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Monograph

Macrolinkages between the Farm and Nonfarm Sectors and the Impact of Monetary Policy Decisions

S. Devadoss
William H. Meyers
Dennis R. Starleaf

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by S. Devadoss, William H. Meyers, and Dennis R. Starleaf

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FOREWORD

The CARD monograph series has been created to showcase selected works, both theoretical and applied, by Center researchers. In general, the criteria for inclusion in this series are the significance and durability of the findings. Other CARD series--those for staff reports, working papers, technical reports, and reprints--provide outlets for our research that is of more specialized interest.

In this lead issue of the monograph series, results are provided linking the farm and nonfarm sectors in the U.S. economy. We believe that analyses in which agriculture is considered within a broadened context are especially important for guiding future policy. Thus, in addition to being first in the CARD series, this monograph is indicative of the general approach to be emphasized in future CARD research.

The specific transmission mechanisms or linkages between agriculture and the macroeconomy investigated herein include the following: exchange rates for exports, interest rates for production decisions, inflation for input demand and asset valuation, and income for farm products demand. In the United States, the primary agricultural sector is small relative to the remainder of the economy. Hence, the model is constructed primarily to provide one-way linkages, albeit in a multimarket equilibrium context.

The research results support the monetary approach to exchange rate determination, the importance of macrovariables to performance of the agricultural sector, and the effects of income and interest rates on the financial stability of the agricultural sector. More generally, they support the view that agriculture, perhaps because it is a primary industry, tends to swing more widely in response to direct and indirect policy incentives. All of these factors suggest that if U.S. agriculture is to grow and prosper, more careful and integrated analyses of macroeconomic, trade, monetary, and domestic sector policies must be undertaken.

--Stanley R. Johnson
Administrator,
Center for Agricultural
and Rural Development

PREFACE

This monograph originated from the doctoral dissertation of the first author, for whom the other two authors were major professors. This study was undertaken in 1983-85 with a view toward examining the crisis experienced within U.S. agriculture in the early 1980s. Since the agricultural sector is closely related to and integrated with the general economy, many economists believe that the problems faced by agriculture were, at least in part, due to macroeconomic policies pursued by the U.S. government. This study examines the interrelationships between these macro phenomena and U.S. agriculture.

We extend our sincere thanks to Stanley R. Johnson, who painstakingly read the manuscript, made numerous valuable comments and suggestions, and provided various insights into the subject matter. His constructive criticisms led to significant improvement in the content and structure of the monograph.

Special thanks also go to Zong-Shin Liu for diligently assisting with the computer analysis, and for carefully reviewing and pointing out errors in the manuscript. The authors wish to express their appreciation to Debbie Stephens, who meticulously reviewed the various manuscript drafts. The authors are grateful to Kathleen Glenn-Lewin for her outstanding editorial contribution to the refinement and improvement of the text.

--S. Devadoss

CHAPTER 1.
THE IMPACT OF MACROVARIABLES ON THE FARM SECTOR

Since the appearance of Schuh's article in 1974 on the relationship between exchange rates and U.S. agriculture, several attempts have been made to investigate the effect of monetary factors on U.S. agriculture. However, much of the literature on the area of agricultural macroeconomics has focused on the exchange rate linkage; less attention has been given to other interconnections. The general concern of this study is to examine the effect of changes in monetary policies on agriculture in a general multimarket equilibrium framework through the linkages of exchange rate, interest rate, inflation, and income. Emphasis is placed on agricultural product markets.

The Problem

A representation of the agricultural sector was a major component of the early macroeconometric models developed by Klein and Goldberger (1955). In the 1960s, accepted macroeconomic theory and the theory of macroeconomics of agriculture followed separate paths of development, apparently because of stable growth in both the nonfarm and farm economies. In 1973, Fox suggested the need for improved econometric models to capture the possible interactions between the macroeconomy and agriculture. Schuh (1974) also called attention to this dual evolution by noting that the sectoral emphasis within agriculture resulted in neglect of the linkages with the rest of the economy. Schuh (1979) further indicated that agricultural commodity markets can no longer be understood in isolation from the capital market and other monetary factors, either domestically or internationally.

Furthermore, the pronounced impacts of factors such as the exchange rate on the farm sector has led to greater awareness among economists of the importance of macroeconomic developments to the health of the agricultural sector. (See, for example, Johnson 1977; Just 1977; Roop and Zeitner 1977; Van Duyne 1979; Penson and Hughes 1979; Chambers 1981; Gardner 1981; Starleaf 1982; and McCalla 1982.)

Although a number of agricultural sector models have been developed specifically for inclusion within a large macromodel (e.g., Cromarty 1959), such models are not entirely satisfactory because linkages between the macroeconomy and agriculture are either missing or specified inadequately. Furthermore, macromodel builders tend to include agriculture as a satellite sector. The agricultural sector in these stand-alone models is influenced by relatively few macroeconomic variables, such as disposable income and the implicit price deflator. Thus, in these models, the transmission mechanisms between farm and nonfarm sectors, through the macrovariables, are not fully recognized.

The increased integration of the U.S. farm sector with the nonfarm sector (both domestic and international) during the past decade has significant implications for farm product prices, input costs, and farm income. This is true especially in light of the effects of exchange rates, interest rates, and inflation on the farm sector. All of these factors are influenced by macroeconomic policies and capital markets.

Schuh (1983) argued that the value of the dollar in terms of other currencies is crucial for agricultural trade. For example, an expansionary monetary policy will reduce the value of the dollar, providing stimulus for dollar exports, and thus increasing aggregate demand for farm commodities.

Like the exchange rate, the interest rate is another macrovariable that has a significant influence on farm income through the farm sector's cost structure. Chambers (1984) emphasized the importance of interest rates on agricultural production. To date, however, no empirical work has addressed the impact of interest rates on agricultural production and inventory storage (Schuh, Hodges, and Orden 1980).

Inflation--a rise in the general price level--is another important macrovariable that has a significant effect on the farming sector. Inflation has led to higher prices of both farm inputs and outputs, and, thus, has influenced production decisions.

Finally, an increase in the real income of the economy means higher spending for the output of the economy. The effect of this increased spending on the farm sector is a higher domestic demand for farm products.

From macrotheory we know that these four variables--exchange rates, interest rates, inflation, and real income--are influenced by macropolicies, particularly by monetary policies of the Federal Reserve. Thus, changes in monetary policy are likely to have significant impacts on the prices and incomes of the agricultural economy.

Given that background, the objectives of this volume are as follows:

1. To investigate the interrelationships between the macrosector and agriculture through exchange rates, interest rates, inflation, and income linkages.
2. To develop an econometric model to capture those four macrolinkages between the farm and nonfarm sectors.
3. To use the model to examine the effects of changes in U.S. monetary policy on the U.S. farm sector, particularly on crop prices, livestock product prices, crop production and demand, exports, inventories, livestock production and demand, and farm income.
4. To evaluate the policy implications from the empirical findings.

Previous Studies on Macroeconomics of Agriculture

The large increase in U.S. agricultural exports and volatile prices and income in the early 1970s caught the attention of many agricultural economists. Some observers explained that bad weather and associated crop failures in many parts of the world in 1972, along with rapid population growth, contributed to an increase in the demand for U.S. farm products and to higher prices. Several other observers have argued that expansion in U.S. and global money supplies caused inflation, which was transmitted among countries, and that it also raised both industrial and agricultural prices. Schuh (1974) suggested that the dollar devaluation was an omitted variable in these explanations. These and other arguments gave impetus to research on possible interrelationships among agricultural, domestic, and international economies.

This section reviews past studies on the effect of monetary policies, exchange rates, interest rates, and inflation on the farm sector. Previous farm sector models dealing with macroconnections also are reviewed. The section concludes with an examination of four basic interfaces among agriculture and the international and domestic economies.

Exchange Rates and Commodity Trade

The relationship between exchange rates and agricultural trade has been the subject of a somewhat controversial literature. In the 1970s a series of theoretical and empirical models was developed to investigate

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Exchange Rates and Commodity Trade

The relationship between exchange rates and agricultural trade has been the subject of a somewhat controversial literature. In the 1970s a series of theoretical and empirical models was developed to investigate the relationship between the exchange rate and agricultural commodity trade. Much of the literature revolved around two issues: exchange rate elasticities of foreign demand for U.S. farm products, and endogenizing the exchange rate.

During the 1970s, U.S. agriculture effectively became part of a world agricultural economy. Agricultural exports burgeoned, with the result that approximately 30 percent of cash marketings were attributed to export sales. This growing internationalization of agricultural commodity markets was a major factor influencing the modeling of the agricultural sector for policy purposes. Schuh (1974) suggested that the magnitude of the exchange rate could have important implications for the increase in U.S. agricultural trade.

In her discussion of how to model exchange rate effects on U.S. agriculture, Vellianitis-Fidas (1975) stressed that the domestic demand and supply elasticities were more important than those of import demand and export supply. Vellianitis-Fidas concluded that U.S. farm exports are inelastic with respect to the U.S. exchange rate, and that the effect of exchange rate changes on agricultural exports and prices is minimal.

A year later, Kost (1976) took exception to the view that the "exchange rate is an important structural variable." He suggested that such conclusions were quite misleading as to the magnitude of the effects we can expect in agriculture when the exchange rate changes. To support his contention, Kost used a two-country, one-commodity, free trade partial equilibrium analysis to analyze the impact of the exchange rate on U.S. agriculture. Kost's principal conclusion was that the proportional increase in price or quantity of traded goods in response to a devaluation was restricted to being less than or equal to the percentage of devaluation. He also concluded that a change in the exchange rate will have only a small impact on agricultural trade.

Kost's paper captured much of the essence of later discussions on modeling the effects of the exchange rate. One of the first to respond to Kost was Bredahl. In particular, Bredahl (1976) argued that within the two-country, one-good model, there was no basis for concluding that the proportional change in quantity traded was constrained by the percentage devaluation. Using linear supply and demand curves, Bredahl developed expressions for the elasticity of exporter price and quantity traded in terms of excess supply and demand elasticities. Bredahl's calculations suggested that the effect on the quantity of exports from a change in the exchange rate is large when both excess supply and demand elasticities are relatively large, and when the elasticity of price with respect to the exchange rate has no a priori lower bound.

An obvious empirical issue in modeling exchange rate effects is the size of foreign import demand elasticity for U.S. agricultural exports. Tweeten (1967) calculated the price elasticity of the total export demand for U.S. agricultural commodities by deriving the following expression:

$$E_{ED} = \Sigma_i [e_{Di} e_{Pi} \frac{Q_{Di}}{Q_x} - e_{Si} e_{Pi} \frac{Q_{Si}}{Q_x}]$$

where i = 1...n is a country index; e_{Di}, e_{Si}, Q_{Di}, and Q_{Si} are elasticities of demand and supply and quantities demanded and supplied in the i^{th} country; and Q_x is the quantity of U.S. exports. The term e_{Pi} is the elasticity of price transmission, which measures the responsiveness of price in country i to changes in the U.S. price. Using the above expression and assuming free world trade, Tweeten initially computed E_{ED} equal to -15.9. However, after considering the world trade restrictions, E_{ED} was reduced to -6.3.

Bredahl, Meyers, and Collins (1979) extended this issue of import demand elasticity by indicating that the government policies of major importers of U.S. commodities should be incorporated to arrive at a realistic estimate of the elasticity. Trade restrictions by importing countries make e_{Pi} approach zero. With $e_{Pi} = 0$, a change in world price or a currency devaluation of an exporter would have no effect on domestic markets in the i^{th} country, and no effect on E_{ED}. They concluded that Tweeten's estimate of the elasticity of excess demand was very high and simply not "in line with what is known about the world with insulated agricultural markets."

The two-country, one-commodity model used by most of the studies is a simple and perhaps excessively abstract representation of the real world. Chambers and Just (1979) suggested that excess demand and supply equations must include all prices and income, since neoclassical demand and supply functions are the result of utility and profit maximization. Their model treated all prices, the exchange rate, and income as demand shifters and all prices and the exchange rate as supply shifters. The implication of their study is that there is no a priori reason to expect the price or quantity change to be less in percentage terms than the change in the exchange rate.

From these studies, it is clear that the magnitude of the elasticity of U.S. farm exports with respect to the exchange rate is crucial in analyzing the effect of money supply on farm commodity trade through the exchange rate.

The second vital issue in agricultural-trade modeling is whether or not the exchange rate should be endogenized. Schuh (1981) gave the following reasons for endogenizing the exchange rate. Suppose that the U.S. government wants to undertake an expansionary monetary policy: the resulting increase in money supply will depreciate the dollar, leading to a higher demand for U.S. farm products by the rest of the world (henceforth to be abbreviated as ROW). Similarly, a tight monetary policy by the U.S. government will increase the value of the dollar, leading to a reduced import demand for U.S. farm products. If the exchange rate is treated as exogenous, then the casual linkage between the money supply and the exchange rate is not realized.

Furthermore, under a fixed exchange rate regime, the rate is viewed as a policy instrument used to correct the disequilibrium in the foreign exchange market. However, under a flexible regime, the exchange rate is determined by monetary factors in the United States and the ROW. Therefore, any change in the money supply in the United States and the ROW will change the value of the exchange rate; that is, the value of the U.S. dollar. Hence, exchange rates under a flexible regime can no longer be considered as exogenous variables.

Shei (1978), in his doctoral thesis, investigated the impact of the money supply and the exchange rate on the agricultural sector. Since the rate was assumed to be fixed in his model, the link between the money supply and the exchange rate was ignored. Chambers and Just (1982) endogenized the exchange rate in their agricultural model of corn, soybeans, and wheat to show the effect of the money supply changes on prices, production, and disappearances of all three commodities.

Interest Rates and U.S. Agriculture

Although the literature on the macroeconomics of agriculture is fairly extensive, relatively little attention has been given to the effect of monetary factors other than the exchange rate on the U.S. farm sector. Past studies (Schuh, Hodges, and Orden 1980; Chambers 1983,

1984) emphasized the importance of changes in the domestic interest rate and its implications on farm production and inventory decisions.

According to macroeconomic theory, monetary policy influences the interest rate, and changes in the interest rate will affect farmers' decisions to borrow. Economists believe that the farm financial crisis of 1983 and 1984 was caused by higher interest rates, which were the result of budget deficits coupled with the tight monetary policy pursued by Federal Reserve authorities (see Harl 1984).

Inflation and U.S. Agriculture

The impact of general price inflation on the farm sector is in dispute. Starleaf, Meyers, and Womack (1985) presented evidence that farmers benefit from an acceleration in the rate of general price inflation. They showed that short-run movements in the rate of increase in prices paid by farmers have generally been accompanied by larger short-run movements in the rate of increase in prices received by farmers. That is, farm output price tends to react more quickly and sharply than does farm input price. Thus, the terms of trade of farmers (the ratio of price received to the price paid by farmers) improve (diminish) as the inflation rate accelerates (decelerates) (also, see Ruttan 1979; Gardner 1981; and Prentice and Schertz 1981). Conversely, Tweeten, in a series of publications, has presented evidence to support the argument that farmers suffer a loss in real income in response to a rise in the general price level. His empirical estimates indicate that, nationwide, inflation raised prices paid by farmers more than it raised prices received by farmers. Thus, inflation worsened the terms of trade (see Tweeten 1983, 1980; Tweeten and Griffin 1976).

Chambers (1983), in discussing Tweeten's paper, suggested that specification of models involving simple ordinary least squares (OLS) regression may be inadequate to study the effect of inflation on the farm sector.

Monetary Policies and the U.S. Farm Sector

Starleaf (1982), after examining macroeconomic policies and their impact upon the farm sector, summarized his results thusly: "In conducting activist macroeconomic demand-management policies, the policy authorities have attempted to affect the short-run performance of the economy. But the nonfarm business sector is so massive that for all practical purposes it is the macroeconomy. Thus, if activist macroeconomic policy actions have had at least a short-run impact upon the real output of the macro (nonfarm business) economy, it appears that they have also had a short-run effect upon the farm economy, particularly the farm output price level" (p. 858). Starleaf cited several instances when monetary policy actions appear to have had an impact upon the macroeconomy and the farm economy. For example, when the money stock growth rate was cut nearly in half between early 1969 and early 1970, declines occurred in the real output of the nonfarm economy and in the farm output price level. Starleaf's emphasis on key relationships between macropolicies and the farm sector is important and should be considered in future modeling efforts.

Shei (1978) included the monetary sector in his general equilibrium model to analyze the effect of exchange rate devaluation on farm sector aggregates such as agricultural trade, prices, and income. Because he treated the exchange rate as exogenous, the link between the money supply and the exchange rate was omitted.

Barnett et al. (1981), using the Granger causality test, presented evidence that both domestic and international monetary expansion had a significant effect on domestic agricultural food prices in the United States and in the world in general during the 1970s. Employing the same technique, Paggi (1984) concluded that there was no statistically significant relationship between changes in the rate of growth in the domestic money supply and wheat or corn exports. However, the relationship between wheat exports and changes in the rate of growth in M1 was marginally significant. He concluded that the domestic money supply has a short-run effect on agricultural exports.

Using dynamic multiplier methods on their empirical models, Chambers and Just (1982) found that the dynamic response of agricultural prices and exports to a decrease in the money supply is eventually elastic. That is, both agricultural prices and exports decrease in the long run by a larger percentage than the original decrease in the money supply. However, as they pointed out, their study linked the agricultural markets to the monetary sector only through exchange rates; interest rates and inflation macrolinkages were not included.

Chambers (1984) developed a theoretical model based on financial and commodity sectors of an economy to examine the various effects of monetary policies on the agricultural sector. His model is of a short-run nature and is not capable of addressing long-run outcomes of policy change. However, it does show that an expansionary monetary policy may improve the competitive position of an export-oriented sector in the short run.

Denbaly (1984) constructed a world trade model of the coarse grain market to investigate the channels through which U.S. monetary policy influences the world coarse grain market. Because his model is a trade model, he considered only the exchange rate macroconnections.

Previous Farm Sector Models

Since the mid-1970s, a number of models have been developed to include the farm sector within a large macro model. In these models the agricultural sector appears as a satellite system with a minimal degree of interface between farm and nonfarm sectors. Penson (1982) classifies these models as first-, second-, or third-generation according to the manner in which they recognize the linkages between agriculture and the rest of the general economy.

First-generation Models

First-generation models view agriculture as a separate entity. These stand-alone models characterize agriculture as influenced by relatively few macroeconomic variables, such as disposable income and the implicit price deflator. Representatives of this set include the aggregative income and wealth (AIW) simulator analysis developed by Penson (1973), the polysim simulator reported by Ray and Richardson (1978), the capital and credit simulation study by Melichar (1972), and the agricultural sector modeling of Duloy and Norton (1973). These studies focusing on the agricultural sector generally omit many of the transmission mechanisms through which events in other sectors of the domestic economy are relayed to agriculture.

Second-generation Models

Second-generation models develop results in a recursive framework. An economywide macroeconometric model is first used to forecast a set of macroeconomic variables that appear in agricultural-sector equations. This information is then used to solve those equations. Finally, the solution values for a selected number of variables are transmitted back to the general economy through a set of definitional linkages. Examples of these linkages include definition of the consumer price index and of the gross national product. This work includes that of Chen (1977) on the Wharton agricultural sector model and of Roop and Zeitner (1977). These two models contain few important intersectoral relationships and policy instrument variables. Also, they do not allow for the direct effects of interest rates and of liquidity variables on supply and inventory-demand behavior.

Another major shortcoming of the second-generation agricultural sector models is the absence of explicit variables to represent sector policies such as acreage diversion, price supports, and loan rates. Moreover, these modeling efforts generally treat the international sector as exogenous; that is, exports are determined exogenously.

Third-generation Models

In response to calls for endogenization of the linkages between agriculture and the rest of the general economy, several econometric models have been developed to determine agricultural outcomes simultaneously with outcomes in other sectors. Among the first of these models is a study by Shei (1978). His model was constructed primarily to study the effects of an autonomous change in the U.S. dollar exchange rate on U.S. agriculture. As mentioned before, the only linkage considered in his study is that of the exchange rate; other linkages were not considered. Moreover, many agricultural-sector policy instrument variables were not included in the model. In another study, Lamm (1980) developed an aggregate model of the U.S. economy. Lamm's is a closed economy model in which ROW import and export demands are assumed to be exogenous; therefore, the model does not consider the important macrolinkage of exchange rate effects.

Hughes and Penson (1980) generated a model based on a massive data collection. This impressive modeling effort was based on annual data interpolation from U.S. census and farm accounts. In their model, significant emphasis was placed on financial linkages, and little attention was given to the exchange rate determination process. Freebairn, Rausser, and de Gorter (1982) developed a model to analyze the forward and backward links between the agricultural and general economies. Since they used OLS estimation, their model is subject to simultaneous bias. Moreover, most of the linkages are captured in a series of identities rather than in the form of behavioral equations.

These, according to Johnson (1977), do not explain the macroconnections adequately.

Transmission Mechanisms between the Macroeconomy and Agriculture

This section examines the four basic interfaces considered in developing the theoretical model in the next chapter. The macrolinkages considered are (1) impacts of exchange rate changes on U.S. agricultural exports, (2) the relationship between agriculture and national financial markets through interest rates, (3) the effect of inflation on farm input demands and production, and (4) the income effect on demand for farm products.

Two crucial points considered with respect to empirical measurement of exchange rate effects on agricultural commodity trade are (1) the appropriate exchange rate elasticity of foreign demand for U.S. agricultural exports, and (2) the issue of endogenizing the exchange rate. The pass-through effect of real interest rates from the general economy to the farm sector, specifically on agricultural production, inventory, and investment decisions, is considered. The effect of inflation caused by money supply increase is incorporated as a cost-price factor in the farm input demand equation. The effect of income growth is considered in the farm product demand equations. The wealth effect of inflation is not considered because of the complex nature of the model.

Suppose the government conducts an expansionary monetary policy to stimulate the growth of the economy. From macrotheory, we know this will put upward pressure on the general price level and downward pressure on the exchange rate and the interest rate. It also will increase the overall output of the economy. The effects of these changes on the farm sector are analyzed below.

Exchange Rate Effects (Trade Effects)

According to the monetary approach to exchange rate determination, an increase in the money supply reduces the value of the dollar. This reduction in the value of the dollar is further exacerbated by capital outflow from the United States to the rest of the world, as the domestic interest rate decreases with the eased monetary policy. Depreciation of the dollar stimulates exports, leading to an increase in the demand for U.S. farm exports (trade effect). As noted earlier, a number of empirical studies on the effect of exchange rates on agricultural commodity trade have been completed. For the most part, these focus on the effect of a dollar devaluation on U.S. exports in a partial equilibrium framework. In one study, Chambers and Just (1982) endogenized the exchange rate in their econometric model of corn, soybeans, and wheat to assess the effect of changes in domestic credit on exports and price levels of these three commodities. A recent study by Denbaly (1984) followed the same approach in endogenizing the exchange rate to investigate the relationship between U.S. monetary policy and the world coarse grain market.

Interest Rate Effects (Stock and Cost Effects)

Under an easy monetary policy, downward pressure on interest rates can affect the farm sector in two ways. First, a lower interest rate will reduce the cost of production loans; this helps to lower the cost of production and thereby increases farm supply (a cost effect). At the same time, a decline in the interest rate will lower the storage cost of commodity reserves and will induce farmers to accumulate inventories, thereby increasing the demand for stock inventories (a stock effect). As mentioned before, there have been no empirical studies of the effect of interest rates on farm demand and supply. However, the importance of the changes in the domestic interest rate and its implications on the farm sector was emphasized by Schuh, Hodges, and Orden (1980); Chambers (1983, 1984); and Freebairn, Rausser, and de Gorter (1982).

Effects of Inflation and Income

The growing dependence of U.S. agriculture on other sectors has resulted in the general economy more directly influencing returns to agriculture. Higher general price levels, induced by a change in monetary policy, increase the cost of nonfarm inputs such as machinery, fertilizer, and fuel. This leads to a reduction in the supply of farm products (a cost effect).

An economic upswing due to an expansionary monetary policy increases the growth of per capita income, which leads to a high demand for high-income-elasticity goods (e.g., meats). The result is increase in domestic demand for farm commodities.

In summary, an easy monetary policy will increase the aggregate demand through trade, stock, and income effects (see Fig. 1.1). On the other hand, farm supply might decrease because of a higher cost of farm inputs (Fig. 1.1), or it might increase because of lower costs of production loans (Fig. 1.2). In the case of a decrease in farm supply, an increased money supply will raise farm prices. However, the effect on farm income is not clear, because a larger decline in farm product supply might decrease the equilibrium quantity. In the case of an increase in farm supply, the effect of an expansionary monetary policy on price and farm income is ambiguous, even though the equilibrium quantity will be higher now. Past studies have shown that expansionary monetary policies increase farm prices. If that is the case, then farm income will also increase.

These effects on the farm sector can be attributed to expansion in the macroeconomy as a result of an easy monetary policy. However, any other form of activist expansionary demand management policies in the macroeconomy will probably influence the exchange rate, interest rate, inflation, and income differently; thus, the farm sector will respond differently to such policies.

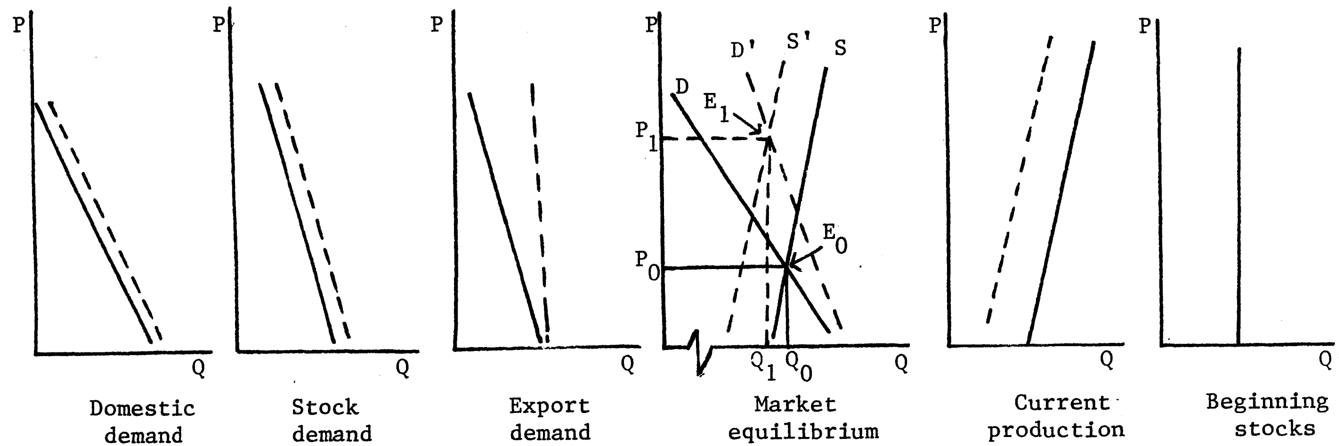

Figure 1.1. The effect of money supply increase on the farm sector (a case of decline in the farm supply)

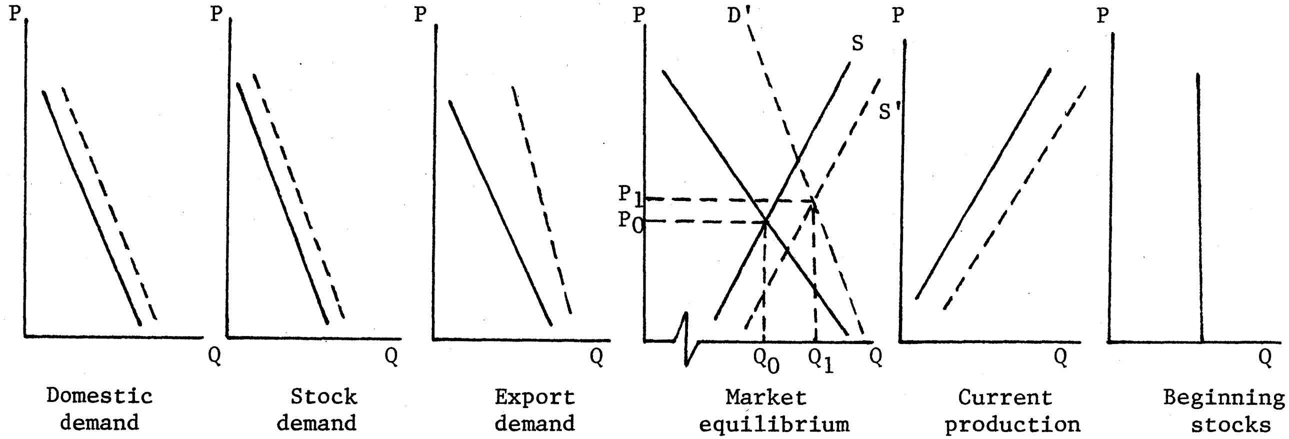

Figure 1.2. The effect of money supply increase on the farm sector (a case of increase in the farm supply)

CHAPTER 2. A THEORETICAL MODEL OF THE MACROLINKAGES

Chapter 1 provided an overview of current literature on the effect of monetary factors on the farm sector, selected macrolinkages between the general economy and the agricultural sector, and previous farm sector models. This chapter introduces a theoretical model that can be used to empirically investigate the impact of money supply changes on the agricultural sector.

Graphical Representation

Forward Macroconnections from Nonfarm Sector to Farm Sector

Figure 2.1 indicates the macroconnections within the model. The farm block of the model consists of crop and livestock sectors. The crop sector is described by crop supply, demand, inventory, exports, input demand relationships, and an equilibrium condition. Crop price, output, and income are endogenously determined in the crop sector part of the model. The livestock sector includes supply, demand for livestock products, feed demand, and market clearing conditions. Livestock price, output, and income are endogenously determined in the livestock sector of the model. The incomes from the crop and livestock sectors aggregate to give the total income in the farm sector.

The macro block consists of the goods market, the money market, and the foreign exchange market. The goods market contains output supply, consumption demand, and an equilibrium condition. The money market, which is the catalyst sector of the entire model, consists of money demand and supply functions and money market equilibrium. The foreign exchange market includes the balance of payments identity, international capital flow, and an exchange rate equation to determine the exchange rate endogenously.

The transmission mechanisms described in the previous chapter can be better understood with the aid of Fig. 2.1. This schematic diagram explains the four channels--exchange rates, interest rates, inflation, and income--through which U.S. monetary policy influences agricultural commodity markets.

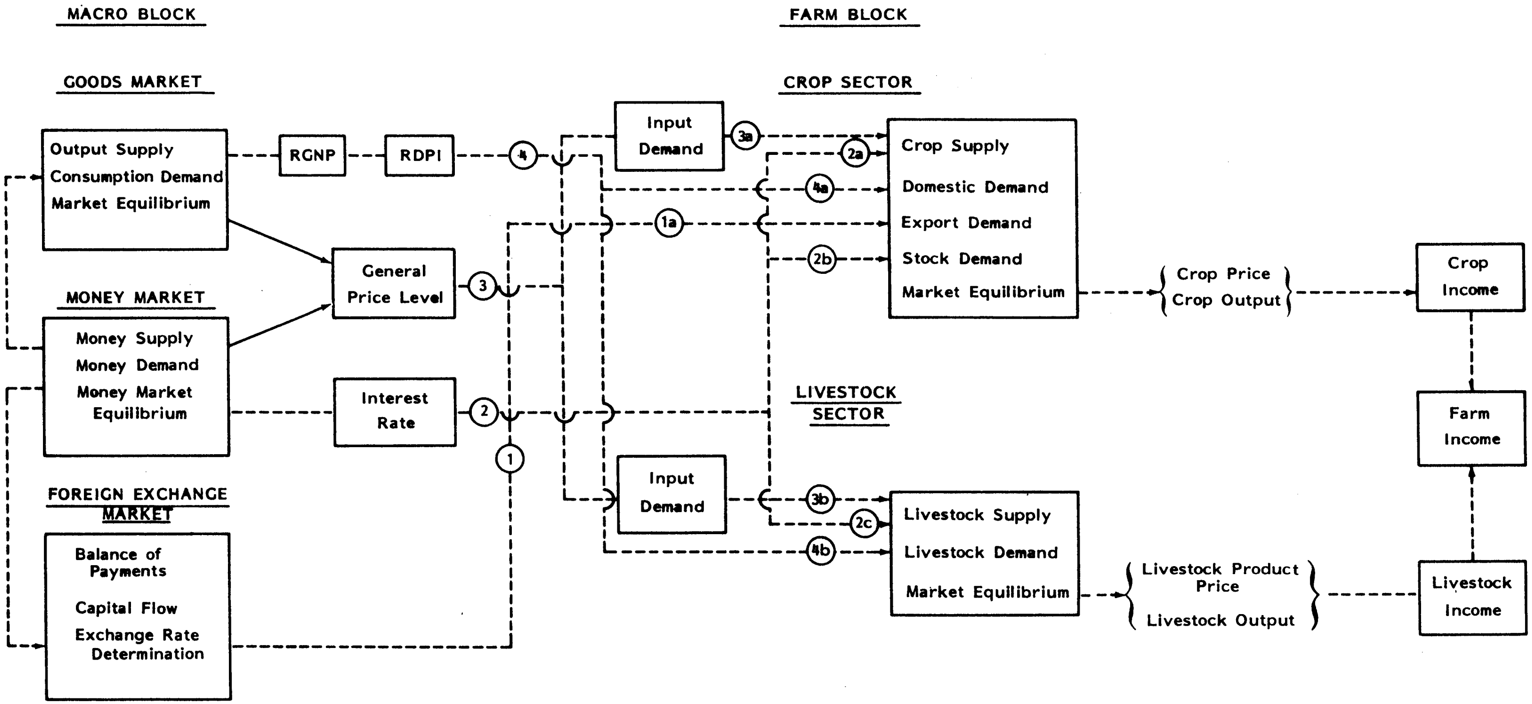

Figure 2.1 General equilibrium structure of the econometric model

RGNP = Real gross national product

RDPI = Real disposable income

First, consider the exchange rate linkage. The monetary approach to exchange rate determination uses the money markets both in the United States and in the ROW to determine the exchange rate. Therefore, changes in the money supply in the United States that keep the money supply constant in the ROW will decrease the exchange value of the dollar. The trade effect of this decline in the value of the dollar is to increase crop exports (line 1). If the monetary policy is intended to stimulate economic growth, then the increase in money supply will lead to a higher export demand for U.S. farm products by the ROW because of a decline in the U.S. dollar value. This higher export demand will add to the total demand for U.S. crop products; hence, crop prices will tend to rise.

The second linkage is through the interest rate. As previously noted, interest rate changes have two effects--a cost effect and a stock effect. Given an expansionary monetary policy, the cost effect of a decrease in the interest rate is lower production costs (because of easy credit) and, therefore, increased supplies of crop and livestock products (lines 2a, 2c). This increase in supply will put downward pressure on price levels. The stock effect of the lower interest rate is increased demand for stock inventories of crops, and, therefore, a tendency toward higher crop prices (line 2b).

The third linkage stems from the inflationary effect. Higher inflation is reflected as a cost effect in the demand for inputs that leads to a reduction in the supply of crop and livestock products (lines 3a, 3b). This reduction in the supply of farm products will put upward pressure on the farm price levels.

The fourth linkage is through income. One of the goals of monetary policy activism is to achieve a higher real output of the economy; that is, increased total spending for the economy's output. The effect of this increased spending on the farm sector is captured in the income or demand-effect linkage (lines 4a, 4b) as a higher domestic demand for crop and livestock products. Thus, expansionary monetary policy actions affect the real output of the economy, which leads to a higher demand for farm products and, thereby, higher farm prices (see Starleaf 1982).

In summary, the forward macroconnections of an easy monetary policy augment the aggregate demand for farm products by increasing domestic, stock, and export demands of the farm commodities (see Figs. 1.1 and 1.2). The effect on the farm supply is not clear. The farm supply might decline because of higher costs of farm inputs, or it might increase because of lower costs of production loans. The ultimate effect on prices, quantities, and income depends on the supply shifts and on the elasticities of supply and demand (see the market equilibria in Figs. 1.1 and 1.2). However, recent studies have shown that easy monetary policy improves the comparative position of the agricultural sector, leading to higher prices and incomes (Chambers 1984). Thus, one would expect prices and outputs to increase.

Feedback Linkages from Farm Sector to Nonfarm Sector

Since the structure of the model involves an integrated treatment of the agricultural sector with the general economy, it is possible to analyze the feedback linkages from the farm sector to the nonfarm sector. It is also possible to examine the effect of farm policies such as price supports and acreage diversion programs.

Farm exports comprise 20 percent of total U.S. exports. Hence, changes in U.S. exports caused by supply and demand changes and income growth changes in the importing countries will influence the current account. For example, the unprecedented surge in U.S. trade deficits in recent years was partly caused by a sharp decline in U.S. agricultural exports and a continuous increase in imports of foreign goods. Furthermore, farm exports have significant influence on the farm income. The repercussions of farm income changes are likely to affect demand for nonfarm products, which would lead to changes in prices and output in the nonfarm sector.

Another feedback linkage is from farm product prices to the consumer price index. Since agricultural product prices are components of consumer price indexes, changes in agricultural product prices will influence the index. In addition, the interrelationships between farm and nonfarm sectors establish a dynamic pattern of forward and feedback effects among prices, outcomes, and incomes.

To keep the flow chart in Fig. 2.1 simple, the feedback linkages are not shown. Actually, those linkages in the model are relatively limited. The model does not incorporate rational expectations and, thus, feedbacks between agricultural and nonagricultural sectors cannot be very rapid.

Mathematical Representation

The general equilibrium structure of the model illustrated in Fig. 2.1 is described by an econometric model, below. The model consists of behavioral relationships, identities, and variable specifications for agriculture and the general economy. The expected signs of the partial derivatives of each variable in an equation are shown within parentheses above the variables.

The Agricultural Sector

This section contains specifications of the model to represent the crop and livestock sectors of the farming economy.

Crop Output Supply

Because harvest prices cannot be known at the time of planting, the real annual domestic supply of crops is determined using information available from the previous year. The available information includes lagged prices of crops, lagged prices of inputs used in production, and lagged prices of alternative outputs (i.e., livestock products), which might be produced using the same factors of production. Other factors include technological improvements and innovations, government policies, and weather. Therefore, the real value of the domestic supply of crops during the current year is specified as a function of the lagged real price index of crops, lagged real price index of inputs, lagged real price index of livestock products, real rate of interest in agriculture, real support price index, a weather index, and the total cropland diverted from crop production. The policy variables of price support and acreage diversion have been demonstrated to be important determinants of U.S. aggregate crop output in previous studies.

$$C_t^p = F_1[\overset{(+)}{(\frac{P^c}{CPI})_{t-1}}, \overset{(-)}{(\frac{P^i}{CPI})_{t-1}}, \overset{(-)}{V_t^a}, \overset{(-)}{(\frac{P^l}{CPI})_{t-1}}, \overset{(+)}{(\frac{PS}{CPI})_t}, \overset{(-)}{AD_t}, \overset{(+)}{WH_t}, Z_{1,t}] \quad (2.1)$$

where

C_t^p = real value of crop production,

P_t^c = the aggregate price index of crops,

CPI_t = the consumer price index,

P_t^i = the aggregate price index of inputs used in crop production,

P_t^l = the aggregate price index of livestock products,

PS_t = the support price index,

V_t^a = the real interest rate in agriculture, defined as $r_t^a - [(CPI_t - CPI_{t-1})/CPI_{t-1}]$; r_t^a is the nominal interest rate in agriculture,

AD_t = acreage diversion in year t,

WH_t = the weather index, and

$Z_{1,t}$ = the random disturbance. $Z_{i,t}$ is the random disturbance term in the i-th equation. Hence, its description is not repeated in the following equations.

Domestic Disappearance of Crops

Specification of a domestic disappearance equation follows from neoclassical demand theory, where it is assumed that demand for a commodity is determined as the result of consumers maximizing preference functions subject to budget constraints. The aggregate demand for crop product can be written as

$$c_t^d = F_2[\overset{(-)}{(\frac{P^c}{CPI})_t}, \overset{(+)}{(\frac{P^l}{CPI})_t}, \overset{(+)}{(\frac{RDPI}{USPOP})_t}, Z_{2,t}] \tag{2.2}$$

where

c_t^d = real value of aggregate demand for crops,

$RDPI_t$ = the aggregate real disposable income, and

$USPOP_t$ = U.S. total population.

Crop Inventories

The domestic demand for carryover stocks is specified as a function of stocks at the beginning of the period, current market price, the real interest rate, a government policy variable (an index of loan rates), and current production.

$$c_t^s = F_3[\overset{(-)}{(\frac{P^c}{CPI})_t}, \overset{(-)}{V_t^a}, \overset{(+)}{L_t^c}, \overset{(+)}{c_t^p}, \overset{(+)}{c_{t-1}^s}, Z_{3,t}] \tag{2.3}$$

where

c_t^s = real value of crop inventories, and

L_t^c = index of loan rates.

Crop Exports

The real value of U.S. crop export demand is specified as a function of the real export price index, the exchange rate, per capita income in the ROW, and crop production in the ROW.

$$c_t^x = F_4[\overset{(-)}{(\frac{PX^c}{CPI^f})_t}, \overset{(+)}{e_t}, \overset{(+)}{(\frac{y^f}{POP^f})_t}, \overset{(-)}{c_t^{p,f}}, Z_{4,t}] \tag{2.4}$$

where

c_t^x = real value of net crop exports by the United States,

PX_t^c = aggregate export price index of crops in foreign currencies,

CPI_t^f = consumer price index in the foreign countries,

$(\frac{Y^f}{POP^f})_t$ = per capita real income in the foreign countries,

$c_t^{p,f}$ = crop production in the foreign countries, and

e_t = the exchange value of the U.S. dollar in terms of special drawing rights (SDR); i.e., \$/SDR.

The rationale for using the SDR is that the exchange rate of the SDR vis-a-vis the dollar gives a more accurate representation of the dollar's overall competitive position, and it eliminates the need for construction of a basket index of exchange rates (see Chambers 1979).

In equation 2.4, the exchange rate is considered a separate regressor instead of being multiplied with the export price index. The justification, according to Orcutt's suggestion, is that treating the exchange rate as a separate regressor simplifies the estimation procedure by avoiding nonlinearity. Second, it enables both fixed and flexible exchange rate regimes to be incorporated in the model. Third, the specification does not rely upon the purchase power parity condition, since the law of one price may not hold at the aggregate level (see, e.g., Isard 1977). However, it should be noted that crop exports, as the dependent variable, will be sensitive depending upon whether the exchange rate is treated as a separate regressor or as a multiplicative term.

Crop Input Demand

The demand for inputs used in crop production is specified as

$$P_t^i = F_5[\overset{(-)}{Q_t^i}, \overset{(+)}{CPI_t}, \overset{(+)}{P_{t-1}^i}, Z_{5,t}] \tag{2.5}$$

where

Q_t^i = quantity of inputs used in crop production.

This inverted form of the input demand equation is specified to link the cost of inputs to the crop supply.

The Market Clearing Condition for the Crop Sector

The equilibrium condition for the crop sector is given by

$$c_t^p + c_{t-1}^S = c_t^d + c_t^S + c_t^x \tag{2.6}$$

where

$c_t^p + c_{t-1}^S$ = current production + lagged inventories = total supply, and

$c_t^d + c_t^S + c_t^x$ = domestic disappearance + inventory demand + export demand = total demand.

Supply of Livestock Products

The livestock product supply is specified as a function of the livestock herd size in the past year, the real price index of livestock products, the real price index of feed, and the real interest rate.

$$l_t^s = F_7[\overset{(+)}{(\frac{P^l}{CPI})_{t-1}}, \overset{(-)}{(\frac{P^f}{CPI})_{t-1}}, \overset{(-)}{V_t^a}, \overset{(+)}{H_{t-1}}, Z_{7,t}] \quad (2.7)$$

where

l_t^s = the real value of aggregate supply of livestock and livestock products,

P_t^f = the index of price paid by farmers for feed, and

H_{t-1} = the herd size in the previous year.

Domestic Demand for Livestock Products

The real domestic disappearance for livestock products is specified as

$$l_t^d = F_8[\overset{(-)}{(\frac{P^l}{CPI})_t}, \overset{(+)}{(\frac{P^c}{CPI})_t}, \overset{(+)}{(\frac{RDPI}{USPOP})_t}, Z_{8,t}] \quad (2.8)$$

where

l_t^d = the real value of aggregate demand for livestock products.

Feed Demand

Similar to crop input demand, feed demand is an inverted form to link the feed price to the supply of livestock products.

$$P_t^f = F_9[\overset{(-)}{q_t^f}, \overset{(+)}{CPI_t}, \overset{(-)}{P_t^c}, Z_{9,t}] \quad (2.9)$$

where

q_t^f = quantity of feed used in livestock production in year t.

Market Clearing Condition for Livestock Products

The equilibrum condition for livestock products is given by

$$l_t^S = l_t^d - l_t^m \tag{2.10}$$

where

l_t^m = the real value of U.S. net imports of livestock and livestock products.

The net imports of livestock products, because of U.S. trade policies restricting the importation of livestock products (usually through import quotas), are assumed to be exogenously determined.

The total cash receipts from crop and livestock production in the farm sector are computed as

$$Y_t^a = P_t^c \bullet c_t^p + P_t^l \bullet l_t^s \tag{2.11}$$

where

Y_t^a = total cash receipts in the farm sector.

In addition to the aforementioned supply and demand relationship in the agricultural sector, a behavioral function for agricultural investment, based on Bischoff's (1971) study, is specified:

$$i_t^a = F_{12}[\overset{(-)}{V_t^a}, \overset{(+)}{(\frac{Y^a}{CPI})_t}, Z_{12,t}] \tag{2.12}$$

where

i_t^a = real agricultural investment.

Investments in the farm sector and in the general economy form the total investment. Estimation of this is needed to complete the GNP identity, in that GNP is the sum of total consumption, investment, government expenditure, and net exports.

The interest rate in the agricultural sector is related to the interest rate in the general economy in the form of a distributed lag model.

$$r_t^a = F_{13}[r_t, r_{t-1}, \ldots, r_{t-j}, Z_{13,t}] \tag{2.13}$$

where

r_t = the nominal interest rate in the general economy.

General Economy

The manufacturing-service sector of the economy is described by a supply function, a consumption function, and an investment supply function.

The specification of the real value of domestic supply of manufactured goods is based on Gordon (1975) and Shei (1978).

$$\frac{\dot{P}^m}{P^m_{t-1}} = F_{14}[(\overset{(+)}{\frac{\dot{W}}{W_{t-1}}}), (\overset{(-)}{\frac{\dot{PR}}{PR_{t-1}}}), Z_{14,t}] \qquad (2.14)$$

where

P^m_t = the aggregate price index of manufactured goods,

$\dot{P}^m = P^m_t - P^m_{t-1}$ = the net change in the aggregate price index of manufactured goods,

W_t = the wage rate in the industrial sector,

$\dot{W} = W_t - W_{t-1}$ = the net change in the wage rate in the industrial sector,

PR_t = the aggregate productivity index in the industrial sector, and

$\dot{PR} = PR_t - PR_{t-1}$ = the net change in the productivity index in the industrial sector.

The expression $\frac{\dot{PR}}{PR_{t-1}}$ is used to represent the technological progress in which innovations, capital accumulation, and economies of scale all contribute to a cumulative rise in total output.

Extensive empirical research on the behavior of the wage rate in the United States has been carried out at the Brookings Institution by, among others, Gordon (1975), Schultz (1971), and Wacher (1976). The following specification of the wage rate equation is based on the discussion of Wacher's and Gordon's studies.

$$\frac{\dot{W}}{W_{t-1}} = F_{15}[(\overset{(+)}{\frac{\dot{HPM}}{HPM_{t-1}}}), \overset{(-)}{U_t}, Z_{15,t}] \qquad (2.15)$$

where

HPM_t = high-powered money or monetary base,

$\dot{HPM}_t$ = the net change in high-powered money, and

U_t = the unemployment rate.

Equation 2.15 is an empirical specification of the Phillips curve. The rate of change in the stock money supply in the wage rate equation reflects the upward pressure of excess demand in the goods market on the wage increase. On the other hand, the unemployment rate reflects the downward pressure of excess demand in the labor market on the wage rate.

The consumption function for this sector is

$$m_t^d = F_{16}[\overset{(-)}{(\frac{P^m}{CPI})_t}, \overset{(+)}{(\frac{RDPI}{USPOP})_t}, Z_{16,t}] \quad (2.16)$$

where

m_t^d = the real value of per capita consumption of industrial goods. The expression m_t^d includes only the expenditures on industrial goods. The food components--that is, crop and livestock products--are endogenously estimated in the farm sector.

The market equilibrium in the industrial sector is defined as

$$m_t^s = (USPOP_t \cdot m_t^d) + m_t^x \quad (2.17)$$

where

m_t^s = real value of output in the industrial sector, and

m_t^x = net exports of industrial goods.

The investment in the manufacturing sector is defined as

$$i_t^m = F_{18}[\overset{(-)}{V_t}, \overset{(+)}{m_t^s}, Z_{18,t}] \quad (2.18)$$

where

i_t^m = the real value of industrial investment, and

V_t = the real interest rate in the general economy, defined as $r_t - [(CPI_t - CPI_{t-1})/CPI_{t-1}]$; r_t is the nominal interest rate in the industrial sector.

Money Market

The monetary sector, from which the macrolinkages originate, is the nucleus of the model. The money market consists of money demand and supply functions and money market equilibrium. The demand for the real money balance is defined as a function of real income, the nominal interest rate, and lagged real money balances.

$$(\frac{HPM}{CPI})_t = F_{19}[\overset{(+)}{y_t}, \overset{(-)}{r_t}, \overset{(+)}{(\frac{HPM}{CPI})_{t-1}}, Z_{19,t}] \qquad (2.19)$$

where

HPM = the nominal money balances, and

y_t = the real gross national product.

The demand function above is considered in early work by Teigen (1964). This is a simple Keynesian-Friedman function with lagged real balances included to represent delayed responses in the demand for money.

The money supply existing at any time will be the money multiplier times the sum of assets backing the domestic money supply; that is, international reserves and domestic credit, which can be written as

$$M_t^s = MUL \cdot (D_t + R_t) \qquad (2.20)$$

where

M_t^s = the nominal stock of money,

MUL = money multiplier,

D_t = the net domestic credit, which is equal to government securities (GS) + discounts and advances (DA) + treasury deposits (TD) - other liabilities (OL) - net worth (NW), and

R_t = the central bank's net holdings of international reserves, which is equal to gold certificates (G) + special drawing rights (SDR) + foreign assets (FA) - foreign deposits (FD) - federal reserve notes held by foreign official agencies (FRNF).

Money market equilibrium is, therefore, represented as

$$[D_t + R_t] = CPI_t \cdot F_{21}[y_t, r_t, (\frac{HPM}{CPI})_{t-1}, Z_{21,t}] \qquad (2.21)$$

where it is assumed that the money multiplier is constant so that it can be subsumed into the functional form of F_{21}.

Capital Market and Endogenous Determination of the Exchange Rate

Under the purchasing power parity doctrine, inflation is easily transmitted among countries under a fixed exchange rate system.

Therefore, changes in the money supply of a country, given other variables, leave the relative prices unchanged. But, under a floating exchange rate regime, different rates of inflation exist among countries. Furthermore, under a flexible rate system, monetary policy translates into exchange rate movements, particularly when capital is mobile among countries. Schuh (1977, 1979) argues that evolution of the flexible exchange rate system and internationally integrated capital markets are sources of instability for U.S. agriculture.

Suppose the Federal Reserve Board undertakes an expansionary monetary policy. This will put downward pressure on the rate of interest, leading to a capital outflow until domestic and international interest rates are equalized. The reduction in the value of the dollar because of this easy monetary policy is exacerbated by capital outflow. The consequence of dollar depreciation is to provide stimulus to dollar exports, leading to an increase in the demand for U.S. farm exports.

The crucial point is that the channels through which the economy is stimulated are somewhat different than they would be if capital were immobile and exchange rates were fixed. Since, under the fixed exchange rate system, changes in the money supply did not affect the relative prices among countries, little effect occurred with respect to agricultural commodity trade. However, an easy monetary policy stimulates construction, investment, and consumption in the domestic economy through its impact on internal interest rates. Therefore, the important conclusion is that, under the flexible exchange rate system, trade-competing sectors bear a major share of the adjustment to changing monetary policies. Hence, the agricultural sector, because of its significant contribution to U.S. trade, may be subject to more instability under a regime of floating exchange rates and free capital mobility than under a regime of fixed exchange rates with barriers to capital mobility.

McKinnon (1982) has argued that the bouts of inflation and recession in the United States and the world are better explained by wide swings in the world money supply than they are by movements in aggregate domestic supply. This instability is transmitted globally because of increased capital market integration.

Considering the importance of the foreign exchange market to U.S. agriculture, the exchange rate is endogenized and the capital market is incorporated into the model.

The general specification of the identity for the value of U.S. transactions with the ROW, or the balance of payments, is given by

$$(PX_t^c \cdot e_t) \cdot c_t^x - (PM^l \cdot e_t) \cdot l_t^m + (PX_t^m \cdot e_t) \cdot m_t^x$$
$$+ CAP_t + R_t + SD_t = 0 \qquad (2.22)$$

where

PM^l = import price index of livestock and livestock products,

PX_t^m = export price index of industrial goods,

CAP_t = the net change in private capital assets (defined as change in U.S. private assets abroad plus change in foreign private assets in the United States), and

SD_t = statistical discrepancy.

The net change in private capital assets held by U.S. residents and foreigners, CAP_t, is incorporated following the simplified portfolio capital approach used by Freebairn, Rausser, and de Gorter (1982):

$$CAP_t = F_{23}[\overset{(-)}{V_t}, \overset{(+)}{V_t^f}, Z_{23,t}] \qquad (2.23)$$

where

V_t^f = the real interest rate in the foreign countries, defined as $r_t^f - [(CPI_t^f - CPI_{t-1}^f)/CPI_{t-1}^f]$; r_t^f is the nominal interest rate in the foreign countries.[1]

Now, turning to the issue of exchange rate determination, the approach taken in modeling the exchange rate is essentially a monetary one (see Frenkel 1976). The monetary approach emphasizes the role of money in determining the balance of payments when the exchange rate is pegged, and in determining the exchange rate when it is flexible. A brief review of the monetary approach to exchange rate determination is useful here.

Consider the simple model of the U.S. money market, $M = P \cdot L(y,r)$, where M is the money supply, P is the domestic price level, and L(y,r) is the demand for real money balances as a function of income and interest rates. Assuming that purchasing power parity holds, $P = eP^*$, where P^* is the ROW price level in terms of international currency and e is the exchange rate defined as U.S. dollars per SDR. Combining the money market equilibrium and purchasing power parity condition results in $M = eP^* \cdot L(y,r)$.

The functional relationship among these variables can be expressed in terms of growth rates per unit of time,

$$g_M = g_e + g_{p*} + N_y g_y + N_r g_r$$

and, on rearranging the terms, as

$$g_e = g_M - (g_{p*} + N_y g_y + N_r g_r)$$

where g_k denotes the growth rate of subscripted variable k, and N_y and N_r denote the elasticity of demand for real money balances with respect to real output and the interest rate, respectively.

In the above equation, an increase in the U.S. money supply growth, ceteris paribus, will depreciate the value of the U.S. dollar; that is, g_e will increase, since the exchange rate is defined as dollars per SDR. Similarly, keeping all other variables constant, an increase in the rate of growth of real income will appreciate the value of the dollar; and an increase in the rate of growth of the interest rate will cause its value to decline.

The equation above is derived assuming the ceteris paribus condition in the ROW money market. However, according to the monetary approach, changes in the money supply in the ROW will also affect the value of the U.S. dollar. Therefore, the ROW money market has to be included in endogenizing the exchange rate.

Consider the ROW money market, $M^* = P^* \cdot L^*(y^*,r^*)$, where M* is the money supply in the ROW, P* is the price level in the ROW, and $L^*(y^*,r^*)$ is the demand for real money balances in the ROW as a function of ROW income and interest rates.

Solving the money market equilibriums of the United States and the ROW, and the purchasing power parity equation for the exchange rate, we obtain

$$e = \left(\frac{M}{M^*}\right) \cdot \left(\frac{L^*(y^*,r^*)}{L(y,r)}\right).$$

The equation above can be written in functional form as

$$e = F[M, M^*, y, y^*, r, r^*].$$

Following the notation of the text, the equation above is rewritten with expected signs for the explanatory variables, and with the error term as

$$\overset{(+)}{e_t = F_{24}[M_t^s,}\ \overset{(-)}{M_t^{s,f}},\ \overset{(-)}{y_t},\ \overset{(+)}{y_t^f},\ \overset{(+)}{r_t},\ \overset{(-)}{r_t^f},\ Z_{24_t}]. \tag{2.24}$$

The intuition behind these expected signs can be explained by analyzing the money markets. For example, an increase in the U.S. money stock brings about an excess supply of money, which leads to a decline in the value of the dollar (i.e., $\frac{\partial e_t}{\partial M_t^s} > 0$, e increases, since e is defined as $/SDR). On the other hand, an increase in the ROW money stock puts upward pressure on the value of the dollar (decline in e, $\frac{\partial e_t}{\partial M_t^{s,f}} < 0$). Given that income elasticity of money (N_y or N_y^f) is positive, an increase in the U.S. income will increase the value of the U.S. dollar, whereas an increase in ROW income will decrease the dollar's value ($\frac{\partial e_t}{\partial y_t} < 0$, $\frac{\partial e_t}{\partial y_t^f} > 0$). Since the interest rate elasticity of money demand (N_r or N_r^f) is negative, an increase in the U.S. interest rate will put downward pressure on the value of the U.S. dollar; an increase in the ROW interest rate will push up the dollar's value ($\frac{\partial e_t}{\partial r_t} > 0$, $\frac{\partial e_t}{\partial r_t^f} < 0$).

International Price Linkages

The domestic price index of commodities is the aggregation of all tradable and nontradable goods, with appropriate weights attached to each individual commodity. The export price index of commodities is an aggregation of only tradable goods. Thus, the nontradable goods component causes a deviation of the export price index from the domestic price index. In recognition of this fact, the international price linkage for crop export price is developed (see Shei 1978).

$$PX_t^c = \left(\frac{P_t^c}{e_t}\right)(1 + b_t^c) \tag{2.25}$$

where

b_t^c = the adjustment factors reflecting the difference in commodity composition of domestic and (net) export price index for crop products.

The rationale for this linkage is that, even under unchanging exchange rates, imperfect aggregation results in uneven movement of the indices of domestic and export prices.

The effect of money supply and aggregate output of the economy on the general price level is captured by the following equation:

$$CPI_t = F_{26}[\overset{(+)}{(\frac{M^s}{y})_t}, \overset{(+)}{(\frac{M^s}{y})_{t-1}}, CPI_{t-1}, Z_{26,t}]. \quad (2.26)$$

Finally, to close the system, the following accounting identities are specified.

$$y_t = c_t + i_t + g_t + x_t, \quad (2.27)$$

$$c_t = c_t^d + l_t^d + m_t^d, \quad (2.28)$$

$$i_t = i_t^a + i_t^m, \quad (2.29)$$

$$x_t = c_t^x + m_t^x - l_t^m, \quad (2.30)$$

$$RDPI_t = y_t - TD_t \quad (2.31)$$

where

c_t = total real consumption of the economy,
i_t = total real investment of the economy,
g_t = real government expenditures,
x_t = total real net exports of the economy, and
TD_t = taxes and other deductions in real terms.

In summary, the theoretical model developed in this chapter closely reflects the schematic diagram of the general equilibrium structure of the model presented in Fig. 2.1. The model consists of a farm block and a macro block. The farm block of the model is divided into a crop sector and a livestock sector. The crop sector is described by crop supply, demand, inventory, export, input demand relationships, and an equilibrium condition. The livestock sector includes supply, demand for livestock products, feed demand, and market clearing conditions.

The macro block consists of the goods market, the money market, and the foreign exchange market. The goods market contains output supply, consumption demand, and an equilibrium condition. The money market, from which all the macroeconomic linkages originate, is the catalyst section of the entire model. The monetary sector consists of the money demand and supply functions and a money market equilibrium equation.

The foreign exchange market includes the balance of payments identity, international capital flow, and an exchange rate equation to determine the exchange rate endogenously.

By incorporating these macroconnections, the model enables investigation of the impacts of U.S. monetary policies on the farm sector through the four channels of exchange rates, interest rates, inflation and income.

CHAPTER 3. EMPIRICAL ANALYSIS AND MODEL VALIDATION

This chapter provides a discussion of the estimation techniques, the data base, operational definitions of the variables, results of the estimation, and the validation of the model.

Estimation

The mathematical structure of the model presented in chapter 2 is nonlinear. In general, fundamental identities, as well as many other basic variables (e.g., relative prices), form ratios that render the model nonlinear. Moreover, a linear simultaneous equations system, with autocorrelated error terms, can lead to nonlinearities (see Judge et al. 1982). In view of the model's nonlinear nature, nonlinear three-stage least square (N3SLS) was used for the final estimation of the model.[1] The empirical model is presented in Table 3.1.

Only the final form of the model estimated by N3SLS is shown in Table 3.1. The model consists of 31 equations, including 18 behavioral relationships and 13 identities. For each equation, the estimated coefficients, t-statistics (parentheses), and elasticities of major variables (brackets) are reported. The estimates of each structural equation are discussed with respect to sign, own price, and income elasticities.

The Data Base

Annual data for the period 1950-1982 were used to estimate the model. Table 3.2 contains the complete list of variable names, descriptions, and data sources.

Since the study focused on aggregate modeling, numerous problems were encountered in obtaining the appropriate data. In a few cases, because of the unavailability of data, appropriate proxy variables were used to estimate the model. For example, in the crop supply equation, the index of prices paid by farmers was chosen originally for crop input prices. However, the prices paid index also includes some price components for purchased feed, livestock, and seed that are also part of prices received

Table 3.1. Estimated equations and equilibrium conditions in the model

Farm Sector

Crop Production

$$C_t^p = \underset{(5.74)}{391.667} + \underset{\substack{(0.57)\\[0.18]}}{29.184} \left(\frac{P^c}{CPI}\right)_{t-1} - \underset{\substack{(-3.83)\\[-1.07]}}{187.738} \left(\frac{P^i}{CPI}\right)_{t-1} - \underset{\substack{(-2.74)\\[-0.11]}}{6.05}\, V_t^a \qquad (3.1)$$

$$- \underset{\substack{(-3.21)\\[-0.67]}}{113.815} \left(\frac{P^l}{CPI}\right)_{t-1} + \underset{\substack{(4.52)\\[0.67]}}{150.908} \left(\frac{PS}{CPI}\right)_t - \underset{(-4.08)}{0.982}\, AD_t - \underset{(-1.76)}{35.379}\, D1$$

Crop Demand

$$C_t^d = \underset{(3.31)}{288.737} - \underset{\substack{(-3.83)\\[-2.32]}}{323.263} \left(\frac{P^c}{CPI}\right)_t + \underset{\substack{(0.04)\\[0.01]}}{0.066} \left(\frac{RDPI}{USPOP}\right)_t + \underset{\substack{(3.57)\\[1.49]}}{216.807} \left(\frac{P^l}{CPI}\right)_t \qquad (3.2)$$

Crop Inventory

$$C_t^s = \underset{(4.39)}{69.511} - \underset{\substack{(-2.67)\\[-0.25]}}{21.611} \left(\frac{P^c}{CPI}\right)_t - \underset{\substack{(-2.38)\\[-0.05]}}{1.487}\, V_t^a + \underset{(7.03)}{0.602}\, C_{t-1}^s + \underset{(4.97)}{27.949}\, D2 \qquad (3.3)$$

Net Crop Exports

$$C_t^x = \underset{(-9.04)}{-149.14} - \underset{\substack{(-1.88)\\[-0.37]}}{868.274} \left(\frac{PX^c}{CPI}\right)_t + \underset{\substack{(6.52)\\[3.93]}}{1.052}\, e_t + \underset{\substack{(5.37)\\[2.67]}}{26.636} \left(\frac{Y^f}{POP^f}\right)_t \qquad (3.4)$$

Crop Input Demand

$$P_t^i = \underset{(5.41)}{31.119} - \underset{(-3.61)}{0.286}\, Q_t^i + \underset{(8.14)}{3.202}\, CPI_t - \underset{(-6.44)}{2.944}\, CPI_{t-1} + \underset{(8.33)}{0.588}\, P_{t-1}^i \qquad (3.5)$$

Market Equilibrium in the Crop Sector

$$C_t^p + C_{t-1}^s = C_t^d + C_t^s + C_t^x \qquad (3.6)$$

Supply of Livestock Products

$$l_t^s = \underset{(1.90)}{42.668} + \underset{\substack{(2.11)\\[0.10]}}{20.934} \left(\frac{P^l}{CPI}\right)_{t-1} - \underset{\substack{(-13.67)\\[-0.49]}}{101.546} \left(\frac{P^f}{CPI}\right)_{t-1} - \underset{\substack{(-1.39)\\[-0.01]}}{0.809}\, V_t^a \qquad (3.7)$$

$$+ \underset{(18.02)}{2.838}\, H_{t-1} - \underset{(-4.33)}{9.402}\, D3$$

Domestic Demand for Livestock Products

$$l_t^d = \underset{(7.96)}{158.11} - \underset{\substack{(-4.50)\\[-0.62]}}{131.222} \left(\frac{P^l}{CPI}\right)_t + \underset{\substack{(13.62)\\[0.73]}}{6.337} \left(\frac{RDPI}{USPOP}\right)_t + \underset{\substack{(1.96)\\[0.20]}}{40.968} \left(\frac{P^c}{CPI}\right)_t \qquad (3.8)$$

Feed Demand

$$P_t^f = \underset{(3.48)}{13.674} - \underset{(-2.46)}{0.025}\, q_t^f + \underset{(5.56)}{0.147}\, CPI_t + \underset{(30.33)}{0.793}\, P_t^c \qquad (3.9)$$

Market Equilibrium in the Livestock Sector

$$l_t^s = l_t^d - l_t^m \qquad (3.10)$$

Total Cash Receipts

$$Y_t^a = P_t^c \cdot c_t^p + P_t^l \cdot l_t^s \qquad (3.11)$$

Agricultural Investment

$$i_t^a = \underset{(1.11)}{6.022} - \underset{\substack{(-2.35)\\[-0.05]}}{0.883}\, V_t^a + \underset{\substack{(11.81)\\[0.95]}}{0.137} \left(\frac{Y^a}{CPI}\right)_t \qquad (3.12)$$

Interest Rate in the Farm Sector

$$r_t^a = \underset{(16.41)}{3.902} + \underset{(11.60)}{1.159}\, r_t - \underset{(-5.13)}{0.566}\, r_{t-1} \qquad (3.13)$$

General Economy

Supply Function

$$\frac{\dot{P}^m}{P_{t-1}^m} = \underset{(-1.83)}{-0.021} + \underset{(9.52)}{1.516} \left(\frac{\dot{W}}{W_{t-1}}\right) - \underset{(-5.74)}{1.096} \left(\frac{\dot{PR}}{PR_{t-1}}\right) \qquad (3.14)$$

Wage Rate Equation

$$\frac{\dot{W}}{W_{t-1}} = \underset{(2.63)}{0.022} + \underset{(5.97)}{0.537} \left(\frac{\dot{HPM}}{HPM_{t-1}}\right) - \underset{(-1.19)}{0.002}\, U_t \tag{3.15}$$

Consumption Function

$$m_t^d = \underset{(23.95)}{16.516} - \underset{\substack{(-30.20)\\ [-1.05]}}{17.836} \left(\frac{P^m}{CPI}\right)_t + \underset{\substack{(85.93)\\ [1.12]}}{0.753} \left(\frac{RDPI}{USPOP}\right)_t \tag{3.16}$$

Market Equilibrium in the Industrial Sector

$$m_t^s = (USPOP_t \cdot m_t^d) + m_t^x \tag{3.17}$$

Investment in the Industrial Sector

$$i_t^m = \underset{(0.32)}{20.691} - \underset{\substack{(-2.03)\\ [-0.02]}}{13.58}\, V_t + \underset{\substack{(18.91)\\ [1.00]}}{0.165}\, m_t^s \tag{3.18}$$

Money Demand

$$\left(\frac{HPM}{CPI}\right)_t = \underset{(4.90)}{181.352} - \underset{\substack{(-8.85)\\ [-0.35]}}{17.753}\, r_t + \underset{\substack{(7.71)\\ [0.78]}}{0.032}\, y_t + \underset{(4.76)}{0.464} \left(\frac{HPM}{CPI}\right)_{t-1} \tag{3.19}$$

Money Supply

$$M_t^S = MUL \cdot HPM_t = MUL \cdot (D_t + R_t) \tag{3.20}$$

Money Market Equilibrium

$$\frac{D_t + R_t}{CPI_t} = \left(\frac{HPM}{CPI}\right)_t \tag{3.21}$$

General Price Level

$$CPI_t = \underset{(-2.22)}{-5.518} + \underset{(6.24)}{2.402} \left(\frac{M^S}{y}\right)_t - \underset{(-6.06)}{2.369} \left(\frac{M^S}{y}\right)_{t-1} + \underset{(81.17)}{1.086}\, CPI_{t-1} \tag{3.22}$$

Balance of Payments Identity

$$(PX_t^c \cdot e_t) \cdot c_t^x - (PM_t^l \cdot e_t)\, l_t^m + (PX_t^m \cdot e_t) \cdot m_t^x + CAP_t + R_t + SD_t = 0 \tag{3.23}$$

International Capital Flow

$$CAP_t = -5539.36 - 2278.08\, V_t + 4936.251\, V_t^f \qquad (3.24)$$
$$\quad (-2.68) \quad (-3.38) \quad (6.67)$$

Exchange Rate Determination

$$e_t = 99.909 - 190.649\, \delta_t + 0.00054\, (\delta_t \cdot M_t^s) - 0.461\, (\delta_t \cdot M_t^{s,f}) \qquad (3.25)$$
$$(358.95) \quad (-14.57) \quad (4.88) \quad (-8.98)$$
$$(149.69)^a \quad (-6.08)^a \quad (2.04)^a \quad (-3.75)^a$$
$$[2.75] \quad [-2.46]$$

$$- 0.0096\, (\delta_t \cdot y_t) + 1.82\, (\delta_t \cdot y_t^f) + 2.409\, (\delta_t \cdot r_t) - 2.38\, (\delta_t \cdot r_t^f)$$
$$(-8.05) \quad (11.73) \quad (4.82) \quad (-9.19)$$
$$(-3.35)^a \quad (4.89)^a \quad (2.01)^a \quad (-3.83)^a$$

International Price Linkages

$$PX_t^c = \left(\frac{P_t^c}{e_t}\right)(1 + b_t) \qquad (3.26)$$

Accounting Identities

$$y_t = c_t + i_t + g_t + x_t \qquad (3.27)$$

$$c_t = c_t^d + l_t^d + m_t^d \qquad (3.28)$$

$$i_t = i_t^a + i_t^m \qquad (3.29)$$

$$x_t = c_t^x + m_t^x - l_t^m \qquad (3.30)$$

$$RDPI_t = y_t - TD_t \qquad (3.31)$$

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[a]Adjusted t-statistics; see the appendix for further details.

Table 3.2. Description of variables, units, and data sources

Variable[a]	Description	Units	Sources[b]
Endogenous variables			
c_t^p	Cash receipts of crop production divided by crop price index	Million dollars	USDA (Agricultural Statistics, various issues)
P_t^c	Aggregate price index of crop products received by farmers	Index, 1967=100	USDA (Agricultural Statistics, various issues)
CPI_t	Consumer price index	Index, 1967=100	Economic Report of the President, 1983
P_t^i	Fertilizer price index	Index, 1967=100	USDA (Agricultural Statistics, various issues)
P_t^l	Aggregate price index of live-stock products received by farmers	Index, 1967=100	USDA (Agricultural Statistics, various issues)
r_t^a	Nominal interest rate charged by Production Credit Association for production loans	Percent	USDA (Agricultural Statistics, various issues)
V_t^a	Real interest rate in the agricultural sector (nominal interest rate minus inflation)	Percent	Computed
c_t^d	Domestic disappearance of crop output	Million dollars	Calculated from the market equilibrium condition
$RDPI_t$	The aggregate nominal disposable income divided by the consumer price index	Million dollars in 1967 prices	Economic Report of the President, 1983
c_t^s	Nominal value of crops stored on and off farms divided by crop price index	Million dollars	Economic Indicators of the Farm Sector Income and Balance Sheet--USDA, 1982
c_t^x	Nominal value of net exports of crops divided by export price index of crops	Million dollars	U.S. Foreign Agricultural Trade Statistical Report--USDA (various issues)

Table 3.2. continued

Variable[a]	Description	Units	Sources[b]
PX_t^c	Export price index of crops = ag. export price index * (value of ag. exports / value of crop exports) - export price index of livestock products * (value of livestock exports / value of crop exports) (see Shei 1978)	Index, 1967=100	USDA (*Agricultural Statistics*, various issues)
e_t	The exchange value of the U.S. dollar in terms of special drawing rights (SDR)	Index	*IMF,IFS (International Financial Statistics*, various issues)
l_t^s	Cash receipts from marketings of total livestock and products divided by livestock product price index	Million dollars	USDA (*Agricultural Statistics*, various issues)
P_t^f	Index of price paid by farmers for feed	Index, 1967=100	USDA (*Agricultural Statistics*, various issues)
l_t^d	Domestic demand for livestock products	Million dollars	Calculated from the market equilibrium condition
i_t^a	Real total farm private domestic investment	Million dollars in 1967 prices	*Economic Indicators of the Farm Sector Income and Balance Sheet--USDA*, 1982
Y_t^a	Total cash receipts of farm products	Million dollars	Calculated from the farm income identities
P_t^m	Aggregate price index of manufactured goods	Index, 1967=100	*Economic Report of the President*, 1983
W_t	Wage rate in the industrial sector	Dollars per hour	*Economic Report of the President*, 1983
m_t^d	Real value of per capita consumption of industrial goods divided by price index of manufactured goods	Million dollars	*Economic Report of the President*, 1983
m_t^s	Real value of output in the industrial sector	Million dollars in 1967 prices	*Economic Report of the President*, 1983

Table 3.2. continued

Variable[a]	Description	Units	Sources[b]
i_t^m	Real value of industrial investment	Million dollars in 1967 prices	Economic Report of the President, 1983
r_t	Nominal interest rate (AAA corporate bonds rate)	Percent	Economic Report of the President, 1983
V_t	Real interest rate (nominal interest rate minus inflation)	Percent	Computed
HPM_t	High-powered money or monetary base	Million dollars	Federal Reserve Bank, St. Louis
M_t^s	Nominal money supply (M1)	Million dollars	Economic Report of the President, 1983
y_t	Real gross national product	Million dollars in 1967 prices	Economic Report of the President, 1983
CAP_t	Net change in private capital assets (defined as change in U.S. private assets abroad plus change in foreign private assets in the United States)	Million dollars	IMF, IFS (various issues)
c_t	Real total consumption expenditures	Million dollars in 1967 prices	Economic Report of the President, 1983
i_t	Real gross domestic investment	Million dollars in 1967 prices	Economic Report of the President, 1983
x_t	Real net exports of all goods	Million dollars in 1967 prices	U.S. Foreign Agricultural Trade Statistical Report--USDA (various issues)
Exogenous variables			
PS_t	Support price index of major price support commodities, weighted by production (Egbert 1969)	Index, 1967=100	Calculated

Table 3.2. continued

Variable[a]	Description	Units	Sources[b]
AD_t	Acreage diverted from crop production	Million acres	USDA (*Agricultural Statistics* various issues)
D1	Dummy variable to reflect the farm price increase in 1973 and 1974	(1973-1974)=1 otherwise=0	
$USPOP_t$	U.S. total population	Numbers	*Economic Report of the President*, 1983
CPI_t^f	Consumer price index in the world	Index, 1967=100	*IMF, IFS* (various issues)
D2	Dummy variable to represent the interest rate increase in 1982 caused by the budget deficit	1982=1 otherwise=0	
y_t^f	Real gross domestic product in the world	Index	*IMF, IFS*, 1983
POP_t^f	Population in the world	Millions	*U.N. Statistical Yearbook* (various issues)
Q_t^i	Quantity of fertilizer used in crop production	Index, 1967=100	USDA (*Agricultural Statistics*, various issues)
H_{t-1}	Herd size in the past year	Index, 1967=100	USDA (*Agricultural Statistics*, various issues)
D3	Dummy variable to capture cyclic fluctuation in the livestock product supply		
PX_t^m	Export price index of industrial goods	Index, 1967=100	USDA (*Agricultural Statistics* various issues)
	= total commodity export price index $* \left(\frac{\text{value of commodity exports}}{\text{value of industrial exports}}\right)$ − ag. export price index $* \left(\frac{\text{value of agricultural exports}}{\text{value of industrial exports}}\right)$		
PM_t^l	Import price index of livestock and livestock products	Index, 1967=100	USDA (*Agricultural Statistics* various issues)

Table 3.2. continued

Variable[a]	Description	Units	Sources[b]
l_t^m	Nominal value of U.S. net imports of livestock and livestock products divided by the import price index	Million dollars in 1967 prices	Foreign Agricultural Trade Statistical Report--USDA (various issues)
q_t^f	Quantity of feed used in livestock production	Million tons	USDA (Agricultural Statistics, various issues)
PR_t	Aggregate productivity index in the industrial sector	Index, 1967=100	USDL Bulletin, 1983
R_t	Foreign exchange reserves	Million dollars	IMF, IFS (various issues)
D_t	Net domestic money asset	Million dollars	IMF, IFS (various issues)
U_t	Total unemployment rate	Percent	Economic Report of the President, 1983
MUL_t	Money multiplier (ratio of M_t^s to HPM_t)		Calculated
SD_t	Statistical discrepancy in the balance of payments identity	Million dollars	IMF, IFS (various issues)
r_t^f	Average of interest rates in West Germany (call money rate), Canada (treasury bill rate), United Kingdom (treasury bill rate), Italy (government bond yield rate), and France (call money rate)	Percent	IMF, IFS (various issues)
V_f	Foreign interest rate minus foreign inflation	Percent	Computed
$M_t^{s,f}$	Money supply in the world	Index, 1967=100	IMF, IFS, 1983
δ_t	Grafted polynomial variable to connect the fixed and flexible exchange rate systems	(1950-1971)=0 1972=1 1973=2 (1974-1982)=3	
g_t	Real government expenditures	Million dollars in 1967 prices	Economic Report of the President, 1983

Table 3.2. continued

Variable[a]	Description	Units	Sources[b]
TD_t	Taxes and other deductions	Million dollars in 1967 prices	Economic Report of the President, 1983

[a]Variables are listed in the order of their appearance in Table 3.1.

[b]For more information, see "References."

by farmers. This led to a multicollinearity problem between input and output prices in the crop supply equation. In view of this problem, a nonfarm input price index was considered; however, the data on this series was available only from 1965 onward. Since the data period of this study is from 1950 to 1982, the nonfarm input price index could not be used. Finally, the index of fertilizer prices paid was used as a proxy for the crop input prices.

Since there was no series available for the livestock export price index, the domestic livestock product price index was used as a proxy for the export price index of livestock products. Many studies suggest that use of the SDR to represent the value of the dollar is not appropriate, in that SDR represents only a handful of member countries of the International Monetary Fund. However, no other consistent exchange rate series is available for the study period 1950-1982. In view of this problem, SDR was used in this study. The data for the crop export price index and the manufactured goods export price index were not reported. These two series were computed following Shei's (1978) work (see Table 3.2). Since this study deals with aggregate data, the identities do not match very often. To avoid this problem, computed residual components were included in the identities as exogenous variables.

Rest-of-the-world aggregate variables such as consumer price index, real gross national product, and money supply were not available. However, data for the world consumer price index, the real gross domestic product, and money supply were reported in International Financial Statistics and were used in the estimation. Since there is no single series available for the ROW interest rate, an average of the interest rates of West Germany (call money rate), Canada (treasury bill rate), the United Kingdom (treasury bill rate), Italy (government bond yield rate), and France (call money rate) were used in the estimation.

The values of domestic demand for crops and livestock products refer to the expenditures on both intermediate (indirect) and final demand for consumption. The value of domestic consumption demand for industrial goods and services refers only to the final demand for direct consumption. The values of domestic supply of crops and livestock products refer to the value of total outputs of crops and livestock sectors, respectively. On the other hand, the nominal value of domestic supply of industrial goods and services refers to the value of total final output for direct use. In international commodity trade, net concept is used. That is, the United States is usually a net exporter of crop products and a net importer of livestock products. In the final results, the parameters of the estimated equations all have the anticipated sign, suggesting that the model can be used successfully for the simulation experiments.

Farm Sector

Crop Supply

The estimated coefficients of the crop supply equation (3.1) display expected signs. For the crop input prices, the index of prices paid by farmers was used in the specification. Since the prices-paid index includes some price components for purchased feed, livestock, and seed that are also part of prices received by farmers, the estimated coefficients for crop input and output prices resulted in unexpected signs. The index of prices paid by farmers for inputs of nonfarm origin was considered for the specification; however, the data for this variable were available only from 1965 onward, so that index could not be used. In view of this problem, the index of fertilizer prices paid by farmers was used as a proxy for the crop input prices.

The farm policy variables--support price and acreage diversion--have the anticipated signs and are significant, indicating the importance of the farm policy programs. Since there was no single aggregate variable to represent weather conditions across the country, pasture condition was tried as a proxy for the weather index. However, it produced unsatisfactory results and was dropped from the equation. Results indicate that the output-price elasticity of crop supply is inelastic at 0.18, which is in line with the elasticities obtained by other studies (e.g., 0.26, Egbert 1969; 0.17, Tweeten and Quance 1969; 0.28 to 0.30, Griliches 1959). The input-price elasticity of crop supply is -1.07, which is higher than that estimated by Egbert (1969) at -0.86. The real interest rate seems to be an important variable in the crop supply equation since the estimated coefficient for this variable has the anticipated sign and is significant at the 1 percent level. The elasticity of crop output, with respect to the real interest rate, is inelastic at -0.11. The cross-price effect of livestock product price on crop supply is negative and inelastic (-0.67).

Livestock Product Supply

The livestock product supply equation (3.7) has the anticipated signs for all the estimated coefficients. The output-price elasticity of livestock product supply is 0.10, which is inelastic, as suggested by other studies. For example, Tweeten and Quance (1969) and Griliches (1959) estimated the output-price elasticity as 0.38 and 0.2-0.3, respectively. The input-price variable--that is, the index of prices paid for feed--is significant, and the estimated elasticity of livestock product supply, with respect to feed price, is inelastic at -0.49. The real interest rate was retained in the livestock product supply equation, even though the t-ratios are low, because (1) the sign is theoretically consistent with a priori expectations, and (2) the real interest rate is needed to capture the cost effect of interest rates in the livestock product supply.

Domestic Demand for Crop and Livestock Products

Domestic crop demand (3.2) is expressed as a function of real crop price, per capita real disposable income, and real livestock product price. All signs are consistent with conventional theory; in particular, the cross-price effect of livestock products has the expected positive sign. The domestic livestock product (3.8) is regressed as a function of real livestock product price, per capita real disposable income, and real crop price. The income elasticity of crop demand is 0.01, which is considerably less than the elasticity (0.67) estimated by Shei (1978). However, the income elasticity of livestock product demand is 0.73, almost equal to the elasticity (0.72) obtained by Shei. The estimated coefficients for the income variable reflect the income effect of an expansionary monetary policy.

Crop Inventory

Crop inventories are affected negatively by real crop prices and real interest rates, and positively by lag crop inventories. The negative coefficient for the real interest rate reflects the opportunity cost of higher interest rates in storing crop inventories; thus, it captures the stock effect of higher interest rates, leading to a reduction in crop storage. Stock demand is own-price inelastic at -0.25, which is close to the elasticity of -0.44 estimated by Egbert (1969). Past inventory accumulation appears to be a key determinant of the current level of inventories.

Net Crop Exports

As indicated in chapter 2, crop exports are estimated with a separate exchange rate regressor. The estimated coefficients are consistent with prior expectations and are statistically significant. The exchange rate appears to be a very important determinant of crop exports, with an elasticity of 3.93. The magnitude of the exchange rate elasticity of crop export demand is critical in determining the trade effect of exchange rate changes. The higher the exchange rate elasticity of U.S. crop exports, the greater will be the effect of exchange rate changes on exports. The evidence indicates, therefore, that exchange rate fluctuations since the early 1970s were important factors in bringing about changes in crop exports. A comparison of the price elasticity of export demand (-0.37) with that of other studies shows that it is smaller than that obtained by Tweeten (1969, -6.4); however, it is in line with the elasticities estimated by Houthakker and Magee (1969, -0.96), Clark (1974, -0.38), and Hooper and Wilson (1974, -0.88).

Input Demands

Estimated equations 3.5 and 3.9 are the crop input demand and feed demand relationships, respectively. Equation 3.5 relates the general price level changes to the crop supply through fertilizer price. Similarly, equation 3.9 links the general price level changes to the livestock product supply through feed prices. The coefficients of the consumer price index in both the equations are significant and are greater than one; therefore, they reflect the cost-price squeeze of inflation on the farm sector.

Agricultural Investment

The agricultural investment relationship is shown in equation 3.12. Both real interest rates and real farm income have the anticipated signs and are significant at the 1 percent level. The long-run elasticity of agricultural investment, with respect to changes in farm output, is 0.95, which is close to unity, as estimated by Bischoff (1971). The interest rate effect is inelastic at -0.05.

Interest Rate

Equation 3.13 relates the interest rate in the agricultural sector to the interest rate in the general economy in distributed lag form. The number of lags considered for the general economy interest rate is one, since the equation had a good fit with one lag. The coefficient for the current interest rate in the general economy has the expected positive sign and is significant at the 1 percent level.

General Economy

Supply Functions

The estimated coefficients of the industrial goods price equation (3.14) have the expected signs. In the wage-rate equation (3.15), a positive relationship is anticipated between changes in the supply of high-powered money and changes in the wage-rate index, similar to the Phillips curve type of relationship. A negative relationship between the unemployment rate and changes in the wage rate implies that when the unemployment rate decreases, the labor market will be tighter, and that will put upward pressure on the wage rate.

Consumption Function

In the consumption function (3.16), per capita real consumption expenditure on industrial goods is regressed as a function of real price levels of manufactured goods and per capita real disposable income. The marginal propensity to consume (mpc) is 0.75. This is lower than the mpc found in other studies (e.g., Dornbusch and Fischer (1981) estimated the mpc at 0.88) because the consumption expenditures include only manufactured goods spendings and do not include expenditures on food items. The food component that consists of domestic demands for crop products and livestock products is endogenously estimated in the farm sector.

Investment Function

Investment in the manufacturing sector is estimated as a function of output and interest rate in that sector (3.18). The estimated results are similar to that of Bischoff's (1971) study in terms of coefficients and elasticities.

Money Demand

The estimated results for the money demand function (3.19) are consistent with prior expectations and are significant. The long-run elasticities of demand for money, with respect to changes in the interest rate and in real income, are -0.35 and 0.78, respectively; these are close to what theory suggests. For example, representative long-run elasticities of demand for money from Goldfeld's (1973) article are about

-0.25 for changes in the interest rate, and 0.7 for changes in real income.

General Price Level

In the general price level equation (3.22), the consumer price index is related to the money supply and real gross national product. This consumer price index is linked to fertilizer and feed demands to analyze the cost-push inflationary effect on crop and livestock product supply, respectively.

Capital Flow

Following the simplified portfolio capital approach, the net change in private capital assets is estimated as a function of domestic and foreign real interest rates. The estimates in the capital flow equation indicate that changes in domestic and world real interest rates are significant causal variables.

Exchange Rate Determination

The estimated results of exchange rate determination are presented in equation 3.25. Under a fixed exchange rate regime (1950-1971), movements in the rate were not explained by the explanatory variables in the exchange rate equation. Those variables are crucial in determining the rate under the flexible regime. Therefore, it is not appropriate to estimate the equation over the entire sample period. In recognition of this problem, the grafted polynomial technique developed by Fuller (1976) is used to link the fixed and flexible regimes in estimating the exchange rate equation. (A detailed discussion of the use of the grafted polynomial technique is given in the appendix.) The elasticity of the exchange rate for the U.S. money supply is 2.75. This implies that a 1 percent increase in the money supply will raise the value of the U.S. dollar price of the SDR by 2.75 percent.

To summarize these econometric results, the estimated coefficients in all the equations conform to the prior expectations established in the theoretical model. Also, the transmission mechanisms explained in chapter 1 are captured well (refer to Fig. 2.1). For example, the trade effect is explained by the exchange rate and crop export equations. In the exchange rate relationship, the U.S. money supply has a significant influence on the exchange rate, and the changes in the value of the exchange rate affect the net crop exports in the crop export equation.

The stock effect involves three structural relationships: the interest rate equation in the general economy, the interest rate equation in the farm sector, and the crop inventory equation. The impact of money supply changes on the interest rate in the farm sector is relayed through the interest rate in the general economy, and the interest rate in the farm sector feeds into the crop inventory equation to determine the stock effect of the interest rate.

The cost effect on crop and livestock product supply stems from the input price changes and interest rate changes. The impact of money supply changes on farm input prices is related through the general price level. These input prices are linked to crop supply and livestock product supply to capture the inflationary effect. Similarly, the cost effects of the interest rate changes are fed into the crop and livestock product supply. Finally, the income effect traces the effect of changes in the real output of the economy on the demand for farm products through per capita real disposable income. An important point is that all the estimated coefficients of the variables involved in these four macrolinkages have the anticipated signs.

Validation of the Model

The estimated structural equations and identities were used to test the overall ability of the model to replicate the sample values of the endogenous variables. They also served to test the stability of the model. Since the model is to be used for multiplier and dynamic simulation analysis, a rigorous validation procedure was undertaken.

In the validation run, the structural form of the model was dynamically simulated over the entire study period. The simulation procedure is dynamic in the sense that solved values--rather than the actual values--are used for lagged values of endogenous variables. A dynamic simulation is preferable since it allows the researcher to study the evolutionary character of the model over time. Because the model is nonlinear, a nonlinear simulation procedure was used in its solution. The Gauss-Siedel solution method was used for the validation run and for all future simulations.

Root mean square error (RMSE) and root mean square percentage error (RMSPE) are two common measures used to evaluate the historical simulation. The RMSE is a measure of the deviation of the simulated variable from its actual value. RMSPE expresses RMSE in percentage terms. The overall goodness of fit of the model is judged from the RMSE, the RMSPE, and the prediction of turning points. For large econometric models, an RMSPE of less than 25 percent is considered to be good. In general, the model performs very well in tracking the observed values. Table 3.3 presents RMSE and RMSPE for important endogenous The observed and predicted values for key endogenous variables are plotted in Figs. 3.1-3.8.

At 0.71, the RMSPE for crop exports is by far the largest. The next largest error, at 0.23, is for the crop export price index. For all other variables, the RMSPE is quite small (less than 0.21), which would imply that the simulated values track the actual values fairly closely.

What about the ability of the model to duplicate turning points or rapid changes in the actual data of some key endogenous variables? As Figures 3.1-3.8 illustrate, the simulated series do seem to reproduce the general long-run behavior of the actual series, although a few short-run fluctuations in the actual series are not reproduced. It is also clear that the endogenous variables in the nonfarm sector in general simulate the actual series better than the endogenous variables in the farm sector. This may be due to the fact that agriculture is subject to higher risk and uncertainty than is the general economy; as a result, farm variables tend to have more short-run fluctuations than do the nonfarm variables. Therefore, it is relatively difficult to precisely track the actual values of the endogenous variables in the farm sector.

For the crop supply, the simulated values are closer to the actual values, particularly after 1974. By far the biggest differences between the actual and simulated values of crop supply are in 1972, 1973, and 1974. This might be due to the larger price fluctuation in those periods. Livestock product supply performs relatively better than crop product supply. Crop price has two turning point errors in 1981 and 1982; however, the sharp increase in U.S. crop price in 1973 and 1974 was predicted very well. The livestock product price performs extremely well except for the last few years. A relatively poor job seems to have been done in tracking the net crop exports after 1975; it might be due to the high volatility of crop exports in those periods. Total farm cash receipts has a perfect fit except for small differences in the last three years.

Table 3.3. Root mean error square and root mean square percentage error from the dynamic simulation

Variable	RMSE	RMSPE
Real crop supply (c_t^p)	27.7964	0.1491
Domestic demand for real crop output (c_t^d)	25.9225	0.1566
Real crop inventories (c_t^s)	15.4808	0.1473
Real crop net exports (c_t^x)	14.0490	0.7119
Crop price (P_t^c)	37.3352	0.2058
Fertilizer price (P_t^i)	17.0388	0.1293
Crop export price (PX_t^c)	1.4280	0.2271
Real livestock product supply (l_t^x)	13.3481	0.0588
Domestic demand for livestock products (l_t^d)	13.3488	0.0589
Livestock product price (P_t^l)	36.0982	0.1692
Feed price (P_t^f)	30.3596	0.1775
Real agricultural investment (i_t^a)	10.6447	0.1639
Interest rate in the farm sector (r_t^a)	1.3942	0.1656
Cash receipts in the farm sector (Y_t^a)	11421.3	0.1053
Real output in the industrial sector (m_t^s)	188.093	0.0231
Per capita consumption of industrial goods (m_t^d)	0.9237	0.0454
Manufactured goods price (P_t^m)	11.4674	0.0915
Real investment in the industrial sector (i_t^m)	109.542	0.0840
Interest rate in the economy (r_t)	1.1623	0.2015
Consumer price index (CPI_t)	6.2057	0.0426
Exchange rate (e_t)	5.9535	0.0498
Real gross national product (y_t)	144.909	0.0165

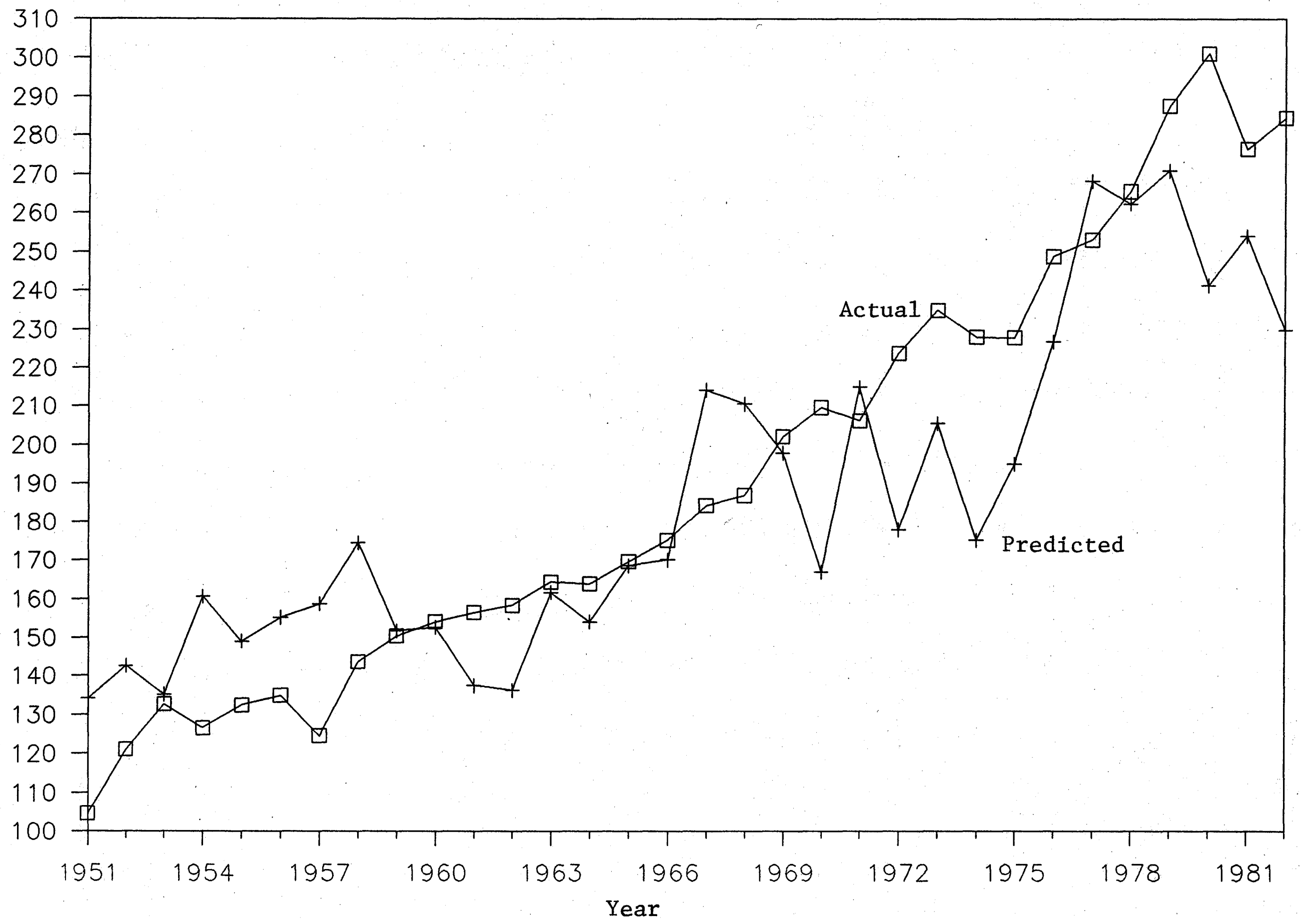

Figure 3.1. Predicted versus actual values of real crop supply (mil. dol. in 1967 prices)

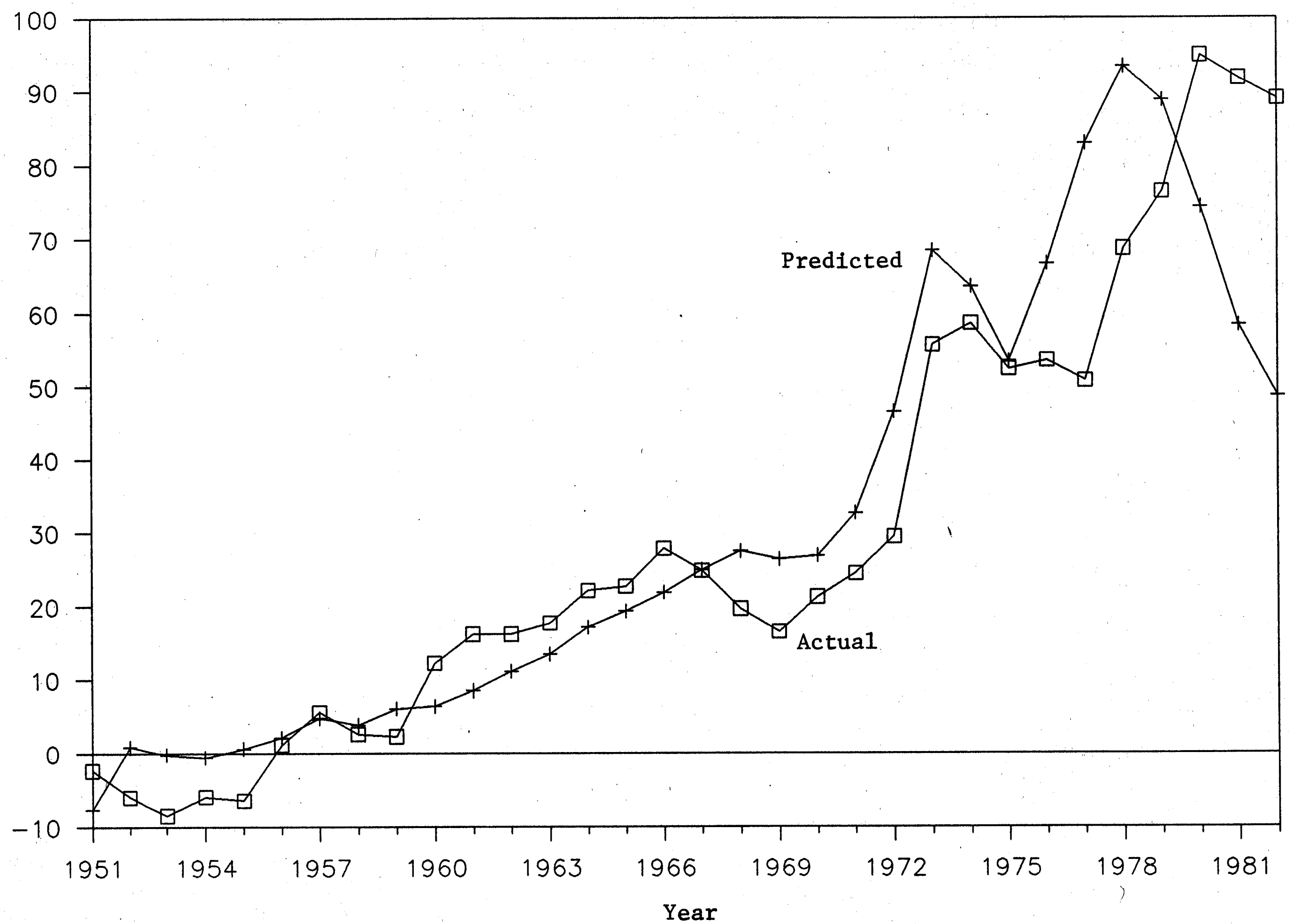

Figure 3.2. Predicted versus actual values of real net crop exports (mil. dol. in 1967 prices)

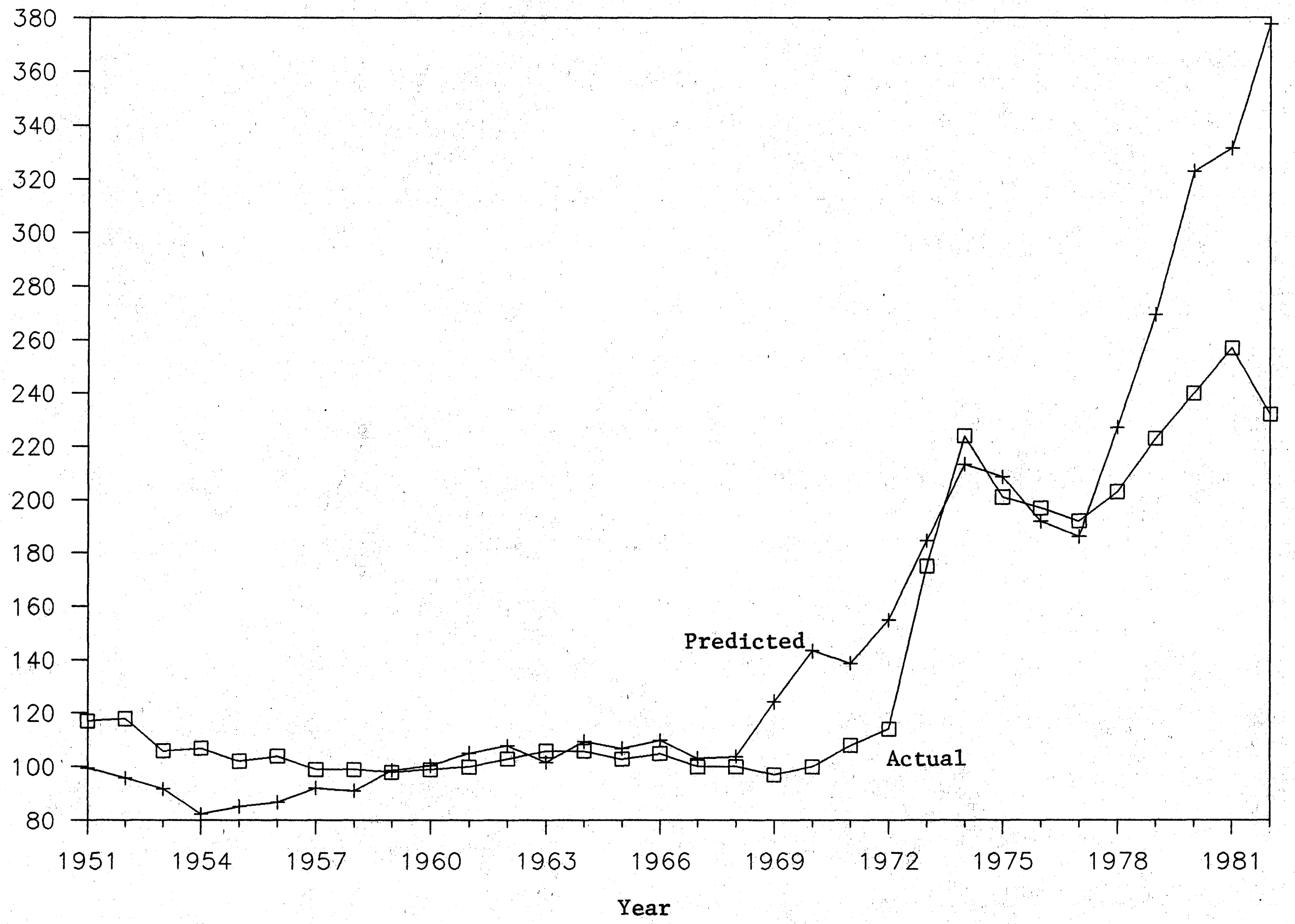

Figure 3.3. Predicted versus actual values of crop price (index, 1967=100)

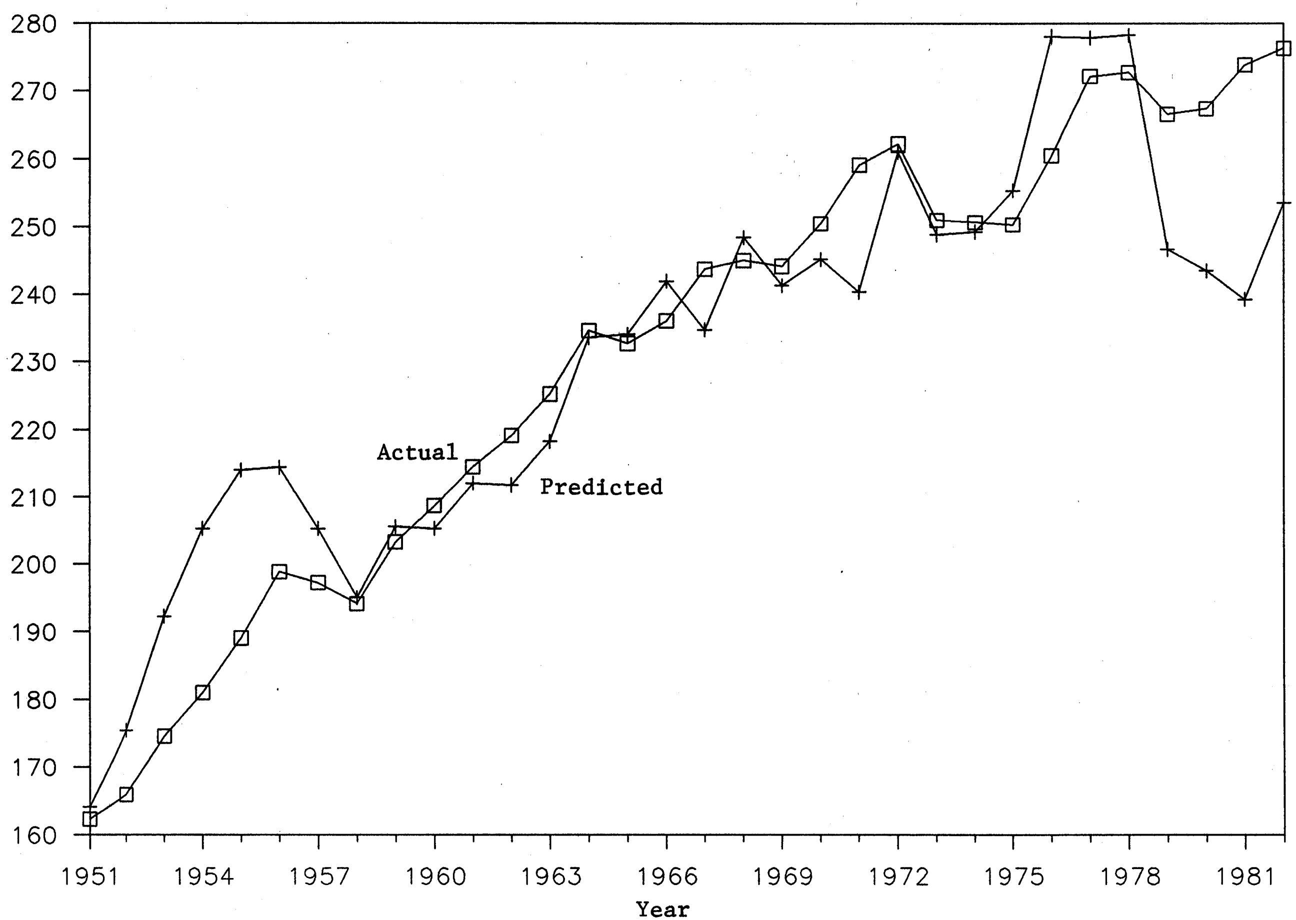

Figure 3.4. Predicted versus actual values of real livestock product supply (mil. dol. in 1967 prices)

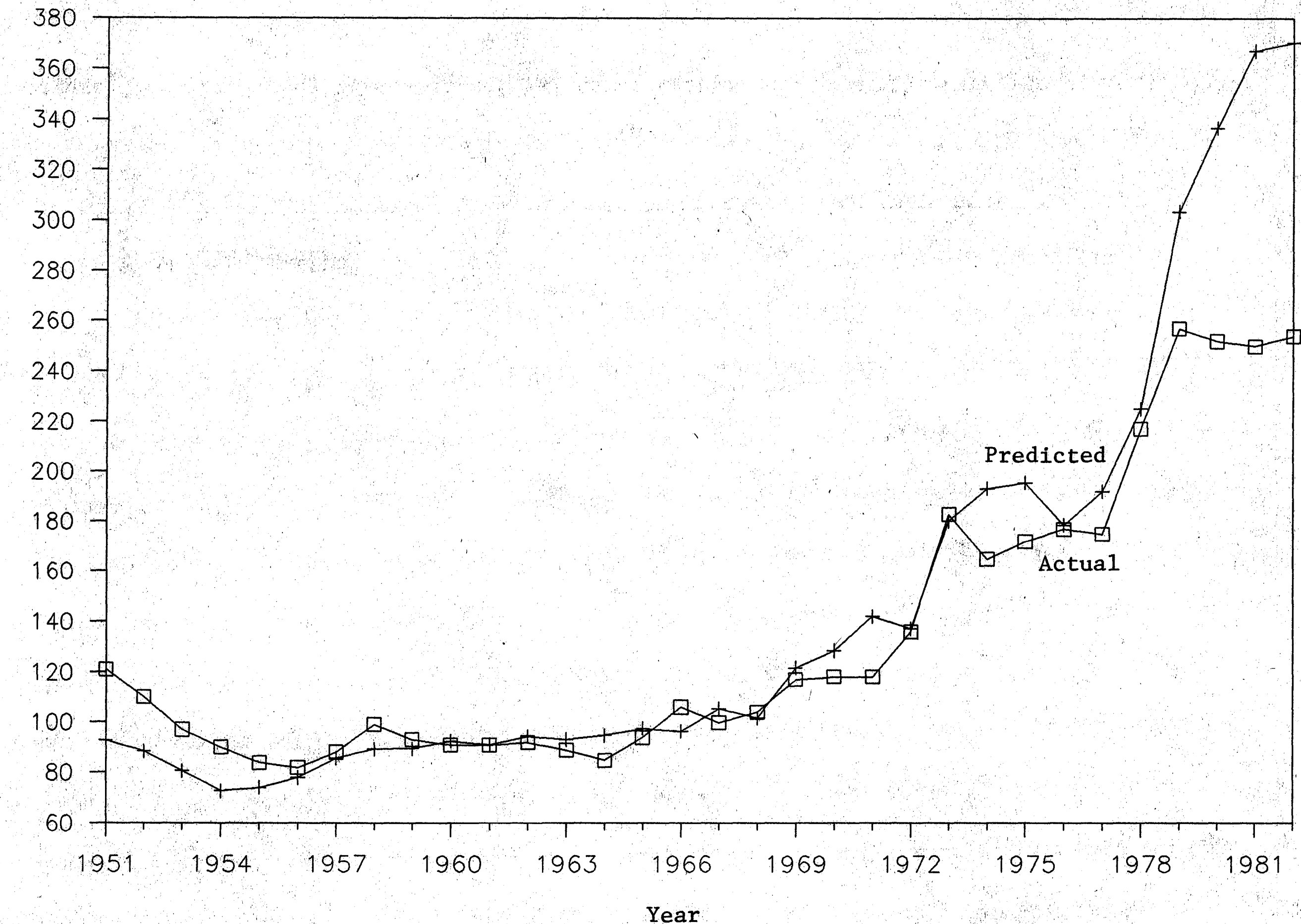

Figure 3.5. Predicted versus actual values of livestock product price (index, 1967=100)

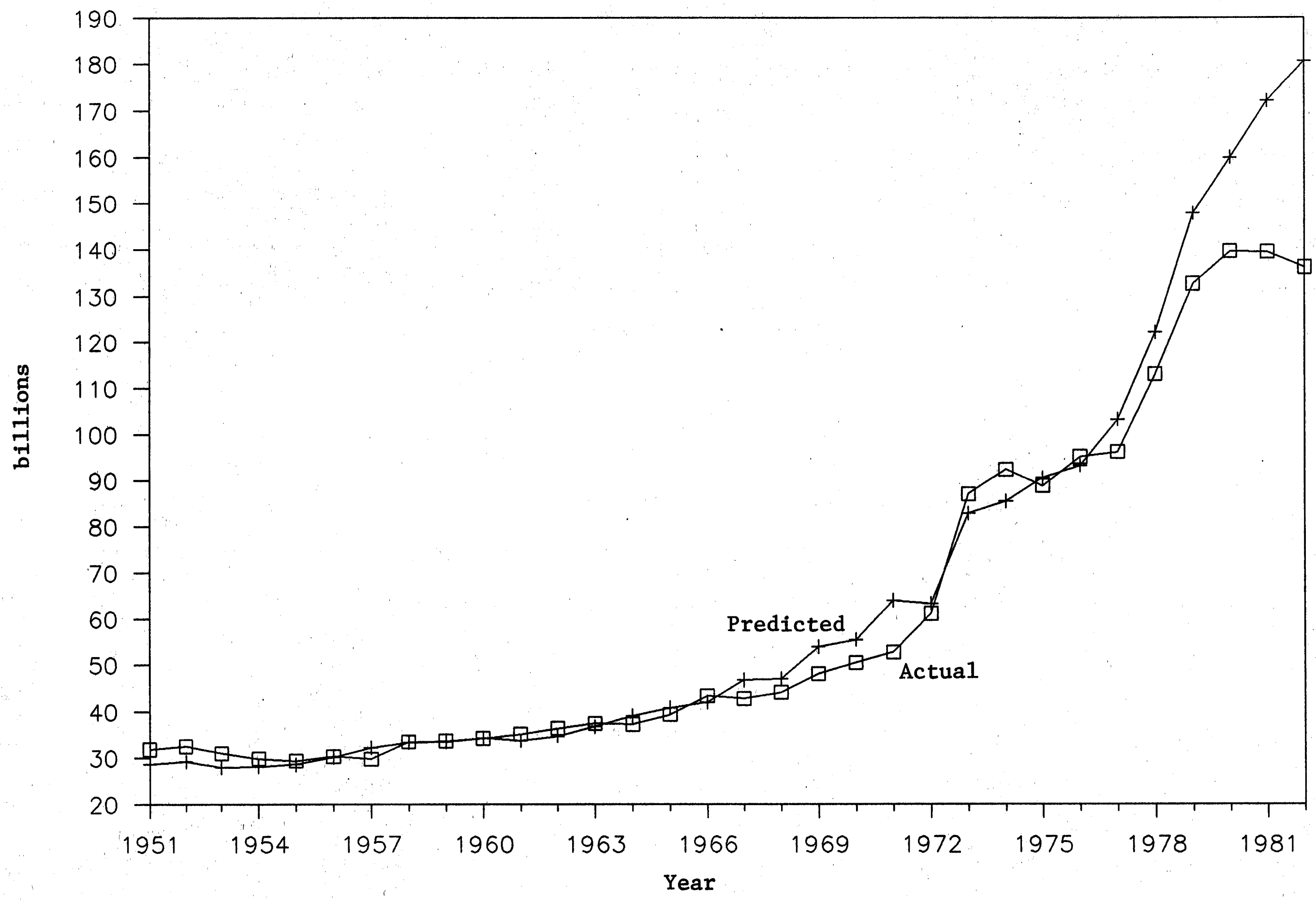

Figure 3.6. Predicted versus actual values of cash receipts in the farm sector (bil. dol.)

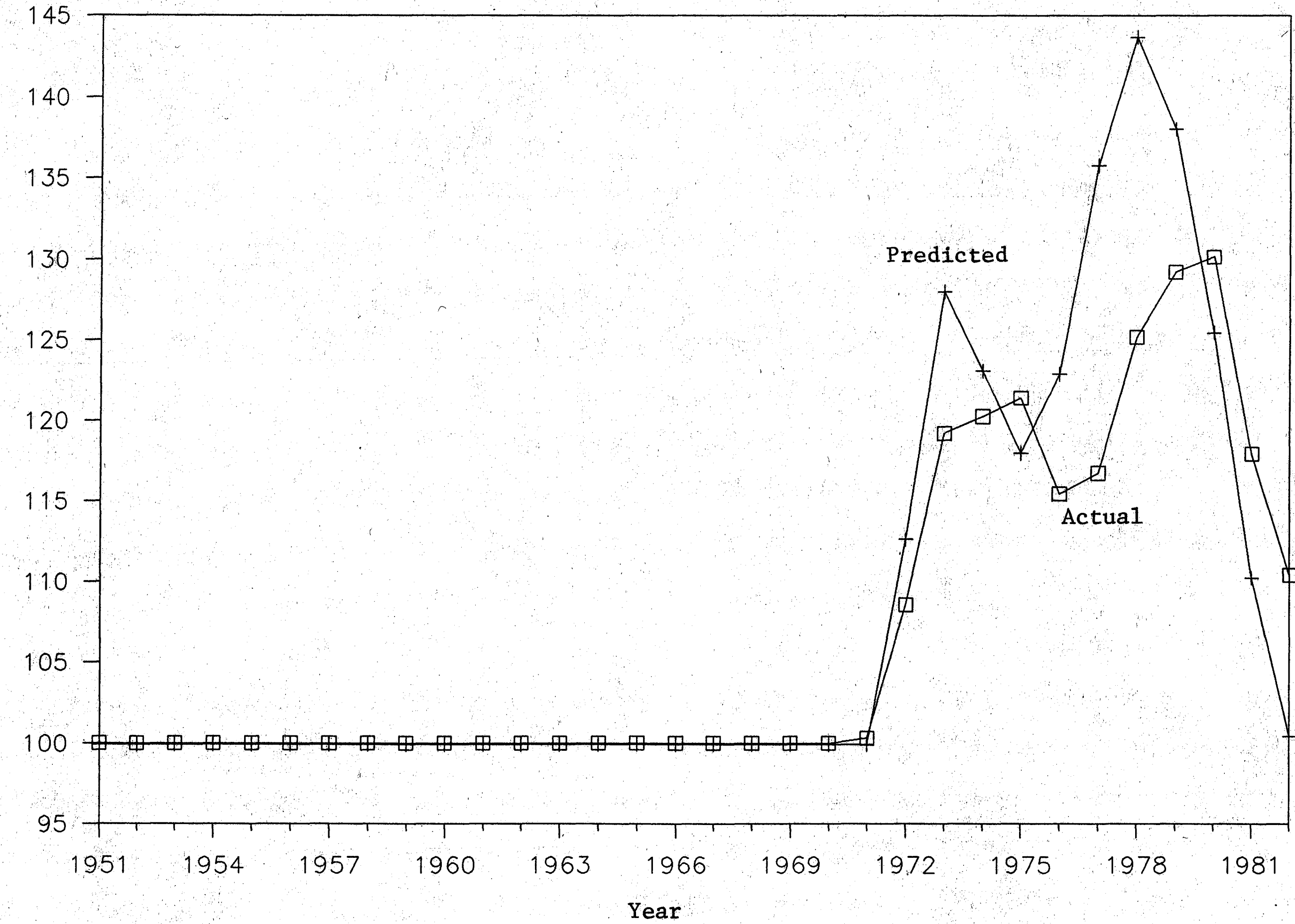

Figure 3.7. Predicted versus actual values of the exchange rate (U.S. $/SDR)

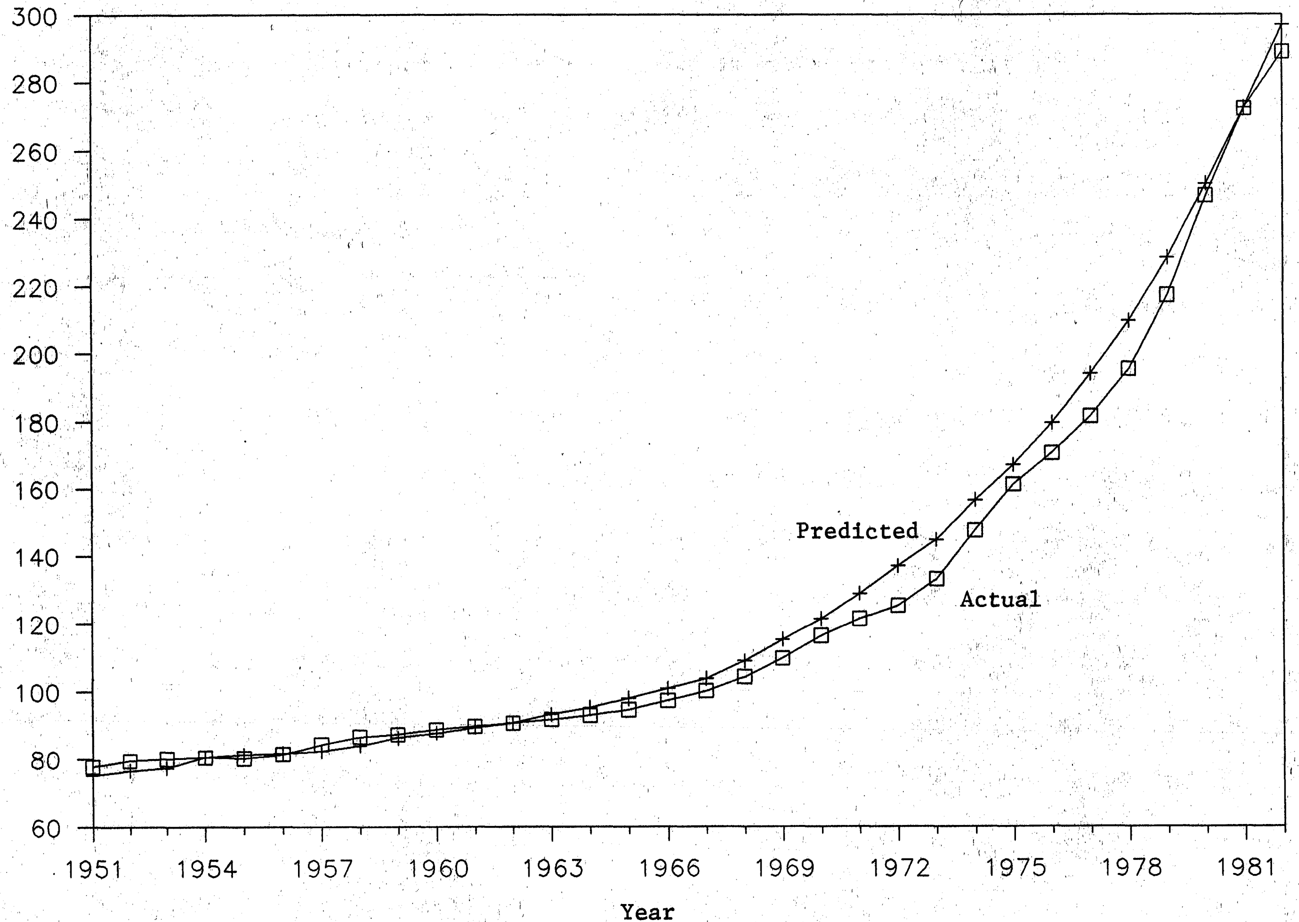

Figure 3.8. Predicted versus actual values of Consumer Price Index (1967=100)

Turning to the exchange rate variable, even though there is some minor deviation of simulated values from actual values, all the turning points since the beginning of the floating exchange rate system were predicted accurately.

One way of testing model stability is to perform a series of simulations over different periods of time, using different time paths for the exogenous variables in the model. In this case, the money supply growth rate in 1972 was exogenously increased by 3 percent to test the stability of the model. If the changes wrought in the endogenous variables by this shock decline as time passes, and the simulation values move back to base values, then the model is stable. The faster the adjustment back toward the base simulated values, the more stable the model.

The year 1972 was chosen for the test because that was the year the floating exchange rate regime was in effect; thus, one would expect the changes in the money supply growth rate to affect the endogenous variables, such as crop exports, through the exchange rate. Given this shock, the simulation was rerun for the period 1972-1982. Table 3.4 reports the base simulated values and the changes in the values of the key endogenous variables from the base solution caused by money supply growth in 1972. The percentage change of all variables decreases as time passes, and all simulated results eventually approach the base solutions.

As discussed in the theoretical formulation, the immediate effect of money supply increase should be on the consumer price index, interest rates, and exchange rates. In the test, the percentage change of the consumer price index steadily declined from 1.03 percent to 0.11 percent from 1972 to 1982. The value of exchange rates ($/SDR) rose by 1.84 percent in 1972 and steadily decreased to 0.08 in 1982. The immediate effect of an increase in the money supply growth rate was to lower interest rates by 5.83 percent in 1972; however, interest rates increased by 3.32 percent the next year. This is similar to what theory suggests. For example, Friedman (1968) argues that an increase in the rate of growth of the money stock will initially cause market interest rates to fall. Then, market interest rates will return to their previous level. Finally, market interest rates will rise to a level above what they would have been had the rate of growth of money stock not been increased.

Table 3.4. Dynamic impact of an increase in the U.S. money supply growth rate by 3 percent in 1972

		Year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Exchange Rate	e	Base	112.53	127.80	123.00	117.93	122.88	135.91	143.69	138.02	125.40	110.25	100.36
U.S. $/SDR		Change	2.07	1.78	0.02	0.08	0.09	0.09	0.10	0.09	0.09	0.09	0.08
		Percent change	1.84	1.40	0.02	0.06	0.07	0.06	0.07	0.07	0.07	0.08	0.08
Interest Rate in	r	Base	8.96	9.28	9.45	9.54	9.95	10.44	10.63	11.24	11.31	12.17	12.68
the General Economy		Change	-0.52	0.31	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
(Percent)		Percent change	-5.83	3.32	0.05	0.24	0.23	0.22	0.21	0.19	0.18	0.16	0.16
Consumer Price	CPI	Base	136.91	144.76	156.45	166.92	179.44	194.07	209.73	228.40	250.11	272.57	296.81
Index (1967=100)		Change	1.42	0.29	0.17	0.17	0.19	0.21	0.23	0.25	0.27	0.29	0.32
		Percent change	1.03	0.20	0.11	0.10	0.10	0.11	0.11	0.11	0.11	0.11	0.11
Real Crop Supply	c^p	Base	175.00	205.92	174.52	194.99	226.20	268.27	262.10	270.79	241.19	254.12	229.61
Mil. Dol.		Change	9.31	-12.90	-2.22	-0.35	-0.61	-0.35	-0.44	-0.43	-0.42	-0.45	-0.42
(1967 prices)		Percent change	5.32	-6.27	-1.27	-0.18	-0.27	-0.13	-0.17	-0.16	-0.17	-0.18	-0.18
Real Crop Net	c^x	Base	46.46	68.26	63.52	53.26	66.66	82.93	93.48	88.69	74.42	58.42	48.60
Exports		Change	3.15	0.79	-0.09	0.10	0.05	0.10	0.08	0.09	0.07	0.07	0.08
Mil. Dol. (1967 prices)		Percent change	6.77	1.16	-0.14	0.19	0.08	0.12	0.09	0.11	0.10	0.11	0.16
Crop Price Index	P^c	Base	155.56	184.98	213.75	208.80	192.23	186.41	227.44	269.82	323.07	331.68	377.78
(1967=100)		Change	5.43	4.23	2.94	1.58	1.31	0.97	1.05	1.01	1.06	1.11	1.18
		Percent change	3.49	2.29	1.38	0.76	0.68	0.52	0.46	0.38	0.33	0.33	0.31
Real Livestock	l^s	Base	262.00	248.22	249.20	255.12	278.04	277.85	278.21	246.61	243.42	239.26	253.56
Product Supply		Change	1.43	-3.76	-1.18	-1.11	-0.44	-0.39	-0.25	-0.25	-0.21	-0.18	-0.18
Mil. Dol. (1967=100)		Percent change	0.55	-1.51	-0.47	-0.44	-0.16	-0.14	-0.09	-0.10	-0.09	-0.08	-0.07
Livestock Product	P^l	Base	136.51	180.94	193.49	195.88	178.91	192.39	225.24	303.70	336.91	367.44	370.48
Price Index		Change	4.05	2.62	2.40	1.99	1.13	0.98	0.88	0.94	0.91	0.94	0.99
(1967=100)		Percent change	2.96	1.45	1.24	1.02	0.63	0.51	0.39	0.31	0.27	0.26	0.27
Total Farm Cash	Y^a	Base	62989	83004	85520	90686	93302	103463	122276	147960	159933	172200	180678
Receipts Mil. Dol.		Change	3711.60	-1608.40	400.00	522.50	413.90	392.00	364.00	314.50	271.20	288.40	296.70
(1967 prices)		Percent change	5.89	-1.94	0.47	0.58	0.44	0.38	0.30	0.21	0.17	0.17	0.16

The effect of the increase in the money supply growth rate on the farm sector is transmitted through inflation, exchange rates, and interest rates. A detailed analysis of the changes in farm sector variables due to different monetary policies will be discussed in the next chapter. The important point here is that the fluctuation response of the farm sector variables to the exogenous shock was to decline from 1972 to 1982. Since all the variables moved back to their equilibrium values after the increase in the money stock growth rate, the model can be judged stable.

These results suggest that the model does an adequate job of depicting the behavior of key endogenous variables. It provides a good foundation upon which to base further empirical research.

CHAPTER 4.
DYNAMIC POLICY ANALYSIS AND CONCLUSIONS

This chapter investigates the impact of different monetary policies on U.S. agriculture using dynamic multiplier analysis. The comparison of the dynamic simulation results with and without the event or policy shows the impact of such an event or policy. Two monetary policy scenarios are examined for the period 1972-1982: first, an expansionary policy of a sustained increase in the money supply growth rate by 3 percent; and second, a contractionary policy of a sustained decrease in the growth rate, also by 3 percent.

Before presenting the results of multiplier analysis, a few comments are necessary about selecting these policy scenarios. First, the changes in the monetary policies were evaluated only for the flexible exchange rate regime (1972-1982), since the money supply had no direct influence on the value of the exchange rate prior to 1972. Second, the money supply was altered by changing the growth rate rather than the level of supply. (This is because, when the Federal Reserve Open Market Committee conducts monetary policy, it does so by changing the money supply growth rate.) Then, the money supply level corresponding to the increase (decrease) in the growth rate of supply for easy (tight) monetary policy was incorporated in the simulation model to analyze the effects of changes in monetary policies on the farm economy.

Since the money supply growth rate is altered every year from 1972 to 1982, simulation results have compounding effects on the endogenous variables. That is, the consequent changes in the endogenous variables in any period include the dynamic effects of the increase in the money supply of all previous periods.

Analysis of Money Supply Increase

Table 4.1 reports the simulation results of the expansionary monetary policy for key endogenous variables. As explained in previous chapters, money supply expansion depreciates (appreciates) the value of the U.S. dollar (SDR). In the simulation, the value of the exchange rate ($/SDR) depreciated continually from 1.84 percent in 1972 to 12.66 percent in 1982, which implies the value of the SDR appreciated by the same magnitude from 1971 to 1982. The increase in the money supply has a negative (positive) effect on the interest rate (consumer price index). The percentage change in the domestic interest rate declined by -5.83 percent in 1972 to -0.96 percent in 1982, whereas the consumer price index continued to rise from 1.03 percent in 1972 to 1.77 percent in 1982.

The impact of this expansionary monetary policy on the crop sector, specifically on crop prices, equilibrium quantities of crop supply, demand, stocks, and exports, can be traced in Fig. 4.1. The depreciation of the dollar caused a higher demand for U.S. crop products by the ROW. Similarly, an increase in the income and a decrease in the interest rate caused respective upward shifts in domestic demand and inventory demand. Therefore, the aggregate demand curve shifts from D to D'. The aggregate supply curve shifts from S to S' because the cost effect of an increase in inflation dominates the cost effect of a decline in the interest rate. Since graphic analysis does not permit an examination of the dynamic changes in the endogenous variables over time, the year 1982 is used to evaluate changes in the endogenous variables of the crop sector.

In the year 1982, the new equilibrium is at E_1, which is the result of money supply expansion in and prior to 1982. At this equilibrium, the crop price rose to P_1; that is, by 11.02 percent (refer to Table 4.1). This rise in crop price is caused by the increase in aggregate crop demand and the decrease in supply schedules. The equilibrium quantity of net crop exports increased by 22.23 percent, which is the major driving force for the crop price increase. However, the equilibrium quantities of domestic demand and stock inventories declined by -14.47 percent and -5.41 percent, respectively, because of the higher price. This suggests that the increased foreign demand for U.S. crops tends to crowd out domestic usages. Because higher prices lead to profit taking on inventory holdings and, hence, a drawdown of stock levels; domestic disappearance decreases as the crop price rises.

Turning to the livestock sector, the percentage changes in the livestock product supply, demand, and prices in 1982 are -3.28, -3.29, and 8.16, respectively. The percentage change in livestock product prices is less than that of crop prices. This is because the livestock commodity trade is exogenous and, therefore, there is no trade effect. Hence, the increase in the livestock product price is due only to changes

Table 4.1. Dynamic impact of a sustained increase in the U.S. money supply growth rate by 3 percent from 1972 to 1982

		Year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Exchange Rate	e	Base	112.53	127.80	123.00	117.93	122.88	135.91	143.69	138.02	125.40	110.25	100.36
U.S. $/SDR		Change	2.07	6.31	6.97	7.18	7.66	8.95	9.03	9.83	10.66	11.74	12.71
		Percent Change	1.84	4.94	5.66	6.08	6.23	6.59	6.29	7.12	8.50	10.65	12.66
Interest Rate in the	r	Base	8.96	9.28	9.45	9.54	9.95	10.44	10.63	11.24	11.31	12.17	12.68
General Economy		Change	-0.52	-0.24	-0.25	-0.24	-0.21	-0.21	-0.17	-0.16	-0.13	-0.13	-0.12
(Percent)		Percent Change	-5.83	-2.55	-2.62	-2.47	-2.13	-2.01	-1.58	-1.45	-1.15	-1.09	-0.96
Consumer Price Index	CPI	Base	136.91	144.76	156.45	166.92	179.44	194.07	209.73	228.40	250.11	272.57	296.81
(1967=100)		Change	1.42	1.83	2.07	2.28	2.54	2.77	3.21	3.43	4.02	4.62	5.26
		Percent Change	1.03	1.27	1.32	1.37	1.42	1.43	1.53	1.50	1.61	1.70	1.77
Real Crop Supply	c^p	Base	175.00	205.92	174.52	194.99	226.60	268.27	262.10	270.79	241.19	254.12	229.61
Mil. Dol. (1967 prices)		Change	9.31	-3.99	-5.48	-2.79	-5.92	-5.84	-9.49	-10.30	-8.92	-13.71	-12.03
		Percent Change	5.32	-1.94	-3.14	-1.43	-2.61	-2.18	-3.62	-3.80	-3.70	-5.39	-5.24
Domestic Demand for	c^d	Base	129.96	142.19	112.27	141.34	155.87	180.44	168.01	183.67	168.10	196.75	154.79
Crop Products		Change	3.51	-8.22	-12.14	-9.85	-12.94	-14.18	-17.59	-18.11	-18.80	-24.58	-22.40
Mil. Dol. (1967 prices)		Percent Change	2.70	-5.78	-10.81	-6.97	-8.31	-7.86	-10.47	-9.86	-11.19	-12.49	-14.47
Real Crop Inventories	c^s	Base	101.22	96.68	95.41	95.81	99.88	104.79	105.40	103.83	102.50	101.45	127.67
Mil. Dol. (1967 prices)		Change	2.65	1.24	-0.14	-1.06	-1.97	-3.23	-3.72	-5.09	-5.89	-6.47	-6.91
		Percent Change	2.62	1.29	-0.15	-1.11	-1.97	-3.08	-3.53	-4.90	-5.75	-6.38	-5.41
Real Crop Net Exports	c^x	Base	46.46	68.26	63.52	53.26	66.66	82.93	93.48	88.69	74.42	58.42	48.60
Mil. Dol. (1967 prices)		Change	3.15	5.64	8.05	7.98	7.93	9.60	8.59	9.18	10.68	11.44	10.81
		Percent Change	6.77	8.26	12.67	14.98	11.90	11.58	9.19	10.35	14.36	19.59	22.23
Crop Price Index	P^c	Base	155.56	184.98	213.75	208.80	192.23	186.41	227.44	269.82	323.07	331.68	377.78
(1967=100)		Change	5.43	3.87	12.42	12.88	15.69	23.11	20.30	39.72	39.54	41.91	41.64
		Percent Change	3.49	2.09	5.81	6.17	8.16	12.40	8.93	14.72	12.24	12.64	11.02

Table 4.1. Continued

		Year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Real Livestock Product	l^s	Base	262.00	248.22	249.20	255.12	278.04	277.85	278.21	246.61	243.42	239.26	253.56
Supply		Change	1.43	-2.36	-0.04	-4.31	-3.63	-4.49	-6.53	-4.70	-10.51	-8.25	-8.31
Mil. Dol. (1967=100)		Percent Change	0.55	-0.95	-0.01	-1.69	-1.30	-1.62	-2.35	-1.91	-4.32	-3.45	-3.28
Domestic Demand for	l^d	Base	267.27	253.60	251.84	255.86	277.66	275.81	278.56	247.02	243.39	236.22	252.32
Livestock Products		Change	1.43	-2.36	-0.04	-4.31	-3.63	-4.49	-6.53	-4.70	-10.51	-8.25	-8.31
Mil. Dol. 91967=100)		Percent Change	0.54	-0.93	-0.01	-1.69	-1.31	-1.63	-2.34	-1.90	-4.32	-3.49	-3.29
Livestock Product Price	P^l	Base	136.51	180.94	193.49	195.88	178.91	192.39	225.24	303.70	336.91	367.44	370.48
Index		Change	4.05	1.75	8.26	11.33	11.57	16.36	15.25	27.17	37.50	34.70	30.25
(1967=100)		Percent Change	2.96	0.97	4.27	5.78	6.46	8.50	6.77	8.95	11.13	9.44	8.16
Total Farm Cash	Y^a	Base	62989	83004	85520	90686	93302	103463	122276	147960	159933	172200	180678
Receipts		Change	3711.6	46.9	2980.4	3888.5	4848.2	8582.5	5645.4	12712.8	11496.3	10512.9	8854.6
Mil. Dol.		Percent Change	5.89	0.06	3.49	4.29	5.20	8.30	4.62	8.59	7.19	6.11	4.90

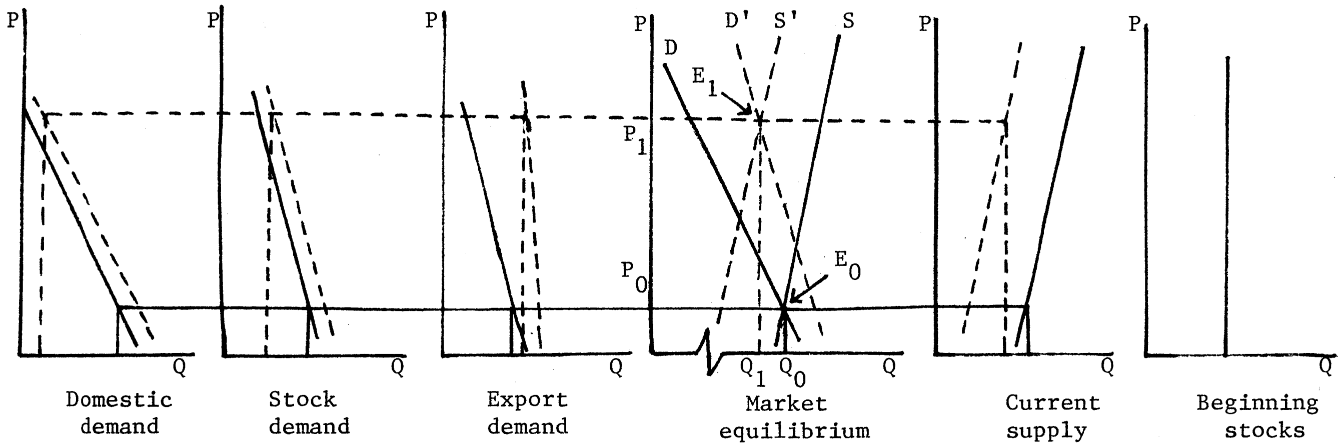

Figure 4.1. The effect of money supply increase on the crop sector

in the domestic market. The equilibrium quantity of domestic demand for livestock products decreases because the price effect dominates the income effect.

Even though the equilibrium quantities of crop and livestock products decrease, because of the inelastic nature of the supply of these products, price increases lead to a rise in total cash receipts.

The long-run elasticities of key endogenous variables, with respect to money supply increases, are reported in Table 4.2. The long-run elasticities of crop price, exports, and domestic demand associated with a 1 percent increase in the money supply are elastic. Chambers and Just (1982) included only exchange rate linkages in analyzing the effect of money supply changes on corn, wheat, and soybean exports. They estimated the long-run elasticities of those exports, with respect to money supply, at 2.23, 2.03, and 0.99, respectively, and their long-run price elasticities at 0.74, 1.76, and 1.17, respectively.

Chambers and Just concluded that the effect of money supply changes on agricultural trade and prices would be magnified if a more complete set of linkages were to be specified in place of only the exchange rate linkage. Results of the model simulation support that conclusion. In the simulation, the elasticities of crop exports and crop price, with respect to money supply, are 4.81 and 4.13, respectively.

At 3.12, the elasticity of livestock product price with respect to money supply expansion is less elastic than that of crop price (4.13). This less elastic response is as anticipated because the livestock commodity trade is exogenous. Hence, there is no trade effect. Therefore, the increase in livestock product price is only attributable to changes in the domestic market.

Another interesting result is the value of 2.17 for long-run elasticity of cash receipts, which implies that changes in monetary policies have significant effects on the farm economy. Furthermore, from the results cited above, it is clear that an expansionary monetary policy favors the agricultural sector by increasing farm prices and income.

Analysis of Money Supply Decrease

The second policy scenario examines the effect of a contractionary monetary policy: a decrease in the money supply growth rate by 3 percent from 1972 to 1982. See Table 4.3 for the dynamic simulation results of this policy.

Table 4.2. Dynamic effect of a sustained increase in the money supply growth rate by 3 percent

Variables	Average Impact[a] of Money Supply Increase (1978-1982)	Long-run[b] Elasticity
Exchange rate (U.S. $/SDR)	10.79	3.01
Domestic interest rate	-0.14	-0.42
Consumer price index (1967=100)	4.11	0.56
Real gross national product (bil. dol. in 1967 prices)	32.35	0.10
Real crop supply (mil. dol. in 1967 prices)	-10.89	-1.49
Real domestic demand for crop output (mil. dol. in 1967 prices)	-20.30	-4.02
Real crop inventories (mil. dol. in 1967 prices)	-5.62	-1.79
Real crop net exports (mil. dol. in 1967 prices)	10.14	4.81
Crop price index (1967=100)	36.62	4.13
Fertilizer price index (1967=100)	5.46	0.81
Real livestock product supply (mil. dol. in 1967 prices)	-7.66	-1.05
Real domestic demand for livestock products (mil. dol. in 1967 prices)	-7.66	-1.05
Livestock product price (1967=100)	28.97	3.12
Feed price index (1967=100)	29.64	3.65
Total cash receipts of farm products (mil. dol. in 1967 prices)	9844.40	2.17

[a]Calculated as average changes of simulated values from the base values. The period 1978-1982 is considered for the purpose of long-run analysis.

[b]Calculated as average changes of the variable in interest divided by average changes of the money supply, and evaluated as the mean over the period 1978-1982.

Table 4.3. Dynamic impact of a sustained decrease in the U.S. money supply growth rate by 3 percent from 1972 to 1982

		Year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Exchange Rate	e	Base	112.53	127.80	123.00	117.93	122.88	135.91	143.69	138.02	125.40	110.25	100.36
U.S. $/SDR		Change	-2.08	-6.39	-6.80	-7.15	-7.60	-7.57	-9.06	-10.08	-10.53	-11.22	-12.87
		Percent change	-1.84	-5.00	-5.53	-6.06	-6.19	-5.57	-6.30	-7.30	-8.40	-10.18	-12.83
Interest Rate in	r	Base	8.96	9.28	9.45	9.54	9.95	10.44	10.63	11.24	11.31	12.17	12.68
the General Economy		Change	0.53	0.26	0.25	0.24	0.22	0.17	0.18	0.18	0.14	0.11	0.13
(Percent)		Percent change	5.96	2.79	2.61	2.54	2.18	1.61	1.71	1.56	1.26	0.94	1.02
Consumer Price Index	CPI	Base	136.91	144.76	156.45	166.92	179.44	194.07	209.73	228.40	250.11	272.57	296.81
(1967=100)		Change	-1.55	-1.82	-2.09	-2.32	-2.55	-2.91	-3.22	-3.68	-4.17	-4.68	-5.25
		Percent change	-1.13	-1.25	-1.34	-1.39	-1.42	-1.50	-1.53	-1.61	-1.67	-1.72	-1.77
Real Crop Supply	c^p	Base	175.00	205.92	174.52	194.99	226.60	268.27	262.10	270.79	241.19	254.12	229.61
Mil. Dol.		Change	-9.41	4.40	1.72	4.01	4.10	5.90	3.69	4.45	6.34	8.28	6.66
(1967 prices)		Percent change	-5.37	2.14	0.99	2.06	1.81	2.20	1.41	1.64	2.63	3.26	2.90
Domestic Demand for	c^d	Base	129.96	142.19	112.27	141.34	155.87	180.44	168.01	183.67	168.10	196.75	154.79
Crop Products		Change	-3.90	9.68	7.84	10.95	11.03	13.30	12.64	15.13	15.12	17.76	20.66
Mil. Dol. (1967 prices)		Percent change	-3.00	6.81	6.98	7.75	7.08	7.37	7.52	8.24	8.99	9.03	13.35
Real Crop Inventories	c^s	Base	101.22	96.68	95.41	95.81	99.88	104.79	105.40	103.83	102.50	101.45	127.67
Mil. Dol. (1967 prices)		Change	-3.26	-1.64	-0.50	0.48	1.46	1.70	2.21	2.61	3.35	3.96	4.51
		Percent change	-3.22	-1.70	-0.53	0.50	1.46	1.62	2.10	2.51	3.27	3.90	3.54
Real Crop Net Exports	c^x	Base	46.46	68.26	63.52	53.26	66.66	82.93	93.48	88.69	74.42	58.42	48.60
Mil. Dol. (1967 prices)		Change	-2.25	-6.89	-7.25	-7.92	-7.91	-7.64	-9.47	-11.08	-9.52	-10.09	-14.56
		Percent change	-4.85	-10.09	-11.42	-14.88	-11.86	-9.21	-10.13	-12.49	-12.80	-17.27	-29.95
Crop Price Index	P^c	Base	155.56	184.98	213.75	208.80	192.23	186.41	227.44	269.82	323.07	331.68	377.78
(1967=100)		Change	2.03	-5.43	-8.54	-11.65	-13.92	-11.35	-16.69	-21.69	-27.73	-34.36	-39.63
		Percent change	1.31	-2.93	-4.00	-5.58	-7.24	-6.09	-7.34	-8.04	-8.58	-10.36	-10.49
Real Livestock Product	l^s	Base	262.00	248.22	249.20	255.12	278.04	277.85	278.21	246.61	243.42	239.26	253.56
Supply		Change	-1.45	-1.98	1.71	2.25	3.52	4.00	2.79	4.05	5.11	5.91	6.98
Mil. Dol. (1967=100)		Percent change	-0.55	-0.80	0.69	0.88	1.27	1.44	1.00	1.64	2.10	2.47	2.75
Domestic Demand for	l^d	Base	267.27	253.60	251.84	255.86	277.66	275.81	278.56	247.02	243.39	236.22	252.32
Livestock Products		Change	-1.45	-1.98	1.71	2.25	3.52	4.00	2.79	4.05	5.11	5.91	6.98
Mil. Dol. (1967=100)		Percent change	-0.54	-0.78	0.68	0.88	1.27	1.45	1.00	1.64	2.10	2.50	2.77
Livestock Product	P^l	Base	136.51	180.94	193.49	195.88	178.91	192.39	225.24	303.70	336.91	367.44	370.48
Price Index		Change	1.61	-1.10	-5.79	-8.27	-10.74	-9.00	-11.91	-17.26	-20.26	-23.47	-32.34
(1967=100)		Percent change	1.18	-0.61	-2.99	-4.22	-6.01	-4.68	-5.29	-5.68	-6.01	-6.39	-8.73
Total Farm Cash	Y^a	Base	62989	83004	85520	90686	93302	103463	122276	147960	159933	172200	180678
Receipts		Change	- 905	- 956	-2257	-3169	-4817	-3777	-6315	-7865	-8129	-9852	-12686
Mil. Dol.		Percent change	-1.44	-1.15	-2.64	-3.49	-5.16	-3.65	-5.16	-5.32	-5.08	-5.72	-7.02

Reduction in the level of money supply increases the value of the dollar. This higher value makes U.S. farm products more expensive in the foreign market and leads to a decline in exports. In the simulation, net crop exports in 1982 decreased by 29.95 percent. That same year the crop price declined by 10.49 percent, a drop triggered primarily by the reduced demand for U.S. products from abroad. Because of this lower crop price, the equilibrium quantity of domestic demand and stock demand increased by 13.35 percent and 3.54 percent, respectively.

Turning to the livestock sector, the livestock product supply increased by 2.75 percent because of lower feed prices. The increase in livestock product supply decreased prices by 8.73 percent, which led to an increase in livestock producer demand of 2.77 percent.

More important, and as expected, cash receipt declined by 7.02 percent in 1982. Clearly, these results show that a contractionary monetary policy has an adverse effect on the farm economy, leading to a decrease in farm prices and incomes.

In reviewing the results of this simulation analysis, several observations are suggested. First, and most important, the exchange rate has significant effects on farm commodity trade. Upward pressure on the U.S. dollar seriously affects the competitive position of U.S. exports in international markets. For sectors such as agriculture that are heavily dependent on the export market, the results could be disastrous; the experiences of recent years bear this out. Furthermore, the effects of the exchange rate spill over to the domestic market: agricultural commodity exports largely determine farm prices, which have significant influence on domestic demand, stock inventories, and production levels.

Second, considering the current farm financial crisis, the effect of the interest rate on the farm sector is crucial. The higher interest rate, caused by the tight monetary policy and an alarming budget deficit, is frequently blamed for the recent farm financial crisis. The evidence in this analysis suggests that higher interest rates do significantly influence farm supply and inventories.

Third, a lower rate of inflation might seem to help the farm sector by way of decreasing input prices. However, a closer examination of a contractionary monetary policy aimed at lower inflation reveals a downward pressure on farm prices and incomes. This is because such a policy action, in addition to lowering inflation, causes the values of the dollar and the interest rate to rise and income to fall. These latter three changes do not seem to favor the farm sector. Thus, the results provide evidence to support Starleaf, Meyers, and Womack's (1985) argument that farmers are hurt by deflation.

Fourth, weak economic growth resulting from a tight monetary policy has a negative impact on the farm economy, because it reduces domestic demand for farm products.

Finally, and most important to the study at hand, specification of a complete set of linkages between the general economy and the agricultural sector captures more fully the effect of money supply change on the farm sector. This type of specification seems to have been absent in most previous empirical studies.

Conclusions and Implications

The empirical findings for effects of U.S. monetary policy on the farm sector, as shown in simulation experiments with the model, can be summarized as follows:

1. In the model, all the estimated coefficients of the variables related to the macrolinkages bear the anticipated signs, and most of them are statistically significant. These provide evidence for the hypothesis that macroeconomic developments are important to U.S. agriculture.

2. The exchange rate was endogenized using a monetary approach to exchange rate determination. All the explanatory variables (money supplies, real incomes, and interest rates of both the United States and the ROW) in the exchange rate equation have the expected signs and are highly significant. Therefore, the results lend support to the monetary approach, implying that the value of the exchange rate is determined by the money markets both in the United States and the ROW.

3. The simulation experiments suggest that the exchange rate has an important impact on U.S. crop exports. Furthermore, this trade effect spills over to the domestic market through crop prices. For example, an easy monetary policy increases U.S. crop exports by depreciating the value of the U.S. dollar. Because availability is practically fixed in the short run, these increased crop exports initially will tend to crowd out domestic usage. Furthermore, higher prices will lead to profit taking on inventory holdings, and, hence, a drawdown of stock levels; domestic disappearance can be expected to decrease as the own price of the commodity increases.

4. The effects of interest rate changes are captured in the supply of farm products and in the stock inventory demand. The higher interest

rate, caused by the tight money policy and budget deficit, is frequently blamed for the recent farm financial crisis. The evidence in this analysis suggests that the higher interest rate has an adverse effect on the farm sector, since farmers pay higher interest on their production loans and other operating expenses.

5. At first glance, the policy designed to meet commonly accepted macroeconomic objectives--that is, lower inflation--might seem to benefit the farm sector through lower farm input prices. But a closer examination of this monetary policy reveals that there is a downward pressure on the farm prices and incomes. Thus, the results in this study provide evidence for the hypothesis that farmers are not benefited by deflation.

6. An overall increase in the output of the economy favors the farm sector, because such an increase leads to higher disposable income and increased demand for farm products.

7. Expansionary monetary policy has a positive impact on the farm sector. An expansion in the level of the money supply increases farm prices and incomes through the four macrolinkages on which this study has focused. On the other hand, simulation results indicate a tight monetary policy has an adverse effect on the farm sector by decreasing farm prices and incomes.

The implication for policy purposes of this analysis is that the performance of U.S. agriculture largely depends on the macroeconomy, in that the agricultural sector is closely related to and integrated with the general economy. Therefore, nonagricultural phenomena such as the exchange rate are likely to have a significant impact on the farm sector. Since U.S. agriculture is heavily dependent on the nonfarm sector, and is also export sensitive and capital intensive, the combined effects of a strong U.S. dollar, high real interest rate, lower inflation, and weak economic growth will have devastating effects on the farming industry. Furthermore, the evidence indicates that policy actions that are usually seen as benevolent, or anti-inflationary, instead may seriously injure the overall position of agriculture relative to other sectors. The results indicate that the effects of monetary policies on the farm economy are too large to be ignored; macroeconomic developments need to be seriously considered in the evaluation and selection of agricultural policies.

Directions for Further Research

The performance of this model depends on the specification and econometric estimation of the structural equations. Although the model deals with highly aggregated data, the empirical results are encouraging--they suggest the feasibility of estimating the effects of changes in monetary policies on the farm sector in a general equilibrium framework. This study probably should be regarded as an empirical exercise based on a conventional theoretical model, an approach potentially fruitful for U.S. agricultural sector analysis. However, several aspects of the empirical implementation of the model merit development in future research.

Farm input demands--fertilizer and feed demands--are linked to crop and livestock product supply through their respective input prices. A useful extension would be to fully endogenize these factor markets. Labor markets in the farm sector were not examined in this study. Since a significant portion of farm income comes from nonfarm employment, adding the labor market would be a major improvement.

Since the factor market was not endogenized here, the total cost of production was not determined, and the impact of monetary policy was examined only on the total cash receipts, not on the net farm income. Endogenizing the factor market would allow analysis of the impact of monetary policy on net farm income, a key performance variable of the farm sector. However, this study does examine the effect of monetary policy on farm production, demand, exports, and inventory stocks.

Whereas the crop sector in this study includes export and inventory markets, in addition to domestic demand and supply, the livestock sector does not. Addition of these two markets in the livestock sector would enable better analysis of the impact of monetary policy on the farm sector.

In analyzing these results, however, it is worth noting that the model was designed specifically to examine the impacts of monetary policies on the agricultural sector. A further extension would be to modify the model to examine the effect of fiscal policies. Investment feedbacks between farm and nonfarm sectors are limited in the current model, in that investments were included mainly to account for gross national product identities rather than to provide additional linkages between the two sectors.

Even though this study examines the effects of the interest rate linkage on the commodity market, the financial market and wealth effects are not fully incorporated. Considering the implications of monetary policies on the financial market, inclusion of the financial market in the model would improve the performance of the model significantly.

Because aggregate data were used, the model can be applied to analyze the effect of macropolicies on aggregate variables, such as crop price, farm income, etc. However, the model can be disaggregated to include important crop and livestock products. Such disaggregation would lead to a more accurate analysis of macropolicies on individual farm products.

APPENDIX

To illustrate the use of grafted polynomials in the estimation of the exchange rate equation in chapter 3 (eq. 3.25), the time series of the exchange rate is divided into three segments: (1) fixed exchange rates (1950-1971), (2) an adjustment period (1972-1973), and (3) flexible rates (1974-1982). These three segments are joined together by a grafted polynomial variable δ, as defined below:

$$\delta = 0, \text{ year} \leq 1970;$$
$$\delta = \text{year} - 1971, \; 1971 \leq \text{year} \leq 1973;$$
$$\delta = 3, \text{ year} \geq 1974.$$

Under the fixed exchange rate regime, many countries pegged their currencies to the U.S. dollar. For example, member countries of the International Monetary Fund pegged their currencies on a collective basis to the U.S. dollar, and that is why the exchange value of SDR to the dollar was one prior to 1971. Even though the flexible exchange rate system was officially adopted in 1973, many countries began the year before to revalue their currencies against the U.S. dollar, thereby breaking away from the fixed rate system. Under the current flexible regime, monetary factors in the U.S. and the ROW are the determinants of the exchange rate.

Equation 3.25 uses the monetary approach to exchange rate determination. The grafted polynomial variable (δ) is defined such that when all the explanatory variables in equation 3.25 are multiplied by the δ, and δ also is included as a separate regressor, the resulting equation (given below) explains the movements in the exchange rate only after 1971.

$$e_t = \Psi_{24,t}[\delta_t, \delta_t \cdot M_t^s, \delta_t \cdot M_t^{s,f}, \delta_t \cdot S_t,$$
$$\delta_t \cdot Y_t^f, \delta_t \cdot r_t, \delta_t \cdot r_t^f, z_{25,t}]$$

Denbaly (1984) used a similar approach to endogenize the exchange rate. The estimated results of the modified exchange rate equation meet the theoretical expectations given in chapter 3. All the coefficients have the anticipated signs. In addition to the t-statistics obtained from the SAS printout, adjusted t-statistics are also reported. The actual t-statistics are adjusted for the degrees of freedom, since all the explanatory variables have zero values prior to 1971.[1] The adjusted or corrected t-statistics are smaller because of the smaller degrees of freedom, but they are still statistically significant.

ENDNOTES

Chapter 2

1. The nominal interest rate in the ROW, r_t^f, is represented by the average interest rates of West Germany, Canada, the United Kingdom, Italy, and France. These countries' currencies are among the most important in influencing U.S. capital flows.

Chapter 3

1. The computer program used for the estimation was SYSNLIN of SAS/ETS(SAS 1982).

Appendix

1. Adjusted t-statistics = actual t-statistics $* \sqrt{\frac{n_1 - k_1}{n - k}}$, where n - k is the original degrees of freedom and $n_1 - k_1$ is the corrected degrees of freedom. In this case, $n_1 - k_1$ is equal to 3(11 - 8).

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