Each yield equation is specified to be a function of expected real profit differentials, the diversion requirement, a time trend to measure technical progress, and a number of indicator variables representing incidents of bad weather. Furthermore, it is expected that yield per acre will increase more with a rise in expected returns from compliance than from the same rise in expected returns under noncompliance since farmers are more certain about their incomes in the former case. Increases in yields per acre are anticipated following increases in the diversion requirement since farmers will presumably remove their poorest quality acres from production when they choose to comply with agricultural programs. The estimated equations are:

Corn and Corn Sorghum Yields

$$\begin{aligned} \text{YLD CGS}_t = & 35.2862 + 1.5639 * T - 9.9072 * D7480_t \\ & (8.0817) \quad (.3390) \quad (6.5951) \\ & - 0.0781 * (\text{NPFGN}_t - \text{NPFGP}_t) \\ & (0.0976) \end{aligned}$$

$$\text{D.W.} = 1.5667$$

$$\bar{R}^2 = 0.524$$

Wheat Yields

$$\begin{aligned} \text{YLDW}_t = & 16.973 + 0.4288 * T + 3.819 * \text{DRW}_t \\ & (1.5854) \quad (0.0629) \quad (1.597) \\ & - 0.03748 * (\text{NPWN}_t - \text{NPWP}_t) \\ & (0.0184) \end{aligned}$$

$$\text{D.W.} = 1.370$$

$$\bar{R}^2 = 0.722.$$

Total production is obtained from acreage and yield by identities representing the product of yields and acreage.

Domestic Utilization. Domestic feed grain consumption is divided into feed and other uses. Only feed use is determined endogenously. Domestic wheat consumption is divided into food consumption and other uses, but only food consumption is determined endogenously.

Domestic feed demand for feed grains is specified to be a function of the inventories of cattle on feed (COF), pigs on feed (PIGOF), and broilers on feed (BROF). Feed grain consumption increases with the number of animals on feed. A ratio of feed costs to meat prices is also included in the livestock demand for feed equation to reflect the margin from feeding. This ratio is computed as:

$$\text{RPFPM}_t = (.15 * \text{PAFS}_t + .85 * \text{PAFC}_t) / (.37 \text{PBEEF}_t + .12 * \text{PBR}_t + .51 * \text{PPORK}_t).$$

Weights for each type of animal and feed were obtained from historical feed utilization data.

Disappearance (Feed and Residual) of Feed Grains

$$\begin{aligned} \text{DLVKFG}_t = & 7.1311 + 0.001964 * \text{COF}_t + 0.000339 * \text{PIGOF}_t \\ & (7.8248) \quad (0.00045) \quad (0.00013) \\ & + 0.00000701 * \text{BROF}_t - 11.4354 * \text{RPFPM}_t \\ & (.00000361) \quad (114.457) \\ & - 9.2872 * Q_1 - 23.8247 * Q_2 - 14.3568 * Q_3 \\ & (1.3777) \quad (1.4433) \quad (1.2202) \end{aligned}$$

$$\text{D.W.} = 1.897$$

$$\bar{R}^2 = 0.917.$$

Domestic per capita food demand for wheat is a function of the real price of wheat, an index of real food prices (the food CPI deflated by the CPI for all goods), and real per capita income. All variables have the expected sign.

Disappearance (Food) of Wheat

$$\begin{aligned}
 DFW_t/N_t = & 0.5731 - 0.0113 * (PAFW_t/CPIU_t) \\
 & (.2849) \quad (.0123) \\
 & + 0.450 * (CPIF_t/CPIU_t) - 0.1103 * (CPINF_t/CPIU_t) \\
 & (.2157) \quad (0.2493) \\
 & + 0.0564 * YD_t/(CPIU_t * N_t) - 0.0343 * Q_1 \\
 & (0.0580) \quad (0.0092) \\
 & - 0.2707 * Q_2 + 0.1827 * Q_3 \\
 & (0.0094) \quad (0.0092)
 \end{aligned}$$

$$D.W. = 1.2102$$

$$R^2 = 0.9789.$$

The food, seed, and industrial uses of feed grains are modeled as a function of the real price of corn, real per capita income, and a time trend. The time trend is included to represent the adoption of new corn based products in the food and beverage processing industries. Because of a high degree of serial correlation in the original specification, the food, seed, and industrial use demand equation was estimated using the difference between current consumption and consumption four quarters ago. The estimated equation is:

$$\begin{aligned}
 DINDFG_t - DINDFG_{t-4} = & 2.024 - .140 * Q_1 - .081 * Q_2 + .230 * Q_3 \\
 & (1.93) \quad (0.11) \quad (0.11) \quad (0.11) \\
 & - .322 * PAFC_t/CPIU_t - 1.237 * [YD_t/(CPIU_t * N_t)] \\
 & (0.17) \quad (0.53) \\
 & + 0.35 * TIME \\
 & (0.02)
 \end{aligned}$$

$$D.W. = 2.228$$

$$R^2 = .336.$$

In recent years the seed, industrial, and livestock demand for wheat has gained increasing importance as a component of total wheat utilization. This

gain is largely the result of falling relative wheat-feed grain prices in the southeastern United States where soft-red winter wheat production has increased substantially. Since the major livestock enterprise in that area is broiler production, most of the wheat that is consumed by livestock is allocated to broiler production.

Livestock demand for wheat is specified as a function of the ratio of wheat price to broiler price, corn price to broiler price, and number of broilers on feed. Lagged livestock demand for wheat is included in the equation to represent the adoption process of wheat feeding in broiler enterprises.

The estimated equation for livestock, seed, and industrial demand for wheat is

$$\begin{aligned} \text{DLVKW}_t = & -133.014 + \frac{18.159}{(72.21)} * Q_1 + \frac{2.295}{(18.97)} * Q_2 + \frac{43.520}{(25.58)} * Q_3 \\ & - \frac{1,390.308}{(818.80)} * (\text{PAFW}_t / \text{PBR}_t) + \frac{3,301.466}{(1,477.35)} * (\text{PAFC}_t / \text{PBR}_t) \\ & + \frac{.00009}{(.00005)} * \text{BROF}_t + \frac{.697}{(0.16)} * \text{DLVKW}_{t-4} \end{aligned}$$

$$\text{D.W.} = 2.371$$

$$\bar{R}^2 = .729.$$

Inventories. Inventory equations are used to complete the model and determine the price of each crop. Inventories are separated into three components: stocks owned by the government, the farmer-owned reserve, and privately held and CCC farmer-held stocks. In general, it is assumed that a measure of the expected profitability of holding stocks along with measures of opportunity costs associated with holding inventories will be the main factors influencing stockholding decisions.

To capture the two different possible effects of interest rates on the farmer-owned reserve (opportunity cost versus higher government subsidization), an interest rate subsidy (COMPR-ICCC) and the real interest rate (RRATE) are included as separate variables. The expectation is that the first will enter with a positive sign while the second will enter with a negative sign.

Lagged dependent variables are included in the CCC and government-owned stock and farmer-owned grain inventory equations to reflect the possibility of only partial adjustment of inventories in a given period. For instance, for most of the sample period, stocks remained in the farmer-owned reserve for a period of three years before market prices reached the release level. Market and nongovernment-owned CCC inventories (defined as KMKTFGE and KMKTWE for feed grains and wheat, respectively) are determined from an identity that links production, utilization, government stockholdings, and the farmer-owned reserve. Finally, real prices are directly determined by behavioral equations. The normalization on price is conceptually appealing, permitting the private storage market to drive price determination. Government-owned and CCC stocks (KGOVFGE and KGOVWE) and the farmer-owned reserve stocks are included in this equation since they represent alternatives to private storage. Furthermore, including government-encouraged stocks provides a test of the effectiveness of removing those stocks from the market.

Ending Inventory (Government Owned) of Feed Grains

$$\begin{aligned} \text{KGOVFGE}_t = & \frac{0.5292}{(1.0066)} + \frac{0.0682}{(0.5547)} * Q_{1t} + \frac{0.7885}{(0.5620)} * Q_{2t} \\ & + \frac{0.18823}{(0.5554)} * Q_{3t} + \frac{0.42265}{(0.0706)} * \text{KGOVFGE}_{t-1} \end{aligned}$$

$$+ \frac{1.6455}{(1.1065)} * (0.95 * SPC_t / PAFC_t) - \frac{0.41491}{(0.1390)} * RRATE_t$$

$$+ \frac{5.5185}{(0.8870)} * DMYEMB_t + \frac{24.8968}{(1.9466)} * DMYPIK_t$$

$$D.W. = 1.213$$

$$R^2 = 0.973.$$

Ending Inventories (Farmer-Owned Reserve) of Feed Grains

$$KFORFGE_t = KFORFG_{t-1} - \frac{9.8977}{(14.571)} - \frac{2.1868}{(2.9612)} * Q_{1t}$$

$$- \frac{7.2357}{(2.9542)} * Q_{2t} - \frac{6.6421}{(2.9628)} * Q_{3t}$$

$$+ \frac{15.1979}{(9.1272)} * (RELFORC_t / PAFC_t) - \frac{1.1247}{(2.9309)} * (PAFC_t / SPC_t)$$

$$- \frac{0.3027}{(0.5059)} * (COMPR_t - ICCC_t) - \frac{.61695}{(0.6827)} * RRATE_t$$

$$+ \frac{3.2226}{(3.341)} * DMYEMB_t - \frac{18.1914}{(8.372)} * DMYPIK_t$$

$$D.W. = 1.807$$

$$R^2 = 0.452.$$

Market and Nongovernmental-Owned Inventories of Feed Grains

$$KMKTFG_t = KMKTFG_{t-1} + KFORFGE_{t-1} + KGOVFGE_{t-1}$$

$$+ PRDFGE_t + MFG_t - XFG_t - DLVKFG_t$$

$$- DINDFG_t - KFORFGE_t - KGOVFGE_t$$

Ending Inventories (Government Owned) of Wheat

$$KGOVWE_t = \frac{20.4351}{(17.0388)} + \frac{4.9396}{(10.616)} * Q_{1t} + \frac{22.5979}{(10.678)} * Q_{2t}$$

$$- \frac{2.109}{(10.254)} * Q_{3t} + \frac{0.5582}{(0.0671)} * KGOVWE_{t-1}$$

$$\begin{aligned}
& + \frac{8.8435}{(20.312)} * (SPW_t / PAFW_t) + \frac{8.0352}{(2.3654)} * (COMPR_t - ICCC_t) \\
& - \frac{6.2108}{(2.603)} * RRATE_t + \frac{92.5485}{(16.561)} * DMYEMB_t - \frac{221.95}{(27.284)} * DMYPIK_t \\
& \text{D.W.} = 1.885 \\
& R^2 = .934.
\end{aligned}$$

Market and Nongovernment-Owned Inventories of Wheat

$$\begin{aligned}
KMKTWE_t &= KMKTWE_{t-1} + KFORWE_{t-1} + KGOVWE_{t-1} + PRDWE_t + MW_t - XW_t \\
& - DLVKW_t - DFW_t - KFORW_t - KGOVW_t
\end{aligned}$$

Ending Inventory (Farmer-Owned Reserve) of Wheat

$$\begin{aligned}
KFORWE_t &= KFORWE_{t-1} - \frac{128.5516}{(89.953)} + \frac{10.4085}{(30.335)} * Q_{1t} - \frac{36.393}{(30.538)} * Q_{2t} \\
& - \frac{18.4766}{(30.066)} * Q_{3t} + \frac{135.0337}{(79.1967)} * (RELFORW_t / PAFW_t) \\
& + \frac{5.1041}{(5.873)} * (COMPR_t - ICCC_t) - \frac{1.9526}{(6.5402)} * RRATE \\
& + \frac{3.2226}{(3.3414)} * DMYEMB - \frac{18.1914}{(8.3715)} * DMYPIK \\
& \text{D.W.} = 1.807 \\
& R^2 = .452.
\end{aligned}$$

Farm Price of Corn

$$\begin{aligned}
\frac{PAFC_t}{CPIU_t} - \frac{SPC_t}{CPIU_t} &= \frac{0.81028}{(0.3515)} + \frac{0.76229}{(0.0969)} * \left(\frac{PAFC_{t-1} - SPC_{t-1}}{CPIU_{t-1}} \right) \\
& - \frac{0.14812}{(0.1286)} * Q_{1t} - \frac{0.33779}{(0.1847)} * Q_{2t} - \frac{0.44839}{(0.2363)} * Q_{3t} \\
& - \frac{0.000426}{(0.00141)} * KFORFGE_t - \frac{0.00535}{(0.00199)} * KMKTFGGE_t
\end{aligned}$$

$$\begin{aligned}
 & - \frac{0.00748}{(0.00508)} * KGOVFGE_t - \frac{0.02544}{(0.010875)} * (COMPR_t - ICCC_t) \\
 & - \frac{0.005574}{(0.01065)} * RRATE
 \end{aligned}$$

$$D.W. = 2.309$$

$$\bar{R}^2 = 0.836.$$

Farm Price of Wheat

$$\begin{aligned}
 \frac{PAFW_t}{CPIU_t} - \frac{SPW_t}{CPIU_t} = & \frac{2.1858}{(0.3815)} + \frac{0.52112}{(0.0939)} * \left(\frac{PAFW_{t-1} - SPW_{t-1}}{CPIU_{t-1}} \right) \\
 & - \frac{0.67009}{(0.1453)} * Q_{1t} - \frac{1.15416}{(0.1981)} * Q_{2t} - \frac{0.46048}{(0.14845)} * Q_{3t} \\
 & - \frac{0.000509}{(0.00021)} * KFORWE_t - \frac{0.001134}{(0.000207)} * KMKTWE_t \\
 & - \frac{0.0004769}{(0.00061)} * KGOVWE_t - \frac{0.0135680}{(0.01886)} * RRATE_t
 \end{aligned}$$

$$D.W. = 1.957$$

$$\bar{R}^2 = 0.895.$$

Demand for Meats. Per capita meat demand is modeled in price-dependent form as a function of own price, the price of substitute meats, and income. Prices and income are measured in constant dollars, and income is per capita. A non-agricultural price index (CPINF) representing the price of substitute nonfood items is also included in the meat demand equations. All variables enter with their expected signs, with the income elasticity of demand for pork and broilers being fairly low.

Retail Price of Choice Beef

$$\begin{aligned} \frac{PBEEF_t}{CPIU_t} = & \frac{-59.3128}{(100.2706)} - \frac{1.5352}{(0.6166)} * \frac{DDBEEF_t}{N_t} + \frac{.4202}{(.1947)} * \frac{PPORK_t}{CPIU_t} \\ & + \frac{17.6721}{(14.1179)} * \frac{YD_t}{(CPIU_t * N_t)} + \frac{107.4208}{(94.5877)} * \frac{CPINF_t}{CPIU_t} \\ & + \frac{.0698}{(.9195)} * Q_1 + \frac{1.6447}{(.9345)} * Q_2 + \frac{1.0661}{(.5861)} * Q_3 \end{aligned}$$

$\hat{p} = .8476$
 $\bar{R}^2 = .733.$

Retail Price of Pork

$$\begin{aligned} \frac{PPORK_t}{CPIU_t} = & \frac{74.4804}{(54.5486)} - \frac{4.0423}{(0.5215)} * \frac{DDPORK_t}{N_t} + \frac{.3041}{(0.1193)} * \frac{PBEEF_t}{CPIU_t} \\ & + \frac{.5111}{(0.2163)} * \frac{PRB_t}{CPIU_t} - \frac{2.9860}{(8.3542)} * \frac{YD_t}{(CPINF_t * N_t)} + \frac{32.1498}{(46.8783)} * \frac{CPINF_t}{CPIU_t} \\ & - \frac{4.8488}{(0.8784)} * Q_1 - \frac{7.2447}{(0.8137)} * Q_2 - \frac{8.7364}{(0.9824)} * Q_3 \end{aligned}$$

$\hat{p} = .5047$
 $\bar{R}^2 = .942.$

Four-Region Average Retail Price of Broilers

$$\begin{aligned} \frac{PRB_t}{CPIU_t} = & \frac{121.7004}{(66.4276)} - \frac{3.7589}{(1.0461)} * \frac{DDBR_t}{N_t} + \frac{.2982}{(.0644)} * \frac{PBEEF_t}{CPIU_t} + \frac{.1712}{(.0708)} * \frac{PPORK_t}{CPIU_t} \\ & + \frac{1.7521}{(6.4345)} * \frac{YD_t}{(CPIU_t * N_t)} - \frac{105.1426}{(59.6668)} * \frac{CPINF_t}{CPIU_t} + \frac{.7967}{(0.6876)} * Q_1 \\ & + \frac{3.7001}{(1.0318)} * Q_2 + \frac{4.4322}{(0.9857)} * Q_3 \end{aligned}$$

$\hat{p} = .3122$
 $\bar{R}^2 = .882.$

Beef Disappearance

$$DDBEEF_t = PRDBEEF_t + MBEEF_t - XBEEF_t$$

Pork Disappearance

$$DDPORK_t = PRDPORK_t + MPORK_t - XBEEF_t$$

Broiler Disappearance

$$DDBR_t = PRDBR_t - XBEEF_t$$

Meat Production. The supply of meat for consumption is determined by previous placements of animals on feed and a measure of the relative profitability of feeding livestock. In addition, for pork and beef, part of the current meat supply is determined by the liquidation or accumulation of breeding inventories. As expected, increasing meat prices correspond to reduced current supplies due to retention of animals for breeding herds, while increases in feed costs corresponds to increased current supply due to reduced profitability of livestock production.

Commercial Production of Beef

$$\begin{aligned} PRDBEEF_t = & 4,185.068 + \frac{16.4227}{(506.1477)} * Q_1 - \frac{187.9163}{(164.1059)} * Q_2 \\ & - \frac{76.5143}{(92.1056)} * Q_3 - \frac{.2251}{(.0309)} * (TCOWKE_t - TCOWKE_{t-2}) \\ & + \frac{.1074}{(0.0713)} * CATPL_{t-2} + \frac{68,556.40}{(11,972.43)} * \left(\frac{PAFC_{t-1}}{PBEEF_{t-1}} \right) \end{aligned}$$

$$D.W. = .8476$$

$$R^2 = 0.9604.$$

Commercial Production of Pork

$$\begin{aligned} \text{PRDPORK}_t = & -163.7924 + 347.6416 * Q_1 + 352.7452 * Q_2 + 545.9152 * Q_3 \\ & (467.6178) \quad (104.9475) \quad (97.1138) \quad (150.2064) \\ & + .1976 * \text{PIGC}_{t-2} - .0161 * (\text{BRHOGKE}_t - \text{BRHOGKE}_{t-1}) \\ & (0.1973) \quad (0.1564) \\ & + 1,342.606 * \left(\frac{\text{PAFC}_{t-1}}{\text{PPORK}_{t-1}} \right) \\ & (8,494.163) \end{aligned}$$

$$\text{D.W.} = 1.4552$$

$$\bar{R}^2 = 0.7996.$$

Commercial Production of Broilers

$$\begin{aligned} \text{PRDBR}_t = & 596.4659 + 134.5693 * Q_1 + 131.8571 * Q_2 - 121.3435 * Q_3 \\ & (99.2464) \quad (25.9959) \quad (25.6173) \quad (26.4201) \\ & + .0032 * \text{BRCH}_{t-1} + 2,245.278 * \left(\frac{\text{PAFC}_{t-1}}{\text{PBR}_{t-1}} \right) \\ & (.00007) \quad (1,378.037) \end{aligned}$$

$$\text{D.W.} = 1.6987$$

$$\bar{R}^2 = .9804.$$

Livestock Placements. Placement of livestock on feed depends on previous breeding inventories and expected profitability of feedings. The lagged values for breeding inventories are included to measure the number of animals currently available for placement in feeding inventories. Again, expected profitability is measured by feed costs as a percentage of meat prices.

Placement of Cattle on Feed (Thirteen States)

$$\begin{aligned} \text{CATPL}_t = & 1,475.963 - 1,901.682 * Q_1 - 1,636.137 * Q_2 \\ & (1,293.466) \quad (190.5938) \quad (185.9975) \\ & - 1,582.410 * Q_3 + \sum_{i=6}^{10} \alpha_i * \text{ECOWINV}_{t-1} + \sum_{k=0}^4 \beta_k * \left(\frac{\text{PAFC}_{t-k}}{\text{PBEEF}_{t-k}} \right) \\ & (185.9567) \end{aligned}$$

$$\text{D.W.} = 1.5468$$

$$\bar{R}^2 = 0.7976$$

where

$$\alpha_6 = \begin{matrix} .0099 \\ (.0019) \end{matrix}$$

$$\alpha_7 = \begin{matrix} .0198 \\ (.0037) \end{matrix}$$

$$\alpha_8 = \begin{matrix} .0296 \\ (.0056) \end{matrix}$$

$$\alpha_9 = \begin{matrix} .0395 \\ (.0075) \end{matrix}$$

$$\alpha_{10} = \begin{matrix} .0494 \\ (.0093) \end{matrix}$$

$$\beta_0 = \begin{matrix} -51,947.9095 \\ (8,642.0342) \end{matrix}$$

$$\beta_1 = \begin{matrix} -41,558.3276 \\ (6,913.6273) \end{matrix}$$

$$\beta_2 = \begin{matrix} -31,168.7457 \\ (5,185.2205) \end{matrix}$$

$$\beta_3 = \begin{matrix} -20,779.1638 \\ (3,459.8137) \end{matrix}$$

$$\beta_4 = \begin{matrix} -10,389.5819 \\ (1,728.4068) \end{matrix}$$

Pig Crop (Ten States)

$$\text{PIGC}_t = \begin{matrix} 7,552.537 \\ (2,266.338) \end{matrix} - \begin{matrix} 2,456.050 \\ (479.3789) \end{matrix} * Q_1 + \begin{matrix} 2,855.243 \\ (478.9968) \end{matrix} * Q_2$$

$$- \begin{matrix} 172.4839 \\ (479.2586) \end{matrix} * Q_3 + \sum_{i=1}^4 \alpha_t * \text{MBHOG}_{t-1} + \sum_{k=0}^3 \beta_k * \left(\frac{\text{PAFC}_{t-k}}{\text{PPORK}_{t-k}} \right)$$

$$\text{D.W.} = 0.6735$$

$$R^2 = .8304$$

where

$$\alpha_1 = \begin{matrix} .8359 \\ (.1281) \end{matrix}$$

$$\alpha_2 = \begin{matrix} .6269 \\ (.0961) \end{matrix}$$

$$\alpha_3 = \begin{matrix} .4179 \\ (.0641) \end{matrix}$$

$$\alpha_4 = \begin{matrix} .2090 \\ (.0320) \end{matrix}$$

$$\beta_0 = \begin{matrix} -88,168.8723 \\ (19,140.1160) \end{matrix}$$

$$\beta_1 = \begin{matrix} -66.126.6542 \\ (14,355.0870) \end{matrix}$$

$$\beta_2 = \begin{matrix} -44,084.4361 \\ (9,570.0580) \end{matrix}$$

$$\beta_3 = \begin{matrix} -22,042.2181. \\ (4,785.0290) \end{matrix}$$

Broiler Chicks, Hatched

$$\text{BRCH}_t = \begin{matrix} -108,058.8 \\ (54,639.02) \end{matrix} + \begin{matrix} 54,639.02 \\ (19,376.64) \end{matrix} * Q_1 + \begin{matrix} 112,972.3 \\ (20,347.26) \end{matrix} * Q_2$$

$$+ \frac{31,999.18}{(19,385.41)} * Q_3 + \sum_{i=0}^4 \alpha_t * CPL_{t-1} \sum_{k=0}^2 \beta_k * \frac{PAFC_{t-k}}{PBR_{t-k}}$$

$$D.W. = 0.3009$$

$$R^2 = .8937$$

where

$$\alpha_0 = \frac{25.4804}{(8.8656)} \quad \alpha_1 = \frac{27.9307}{(2.5615)} \quad \alpha_2 = \frac{26.6078}{(2.7834)}$$

$$\alpha_3 = \frac{21.5117}{(4.2409)} \quad \alpha_4 = \frac{12.6424}{(3.3640)}$$

$$\beta_0 = \frac{-16,652.1767}{(62,744.359)} \quad \beta_1 = \frac{-11,101.4511}{(418,295.7)} \quad \beta_2 = \frac{5,550.7256}{(209,147.87)}$$

Equations representing breeding inventories complete the relations in the livestock sector. Explanatory variables include previous inventories, distributed lags on percentage feed costs, and interest rates. The latter two variables measure costs of holding and feeding livestock. Increases in these cost measures are expected to result in a net reduction in breeding inventories. The lagged dependent variable is included to reflect slow adjustments in breeding operations.

Inventory Cows and Heifers that Have Calved

$$\Delta TCOWKE_t = \frac{2,852.412}{(497.45)} + \frac{697.0558}{(148.05)} * Q_1 + \frac{709.368}{(147.786)} * Q_2 - \frac{7.061}{(147.59)} * Q_3$$

$$+ \sum_{j=1}^{12} \lambda_j * \left(\frac{PAFC}{PBEEF} \right)_{t-j} + \sum_{j=0}^{11} z_j * RRATE_{t-j}$$

$$D.W. = 1.232$$

$$R^2 = 0.735$$

where

$$\begin{array}{lll}
 \lambda_1 = -5,885.96 & \lambda_2 = -1,0877.26 & \lambda_3 = -14,973.89 \\
 (1,099.17) & (1,931.001) & (2,504.73) \\
 \lambda_4 = -18,175.8 & \lambda_5 = -20,483.14 & \lambda_6 = -21,895.77 \\
 (2,836.4) & (2,955.67) & (2,920.49) \\
 \lambda_7 = -22,413.7 & \lambda_8 = -22,037.01 & \lambda_9 = -20,765.4 \\
 (2,845.8) & (2,933.87) & (3,422.14) \\
 \lambda_{10} = -18,559.6 & \lambda_{11} = -15,538.9 & \lambda_{12} = -11,583.5 \\
 (4,421.9) & (5,896.6) & (7,777.29) \\
 \\
 z_0 = -5.089 & z_1 = -9.288 & z_2 = -12.596 \\
 (2.74) & (7.002) & (3.852) \\
 z_3 = -15.014 & z_4 = -16.54 & z_5 = -17.18 \\
 (4.807) & (6.47) & (5.744) \\
 z_6 = -16.924 & z_7 = -15.78 & z_8 = -13.746 \\
 (6.198) & (5.42) & (9.29) \\
 z_9 = -10.821 & z_{10} = -7.055 & z_{11} = -2.299. \\
 (6.92) & (4.179) & (13.85)
 \end{array}$$

Inventory: Breeding Hogs on Farms

$$\begin{aligned}
 BRHOGKE_t = & 1,679.69 - 13.01 * Q_1 + 99.469 * Q_2 - 205.105 * Q_3 \\
 & (528.19) \quad (92.35) \quad (92.58) \quad (93.25) \\
 & + 0.8364 * BRHOGKE_{t-1} + \sum_{j=1}^5 k_j * \left(\frac{PAFC}{PPORK} \right)_{t-j} \\
 & \quad (0.0649) \\
 & + \sum_{j=1}^5 \gamma_j * \left(\frac{PAFC}{PPORK} \right)_{t-j}
 \end{aligned}$$

$$D.W. = 1.60$$

$$R^2 = 0.864$$

where

$$\begin{array}{lll}
 k_1 = -8,512.50 & k_2 = -6,810.07 & k_3 = -5,107.55 \\
 (3,582.15) & (2,865.72) & (2,149.29) \\
 k_4 = -3,405.03 & k_5 = -1,702.52 & \\
 (1,432.86) & (716.430) &
 \end{array}$$

$$\gamma_1 = \frac{-14.263}{(5.331)}$$

$$\gamma_2 = \frac{-11.411}{(4.265)}$$

$$\gamma_3 = \frac{-8.558}{(3.198)}$$

$$\gamma_4 = \frac{-5.705}{(2.133)}$$

$$\gamma_5 = \frac{-2.852}{(1.066)}$$

Broiler-Type Pullet Chick Placement for Hatchery Supply

$$\text{CPL}_t = 3,389.5 - 43.738 * Q_1 + 221.665 * Q_2 - 929.019 * Q_3$$

$$+ 0.7316 * \text{CPL}_{t-1} + \sum_{j=1}^4 \delta_j * \left(\frac{\text{PAFC}}{\text{PBR}} \right)_{t-j} + \sum_{j=1}^4 \pi_j * \text{RRATE}_{t-j}$$

$$\text{D.W.} = 2.13$$

$$\bar{R}^2 = 0.715$$

where

$$\delta_1 = \frac{-9,732.76}{(8,364.39)}$$

$$\delta_2 = \frac{-7,299.57}{(6,273.3)}$$

$$\delta_3 = \frac{-4,866.38}{(4,182.2)}$$

$$\delta_4 = \frac{-2,433.19}{(2.091.09)}$$

$$\pi_1 = \frac{-15.947}{(24.339)}$$

$$\pi_2 = \frac{11.961}{(18.25)}$$

$$\pi_3 = \frac{7.974}{(12.169)}$$

$$\pi_4 = \frac{3.987}{(6.085)}$$

Chapter 5

Model Validation and Simulation Experiments^{1/}

The validation exercises for each of the three components (macro, international, and agriculture) have focused on the ex post forecasting properties of the model. The flex/fixed price specification or, equivalently, the differential response of markets to changes in money supply has also been investigated. This investigation results in a determination of the degree of money nonneutrality in the short run. To assess the verifiability of the model, the stability characteristics of the model have been examined for the estimated parameters based on the entire sample. Moreover, we have also investigated the stability of the parameters over some major, distinguishable regimes that define the nature and structure of linkages between the agricultural sector and the macro and international economies.

The simulation experiments, only some of which are reported here, are pairwise comparisons. In all of these comparisons, the macromodel is combined with the international model as one submodel; and the agricultural sector representation is treated as one submodel. The within-sample simulations are performed for each of the two submodels as separate structures. These are then compared with the joint simulation of the two submodels running in tandem. Each of these simulations was performed to check that the model tracks the data well and that no apparent specification errors exist.

Some simulation experiments focus on evaluating the effects of two alternative scenarios, one corresponding to a "tax period" and another to a "subsidy period." First, an environment similar to the 1981-1983 period is recreated and is referred to as a tax period. This is compared with a subsidy period similar to the 1973-1975 regime of a weak dollar accompanied by easy

money. Each will be analyzed to determine the extent to which the macro-economic and international environments affect agricultural markets.

There are two versions of the model that are used for the above simulations. First, only the "forward" linkages are included. This set of simulations will be analogous to most econometric models with an agricultural sector; agriculture appears only as a "satellite." Second, the backward linkages from the agricultural sector to the rest of the economy will be incorporated. This set of simulations will allow us to evaluate the extent to which ignoring backward linkages, *ceteris paribus*, has affected previous models and the results derived therefrom. Finally, some simulation experiments are undertaken with different agricultural policies.

The Lucas critique of policy-based econometric models is not applicable to the analysis that will be conducted here. The Lucas critique has relevance for econometric models whose unknown parameters embed policy instruments when there is a major change in the set of policy instruments; when the government is not the dominant player and private sector agents fully anticipate all governmental actions; or when, as Sims notes, the analysis pertains to long-run implications of preannounced policy characterized by fixed rules. None of these concerns is sufficiently important to preclude the use of the model presented in Chapter 4 for policy analysis. All relevant policy instruments are entered directly as explanatory variables in the estimated model. In the policy simulation experiments, the focus is on the dynamic path resulting from changes in existing policy instruments only over the short run. The monetary policy scenarios that are simulated with the existing model do not differ in terms of institutional structures. In particular, the federal reserve is still presumed to target bank reserves. In essence, for both macro- and

sector-specific policies that are examined, agents in their decision-making processes are unable to absorb and process new policy information in the short run and to quickly adjust. It takes time to determine the credibility of major policy changes and their dynamic implications for the economic environment facing these decision-makers.

Validation Exercises

The macro/international submodel performs reasonably well based on the within-sample simulations. For these experiments, the agricultural submodel and the estimated linkage equations are excluded. Overall, prediction errors are well within acceptable bounds. The in-sample tracking properties of the model were assessed using a Gauss-Newton simulation provided by the Time Series Processor (TSP Version 4.0). This algorithm is sufficiently flexible to handle non-linear simulations and uses the sum of squared derivations for each equation as its criterion function.

The model's accuracy in tracking the history for certain crucial variables was one of the validation exercises conducted. For example, in the case of the short-run interest rate and the CPI, the model replicated historical values closely. The model captured the sharp turn in the interest rate between the third and fourth quarters of 1982. Frequently, the model systematically underexplained the CPI but only by a small amount. For the GNP and personal disposable income, the history of both variables was tracked very well indeed by ex post generated values from the model. However, errors appeared during two critical turning points in the economy. Specifically, the model misses by a small amount the recession of 1981 and the subsequent recovery of 1983 by overpredicting in the first case and underpredicting in the second case. An examination of the individual components of aggregate demand reveals

that these two "misses" result from misses in the demand for durables and imports.

In the case of the exchange rate, comparatively favorable results were obtained. As noted in numerous other studies, the exchange rate is indeed difficult to predict based on the fundamental influences since 1979. The high coefficient on the lagged dependent variable in the exchange rate equation also prolongs the effects of any misses that might occur for several periods. In any event, the percentage error in ex post prediction for the exchange rate never exceeded 5 percent. This result is viewed as acceptable given that the exchange rate is measured as the relative value of the dollar to a weighted aggregate of a large number of other currencies. In the case of the nominal wage rate, the model tracks this variable remarkably well. This is largely because nominal wages follow a rather smooth trend; thus, it is easily explained.

Prices and quantities in the agricultural sector representations are subject to the effects of unpredictable factors such as weather and diseases. Moreover, the flexible nature of agricultural commodity markets makes these markets more responsive to changes in supply and demand shocks, policy changes, and shocks in money markets and exchange rate markets. The use of quarterly rather than annual data in estimating the agricultural sector model also increases the difficulty of obtaining well-behaved estimated equations. Inventories, for example, tend to vary significantly between the quarter in which the harvest occurs and the preceding quarter. Annual data obviously tend to "flatten" many of the peaks and troughs that appear in quarterly data. Nevertheless, the ex post errors that are obtained in the validation exercises that were conducted are generally acceptable. In all cases, these errors are random and reveal no systematic behavior.

The model tracks the prices of corn more closely than the prices of wheat. In some cases the percentage ex post forecast errors for wheat are very large. On the whole, the model tracks rather well movements in inventories and their relative share among market, CCC, and farmer-held reserve levels. However, abrupt changes in stocks are "missed" in the second and third quarters of 1981 for the farmer-held reserve which becomes almost zero and immediately thereafter rises to 20 million metric tons in the next quarter when the harvest occurs.

In the case of exports, percent errors and ex post predictions are in some instances quite large. In the case of the second quarter of 1982, for example, the percent error for corn is 8 percent while, in the case of wheat during the same quarter, the percentage error is approximately 12 percent. These comparative results are due to a greater error in wheat prices relative to corn prices and the fact that wheat exports are more sensitive to exchange rate movements than feed grain exports.

For all other endogenous variables appearing in the agricultural sector, the percentage errors between model-generated values and actual historical values are surprisingly small. This is true of the supply response component for wheat and feed grains as well as the domestic demand relationships for corn and wheat. Each of the four subcomponents of the livestock industry--namely, production, breeding stocks, animal placements, and demand--have ex post prediction errors that are generally random and are sufficiently small.

The dynamic stability properties of the complete model have been investigated from a number of different perspectives. First, we have investigated the local, component stability of each of the two submodels: macro/international and agricultural. For each submodel, the analytical stability

properties of the linearized versions were investigated. In each instance, all of the relevant characteristic roots satisfied the conditions for stability. We have also investigated the dynamic properties of the linearized version of the complete model which incorporates the linkages between the macro/international and the agricultural sector submodels. Here again, the analytically derived characteristic roots satisfy the conditions for stability. As yet, however, we have not investigated the global stability properties of the model--that is to say, the model in its original nonlinear form. We have evaluated the dynamic paths of the two nonlinear submodels separately as well as the complete nonlinear model over three-year horizons. The model has been shocked with wide ranges of exogenous variables, as well as initial conditions, and it has generated dynamic paths composed of internally consistent values. Based on these results, we have drawn the conclusion that the nonlinear version of the model is sufficiently stable, at least for the three-year horizons reported here for the simulation experiments.

A major issue of validation relates to the fixed/flex price specification of the model advanced in this study. Without the fixed-price sector, money is nonneutral in the short as well as the long run. Moreover, no overshooting results; thus, there is no need to account for macroeconomic linkages in the design of any agricultural policies. This suggests that it is indeed imperative to determine whether or not the fixed/flex price specification is appropriate.

An eclectic approach may be followed in evaluating the fixed- and flex-price assumptions of the specified model. This involves estimation of both a fixed/flex and flex/flex model and making several comparisons. Ad hoc comparisons are necessary because the nonnested hypothesis testing procedures

are only asymptotically valid, and their behavior is quite uncertain for complex models of the type considered here. The plausibility of the two sets of parameter estimates, their relative success in simulation, their ability to predict outside of the sample, etc., must be evaluated. These comparisons could be conducted to supplement any formal statistical testing. A very important comparison would involve the predictive performance of the two competing models, especially for the flex-price markets.

A simpler approach can be pursued to discriminate between the fixed/flex versus the flex/flex specification. This approach has been used by Rausser, Chalfant, and Stamoulis^{2/} to test for the importance of overshooting. As is well known, no overshooting occurs with the purely flexible price model; it takes some price inflexibility to generate overshooting. Thus, Rausser, Chalfant, and Stamoulis focus on the sensitivity of food and nonfood prices to anticipated money growth as defined by Barro.^{3/} In this analysis, the rate of change of the nonfood CPI is taken as the growth rate of prices that are potentially generated in fixed-price markets while the growth rate of the U. S. Department of Agriculture index of prices received by farmers was used to measure growth in the potentially flex-price markets.

To explain variation in these two rates of change, Rausser, Chalfant, and Stamoulis^{4/} used as explanatory variables the anticipated money growth variable, distributed lags of the gap between potential and actual income, oil price inflation, the differential of wage and productivity growth rates, and a lagged dependent variable. In comparing the coefficients across the two equations, it was found that the lagged dependent variable had a large significant coefficient in the nonfood price inflation equation and an inconsequential coefficient in the food equation. Moreover, anticipated money growth caused

a much greater response in food inflation than for nonagricultural goods. In fact, the estimated coefficient exceeded one, corresponding to overshooting of food prices following money growth. By contrast, the coefficient in the other equation was significantly less than one, implying sluggish response to anticipated money growth. These results strongly support the specification that prices in the nonfood sectors adjust more sluggishly to changes in money growth than do food prices.

In conjunction with the money demand equation, the above results lead to the conclusion that overshooting of food prices results from the nonneutrality of money in the short run. Note also that, with the growth in money, individual willingness to hold real balances is augmented. Since the demand for money is negatively sloped, individuals are willing to hold more real balances if the interest rate falls. Interest rates represent the opportunity costs of storing wealth in the form of real balances. With a fall in interest rates, it would be possible for less of the excess money balances to be spent on food, more money balances would be held, and the resulting price increase in the food market would be reduced.

This reasoning illustrates the importance of interest rates in the overshooting scenario. While money demand is found to be interest elastic, it does not always follow that interest rates can adjust to make individuals willing to hold an increase in real balances. For example, interest rates may not be flexible. Such was the case prior to October, 1979, as the Federal Reserve operated monetary policy so as to "peg" or "target" interest rates maintaining market interest rates within a specified range. As a result, money supply was allowed to vary widely. With the switch to targeting of reserves in managing money growth, interest rates became a flexible price.

When interest rates are fixed and the real balances are initially at their long-run equilibrium level, money growth results in larger food-price increases. Of course, if interest rates can vary, the overshooting is spread into two markets--interest rates will fall somewhat while food prices rise less. Then, as nonfood prices gradually adjust to a new equilibrium level, there is again a reduction in food prices accompanied now by a rising interest rate. Again, subject to the assumption that the structure of the markets is unchanged by any developments during the adjustment phase to money growth, the long-run equilibrium occurs with the price level twice its original level and all quantities and interest rates back to their original levels.

The extent to which the overshooting result causes real price changes in flex-price markets depends on both the interest elasticity of the money demand and the degree of flexibility of interest rates. Overshooting is inversely related to both the demand elasticity and the ease of adjustment of interest rates. This means that, prior to October, 1979, when interest rates were pegged, overshooting was more severe in food markets. After that time, interest rates became flexible and, *ceteris parabis*, the effect of overshooting on food prices was lessened. This phenomenon has been examined by Stamoulis, Chalfant, and Rausser^{5/} who proved the general proposition that the degree of overshooting in a particular flex-price market is decreasing in the number of additional flex-price markets in the system.

The above reasoning does not imply that the degree of instability in food prices will necessarily fall with the introduction of additional flexible price markets. Instead, it simply means that the linkage between interest rate or financial markets and food commodity markets will be smaller as a result of flexible interest rates. If interest rates are shocked significantly,

however, the interaction of the linkage parameters with the large variability in interest rates could, in fact, imply more instability in food prices after the introduction of flexible interest rates.

Empirical implications of the above proposition have been examined in the context of the model presented in Chapter 4 by evaluating the parameter and linkage stabilities over the major regimes of macroeconomic environments facing agriculture. In a context of the number of flexible price markets in the macro/international economy, three major regimes can be distinguished for the sample period employed to estimate the equations of Chapter 4. The period 1965-1972 was a period of fixed exchange rates and pegged interest rates. The period 1973-1979 corresponds to partially flexible exchange rates and target interest rates. During that period, exchange rates are viewed as partially flexible because the U. S. government pursued a "dirty float" policy of exchange rate manipulation. The third and last regime corresponds to 1980-1983, during which time exchange rates as well as interest rates were flexible.

For each of these regimes, the equations in the model that involve interest rates or the exchange rate were reestimated. The results obtained in the form of significant shifts in the parameter estimates support the hypothesis of reduced overshooting in food markets. Because the results are too detailed to present here, only a few of the regime estimated equations will be highlighted.

One of the more interesting sets of parameter shifts occurred for the money demand equation. Prior to 1979 and for the sample as a whole, the lagged dependent variable in the money demand equation had a rather large coefficient reflecting slow adjustment in money balances over time. For the

flexible interest rate period, that coefficient is much smaller and corresponds to more rapid adjustment of money balances. The response to increased opportunity costs of holding money was more rapid adjustment to interest rate changes. The increase in the interest rate elasticity of money demand for the post-1979 period is also consistent with this result.

Another set of interesting results for parameter and linkage stability occurred for the breeding stock equations of the livestock sector. For both cattle and hog inventories, the equations for the entire sample during 1965-1973 show the inventory-reducing effects of increasing interest rates and feed costs. Distributed lags on both variables feature negative coefficients in both equations. However, when these linkage equations are estimated using only observations prior to 1979, the effects of interest rates become insignificant and positive, reflecting the fact that at that time nominal interest rates were not a major determinant of inventory decisions. By contrast, for the last sample regime (1980-1983), there is significant evidence that food markets responded to the change in flexible interest rates. In particular, for cattle inventories, while the first several distributed lagged coefficients are positive, the last few are larger in magnitude, negative, and statistically significant. Similar results were obtained for the hog inventory equations. The results for these equations, however, were complicated by the technological changes that occurred for hog production over the sample period under investigation.

"Tax" and Subsidy Simulation Experiments

In the simulation experiments that have been conducted thus far, the model presented in Chapter 4 provides an internally consistent set of results. In all instances, increases in the real rate of interest and the exchange value

of the dollar have distinct negative effects on commodity prices and the expected money growth rate has a positive effect on these prices. The latter variable causes the long-run equilibrium commodity price path to move in a corresponding direction. Hence, if a very restrictive monetary policy is put in place, the long-run equilibrium commodity price falls with a corresponding rise in the real rate of interest and the exchange value of the dollar. Because of slower adjustments in other markets of the macroeconomy, short-run commodity prices overshoot the new long-run equilibrium commodity price. With a very expansionary monetary policy, all three of these effects run in the opposite direction.

Expressed in terms of macroeconomic and international sector variables, the early 1970s and the early 1980s constitute two distinctly different environments facing the U. S. agricultural sector. As noted in Chapter 1, the macroeconomic and international environment of the early 1970s can be thought of as subsidizing the agricultural sector while the early 1980s can be thought of as taxing agriculture. The macroeconomic policies in the early 1970s caused a change in relative prices between the agricultural and nonagricultural sector in favor of the agricultural sector, while the strict monetary policies of the early 1980s caused flexible agricultural prices to overshoot downward creating a drop in relative prices in favor of the sticky price sector.

The major policy variables that distinguish the tax and subsidy scenarios are related to monetary policy. A path must be selected for those variables as well as the other exogenous variables for the period 1984:1 (one period after the last quarter of the estimated period) to 1986:4. In terms of the macroeconomic model, a tax-versus-subsidy environment is expressed as a "tight" money environment vis-à-vis an "easy" money one.

The key variable in the macroeconomic policy scenario is the percentage of the federal budget deficit financed by monetization. Annual federal expenditure and receipts were obtained by the Congressional Budget Office (actual for 1984 and projected to 1985 and 1986). Quarterly figures were generated by calculating the average percentage of the annual deficit financed each quarter for the period 1981-1983 and using that percentage to calculate quarterly receipts and expenditures for the period 1984:1 to 1986:4. Table 1 shows the results of these calculations. After some preliminary simulations, it was decided that the subsidy scenario would be fueled by a 30 percent monetization, that is, 30 percent of the deficit would be added to the Federal Reserve's holdings of Treasury securities, cumulatively, beginning with the last quarter of 1983. The remaining portion (70 percent) of the deficit is presumed to be financed by the sale of government securities to the public. However, note that in a couple of periods a 30 percent figure resulted in extremely high money growth, so these values were replaced with average growth rates. The level of Federal Reserve's holdings of Treasury securities was adjusted downward accordingly.

A cumulative increase in the Federal Reserve's holdings of Treasury securities augments the monetary base and thus the stock of money and bank reserves. To derive figures for the nonborrowed reserves and required reserves used in the interest rate equation, the historical ratio of these variables to the Federal Reserve's holdings of government securities was used. This ratio has remained fairly constant so the average of that ratio equal to .283 for nonborrowed reserves and .235 for required reserves was used to generate reserve figures from the Federal Reserve's government security holdings. For the sake of simplicity, the growth of money was set equal to

the growth rate of the Federal Reserve's holdings of securities. The money stock was then computed as $MNY1A_t = (1 + MONGRTH_t/100) \cdot MNY1A_{t-1}$.

Deficit monetization affects the nominal short-run interest rate both through the liquidity effect (changes in bank reserves) and through the inflation premium effect (changes in money growth). The part of the deficit that is not monetized enters the model as the capital market pressure variable that directly affects the interest rate and the exchange rate. Table 1 reports values of the monetary policy variables for the 1984:1 through 1986:4 period under the subsidy scenario. Note that actual data are also reported in this table for 1983. For the tax scenario, the Federal Reserve is assumed not to monetize any of the federal government deficit. The Federal Reserve follows a tight policy in which money grows at the rate of growth of potential income (or full employment income) and so do the bank reserve variables in the system. Table 1 reports the nonborrowed reserves under a tax scenario. For the same reasons as for the subsidy scenario, the money growth rates were left exogenous.

Table 1 reveals drastic differences in the implied money growth rates between the two scenarios. Actually, under the subsidy scenario, money growth can be considered unusually high compared with recent history. Actual money growth in the first three quarters of 1984 averaged about 12 percent annual rate which is lower than the one simulated for the subsidy period.

The international sector variables that are used in the model are: foreign GNP (real), a foreign money index (FORM1), the foreign wholesale price index (FORWPI), and the world production of wheat (WPRDW). They affect non-farm exports and imports, farm exports, and the exchange rate. For the period 1984:1 to 1986:4, the growth rates of foreign income from 1981:1 to 1983:4

were used to generate levels of foreign income for the 1984:1 to 1986:4 period. The same process was used for the foreign money variable, while the growth rate of foreign wholesale prices was assumed to follow the growth of foreign money. The international sector variables were set at the same levels for both the subsidy and the tax scenarios. This is a strong assumption since the United States is a large country in the money and financial markets. Thus, its economic policies generally cause reactions from other governments; namely, if the United States increases its money supply causing the dollar to depreciate, other governments may react by increasing their money supplies. Short-run foreign income and/or price effects may occur as a result of these reactions which, in turn, will affect exports and the exchange rate even further. In the simulation experiments reported here, these potential effects are neglected. Finally, for the world production of wheat, values for each of the years of the 1984-1986 horizon were set at the average of 1982 through 1984.

The policy variables for the agricultural sector of the model were set in accordance with the 1981 Food and Agriculture Act. The settings on these instruments are specified in Table 2 for each of the three years of the horizon and one historical year, 1983. These settings are consistent with the provisions of the Act. For 1984 and 1985, the actual settings are used and, for 1986, 1985 values are repeated.

The simulations for the agricultural sector were also conducted under both a "passive" and an "active" public stock policy. In the case of the passive stock policy, if market prices fell below support prices, the government did not intervene by acquiring additional public stocks to raise market prices to the support level. In the case of the active public stock policy, such

actions were undertaken by the government to bring market prices in close proximity to the support levels.⁶ Those values were held constant for both the tax and subsidy periods on the premise that, if sector policies were to change from scenario to scenario, then the separation of the macroeconomic from sector-specific policy effects could not be made.

Macro and International Components

The higher level of monetization of the deficit in the subsidy period pushes up nominal interest rates through inflationary expectations. On the other hand, there is greater upward pressure on real rates of interest in the tax period due to lower growth in liquidity combined with the same large deficit as in the subsidy period. Net results are apparent from Table 3--the nominal interest rate is lower in the subsidy period after the first quarter, while ex post real rates of interest (nominal rates minus the percentage change in the CPI) are substantially lower in all quarters.

In each of these scenarios, nominal short-run interest rates and inflationary expectations were used to determine long-term interest rates (bond rates). The money growth rate used to measure inflation expectations has a greater effect on long-term rates than on short-term rates, making the subsidy period long-term interest rates greater than those in the tax period, as one would expect.

These interest rates, along with assumed paths for a number of other exogenous variables, were used to generate results for the other variables of the macroeconomy which act upon the agricultural sector. Low real interest rates and easy money have the expected effect on income (real GNP) which is 12.6 percent higher in the subsidy period by the end of the 12 quarters.

While lower income, *ceteris paribus*, should cause the dollar to depreciate, this effect is more than offset by the greater attractiveness of dollar-denominated assets in the tax period. Thus, the trade-weighted index of the dollar's value is higher (a lower value for dollars per ROW currency) by more than 100 percent by 1986:4. This represents an appreciation of nearly 20 percent in the tax period and a near 90 percent devaluation in the subsidy over the dollar's 1983:4 value.

Finally, the effects of money growth and income growth on prices are seen in Table 3 by the higher rates of inflation in the subsidy period, running from a differential of 0.69 percent in 1984:1 to a near 8 percent differential by the end of the simulations.

It should be emphasized that the differences reported in Table 3 are based on the assumption that foreign variables remain unchanged in the two scenarios. If foreign variables tend to move in the same direction as U. S. variables do, then the differentials reported above will change. In our case those differences are likely to be the upper bound. The values of the foreign variables generated for the 1984-1986 period were based on growth rates for the 1981-1983 period, a period that can be considered a "tax" period for the world economy. Thus, their values are more in line with the tax scenario settings of the U. S. policy variables. As a result, the levels of foreign money, foreign inflation rates, and foreign prices in the subsidy period probably understate the values that would have resulted had they been linked to their U. S. counterparts. For money and prices, that means a lower pressure on the dollar to fall in the subsidy period while the opposite holds for foreign income. The short-run net effect would depend on the responsiveness of foreign prices, money, and income to U. S. monetary policies.

Higher levels of income in the subsidy period increase the price level by increasing excess demand for goods. This effect is then transmitted to the rest of the price variables in the model. Not surprisingly, the nominal non-food price indexes are higher in the subsidy period. This is due to the money growth and excess demand for goods impact on the CPINF index. As expected, the nominal wage rate is higher in the subsidy period, but this result is reversed when real wages are evaluated. The reason is that the rate of growth of wages adjusts very slowly to changes in the rate of growth of prices. The sum of the coefficients for the six-period distributed lag that evaluates the effects of price inflation on the rate of change of wages is equal to 0.3929. Thus, the inflation rate differentials between tax and subsidy periods are not fully reflected in the rate of change in wages. This sluggish movement in wages, in turn, is part of the reason for stickiness of the CPINF, consistent with the fix-price nature of the nonagricultural sector.

Agricultural Sector

In the simulations for the agricultural sector reported here, only the forward linkages between the macro and international components with the agricultural sector component were admitted. As a result, the endogenous variables generated by the macro and international components were treated as predetermined in the simulation results reported for the U. S. agricultural sector.

The supply response implications of the two alternative scenarios are not dramatic (see Table 4). This is in large part because of the very favorable settings for target prices. In the case of feed grains, the endogenous expected prices that are generated do not exceed the target prices. In the case of wheat, however, target prices are exceeded for the last year of the horizon during the subsidy scenario.

Acreage, yields, and thus production of both wheat and feed grains are functions of expected real profits from participation and from nonparticipation. As expected, nonparticipation profits grow during the subsidy period particularly for wheat. As a result, the acreage allocated to wheat is 5 million acres higher in the last year of the horizon for the subsidy scenario versus the tax scenario. In the case of both feed grains and wheat, the differences in yields are very small. In fact, yields are generally higher in the tax scenario largely because of slippage under program compliance.

Nominal and real prices for wheat are reported in Table 5. Note that rather sizable differences exist in the nominal prices between the two scenarios. As a result, the share of wheat stocks held by the public sector is rather minimal during the subsidy scenario (Table 7). Correspondingly, the governmental costs for the wheat program under the subsidy scenario are relatively small (Table 10). In the case of the real price differentials between the tax and subsidy scenarios for wheat, they grow dramatically from the second quarter of 1985 through the last quarter of 1986 reaching a difference of almost 35 percent. In the case of corn, the nominal differences are distinctly larger during the subsidy scenario for the four quarters of 1985 but larger for only two quarters of 1986. Real prices for the subsidy scenario are generally higher during 1985 but lower during 1986 for corn. This is in large part due to the active public stock policy which forces the government to enter the market and demand stocks from the private sector. The share of stocks held by the government is dramatically higher under the tax scenario versus the subsidy scenario for corn.

Both tax and subsidy periods begin with high nominal prices for the feed grains. These prices are partly the result of conditions prevailing in the

agricultural sector at the end of 1983 following the PIK program and the 1983 summer drought. These conditions carry over to the first few quarters of 1984 prior to the actual harvest of feed grains during 1984. These phenomena were not nearly as important in the case of wheat because the summer drought had no real effect on wheat production, and the PIK program was not nearly as effective in reducing wheat output as it was in the case of corn.⁷

Without the active public stock policy, the depressing effects of the macroeconomic factors would drive corn prices below support levels in the last five quarters of the tax period with real prices also dropping dramatically. Historically, corn prices have fallen below support during the last quarter of 1981 and the last two quarters of 1982 with the 1982 harvest market price being 39 cents below support. Hence, the model replicates fairly well the effects of a "tax" period macroeconomic conditions on corn prices. Real prices for corn for the period 1984:4 to 1986:4 are indeed low. Historically, for the 1981-1983 period, real corn prices reached an all-time low during the fourth quarter of 1982 when real prices reached 0.7225 dollars per bushel.

As can be seen from the results recorded in Table 6, exports play a major role in transmitting the effects of macroeconomic monetary/fiscal policy to the agricultural sector. Particularly in the case of wheat, macroeconomic "subsidy type" policies generate values of the exchange rate which dominate the effects of higher wheat prices. Wheat, of course, is far more sensitive to exchange rate movements than feed grains. In the case of wheat, export utilization dominates domestic utilization whereas the opposite situation exists for feed grains.

The difference between exports for both wheat and feed grains across the two scenarios increases at an increasing rate over the horizon. This is in

large part due to the same behavior in the exchange rate over the subsidy period compared to the tax period (Table 3). On the domestic front, food demand for wheat is basically the same under both the tax and subsidy scenarios. It is slightly lower under the subsidy scenario because of the higher level of prices. However, the higher income levels that are generated under the subsidy scenario almost compensate for the higher wheat prices. For domestic feed grain demand, steadily larger disappearance occurs under the subsidy scenario over the three-year horizon. This outcome is explained by the smaller difference between feed grain prices under the tax and subsidy scenarios and the improved profitability of the livestock sector (Tables 8 and 9).

According to the estimated equations for prices of wheat and feed grains, movements in inventories are a major determinant of real prices. Higher inventories of any type tend to reduce real prices of both wheat and feed grains. The degree to which the various types of inventory influence real prices should reflect the differentials in the speeds at which different stock types can be supplied to the market. Hence, privately owned inventories and CCC nongovernment-owned inventories (nondefaulted loans) are readily available and can be sold when the price is "right." These two categories of inventories will be referred to as market-oriented inventories. On the other hand, government-owned stocks and the farmer-owned reserve can only be released when prices exceed certain limits, namely, the release price for the farmer-owned reserve and at least 110 percent of the support price for government-owned stocks. The latter rule, while discretionary, was applied in the active stock policy simulations as long as government-owned stocks were above a negligible amount. Releases from the farmer-owned reserve, while not imposed on the model, would have occurred only in 1986 and only for wheat.

Turning to inventories and their distribution across the public and private sectors, the simulation results are surprisingly well behaved. For both wheat and corn stocks, as we would expect, the total level of inventories is higher under the tax scenario. For the last year of the horizon, 1986, it is dramatically higher for both wheat and the feed grains (see Table 7). The distribution of stocks across the government-owned stocks, farmer-owned reserve, and readily available stocks behaves exactly as theory would suggest. The real rate of interest exerts a portfolio effect on the price of the storable commodities. The high real rates of interest during the tax period (see Table 3) exert significant pressure on the market-available stocks to be liquidated, thus indirectly leading to further declines in prices and increases in the share of stocks held in government positions.

The share of market-oriented stocks steadily declines over the three-year horizon for feed grains but rises dramatically for wheat under the subsidy scenario. In the case of feed grains, the expected price appreciation does not compare favorably with the real rate of interest. For this reason, a much smaller share of the total amount of inventories is carried in the market-oriented category for feed grains than is the case for wheat. In fact, in the case of wheat, the government-owned level of stocks is approximately zero throughout the last two years of the horizon. Under the tax scenario, as expected, the percentage of stocks held by the public sector increases dramatically over the horizon for both grains, especially feed grains. The latter result reflects, in part, the active public stock policy for corn and the level of subsidization emanating from the agricultural sector policies that hold resources in the production of feed grains as well as wheat.

As Tables 8 and 9 reveal, a major beneficiary of the "subsidy" macro-economic policies is the livestock sector. Table 8 presents nominal and real

prices for beef, pork, and broilers for each of the two scenarios; and Table 9 presents the breeding inventories for each of the three types of meats, again under both scenarios. Inspection of the results shows much higher nominal prices, as well as higher real prices, for all three livestock products over the subsidy period. For beef, real prices under the subsidy scenario versus the tax scenario steadily increase over the horizon as they do for pork and poultry. In the early part of the horizon, real prices of poultry are higher under the tax period with nominal prices being basically the same. This is in large part due to the rapid adjustment of the poultry sector owing to the shorter biological lags than beef and pork.

Because of the favorable profitability levels under the subsidy scenario, animals are retained for breeding purposes in all three livestock sectors, especially the hog and poultry systems over the specified horizon. As shown in Table 9, a significant amount of liquidation occurs in all three sectors under the tax scenario due largely to the high levels of real interest rates.

The demand for beef under the subsidy scenario increases due to the higher levels of income generated vis-à-vis the tax scenario. The lower interest rates also enhance profitability to the sector. Perhaps more importantly, feed grains, due to their high production levels and reasonably stable prices under both the tax and subsidy scenarios over the specified horizon (which, in turn, are due in part to the high level of prices represented by the initial conditions at the beginning of 1984) do not adversely affect a number of decisions that are undertaken in the livestock sector. The prices of feed grains under the subsidy scenario relative to the tax scenario are not sufficiently different to lead to perceptible differences in the placements of animals on feed or in the current supply of slaughter animals. The relative feed grain

prices between these two scenarios also have little if any impact on the weight at which animals are marketed. The influence of feed grains and the lower real rate of interest are the major determinants explaining the willingness to retain animals for breeding purposes under the subsidy scenario.

The Treasury exposure for the policy instruments set at the levels indicated in Table 1, including the active public stock policy, is reported in Table 10. These measures include the direct governmental costs as well as the "off agency" and opportunity cost of governmental intervention. The major components of cost include deficiency payments; carrying costs of governmental-held inventories, the direct cost associated with the acquisition and release of government-owned inventories; and the opportunity cost of holding governmental stocks. As can be seen from Table 10, these costs are significantly higher during the tax scenario in nominal terms. They are also generally higher during the tax period in real terms, but the differences are less dramatic. Even so, the real cost of governmental intervention is as much as 45 times larger under the tax scenario for some quarters than under the subsidy scenario (see wheat 1986:3).

For all years of the horizon under the tax scenario, governmental costs of the wheat program rise steadily and exceed the current 1983 costs by almost 100 percent in 1986. In contrast, governmental costs under the subsidy scenario steadily declined over the horizon amounting to only 10 percent in 1986 of the governmental costs that were actually experienced in 1983.⁸ In the case of wheat, the major component of governmental costs is the deficiency payments that are incurred especially under the tax scenario.

For corn, the results show little difference during the first year of the horizon due to the favorable prices that occur at the beginning of the horizon. However, for the latter two years, 1985 and 1986, the results are indeed

dramatic. In real terms the cost of the corn program under the tax scenario exceeds the cost under the subsidy scenario by almost 100 percent in 1985 and by an order of 10 times in 1986. These large differences are due to the deficiency payments that are incurred in the program under the tax scenario as well as the active public stock acquisition policy that must be implemented for this scenario.

For the last two years of 1985 and 1986 in the tax scenario, the governmental costs of the corn program in nominal terms exceed by three times the governmental cost experienced in 1983. In the case of the subsidy scenario, the government runs a surplus in the first year of the horizon due to an increase in the value of the inventories owned by the government and/or sold, expenditures jump significantly in 1985 to almost twice the cost experience of 1983; and falls to almost one-half of the cost incurred in 1983 in the final year of the horizon in 1986.

Neglecting the time value of money, governmental costs for the wheat program over the three-year horizon sum to \$9.8 billion under the tax scenario and \$2.99 billion under the subsidy scenario. In the case of corn, these same numbers are \$27 billion versus \$7.4 billion. The total of the two costs, that is, governmental costs for feed grains and wheat under the tax scenario, run in the neighborhood of \$37 billion; and, under the subsidy scenario, the same total cost is slightly more than \$10 billion. These nominal differences reflect the large transfer payments made under the deficiency scheme and the government's role in supporting market prices at or above the loan rate. The magnitudes of these numbers also reflect the impact of overshooting on the public sector when commodity prices are inflexible downward, and an active stock policy is followed.

Net farm incomes for feed grains and wheat are reported in Table 11 along with an approximate income measure for livestock. In computing these measures, no storage activity was considered; instead, total production is sold in the quarter in which it is produced at the market price or the support price depending on which is applicable. Government transfer payments are included in gross income for both feed grains and wheat. The cost measure is simply the variable cost reported in Table 4 times the number of planted acres plus storage costs of the farmer-owned reserve. Under the tax scenario, all computations presume a 100 percent participation rate while, under the subsidy scenario, a 60 percent participation rate is imposed. For the income measures from livestock operations, the retail price of meats rather than the farm level price is employed. As a result, gross income is overstated by some proportion of the difference between retail and farm level prices for each of the respective meats. Since the margins between retail and farm level are fairly stable, the directional changes over time and between the tax and subsidy scenarios will be directly associated with the actual measures. In the results reported in Table 11, the only cost measure that is included for each livestock operation is the feed cost.

As can be seen from Table 11, income is generated during the harvest quarter, and the remaining quarters' carrying cost charges on the farmer-owned reserve are incurred for both wheat and feed grains. For the first two years of the horizon, wheat growers prefer a tax scenario combined with the sector policies outlined in Table 2. In the last year of the horizon, they prefer the subsidy scenario in nominal terms but, once again, the tax scenario in real terms. In the case of corn growers, a clear preference for the tax scenario, along with the sector policies outlined in Table 2, is preferred to the

subsidy scenario. These results reflect in large part the huge transfer payments that are made by the government for both programs and the assumption of 100 percent participation under the tax scenario relative to a 60 percent participation under the subsidy scenario.

The major beneficiaries of the subsidy scenario are the livestock producers. They benefit both nominally and in real terms from the expansionary monetary policies. In the case of the tax scenario, they bear much of the brunt of feed grain prices being kept at the support level, and these producers suffer immensely from the high real rates of interest that are generated under the tax scenario. The real differences between the subsidy and tax scenarios for all three groups of livestock producers steadily increases from the first quarter of 1984 to the last quarter of 1986 where the real percentage difference in income is almost 30 percent.

Chapter 6

Concluding Remarks

To the extent that money is nonneutral in the short run, analysis of agricultural market dynamics must take into account not only real demand and supply forces and the effects of sectoral governmental intervention but also the macroeconomic policies of the federal government. The fixed/flex price dichotomy of the U. S. economy implies that money is in fact nonneutral. Because some goods and services do not respond to changes in demand in the short run, namely, the "customer" goods defined by Okun^{1/} or the fixed-price goods defined by Hicks,^{2/} analysis of commodity markets requires an explicit treatment of monetary factors and the linkages with the macroeconomy. The prices of most other goods are sticky while the prices of agricultural commodities, in the absence of governmental intervention, are free to respond to fluctuations in demand and supply.

Since the general price level is not free to respond fully in the short run, changes in nominal money supply are also changes in the real money supply and, therefore, induce changes in the real interest rate which, in turn, induce changes in relative prices. As a result, changes in the money supply will lead to overshooting in flex-price markets. Through much of the 1970s and 1980s, exchange rates have been flexible; hence, changes in the money supply will lead to changes in the value of the dollar that are more than proportionate to the change in money supply. Only when the dollar is "overvalued" ("undervalued") will investors rationally expect a future rate of depreciation (appreciation) that is sufficient to offset the interest rate differential so that the interest rate parity condition holds and investors are willing to hold foreign currency.

In the short run, the exchange rate overshoots its long-run equilibrium. This quite obviously happened from 1980 to 1982 when the Federal Reserve adopted a stringent monetary policy. Unlike the 1970s, the resulting higher nominal interest rates did not reflect higher expected inflation but, rather, represented higher real interest rates. As a consequence, the dollar appreciated sharply.

In the "tax" and "subsidy" simulation experiments conducted in the analysis presented here, overshooting was found to occur in U. S. feed grain and food grain markets. This overshooting is a direct implication of the fixed/flex price framework. This framework was formally tested, and the empirical results corroborate the differential response of nonfood market prices and food market prices to changes in anticipated money growth. Factors affecting commodity price overshooting were shown to be the number of fixed-price markets, the speed of adjustment of those prices, and the interest rate elasticity of money demand.

Nonmonetization of large federal government deficits can be interpreted as a restrictive monetary policy. Such a restrictive monetary policy leads to increases in the real rate of interest and the exchange value of the dollar and to decreases in the long-run equilibrium feed grain and wheat commodity price path. Because of slower adjustment in other segments of the macroeconomy, commodity prices in the short run add insult to injury by overshooting the new long-run equilibrium commodity price. With a very expansionary monetary policy, all of these factors run in the opposite direction.

The simulation results reported in this paper demonstrate that macroeconomic policies are indeed important in generating the price and income

paths for U. S. agriculture. To be sure, the implicit taxes resulting from overshooting that are imposed on U. S. agriculture are modified by the current U. S. agricultural policy. In particular, price supports imply downward inflexibility of some commodity prices which, in turn, cause the incidence of the macroeconomic policy tax on agriculture to show up as an unexpected increase in the cost of maintaining price supports and the various forms of government stockholding. Overshooting agricultural commodity markets in the downward direction places some of the implicit tax on the private sector and some on the public sector. Due to the form and shape of current U. S. agricultural policies, the overshooting effects of expansionary monetary policies are asymmetric. Much, if not all, of the subsidy accrues to the private sector.

In the long run, if money is neutral, agricultural sector policies will have a more significant influence on resource allocation to the U. S. agricultural sector than do macroeconomic policies. The sector policies that provide incentives for overallocation of resources to agricultural production lower the long-run equilibrium of commodity prices. They quite obviously make the sector especially vulnerable to macroeconomic policies that impose implicit taxes via overshooting. Such sector policies, when combined with macroeconomic policies that "subsidize" U. S. agriculture, must by definition lead to a financial crisis for both private and public sectors if and when macroeconomic policies begin to impose "taxes" via overshooting on agriculture. The dynamic path composed of a subsidy period followed by a tax period during which sector policies provide incentives for overallocation of resources to agricultural production can be expected to create crises.

For the subsidy scenarios generated, farm incomes were observed to be substantially above present levels, and inventories were significantly lower.

Repeating a macroeconomic experience similar to the years of 1973-1975 leads to rapid growth in U. S. money supply, lower real rates of interest, and exchange values significantly below present levels. These phenomena lead to increasing export sales and reduced inventories.

Under the evaluated tax scenario, 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 are reductions in real income, employment, and consumption expenditure including that on food--more so for income-elastic beef. At the same time, the high interest rates encourage greater capital inflow which, together with the fall in imports caused by the slowdown of real income growth, causes appreciation of the exchange rate. In addition, the higher interest rates induce the private sector to hold less grain inventories. After extended lags, the forces of lower rates of price increases reduce the rate of decline in real money balances and modify pressures on nominal interest rates.

The implications of this study for the 1985 Food and Agriculture Act must, of course, focus on the overshooting phenomenon. If macroeconomic policies were appropriately designed, there would be no need for the sector-specific policies to address the implications of overshooting for the U. S. food and agriculture system. Presuming that no significant changes will take place in the design and implementation of fiscal and monetary policies, the normative justification for governmental intervention in food and agriculture continues to be excessive instability and the nonexistence of a complete set of markets for risk transfer. As noted in the introductory comments, this market failure

provides an efficiency justification for governmental intervention to reduce the degree of inherent instability in agricultural markets.^{3/}

For the objective of risk reduction or, equivalently, the management of instability in food and agriculture markets, flexible storage and conditional target price policies introduced by Just and Rausser^{4/} are appropriate. These conditional policies are designed to reduce risk, meet minimal food security goals, achieve an adaptable farm sector, minimize treasury cost, and minimize the probability of political failure. The implications of overshooting for instability in agricultural commodity markets resulting from macro-economic policies is not addressed in the design of the conditional policies advanced by Just and Rausser. The augmentation to the degree of instability by the phenomenon of overshooting can and should be recognized and taken into account in setting the flexible storage and target price policies. Failure to condition agricultural programs on monetary and fiscal policies will result in crises of the type generated by the PIK Program and the unexpected imposition of huge treasury costs. In essence, the flexible storage and target price policies are concerned with the distribution of tax and subsidies across the private and public sectors. Aside from the need to manage inherent instability during periods of "subsidy overshooting," the flexible storage and target price policies would impose a self-regulating tax on agriculture. For periods of "tax overshooting," the conditional policies would involve a self-regulating subsidy to agriculture.

In the actual implementation of agricultural policies, there are goals or objectives in addition to those listed above. As noted in Rausser and Foster,^{5/} these additional goals might include income distribution, reasonable food prices, preservation of the family farm, and conservation of resources. The flexible storage-price and target-price policies outlined above

do not address these specific objectives. As argued by numerous analysts, the conservation of resources objective can be handled through land-retirement programs while the preservation of family farms and the redistribution of income are most effectively dealt with through direct subsidies to the "family farm" component of the trifurcated farming sector. The most efficient means of implementing the direct-payment scheme is through negative income taxes. Additional improvements in the adaptable farm sector objective can be obtained by eliminating the current tax shelter provisions of investments in agricultural production. This would reduce the bias in resource allocation to agricultural production. It should also be noted that the conservation of resources objective would be enhanced by conditional storage and target prices which specifically address the overshooting phenomenon emanating from macro-economic policies. Overshooting resulting from restrictive monetary policies provides little incentive for farmers to maintain the quality of their land resource. Insulation from the spillover effects of monetary policy would most certainly result in an improvement in the conservation of agricultural resources.

The above recommendations are prescriptive; their applicability depends on the specified objectives and goals of public policy for food and agriculture. Political feasibility or the positive aspects of governmental intervention in food and agriculture are not explicitly addressed by the analysis contained in this paper. The implementation features of any designed food and agriculture policy, however, must also be evaluated in terms of its effect on the probability of political or governmental failure.

Footnotes

Chapter 1

1/ Coming into the 1981 crop year, substantial quantities of stocks already existed in the farmer-held reserve. The addition in stocks from the 1981 and 1982 record crops was considered excessive relative to the stabilizing and food-security objectives for the farmer-held reserves. With the accumulation of public stocks of more than 1 billion bushels of wheat and over 2.5 billion bushels of feed grains and the associated escalation and U. S. Treasury outlays, strong voices of criticism surfaced; and some stopgap, crises-driven policy provisions had to be enacted.

2/ These huge stocks resulted from the U. S. governmental holding price supports above market equilibrium prices throughout much of the 1950s and 1960s.

3/ G. Brandow, "Policy for Commercial Agriculture, 1945-1971," in A Survey of Agricultural Economics Literature, edited by L. Martin (Minneapolis: University of Minnesota Press, 1977).

Bruce L. Gardner, "Policy Options for Grains," in Alternative Agricultural and Food Policies and the 1985 Farm Bill, edited by Gordon C. Rausser and Kenneth R. Farrell, Giannini Foundation of Agricultural Economics, Division of Agriculture and Natural Resources (Berkeley: University of California, 1984).

Gordon C. Rausser and Kenneth R. Farrell (eds.), Alternative Agricultural and Food Policies and the 1985 Farm Bill, Giannini Foundation of Agricultural Economics, Division of Agriculture and Natural Resources (Berkeley: University of California, 1984).

4/ Richard E. Just and Gordon C. Rausser, "Uncertain Economic Environments and Conditional Policies," in Alternative Agricultural and Food Policies and the

1985 Farm Bill, edited by Gordon C. Rausser and Kenneth R. Farrell, Giannini Foundation of Agricultural Economics, Division of Agriculture and Natural Resources (Berkeley: University of California, 1984).

5/ The U. S. Treasury exposure of carrying public stocks became unbearable in the early 1970s. As a result, the "Soviet grain deal" appeared as a savior for the policy disequilibrium that existed. The U. S. government liquidated public stocks which then exposed the economy to the risk of large agriculture commodity price increases. From the standpoint of officials who are struggling to contain inflation, government stocks were liquidated prematurely and thus failed to provide the stabilizing influence which taxpayers supposedly had been paying for so long.

6/ Gordon C. Rausser and Eithan Hochman, Dynamic Agricultural Systems: Economic Prediction and Control (Amsterdam: North-Holland Publishing Company, 1979).

7/ John Maynard Keynes, "The Policy of Government Storage of Foodstuffs and Raw Materials," Economic Journal, Vol. 48, September 1938, pp. 449-60.

8/ H. S. Houthakker, "Economic Policy for the Farm Sector," American Enterprise Institute for Public Policy Research, 1967.

9/ Barry P. Bosworth and Robert Z. Lawrence, Commodity Prices and the New Inflation (Washington, D. C.: Brookings Institution, 1982), Chapter 4.

10/ This is a major reason why the international debt crisis of the 1980s has potentially important implications for U. S. agricultural exports. In particular, it causes some countries, such as Argentina, Brazil, Thailand, and Turkey, to price their agricultural exports on current spot markets and other countries, for example, Mexico, to reduce their imports.

11/ Popular pressure frequently compels such measures as windfall profit taxes, price controls, rationing, export embargoes, and even confiscation.

12/ Accounting only for physical capital, not land, the U. S. agricultural sector is more than twice as capitalized as manufacturing on a per worker basis.

13/ G. Edward Schuh, "U. S. Agriculture in an Open World Economy," testimony presented before the Joint Economic Committee of the U. S. Congress, May 26, 1983, Washington, D. C.

Chapter 2

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

2/ Karl A. Fox, "A Submodel of the Agricultural Sector," The Brookings Quarterly Econometric Model of the United States, edited by J. S. Duesenberry et al. (Amsterdam: North-Holland Publishing Company, 1965).

3/ Arthur M. Okun, "Inflation: Its Mechanics and Welfare Costs," Brookings Papers on Economic Activity, 1975, pp. 351-401.

Robert J. Gordon, "Alternative Responses of Policy to External Shocks," Brookings Papers on Economic Activity, Vol. 6, 1975, pp. 183-204.

Edward Gramlich, "Macroeconomic Policy Responses to Price Shocks," Brookings Papers on Economic Activity, 1979.

4/ Nicholas Kaldor, "Inflation and Recession in the World Economy," Economic Journal, Vol. 86, 1976, pp. 703-15.

Edmund S. Phelps, "Commodity-Supply Shock and Full-Employment Monetary Policy," Journal of Money, Credit, and Banking, Vol. 10, 1978, pp. 206-21.

D. E. Schlagenhauf and F. R. Shupp, "Inflation and Price Controls in a Flexprice-Fixprice Model," Annals of Economics and Social Measure, Vol. 6, 1978, pp. 501-24.

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Chapter 5

1/ The results of this chapter were generated by a collaborative effort with James A. Chalfant, H. Alan Love, and Kostas Stamoulis. This collaborative work is reported in Gordon C. Rausser, James A. Chalfant, H. Alan Love, and Kostas Stamoulis, "Macroeconomic Linkages, Taxes, and Subsidies on the U. S. Agricultural Sector," American Journal of Agricultural Economics, May, 1986, forthcoming.

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government-owned stocks were exhausted or the price fell below 110 percent of support. As a result, many simulations generated prices well above 110 percent of support and zero levels of government-owned stocks.

7/ In the case of corn, actual nominal prices during the last two quarters of 1983 were at their highest levels since mid-1981 when they were at an all-time high.

8/ Please note that the actual governmental costs reported for 1983 do not reflect fully the costs associated with the PIK program. The quantities released from government stocks under the PIK program were valued at support prices rather than market prices.

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3/ There are other potential solutions to the excessive instability for which, unfortunately, there is very little empirical information. In fact, it can be argued that, if the government withdrew from all forms of intervention, other institutional or market solutions would emerge to address the excessive instability. Whether these institutions would offer a profile of benefits and costs that would be superior to governmental intervention is unclear.

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Appendix A: Variable Definition and Sources

1. Domestic Macroeconomy

Endogenous VariablesAggregate Consumption

- CN: Personal consumption expenditures, nondurable goods, 1972 dollars. Billions of dollars seasonally adjusted at annual rates. U. S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts.
- CD: Personal consumption expenditures, durable goods, 1972 dollars. Billions of dollars seasonally adjusted at annual rates. Ibid.
- CS: Personal consumption expenditures, services, 1972 dollars. Seasonally adjusted at annual rates. Ibid.

Aggregate Domestic Investment

- IFIXR: Gross private fixed residential investment, 1972 dollars. Billions of dollars seasonally adjusted at annual rates. U. S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts.
- IFIXNR: Gross fixed private nonresidential investment. Billions of 1972 dollars. Ibid.
- INVCH: Change in business inventories, total, 1972 dollars. Ibid.

Monetary Financial Sector (Domestic)

- MNYIA: Money stock--currency plus demand deposits plus traveler's checks. Billions of dollars seasonally adjusted. U. S. Federal Reserve System, Board of Governors, Statistical Release H.6.

BONDY: Average yield of Moody's AAA corporate bonds. Percent per annum not seasonally adjusted. U. S. Federal Reserve System, Board of Governors, Statistical Release G.13.

COMPR: Money rate on three-to-six month commercial paper. Percent per annum not seasonally adjusted. Average of daily offering rates. Ibid.

Phillips Curve Relationships

CPINF: Consumer price index for all items except food and beverages (all urban). Index base, 1967 = 1.0. Seasonally adjusted. U. S. Department of Labor, Bureau of Labor Statistics.

WAGE: Index of hourly earnings of private nonfarm production workers. Index base, 1967 = 1.0. Adjusted for overtime and interindustry shifts in employment. Data Resources Incorporated, U. S. Model (also, U. S. Department of Labor, Bureau of Labor Statistics).

RU: Unemployment rate (all civilian workers). Percent seasonally adjusted. Ibid., "Employment and Earnings."

CPIU: Consumer price index (all urban, all items). Index base, 1967 = 1.0. Seasonally adjusted. U. S. Department of Labor, Bureau of Labor Statistics.

WPI: Wholesale price index (all commodities). Index base, 1967 = 1.0. Ibid.

PEXNAG: Unit price deflator for nonfarm exports. Index base, 1972 = 1.0. Federal reserve-MIT-model. Variable number X215.

PGNP: Implicit price deflator for gross national product. Index base, 1972 = 1.0. Seasonally adjusted. U. S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts of the U. S.

CPIF: Consumer price index (all urban). Commodities less food and beverages. Index base, 1967 = 1.0. Seasonally adjusted. U. S. Department of Labor, Bureau of Labor Statistics.

Identities and Definitions

Money Growth Rate

$$\text{MONGRTH}_t = 100 * \frac{\text{MNYIA}_t - \text{MNYIA}_{t-1}}{\text{MNYIA}_{t-1}}$$

Inflation Rate (Consumer Price Index, All Items)

$$\text{CPIUNIF}_t = 100 * \frac{\text{CPIU}_t - \text{CPIU}_{t-4}}{\text{CPIU}_{t-4}}$$

Inflation Rate (Nonfood Items)

$$\text{CPINFINF}_t = 100 * \frac{\text{CPINF}_t - \text{CPINF}_{t-1}}{\text{CPIU}_{t-4}}$$

Inflationary Gap

$$\text{INCGAP}_t = \text{GNP}_t - \text{GNPFE}_t$$

Wage Inflation

$$\text{WINFL}_t = 100 * \frac{\text{WAGE}_t - \text{WAGE}_{t-4}}{\text{WAGE}_{t-4}}$$

Unemployment Rate Differential

$$\text{UNEMPDF}_t = \frac{1}{(\text{RU}_t - \text{RUADJ}_t)}$$

Domestic-Foreign Income Differential

$$DINCOME = GNP_t - FORGNP_t$$

Domestic-Foreign Price Differentials

$$DPRICES = CPIUINF_t - FPISTAR_t$$

Exchange Rate Adjusted Foreign Price

$$DOLFORP_t = EXCHFRB_t * FORWPI_t$$

Domestic Income Determination

GNP: Gross national product. Billions of 1972 dollars. Seasonally adjusted at annual rates. U. S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts.

YD: Personal disposable income. Billions of 1972 dollars. Seasonally adjusted at annual rates. Ibid.

Government Finance Sector

GTAXES: Total government revenues. Billions of current dollars. Federal Reserve Bulletin.

Exogenous Variables

N: Total population including armed forces overseas, millions of persons. Estimates are for July 1, 1980. U. S. Department of Commerce, Bureau of Census.

AV23DIV: Average dividend to price ratio of Standard and Poor's daily stock indices. Calculated by Data Resources, Inc.

- RESFRBR: Reserves of federal reserve member banks (required). Billions of current dollars, seasonally adjusted. Board of Governors of the Federal Reserve System. Federal Reserve Bulletin and the H.3 release.
- RESFRBN: Reserves of Federal Reserve System. Member banks (nonborrowed). Billions of current dollars, seasonally adjusted. Ibid.
- RMFRBNY: Discount rate, Federal Reserve Bank of New York. Percent per annum not seasonally adjusted. Board of Governors of the Federal Reserve System. Statistical Release G.13.
- RUADJ: Full employment unemployment rate. Adjusted for demographic labor force changes and the effects of social programs. Calculated by Data Resources, Inc.
- G: Government purchases of goods and services. Billions of 1972 dollars. Seasonally adjusted at annual rates. U. S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts of the U. S.
- OILINFL: Annual rate of change in average acquisition price of crude oil by refiners, dollars per barrel. U. S. Department of Energy, "Monthly Energy Review."
- PRODCH: Rate of change in productivities (annual). Productivity is measured as output of all persons per hour. Index for nonfarm business sector, 1977 = 1.0. Seasonally adjusted. U. S. Department of Labor, Bureau of Labor Statistics.
- MINWAGE: Federal minimum wage. Dollars per hour. U. S. Department of Labor, Employment Standards Administration. Data Resources, Inc.

- GNPFE: Full employment gross national product. In billions of 1972 dollars. Calculated by Data Resources, Inc.
- GEXPEND: Total federal government expenditures. Billions of current dollars. Not seasonally adjusted. Federal Reserve Bulletin.
- DEFIC: Federal government budget deficit. Billions of current dollars not seasonally adjusted. Ibid.

2. International Sector

Endogenous Variables

Nonfarm exports

- EXNAG: Exports of nonagricultural merchandise, 1972 dollars. Calculated at $EXNAG\$ / PEXNAG$ where $EXNAG\$$ are exports of nonfarm merchandise in current dollars international accounts basis and $PEXNAG$ is export unit value index for nonagricultural merchandise, 1972 = 1.0.

Nonfarm Imports

- EMNP: Imports of nonpetroleum merchandise, 1972 dollars. International Accounts Basis. U. S. Federal Reserve System, Board of Governors, Statistical Release 208.

Farm Exports

- WHEXP: Wheat exports, U. S. million bushels. U. S. Department of Agriculture, Economic Research Service, Wheat Outlook and Situation Reports.
- FGEXP: Feed grain exports (corn, sorghum, oats, and barley), U. S. million bushels. U. S. Department of Agriculture, Economic Research Service, Feed Outlook and Situation Reports.

Exchange Rate

EXCHFRB: Bilateral ten-country weighted exchange rate dollar price of foreign currency, 1972 = 100. Weights are average 1955-1976 bilateral shares of trade with United States. Exchange rate data taken from International Monetary Fund, "Finance Statistics."

<u>Country</u>	<u>Weight</u>
Canada	.251
Germany	.160
Japan	.160
United Kingdom	.104
France	.085
Italy	.068
The Netherlands	.061
Belgium	.055

Exogenous Variables

FORGNP: Bilaterally weighted exogenous foreign real gross national product. Country weights are the same as for the exchange rate variable. Index base, 1967 = 100. Nominal values deflated by the foreign weighted gross national product implicit deflator. Index base, 1972 = 1.0. FRB-MIT-PENN model, variable number 300.

FORWPI: Foreign weighted wholesale price index. Bilateral ten-country weights, 1972 = 1.0. Countries and weights same as for exchange rate variable. Index base, 1972 = 1.0. FRB-MIT-PENN model, variable number 296.

FORM 1: Foreign weighted index of individual countries' liquid money.

Multilateral ten-country weight. Index base, March, 1973 = 100.

<u>Country</u>	<u>Weight</u>
Germany	0.208
Japan	0.136
France	0.131
United Kingdom	0.119
Canada	0.091
Italy	0.090
The Netherlands	0.083
Belgium	0.064
Sweden	0.042
Switzerland	0.036

FRSW: Bilaterally weighted short-term interest rate. Bilateral ten-country weights the same as for the EXCHFRB variable.

WPPDFG: Production, feed grains (corn, sorghum, oats, and barley), world. Million metric tons. U. S. Department of Agriculture, Economic Research Service, Corn: Background for 1985 Farm Legislation, Bulletin No. 471.

WPRDW: Production, wheat, world. Million metric tons. U. S. Department of Agriculture, Economic Research Service, Wheat: Background for 1985 Farm Legislation, Bulletin No. 467.

3. Agricultural Sector

Grain Production

ACGS: Acreage planted: corn and grain sorghum. Millions of acres.

U. S. Department of Agriculture, Economic Research Service.

Feed: Outlook and Situation Report.

YLDCGS: Yield per planted acre: corn and grain sorghum. Metric tons per acre. Ibid.

PRDFG: Production: corn and grain sorghum. Million metric tons. Ibid.

PRDOB: Production: oats and barley. Million metric tons. Ibid.

AW: Acreage planted: wheat. Million acres. U. S. Department of Agriculture, Economic Research Service, Wheat: Outlook and Situation Report.

YLDW: Yield per planted acre: wheat. Bushels per acre. Ibid.

PRDW: Production: wheat. Millions of bushels. Ibid.

Costs of Production

CCGS: Variable cost of feed grain production. U. S. Department of Agriculture, Economic Research Service, Economic Indicators of the Farm Sector: Costs of Production. Note that RCCGS is the real variable cost per acre, namely, CCGS/CPIU.

COSTW: Variable cost of wheat production. Ibid. Note RCOSTW is COSTW/CPIU, namely, the real variable cost per acre.

COSTS: Variable cost of soybean production. Ibid. Note RCOSTS is COSTS/CPIU, namely, the real variable cost per acre.

Grain Utilization

- DLVKFG: Disappearance (feed and residual): feed grains. Million metric tons. U. S. Department of Agriculture, Economic Research Service, Feed: Outlook and Situation Report.
- DFW: Disappearance (food): wheat. Millions of bushels. U. S. Department of Agriculture, Economic Research Service, Wheat: Outlook and Situation Report.
- DINDFG: Disappearance (food, alcoholic beverages, and seed feed grains). Million metric tons. Ibid.
- DLVKW: Disappearance (feed and residual): wheat. Million of bushels. U. S. Department of Agriculture, Economic Research Service, Wheat: Outlook and Situation Report.

Grain Inventories

- KGOVFGE: Ending inventory (government owned): feed grains. Million metric tons. U. S. Department of Agriculture, Agricultural Stabilization Conservation Service.
- KFORFGE: Ending inventory (farmer-owned reserve): feed grains. Million metric tons. Ibid.
- KMKTFGE: Ending inventory (free stocks and outstanding CCC loans): feed grains. Million metric tons. Ibid.
- KGOVWE: Ending inventory (government owned): wheat. Million bushels: Ibid.
- KFORWE: Ending inventory (farmer-owned reserve): wheat. Million bushels. Ibid.
- KMKTWE: Ending inventory (free stocks and outstanding CCC loans): wheat. Million bushels. Ibid.

Grain Price

PAFC: Price at farm: corn. Dollars per bushel. U. S. Department of Agriculture, Economic Research Service, Feed: Outlook and Situation Report.

PAFW: Price at farm: wheat. Dollars per bushel. Ibid.

Meat Consumption

DDBEEF: Disappearance (retail weight): beef. Million pounds. U. S. Department of Agriculture, Economic Research Service, Livestock and Poultry: Outlook and Situation Report.

DDPORK: Disappearance (retail weight): pork. Million pounds. Ibid.

DDBR: Disappearance (retail weight): broilers. Million pounds. Ibid.

Meat Production

PRDBEEF: Commercial production: beef. Million pounds. U. S. Department of Agriculture, Economic Research Service, Livestock and Poultry: Outlook and Situation Report.

PRDPORK: Commercial production: pork. Ibid.

PRDBR: Commercial production: broilers. Ibid.

Meat Animal Placements on Feed

CATPL: Placement of cattle on feed, thirteen states, 1,000 head. Ibid.

PIGC: Pig crop, ten states, 1,000 head. Ibid.

BRCH: Broiler chicks hatched. Thousands. U. S. Department of Agriculture, Crop Reporting Board, Eggs, Chickens, and Turkeys.

Animals on Feed

COF: Cattle on feed, thirteen states. 1,000 head. Ibid.

PIGOF: Pigs on feed, ten states. Computed.

BROF: Broilers on feed. Computed.

Meat Animal Breeding Inventories

TCOWKE: Inventory: cows and heifers that have calved. 1,000 head.

U. S. Department of Agriculture, Economic Research Service,
Livestock and Poultry: Outlook and Situation Report.

BRHOGKE: Inventory: breeding hogs on farms, ten states. 1,000 head.
Ibid.

CPL: Broiler-type pullet chick placements for hatchery supply
flocks. Thousands. U. S. Department of Agriculture, Crop Re-
porting Board, Eggs, Chickens, and Turkeys.

Meat Prices

PBEEF: Retail price: choice beef. Cents per pound. U. S. Department
of Agriculture, Economic Research Service, Livestock and
Poultry: Outlook and Situation Report.

PPORK: Retail price: pork. Cents per pound. Ibid.

PBR: Four-region average retail price: broilers. Cents per pound.
Ibid.

Predetermined Variables (Agriculture Sector)

N: Total population; see macrosector.

FPC: Futures price: corn. March price for September contract. Com-
modity Research Bureau, Inc., Commodity Yearbook.

- FPS: Futures price: soybeans. March price for September contract.
Ibid.
- FPW: Futures price: wheat. March price for September contract.
Ibid.
- YD: Disposable personal income; see macrosector.
- CPIU: Consumer price index (all urban); see macrosector.
- CPIF: Consumer price index (food commodities); see macrosector.
- CPINF: Consumer price index (nonfood commodities); see macrosector.
- T: Time trend.
- COMPR: Money rate on three-to-six month commercial paper; see macrosector.
- PAFS: Price at farm: soybeans. Dollars per bushel. U. S. Department of Agriculture, Economic Research Service, Oil Crops: Outlook and Situation Report.
- MW: Imports: wheat. Millions of bushels. Ibid.
- MFG: Imports: feed grains. Million metric tons. U. S. Department of Agriculture, Economic Research Service, Feed: Outlook and Situation Report.
- Q_1 : Quarterly dummy for first quarter.
- Q_2 : Quarterly dummy for second quarter.
- Q_3 : Quarterly dummy for third quarter.
- Q_4 : Quarterly dummy for fourth quarter.
- XBEEF: Exports: beef. Million pounds. U. S. Department of Agriculture, Economic Research Service, Livestock and Poultry: Outlook and Situation Report.
- MBEEF: Imports: beef. Million pounds. Ibid.

XPORK: Exports: pork. Million pounds. Ibid.
 MPORK: Imports: pork. Million pounds. Ibid.
 XBR: Net exports: broilers. Million pounds. Ibid.

Exogenous Policy Variables (Agriculture Sector)

DRW: Diversion requirement: wheat. U. S. Department of Agriculture,
 Economic Research Service, Wheat: Outlook and Situation.
 VDW: Voluntary additional diversion limit: wheat. Ibid.
 VDPW: Voluntary additional diversion payment, per acre: wheat. Ibid.
 DPW: Diversion payment, per acre: wheat. Ibid.
 BAW: Base acreage: wheat. Ibid.
 TPW: Target price: wheat. Ibid.
 SPW: Support price: wheat. Ibid.
 RELFORW: Release price for the farmer-owned reserve: wheat. Ibid.
 SPFORW: Support price for the farmer-owned reserve: wheat. Ibid.
 YLDWP: Program yield for wheat used to calculate deficiency payments.
 Ibid.
 DRFG: Diversion requirement: feed grains. U. S. Department of Agriculture,
 Economic Research Service, Feed: Outlook and Situation.
 VDFG: Voluntary additional diversion limit: feed grains. Ibid.
 VDPC: Voluntary additional diversion payment, per acre: feed grains.
 Ibid.
 DPC: Diversion payment, per acre: feed grains. Ibid.
 BAGS: Base acreage: feed grains. Ibid.
 TPC: Target price: corn. Ibid.
 SPC: Support price: corn. Ibid.

RELFORC: Release price for the farmer-owned reserve: corn. Ibid.

SPFORC: Support price for the farmer-owned reserve: corn. Ibid.

YLDFGP: Program yield for feed grains used to calculate deficiency payments. Ibid.

ICCC: Interest rate charged by the CCC for nonrecourse loans. Ibid.

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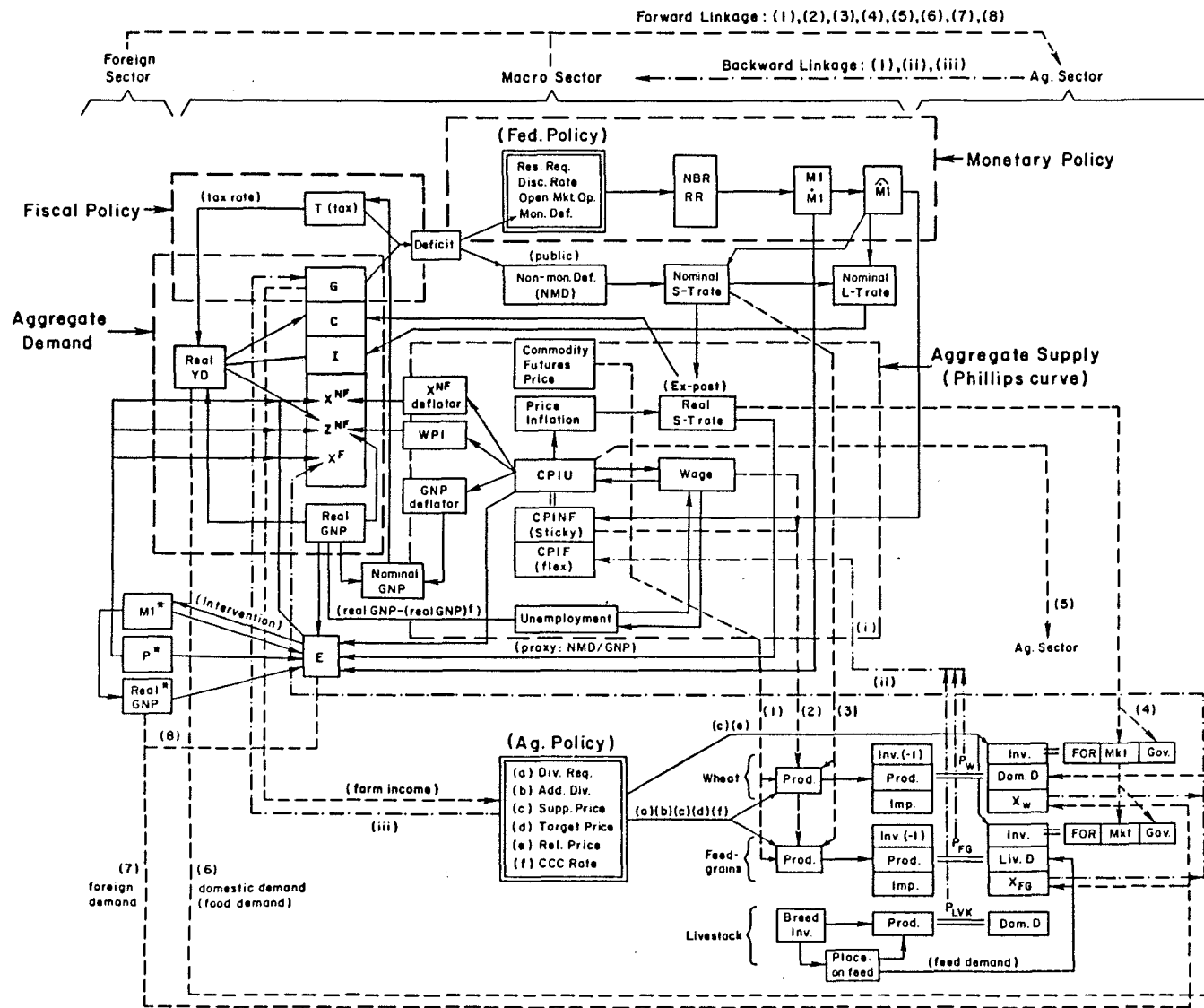


Figure I. Forward and Backward Linkages Among Model Components.

TABLE 1

Fiscal and Monetary Policy Under Subsidy and Tax Scenarios

	Deficits		Nonborrowed reserves	
	Govern- mental	Nonmone- tized	Subsidy scenario	Tax scenario
<u>1983</u>				
Quarter 1	60.96	63.56	33.09	33.09
2	29.19	24.19	33.52	33.52
3	36.94	23.24	34.36	34.36
4	60.38	63.88	35.37	35.37
<u>1984</u>				
Quarter 1	66.94	57.20	37.64	35.66
2	15.79	11.31	38.68	35.95
3	40.95	29.43	41.36	36.22
4	91.31	83.67	43.14	36.49
<u>1985</u>				
Quarter 1	40.37	30.01	45.56	36.76
2	16.50	13.15	46.34	37.04
3	57.48	48.03	48.54	37.32
4	99.64	90.70	50.62	37.59
<u>1986</u>				
Quarter 1	71.87	62.56	52.79	37.83
2	31.97	24.78	54.46	38.08
3	41.79	31.97	56.75	38.34
4	70.76	54.83	60.46	38.60

Source: Computed.

TABLE 2

Setting of Agricultural Policy Variables

	1983	1984	1985	1986
<u>FEED GRAINS</u>				
<u>Setting of sector policy variables</u>				
Diversion requirement (percent of base average)	20	10	10	10
Target price, corn (dollars per bushel)	2.86	3.03	3.03	3.03
Support price, CCC, corn (dollars per bushel)	2.55	2.65	2.55	2.55
Release price, FOR, corn (dollars per bushel)	4.21	4.21	4.21	4.21
Base acreage (million acres)	81.30	81.40	81.40	81.40
<u>WHEAT</u>				
<u>Setting of sector policy variables</u>				
Diversion requirement (percent of base acreage)	20	30	30	30
Target price (dollars per bushel)	4.30	4.38	4.38	4.38
Support price, CCC (dollars per bushel)	3.55	3.65	3.30	3.30
Release price, FOR (dollars per bushel)	4.64	4.64	4.30	4.30
Base acreage (million acres)	90.90	94.00	93.90	43.90

Source: Computed.

TABLE 3
Major Macroeconomic and International Variables
Under Subsidy and Tax Scenarios

	Short-term nominal interest rates		Real short-term interest rates		Nominal exchange rate		Annual rate of inflation		Real GNP	
	Subsidy scenario	Tax scenario	Subsidy scenario	Tax scenario	Subsidy scenario	Tax scenario	Subsidy period	Tax period	Subsidy period	Tax period
<u>1983</u>										
Quarter 1	8.34	8.34	4.74	4.74	0.94	0.94	3.60	3.60	1,491.00	1,491.00
2	8.62	8.62	5.28	5.28	0.92	0.92	3.42	3.42	1,524.80	1,524.80
3	9.34	9.34	6.77	6.77	0.89	0.89	2.57	2.57	1,550.20	1,550.20
4	9.21	9.21	5.90	5.90	0.89	0.89	3.30	3.30	1,572.70	1,572.70
<u>1984</u>										
Quarter 1	11.44	10.92	6.27	6.44	0.88	0.86	5.17	4.48	1,648.79	1,650.20
2	11.77	12.71	5.57	7.92	0.88	0.86	6.20	4.79	1,715.80	1,717.35
3	13.65	13.94	5.31	8.71	0.90	0.84	8.34	5.23	1,777.29	1,779.59
4	14.07	14.82	4.13	9.51	0.91	0.81	9.40	5.30	1,813.57	1,814.76
<u>1985</u>										
Quarter 1	14.02	14.83	3.23	9.73	0.99	0.80	10.79	5.10	1,818.38	1,811.77
2	13.37	14.55	2.76	10.00	1.07	0.79	10.61	4.55	1,825.34	1,816.23
3	14.29	15.35	4.67	11.46	1.16	0.77	9.62	3.89	1,834.85	1,814.35
4	14.70	17.78	5.52	14.37	1.23	0.74	9.20	3.41	1,841.46	1,802.68
<u>1986</u>										
Quarter 1	14.60	18.08	5.88	15.10	1.33	0.72	8.71	2.99	1,869.09	1,805.03
2	14.19	19.52	5.44	16.96	1.44	0.71	8.75	2.56	1,900.02	1,799.95
3	14.65	21.77	5.91	19.68	1.66	0.70	8.74	2.11	1,943.48	1,798.41
4	15.47	22.36	6.20	20.79	1.69	0.69	9.27	1.58	1,983.62	1,790.26

Source: Computed.

TABLE 4
Supply Response Under Subsidy and Tax Scenarios

	1983	1984	1985	1986
<u>Acreage (million acres)</u>				
Subsidy scenario	72.10	96.73	96.30	94.32
Tax scenario		96.21	96.42	95.75
<u>Yields (bushels per acre)</u>				
Subsidy scenario	64.66	90.39	94.03	95.97
Tax scenario		90.69	94.42	96.33
<u>Production (million metric tons)</u>				
Subsidy scenario	136.00	241.89	249.81	249.70
Tax scenario		241.43	251.05	254.09
<u>Cost (variable costs including seed, chemicals, and labor; dollars per acre)</u>				
Subsidy scenario	152.92	145.03	150.69	169.94
Tax scenario		146.18	145.71	169.57
<u>Acreage (million acres)</u>				
Subsidy scenario	76.40	67.51	69.12	70.42
Tax scenario		67.70	65.73	65.70
<u>Yields (bushels per acre)</u>				
Subsidy scenario	31.67	33.37	33.15	33.56
Tax scenario		33.37	33.16	33.61
<u>Production (million bushels)</u>				
Subsidy scenario	2,419.80	2,253.18	2,291.24	2,363.11
Tax scenario		2,259.23	2,179.75	2,207.84
<u>Cost (variable costs including seed, chemicals, and labor; dollars per acre)</u>				
Subsidy scenario	69.76	67.49	64.40	70.60
Tax scenario		67.49	63.09	71.06

Source: Computed.

TABLE 5

Wheat Prices Under Subsidy and Tax Scenarios

	WHEAT			Percentage difference between real prices: subsidy vs. tax scenario ^b percent
	Nominal prices ^a			
	Subsidy scenario	Actual	Tax scenario	
	dollars per bushel			
<u>1983</u>				
Quarter 1		3.61		
2		3.77		
3		3.53		
4		3.54		
<u>1984</u>				
Quarter 1	3.55 (1.15) ^c		3.55 (1.16)	- 0.86
2	3.31 (1.05)		3.36 (1.08)	- 2.78
3	3.25 (1.00)		3.33 (1.06)	- 4.76
4	3.60 (1.08)		3.63 (1.14)	- 5.26
<u>1985</u>				
Quarter 1	3.64 (1.06)		3.53 (1.10)	- 3.63
2	3.44 (0.99)		3.07 (0.94)	5.32
3	3.55 (1.00)		3.23 (0.98)	2.04
4	4.02 (1.10)		3.59 (1.09)	0.92
<u>1986</u>				
Quarter 1	4.25 (1.14)		3.35 (1.01)	12.87
2	4.26 (1.12)		2.90 (0.87)	28.74
3	4.43 (1.14)		3.13 (0.93)	22.58
4	5.24 (1.32)		3.28 (0.98)	34.69

^aPrice at farm, U. S. average.

^b $(P_s - P_t)/P_t$, where P_s = real price under the subsidy scenario and P_t = real price under the tax scenario.

^cFigures in parentheses are real prices.

Source: Computed.

TABLE 6

Export and Major Domestic Demand of Wheat Under Subsidy and Tax Scenarios

	WHEAT					
	Export			Domestic demand		
	Subsidy scenario	Actual	Tax scenario	Subsidy scenario	Actual	Tax scenario
	million bushels					
<u>1983</u>						
Quarter 1		442.10			151.40	
2		228.30			96.80	
3		475.30			210.10	
4		362.60			160.70	
<u>1984</u>						
Quarter 1	346.39		345.54	127.30		127.36
2	213.59		211.78	71.08		71.20
3	489.47		482.84	191.78		191.97
4	343.01		329.00	128.62		129.25
<u>1985</u>						
Quarter 1	346.24		316.41	126.06		126.86
2	243.44		196.58	71.51		72.65
3	542.77		471.23	193.32		194.05
4	401.86		316.07	128.40		129.80
<u>1986</u>						
Quarter 1	410.98		291.96	126.37		127.76
2	328.91		167.60	71.35		72.94
3	639.17		448.39	195.00		195.57
4	504.95		295.97	128.80		130.82

Source: Computed.

TABLE 7
Total Wheat Stocks and Their Shares Across Various Components
Under Subsidy and Tax Scenarios

	WHEAT										
	Total stocks (ending)		Share of stocks						Share of reserved stocks		
			Market and CCC, nongovernment owned			Government held			Farmer owned		
	Subsidy scenario	Tax Actual scenario	Subsidy scenario	Tax Actual scenario	Subsidy scenario	Tax Actual scenario	Subsidy scenario	Tax Actual scenario	Subsidy scenario	Tax Actual scenario	
	million bushels		percent						percent		
<u>1983</u>											
Quarter 1	1,862.00			31.25			9.95			58.81	
2	1,515.10			17.33			12.67			70.00	
3	2,955.20			67.08			5.33			27.59	
4	2,326.40			62.68			7.12			30.20	
<u>1984</u>											
Quarter 1	1,766.06	1,766.84	47.37	47.37	10.14	10.14	42.49	42.49			
2	1,431.91	1,435.11	30.53	18.86	14.63	26.71	54.84	54.43			
3	2,731.51	2,750.44	63.97	58.38	7.90	14.12	28.13	27.50			
4	2,174.23	2,210.89	64.84	60.78	1.43	6.65	33.74	32.57			
<u>1985</u>											
Quarter 1	1,638.75	1,710.45	54.97	47.81	0.00	9.11	45.03	43.07			
2	1,300.38	1,424.34	41.82	32.93	1.81	12.99	56.37	54.08			
3	2,630.59	2,717.70	72.80	65.27	0.95	7.03	26.25	27.70			
4	2,054.74	2,227.36	69.19	58.32	0.00	9.25	30.81	32.43			
<u>1986</u>											
Quarter 1	1,478.67	1,770.44	59.24	44.99	0.00	12.28	40.76	42.73			
2	1,077.62	1,519.72	48.94	0.00	0.00	47.08	51.06	52.92			
3	2,416.56	2,877.11	80.76	47.39	0.00	25.12	19.24	27.48			
4	1,766.70	2,420.21	80.09	49.15	0.00	18.51	19.90	32.34			

Source: Computed.

TABLE 8

Livestock Prices Under Subsidy and Tax Scenarios

	BEEF ^a				PORK ^c			POULTRY ^d				
	Nominal prices			Percentage difference in real prices: subsidy vs. tax ^b scenario	Nominal prices		Percentage difference in real prices: subsidy vs. tax ^b scenario	Nominal prices		Percentage difference in real prices: subsidy vs. tax ^b scenario		
	Subsidy scenario	Actual	Tax scenario		Subsidy scenario	Actual		Tax scenario	Subsidy scenario		Actual	Tax scenario
	cents per pound				cents per pound			cents per pound				
1983												
Quarter 1	237.90			183.00			70.00					
2	245.10			171.10			69.10					
3	238.40			165.40			74.60					
4	231.10			159.80			77.40					
1984												
Quarter 1	266.73 (86.38) ^e	262.64 (85.62)	0.89	180.93 (58.59)	177.68 (57.93)	1.14	90.48 (29.30)	90.87 (29.63)	- 1.11			
2	312.43 (99.12)	303.21 (97.49)	1.67	198.59 (63.00)	191.77 (61.66)	2.17	122.68 (38.92)	122.56 (39.40)	- 1.22			
3	351.20 (108.12)	332.77 (105.48)	2.50	257.02 (79.13)	242.49 (76.87)	2.94	150.55 (46.35)	150.01 (47.55)	- 2.52			
4	365.41 (109.66)	335.26 (105.04)	4.40	265.54 (79.69)	242.41 (75.95)	4.92	153.04 (45.92)	150.47 (47.14)	- 2.59			
1985												
Quarter 1	401.77 (117.44)	355.89 (110.40)	6.38	290.75 (84.99)	256.25 (79.49)	6.92	163.70 (47.85)	157.98 (49.00)	- 2.35			
2	430.61 (123.61)	372.02 (114.41)	7.95	289.65 (83.07)	248.64 (76.46)	8.65	172.45 (49.46)	162.77 (50.05)	- 1.18			
3	447.76 (125.75)	372.92 (113.78)	10.52	318.12 (89.35)	266.46 (81.30)	9.90	183.49 (51.53)	168.22 (51.33)	0.39			
4	446.79 (122.79)	352.98 (106.95)	14.81	307.54 (84.52)	247.39 (74.95)	12.77	171.90 (47.24)	151.19 (45.81)	3.12			

(Continued on next page.)

TABLE 8--continued.

	BEEF ^a			PORK ^c			POULTRY ^d					
	Nominal prices		Percentage difference in real prices: subsidy vs. tax, ^b scenario	Nominal prices		Percentage difference in real prices: subsidy vs. tax, ^b scenario	Nominal prices		Percentage difference in real prices: subsidy vs. tax, ^b scenario			
	Subsidy scenario	Actual	Tax scenario	Subsidy scenario	Actual	Tax scenario	Subsidy scenario	Actual	Tax scenario			
	cents per pound			percent	cents per pound			percent	cents per pound			percent
1986												
Quarter 1	474.66 (127.63)	361.17 (108.79)	17.32	317.08 (85.26)	249.75 (75.23)	13.33	174.16 (46.83)	148.07 (44.60)	5.00			
2	504.31 (133.00)	362.14 (108.60)	22.47	307.24 (81.03)	230.88 (69.23)	17.04	177.57 (46.83)	141.60 (42.46)	10.29			
3	527.78 (136.32)	358.01 (106.97)	27.44	333.00 (86.01)	245.41 (73.33)	17.29	190.05 (49.09)	143.92 (43.00)	14.16			
4	541.06 (136.08)	340.58 (101.59)	33.95	326.69 (82.17)	229.40 (68.43)	20.08	182.78 (45.97)	129.85 (38.73)	18.69			

^aAverage retail price (3 months); choice.^b $(P_s - P_t)/P_t$, where P_s = real price under the subsidy scenario and P_t = real price under the tax scenario.^cAverage retail price (3 months).^dAverage retail price (3 months); four regions.^eFigures in parentheses are real prices.

Source: Calculated.

TABLE 9
Livestock Breeding Inventories Under Subsidy and Tax Scenarios

	Inventories of:								
	BEEF ^a			HOGS ^b			POULTRY ^c		
	Subsidy scenario	Actual	Tax scenario	Subsidy scenario	Actual	Tax scenario	Subsidy scenario	Actual	Tax scenario
	1,000 head			1,000 head			1,000 head		
<u>1983</u>									
Quarter 1		49,293			6,011			9,778	
2		49,600			6,263			9,831	
3		49,102			5,829			8,729	
4		48,603			5,638			9,730	
<u>1984</u>									
Quarter 1	48,714		48,714	5,560		5,560	9,694		9,694
2	48,816		48,802	5,597		5,588	10,012		10,014
3	48,087		48,035	5,311		5,252	9,058		9,066
4	47,330		47,195	5,366		5,216	9,429		9,447
<u>1985</u>									
Quarter 1	47,324		47,042	5,559		5,274	9,742		9,775
2	47,373		46,862	6,033		5,581	10,387		10,437
3	46,705		45,872	6,199		5,558	9,656		9,717
4	46,155		44,885	6,546		5,718	10,140		10,198
<u>1986</u>									
Quarter 1	46,496		44,658	6,784		5,750	10,453		10,495
2	47,021		44,456	7,105		5,842	11,032		11,036
3	46,938		43,463	7,013		5,479	10,205		10,157
4	47,032		42,449	7,103		5,273	10,593		10,492

^aCows and heifers that have calved, total, United States {Quarter 2 = July 1, Quarter 4 = January 1, Quarter 1 = $1/2$ [Quarter 2 + Quarter 4(-1)], Quarter 3 = $1/2$ (Quarter 2 + Quarter 4)}.

^bBreeding hog inventory, 10 states (Quarter 1 = March 1, Quarter 2 = June 1, Quarter 3 = September 1, Quarter 4 = December 1).

^cPullet chicks placed in broiler hatchery supply flocks.

Source: Calculated.

TABLE 10

Governmental Budget Cost of Wheat Farm Programs Under Subsidy and Tax Scenarios

	WHEAT			Ratio of the tax scenario to the subsidy scenario
	Total cost under:			
	Subsidy scenario	Actual	Tax scenario	
	million dollars			
<u>1983</u>				
Quarter 1		174.66 (59.49) ^a		
2		204.10 (68.77)		
3		1,505.66 (502.22) ^b		
4		162.40 (53.58)		
<u>1984</u>				
Quarter 1	183.35 (59.38)		182.77 (59.58)	1.00
2	255.11 (80.93)		911.55 (293.07)	3.62
3	1,516.33 (466.83)		2,386.38 (756.43)	1.62
4	-536.83 (-161.10)		-709.30 (-222.22)	1.38
Total	1,417.96 (446.04)		2,771.40 (886.86)	
<u>1985</u>				
Quarter 1	-13.15 (-3.84)		163.71 (50.78)	-13.22
2	176.29 (50.56)		235.53 (72.43)	1.43
3	1,148.83 (322.65)		2,437.82 (743.80)	2.31
4	-10.82 (-2.97)		203.06 (61.52)	-20.71
Total	1,301.15 (366.40)		3,040.12 (928.53)	
<u>1986</u>				
Quarter 1	80.32 (21.60)		193.37 (58.25)	2.70
2	74.96 (19.77)		1,871.41 (561.18)	28.39
3	65.89 (17.02)		2,615.73 (781.59)	45.92
4	53.15 (13.37)		-616.65 (-183.94)	-13.76
Total	274.32 (71.76)		4,063.86 (1,217.08)	

^aFigures in parentheses are real costs.^bAssume the participation rate = 100 percent.

Source: Computed.

TABLE 11

Net Farm Income for Wheat and Livestock Under Subsidy and Tax Scenarios

	WHEAT			Percent- age differ- ence in real income: subsidy vs. tax scenario ^a	LIVESTOCK			Percent- age differ- ence in real income: subsidy vs. tax scenario ^a
	Net farm income under:		Tax scenario		Net farm income under:		Tax scenario	
	Subsidy scenario	Actual			Subsidy scenario	Actual		
	million dollars				million dollars			
1983								
Quarter 1		-79.52 (-27.08) ^b				19,196.90 (6,538.50)		
2		-87.56 (-29.50)				20,934.70 (7,053.50)		
3		7,214.67 (2,406.50) ^c				20,545.30 (6,853.00)		
4		-61.87 (-20.41)				17,460.10 (5,760.50)		
1984								
Quarter 1	-73.74 (-23.88)		-70.39 (-22.95)	-4.05	21,235.20 (6,877.20)		20,882.40 (6,807.90)	1.02
2	-74.79 (-23.73)		-81.72 (-26.27)	9.67	26,869.00 (8,524.20)		26,183.60 (8,418.40)	1.26
3	5,309.56 (1,634.64)		7,086.85 (2,246.37)	-27.23	30,528.00 (9,398.60)		29,098.50 (9,223.60)	1.90
4	-95.17 (-28.56)		-99.20 (-31.08)	8.11	31,790.30 (9,540.10)		29,603.60 (9,274.90)	2.86
1985								
Quarter 1	-93.91 (-27.45)		-95.42 (-29.60)	7.26	34,298.60 (10,025.70)		30,921.30 (9,591.60)	4.53
2	-84.64 (-24.27)		-83.98 (-25.83)	6.04	37,235.80 (10,679.80)		32,729.00 (10,064.90)	6.11
3	5,128.05 (1,440.22)		6,029.14 (1,839.55)	-21.71	39,171.50 (11,001.40)		33,229.50 (10,138.70)	8.51
4	-97.70 (-26.85)		-117.57 (-35.62)	24.62	38,709.80 (10,638.30)		31,229.70 (4,461.80)	12.43
1986								
Quarter 1	-95.87 (-25.78)		-111.91 (-33.71)	23.52	40,187.90 (10,805.70)		31,043.00 (9,350.30)	15.57
2	-87.10 (-22.97)		-110.45 (-33.12)	30.65	42,330.90 (11,164.10)		31,659.40 (9,493.70)	17.60
3	5,900.07 (1,523.90)		5,546.38 (1,657.27)	-8.05	44,846.20 (11,583.10)		31,937.80 (9,543.10)	21.38
4	-82.74 (-20.81)		-144.34 (-43.05)	51.66	45,438.00 (11,428.20)		30,027.60 (8,956.80)	27.59

^aCalculated by $(I_s - I_t)/I_t$ for $I_s, I_t > 0$ and $-(I_s - I_t)/I_t$ for $I_s, I_t < 0$.

^bFigures in parentheses are real income.

^cAssume the participation rate = 100 percent.