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The impacts of monetary policies on US agriculture

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The impacts of monetary policies on U.S. agriculture

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CHAPTER I. INTRODUCTION

The Problem

A representation of the agricultural sector was a major component of the early macroeconometric models developed by Klein and Goldberger in the 1950s. Since that time, accepted macroeconomic theory and the theory of the macroeconomics of agriculture have followed separate paths of development. Schuh (1974) has called attention to this dual evolution by noting that the sectoral emphasis in agriculture has resulted in the neglect of the linkages of agriculture with the rest of the economy. Schuh (1979) further indicated that the agricultural commodity markets can no longer be understood in isolation from the capital market and other monetary factors either domestically or internationally. The need for improved econometric models to capture the possible interactions between the macroeconomy and agriculture was suggested by Fox (1973).

These two economists' suggestions and the recent effects of the macrovariables, such as the exchange rate, on the farm sector have led to an increasing awareness among economists of the importance of the performance of the agricultural sector in relation to the macroeconomy, and conversely, of the effects of macroeconomic performance on agriculture (see for example, King, 1975; Popkin, 1975; Roop and Zeitner, 1977; Johnson, 1977; Just, 1977; Chambers, 1981; Penson and Hughes, 1979; Van Duyne, 1979; Gardner, 1981; Starleaf, 1982; and McCalla, 1982).

Despite the fact that a number of agricultural sector models have been developed specifically for inclusion within a large macromodel (e.g., Cromarty, 1959), these models are not entirely satisfactory because the linkages between the macroeconomy and agriculture are either missing or specified inadequately. Furthermore, macromodel builders include agriculture as a satellite model in the macromodels. 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 the farm and nonfarm sectors through the macrovariables are not properly recognized.

The increased integration of the U.S. farm sector with the nonfarm sector during the past decade, both domestically and internationally, led to significant implications for farm product prices, input costs, and farm income from developments in international and/or domestic economies. This is true, especially in light of the effects of exchange rates, interest rates, and inflation, all of which are influenced by macroeconomic policies and capital markets, on the farm sector.

Schuh (1983) argues that the value of the dollar in terms of other currencies is very 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 which has a significant influence on the farm income through the cost structure of the farm sector. Chambers (1984) emphasized the importance of interest rates on agricultural production. To date, however, no empirical work has been done to address 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 which 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 the farm products.

From macrotheory, we know that these four macrovariables--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.

Objectives of the Study

Given the statement of the problem, the objectives of this research are:

1. To develop a general equilibrium econometric model of the U.S. to investigate the relationships between the macrosector and agriculture through exchange rates, interest rates, inflation, and income linkages.

2. To examine, through these four linkages, 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 incomes.

3. To evaluate and draw policy implications from the empirical findings.

The present study is organized as follows: Chapter II presents a brief review of the relevant literature and the limitations of the past studies. In Chapter III, possible macrolinkages with agriculture and the transmission mechanisms are illustrated. The theoretical model is developed in Chapter IV to capture the impact of the monetary policies on the U.S. farm sector. Chapter V presents the appropriate estimation procedure, the final estimated equations, interpretations of the results, and validation of the model. Chapter VI is devoted to dynamic simulation and policy analysis. Conclusions and implications of the study and suggestions for further research are presented in Chapter VII.

CHAPTER II. REVIEW OF THE LITERATURE

A 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 higher prices. Several other observers have argued that expansion in the U.S. and global money supply caused inflation, which was transmitted among countries and also raised both industrial and agricultural prices. Schuh (1974) suggested that the dollar devaluation was an omitted variable in these explanations. These arguments gave impetus to research to explore possible interrelationships among the agriculture, domestic, and international economies. In this chapter, past studies on the effect of exchange rates, interest rates, inflation, monetary policies on the farm sector, and previous farm sector models dealing with macroconnections are briefly reviewed.

Exchange Rates and Agricultural Commodity Trade

Like most relatively new areas of research where there is not even common agreement on what are the important problems, the relationship between exchange rates and agricultural trade has been the subject of a somewhat controversial literature. Schuh (1974) was among the first to suggest, using the induced technical change model of Hayami and Ruttan, that the magnitude of the exchange rate could have important implications for agricultural trade. Following Schuh's article, there appeared a series of theoretical and empirical studies to investigate the relationship between the exchange rate and agricultural commodity trade. Much of the literature since 1974 has revolved around two issues--the first is the size of the exchange rate elasticity of foreign demand for U.S. farm products and the second is related to endogenizing the exchange rate. In this section, in addition to a brief review of this literature, inclusion of the exchange rate in this study is examined.

Vellianitis-Fidas (1975) concluded from her econometric studies that U.S. farm exports are inelastic with respect to the U.S. exchange rate and the effect of exchange rate changes on agricultural exports and, therefore, on domestic prices of traded agricultural goods, is minimal. The appropriateness of the econometric procedure, because of the simplistic nature of the model used by Vellianitis-Fidas, was criticized by Schuh (1975). Using a two-country, one-commodity, free trade partial equilibrium analysis, Kost (1976) analyzed the impact of the exchange rate on U.S. agriculture. He argued that a devaluation would generate relatively larger changes in price than in quantity traded because of the inelastic demand and supply of farm products and concluded that a change in the exchange rate will have only a small impact on agricultural trade.

Bredahl (1976) considered elasticities of excess supply and excess demand in analyzing the effect of a devaluation on agricultural exports. Bredahl's calculations suggested that the effect on the quantity of exports for a change in the exchange rate is large when both the elasticities are relatively large and the elasticity of price with respect to the exchange rate has no a priori lower bound.

Tweeten (1967) calculated the price elasticity of the total export demand for U.S. agricultural commodities to be -15.9. However, after considering world trade restrictions, it was reduced to -6.3. Bredahl, Meyers, and Collins (1979) argued that the government policies of major importers of U.S. commodities should be incorporated to arrive at a realistic estimate of the elasticity. They concluded that Tweeten's estimate of the elasticity of excess demand is very high and simply not "in line with what is known about the world with insulated agricultural markets."

Chambers and Just (1979) argued that excess demand and supply equations must include all prices and income, since neo-classical 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, an important point to note is the magnitude of the elasticity of the U.S. farm exports with respect to the exchange rate, since it is very crucial in analyzing the effect of money supply on the farm commodities trade through the exchange rate.

The second and vital issue in agricultural trade modeling is whether the exhcange rate should be endogenized or not. Schuh (1981) gave the following reasons for endogenizing the exchange rate. Suppose that the U.S. government wants to undertake an expansionary monetary policy. Then, the increase in money supply will depreciate the U.S. dollar, leading to a higher import 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 U.S. dollar, leading to a reduced import demand for U.S. farm products by the ROW. 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 exchange rate was 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 U.S. and the ROW, according to a monetary approach to exchange rate determination. Therefore, any change in the money supply in the U.S. and ROW will change the value of the exchange rate, i.e., the value of the U.S. dollar. Hence, exchange rates under flexible regime can no longer be considered as an exogenous variable.

Shei (1978), in his doctoral thesis, investigated the impact of the money supply and the exchange rate on the agricultural sector. Since the exchange rate was assumed to be fixed in his model, the link between the money supply and 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.

From the foregoing review of the exchange rate literature, two crucial points to be considered with respect to empirical measurement of the 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. In this study, efforts are taken to meet these two requirements by proper specification of agricultural trade functions and by endogenizing the exchange rate using the monetary approach to exchange rate determination (explained in Chapter IV).

Interest Rates and U.S. Agriculture

Although the literature on the macroeconomics of agriculture is fairly large, relatively little attention has been given to the effect of other monetary factors, besides the exchange rate, such as interest rates on the U.S. farm sector. Past studies (Schuh et al., 1980; Chambers, 1983, 1984) emphasized the importance of the 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 have effect on farmers' decision to borrow credit. Economists believe that the recent farm financial crisis of 1983 and 1984 was caused by higher interest rates, which were the result of alarming budget deficits coupled with the tight monetary policy pursued by the Federal Reserve authorities (see Harl, 1984). In this study, effort has been made to empirically measure the passthrough effect of real interest rates from the general economy to the farm sector, specifically on agricultural production, inventory, and investment decisions.

Inflation and U.S. Agriculture

The impact of general price inflation on the farm sector is a subject in dispute. Starleaf, Meyers, and Womack (1985) present strong evidence that farmers are benefitted by an acceleration in the rate of general price inflation. They showed that short-run movements in the rate of increase in price paid by farmers have generally been accompanied by larger short-run movements in the rate of increase in prices received by farmers, i.e., farm-output price inflation tends to react quicker and sharper than farm-input price inflation and, thus, the terms of trade of farmers (the ratio of price received to price paid by farmers) improves (diminishes) 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 national inflation raised prices paid by farmers more than it raised price received by farmers and, thus, worsened the terms of trade (see Tweeten, 1983, 1980; Tweeten and Griffin, 1976).

Chambers, in his discussion on Tweeten's paper (1983), suggests that specification of models involving simple OLS regression may be inadequate to study the effect of inflation on the farm sector.

In this study, a general equilibrium approach has been taken to analyze the effect of monetary policy, via inflation as one of the macrolinkages, on U.S. agriculture. More specifically, the effect of inflation caused by money supply increase is incorporated as cost-price effect in the farm input demand equation.

Monetary Policies and the U.S. Farm Sector

Starleaf (1982), by examining the macroeconomic policies and their impact upon the farm sector, summarized his results as, "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." Further, he indicated several instances when monetary policy actions appear to have had an impact upon the macroeconomy and the farm economy. For example, the money stock growth rate was nearly cut in half between early 1969 and early 1970, which led to a decline in the real output of the nonfarm economy and also in the farm output price level. Starleaf's emphasis on key relationships between macropolicies and the farm sector is very 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, income, etc. Because he treated the exchange rate as exogenous, the link between the money supply and 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 statistical technique, Paggi (1984) concluded that there is no significant relationship between changes in the rate of growth in the domestic money supply and wheat or corn exports at the .05 level. However, the relationship between wheat exports and changes in the rate of growth in M1 is statistically significant at the .10 level, and finally he summarized his results as 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, i.e., agricultural prices and exports both decrease in the long run by a larger percentage than the original decrease in the money supply. However, as they correctly pointed out, their study linked the agricultural markets to the monetary sector only through exchange rate; interest rates and inflation macrolinkages were not included.

Chambers (1984), in a recent study, 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. However, his model is of a short-run nature and not capable of addressing long-run outcomes of policy change. He also shows 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. Since his model is a trade model, he considered only the exchange rate macroconnections.

As explained earlier, in this study a macroeconometric general equilibrium model is formulated to analyze the impact of U.S. monetary policies on the agricultural sector through four macroconnections, viz, exchange rates, interest rates, income, and inflation.

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. Nevertheless, in these models the agricultural sector is being modeled as a satellite system with a very minimal degree of interface between farm and nonfarm sectors. Penson (1982) classifies these models into first, second, and third generation models 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. Agriculture in these stand-alone models is influenced by relatively few macroeconomic variables, such as disposable income and the implicit price deflator. Representatives of first generation models include the aggregative income and wealth (AIW) simulator model developed by Penson (1973), the polysim simulator reported by Ray and Richardson (1978), the capital and credit simulation model developed by Melichar (1972), and the agricultural sector modeling of Duloy and Norton (1973). First generation models 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

The second generation models develop forecasts in a recursive framework. An economy-wide macroeconometric model is first used to forecast a set of macroeconomic variables which appear in the agricultural sector equations. This information is then used to solve the agricultural sector equations. Finally, the solution values for a selected number of agricultural 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 of the intersectoral relationships and policy instrument variables that are of importance. However, their models did 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 their failure to include explicit variables to represent sector policies. Such policy instruments as acreage diversion, price supports, and loan rates are neglected. Moreover, these modeling efforts generally treat the international sector as exogenous, i.e., exports are determined exogenously.

<u>Third generation models</u>

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 the agricultural outcomes simultaneously with outcomes in other sectors. Among the first of these models is the 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 the exchange rate linkage and other linkages were neglected. Moreover, many agricultural sector policy instrument variables were not included in the model. Lamm (1980) developed an aggregate model of the U.S. economy. Because Lamm's model is a closed economy model, the ROW import and export demands are assumed to be exogenous; therefore, the model ignores the important macrolinkage, i.e., the 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 the financial linkages and little care was taken on the exchange rate determination process. Freebairn, Rausser, and Gorter (1982) developed a model to analyze the forward and backward links between the agricultural and general economies. Since they used the OLS technique for the 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, which according to Johnson (1977) does not explain the macroconnections adequately.

The foregoing review of literature on modeling of farm and nonfarm sectors suggests that what is missing is an integrative approach to investigate the impact of (1) exchange rates, (2) interest rates, (3) inflation, and (4) income on the farm sector. As mentioned earlier, this study attempts to analyze the impact of monetary policies on the farm sector through these four linkages in a general equilibrium framework.

CHAPTER III. TRANSMISSION MECHANISMS BETWEEN THE MACROECONOMY AND AGRICULTURE

This chapter establishes the basic interfaces among agriculture and international and domestic economies, an understanding of which is crucial in developing the theoretical model in the next chapter. The important macrolinkages considered in this study 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 productions, and (4) the income effect on demand for farm products (see McCalla, 1982, and Hughes and Penson, 1981, for further details on macrointerconnections).

Suppose the government conducts an expansionary monetary policy to stimulate the growth of the economy. From macrotheory, we know this policy action will put upward pressure on the general price level, downward pressure on the exchange rate and the interest rate, and 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 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 the capital outflow, as the domestic interest rate decreases because of the easy monetary policy. The consequence of dollar depreciation is to provide stimulus to dollar exports, leading to an increase in the demand for the U.S. farm exports (trade effect). A number of empirical studies on the effect of exchange rates on agricultural commodity trade have been done (see the section on exchange rate and agricultural commodity trade in Chapter II). These studies mainly analyzed the effect of a dollar devaluation on U.S. exports in a partial equilibrium framework. They did not investigate the effect of the current determinants of the floating exchange rate on agricultural commodity trade. In a later study, Chambers and Just (1982) endogenized the exhcange 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. Devadoss (1983) developed a theoretical macroeconometric model to analzye the impact of money supply on U.S. agriculture by endogenizing the exchange rate using monetary approach to exchange rate determination process. 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 world coarse grain market.

Interest Rate Effects (Stock and Cost Effects)

Downward pressure on interest rates because of an easy monetary policy can affect the farm sector in two ways. First, a lower interest rate will reduce the cost of production loans which in turn helps to lower the cost of production and thereby increases farm supply (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, and thereby increase the demand for stock inventories (stock effect). As mentioned before, there have been no empirical studies which analyzes the effect of interest rates on farm demand and supply. However, the importance of the changes in the domestic interset rate and its implications on the farm sector was emphasized by Schuh et al. (1980), Chambers (1983, 1984), and Freebairn et al. (1982).

Inflation Effects (Cost Effects)

The growing dependence of U.S. agriculture on other sectors for inputs has resulted in the general economy price directly influencing returns to agriculture. A monetary-policy induced higher general price level will increase the cost of nonfarm inputs such as machinery, fertilizer, fuel, etc., leading to a reduction in the supply of farm products (cost effect).

Income Effects

In addition to the above-mentioned effects, there is also the demand (or income) effect. An economic upswing due to an expansionary monetary policy increases the growth of per capita income, which leads to a higher demand for high-income-elasticity goods (e.g., meats) which thereby increases the domestic demand for farm commodities.

In summary, an easy monetary policy will increase the aggregate demand through trade, stock, and income effects (see Figure 3.1). On the other hand, farm supply might decrease due to a higher cost of farm

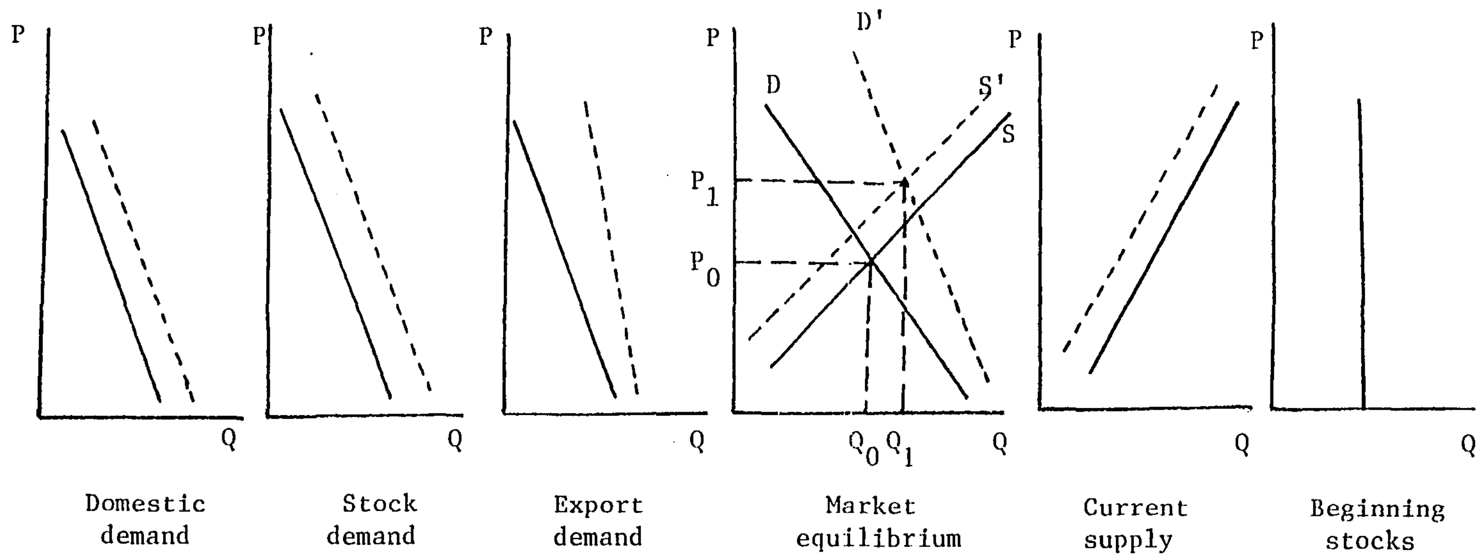


Figure 3.1. The effect of money supply increase on the farm sector (a case of decline in the farm supply)

inputs (Figure 3.1) or it might increase due to lower costs of production loans (Figure 3.2). In the first case (decrease in supply), the effect of an increased money supply is to raise farm prices, domestic demand, exports, and inventories. However, the effect on farm income (price x quantity) is not clear, because a larger decline in supply might decrease the equilibrium quantity. In the second case (increase in supply), the effect of an expansionary monetary policy is to increase the domestic demand, exports, and inventories, but the effect on the price and farm income is ambiguous, even though the equilibrium quantity will be higher now. Past studies have shown that expansionary monetary policies will increase farm prices. If that is the case, then farm income will also increase. A similar analysis can be conducted for tight monetary policy.

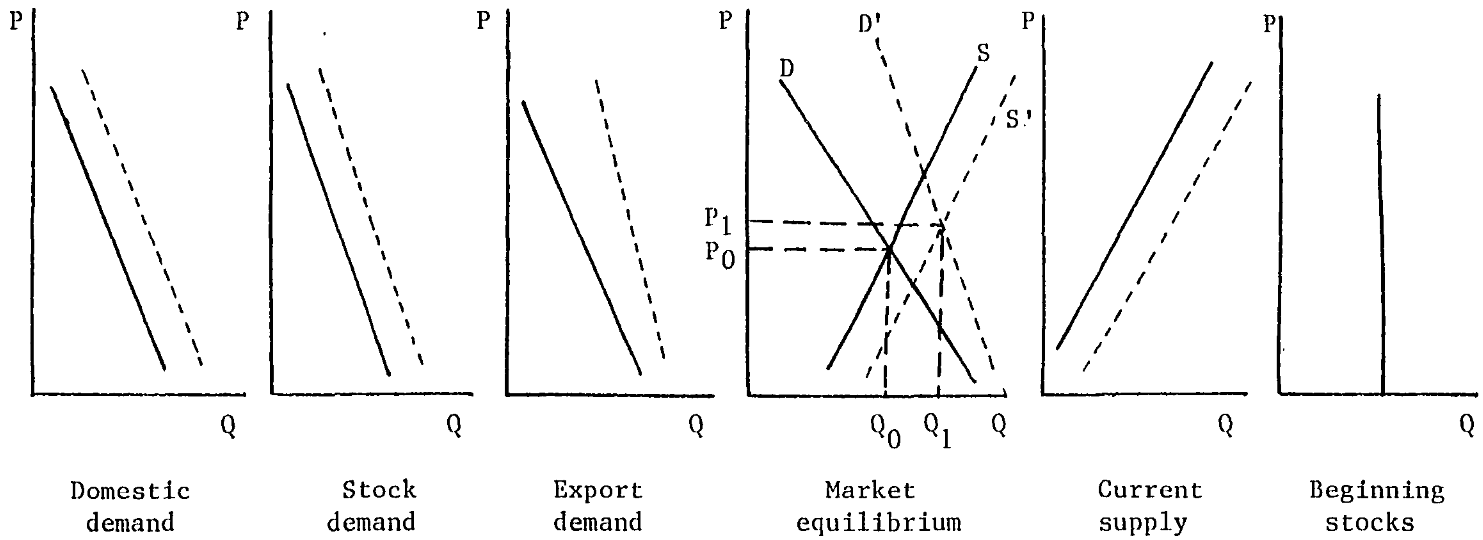


Figure 3.2. The effect of money supply increase on the farm sector
(a case of increase in the farm supply)

CHAPTER IV. METHODOLOGY

The previous chapters have provided an overview of the current literature on the effect of monetary factors on the farm sector, the various macrolinkages between the general economy and the agricultural sector, and previous farm sector models. The present chapter is an attempt to weld these concepts into an econometrically estimable model that can be used to empirically investigate the impact of money supply changes on the agricultural sector.

First, the general equilibrium structure of the macroeconomy and farm sector is schematically summarized in Figure 4.1, which is a flow diagram of the model. Following this illustration, a mathematical conceptual model is developed to describe the theoretical foundation, variable specifications, and expected signs of variables in each equation.

Graphical Representation

Figure 4.1, which is a self-explanatory flow chart, provides the macroconnections within the model. The farm block of the model consists of the crop sector and the livestock sector. The crop sector is described by crop supply, demand, inventory, exports, input demand relationships, and an equilibrium condition. The 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. The livestock price, output, and

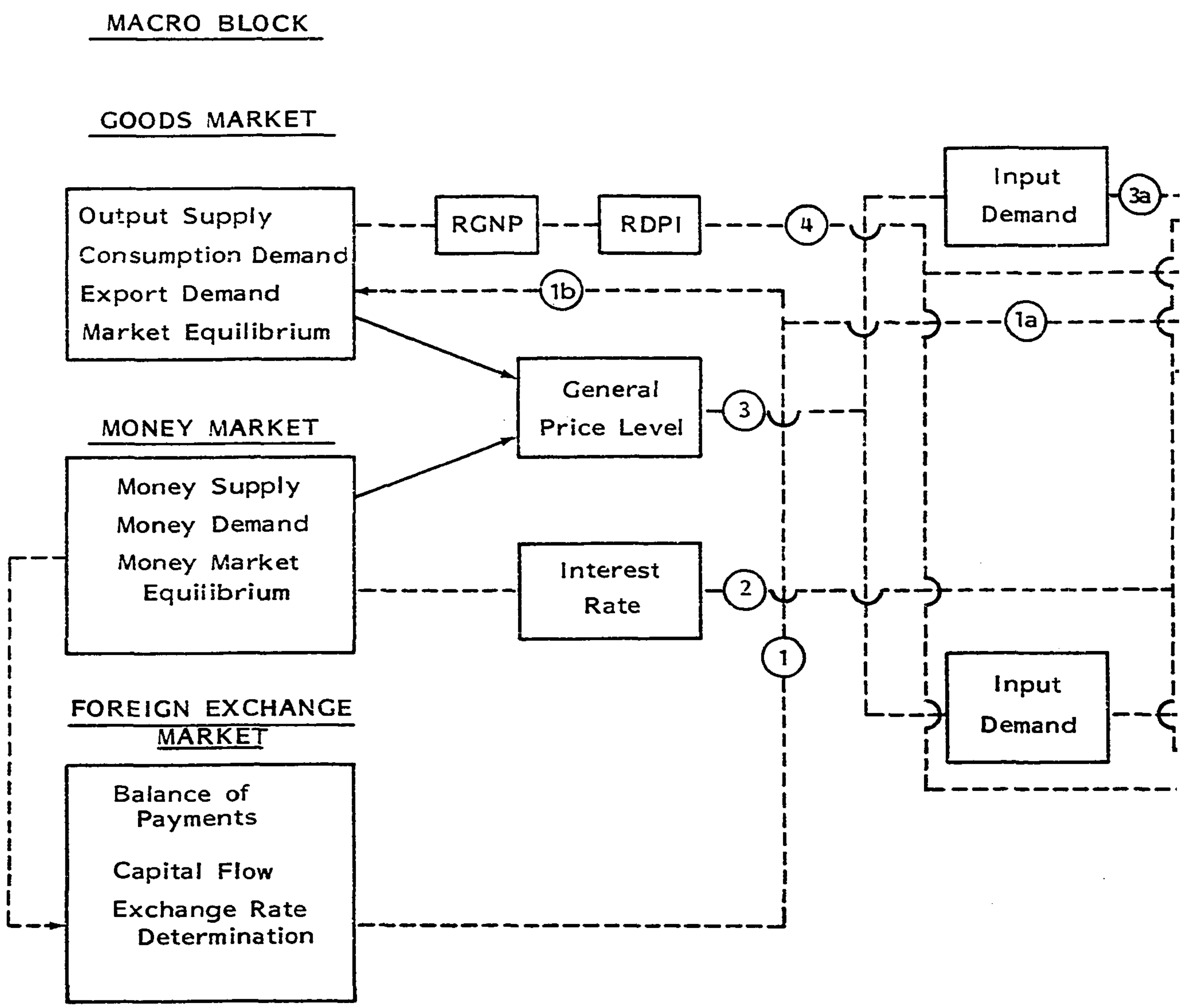
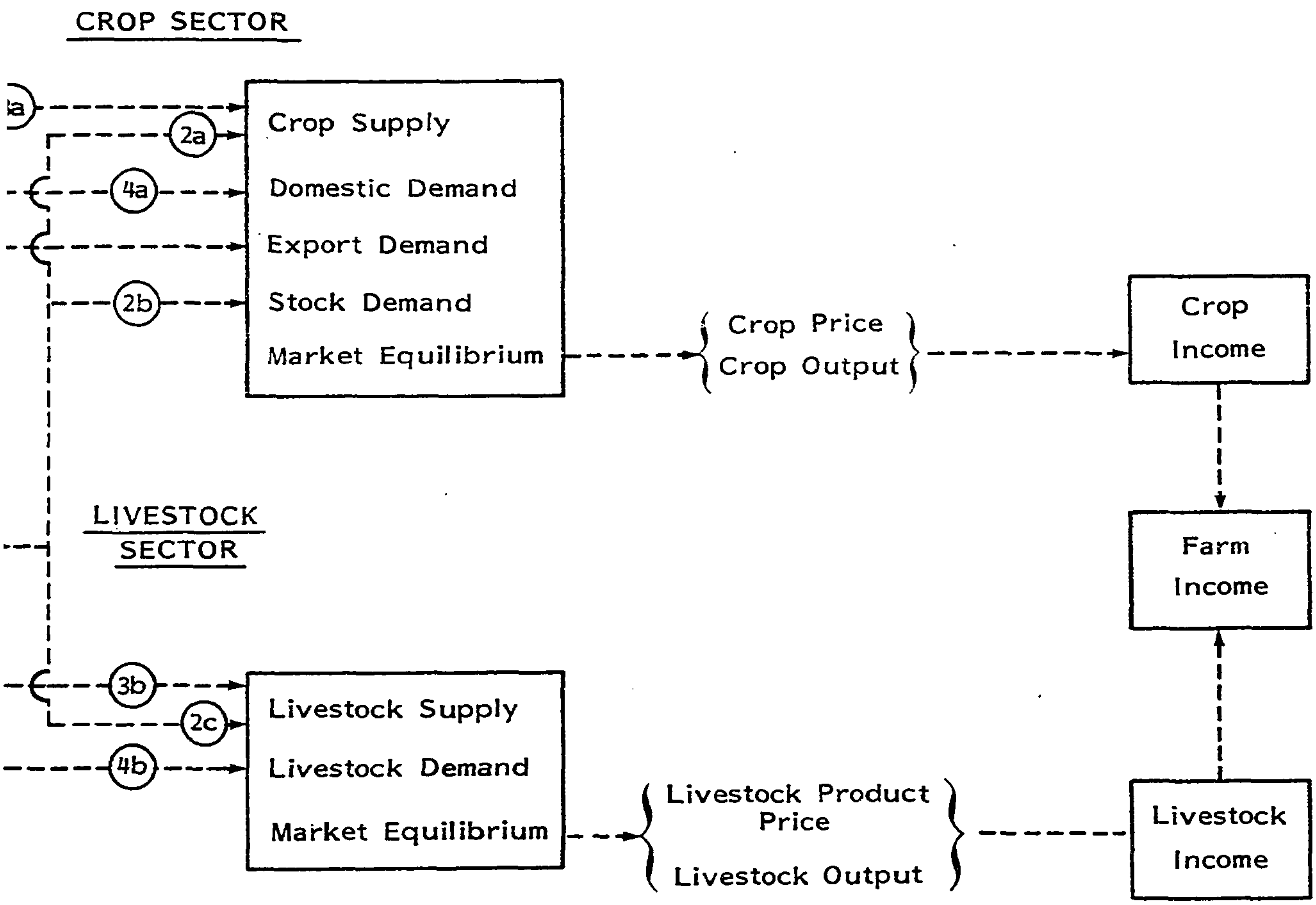


Figure 4.1 General equilibrium structure of the econometric model.

RGNP = Real gross national product

RDPI = Real disposable income

FARM BLOCK


CROP SECTOR
1a
2a
4a
2b
Crop Supply
Domestic Demand
Export Demand
Stock Demand
Market Equilibrium
Crop Price
Crop Output
Crop Income
Farm Income
LIVESTOCK SECTOR
3b
2c
4b
Livestock Supply
Livestock Demand
Market Equilibrium
Livestock Product Price
Livestock Output
Livestock Income

income are endogenously determined in the livestock sector of the model. The incomes from crop and livestock sectors add up to give the total income in the farm sector.

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

The transmission mechanisms described in Chapter III can be better understood with the aid of Figure 4.1. This schematic diagram explains the four channels--exchange rates, interest rates, inflation, and income, through which U.S. monetary policy influences agricultural commodity markets.

First, consider the exchange rate linkage. The monetary approach to exchange rate determination (explained in detail later in this chapter) uses the money markets both in the U.S. and in the ROW to determine the exchange rate. Therefore, changes in the money supply in the U.S., keeping 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 and manufactured goods exports (lines 1a, 1b). 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, and, hence, crop prices will tend to rise.

The second linkage is the interest rate linkage. As explained in Chapter III, the interest rate changes have two effects--cost effect and stock effect. The cost effect of a decrease in the interest rate due to an expansionary monetary policy is to reduce the cost of production because of the easy credit and thereby increase the supply of crop and livestock products (lines 2a, 2c). This increase in supply will put a downward pressure on the price levels. The stock effect of the lower interest rate is to increase the demand for stock inventories of crops, and, therefore, will tend to raise the crop price (line 2b).

The third linkage stems from the inflationary effect. The higher inflation is reflected as cost effect in the demand for inputs which 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 an upward pressure on the farm price levels.

The fourth linkage comes from the income effect. One of the goals of the monetary policy activism is to achieve a higher real output of the economy; which means increased total spending for the output of the economy. 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, activist monetary policy actions have an effect on the real output of the economy, which leads to a higher demand for farm products and thereby increases the farm prices (see Starleaf, 1982).

In summary, the forward macroconnections of an easy monetary policy are to augment the aggregate demand for farm products by increasing the domestic, stock, and export demands of the farm commodities (see Figures 3.1 and 3.2). The effect on the farm supply is not clear. The farm supply might decline due to higher costs of farm inputs or it might increase due to 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 equilibriums in Figures 3.1 and 3.2). However, recent studies have shown that an activist 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 as depicted in Figures 3.1 and 3.2.

Since the structure of the model involves an integrated treatment of the agricultural sector with the general economy, it is possible to analyze the effect of farm policies, such as price supports, acreage diversion on the overall economy, and, also, the feedback linkages from the farm sector to the nonfarm sector. These feedback linkages investigate the effect of the resulting endogenous variables in the agricultural sector on the general economy. For example, higher farm exports will help to reduce the trade deficit which will have an effect on the balance of payments. Similarly, the repercussions of the economic progress in the agricultural sector because of the increased farm income are to demand more of nonfarm products and thereby increase the price levels in the macroeconomy. In addition, the interrelationships between farm and nonfarm sectors establish a dynamic pattern of forward and feedback effects among prices, outputs, and incomes.

Mathematical Representation

The general equilibrium structure of the model illustrated in Figure 4.1 is described by an econometric model below. The model consists of behavioral relationships, identities, and variable specifications for the agricultural and general economies. 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 The real domestic supply of crops during a given year depends on the information available from the previous year, because the price to be received at harvest cannot be known at the time of planting. The available information includes lagged price of crops, lagged price of inputs used in production, lagged prices of alternative outputs (i.e., livestock products) which might be produced using the same factors of production, and others such as 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--price support and acreage diversion--have been demonstrated to be important determinants of U.S. aggregate crop output in previous studies.

$$\left(\frac{S^c}{P^c}\right)_t = F_1\Big[\overset{(+)}{\left(\frac{P^c}{CPI}\right)_{t-1}},\ \overset{(-)}{\left(\frac{P^I}{CPI}\right)_{t-1}},\ \overset{(-)}{\left(\frac{P^L}{CPI}\right)_{t-1}},\ \overset{(+)}{\left(\frac{P^S}{CPI}\right)_t},\ \overset{(-)}{V^a_t},\ \overset{(-)}{AD_t},\ \overset{(+)}{WH_t},\ Z_{1,t}\Big] \qquad (4.1)$$

where

P^c_t = the aggregate price index of crops,

S^c_t = the nominal value of aggregate supply of crops,

CPI_t = the consumer price index,

P^I_t = the aggregate price index of inputs used in crop production,

P^L_t = the aggregate price index of livestock products,

P^S_t = the support price index,

V^a_t = the real interest rate in agriculture, defined as $r^a_t - [(CPI_t - CPI_{t-1})/CPI_{t-1}]$; r^a_t 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.

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*$Z_{i,t}$ 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 usually assumed that demand for a commodity is determined as the result of consumers maximizing preference functions subject to budget constraints. Assuming that a consistent method of aggregating individual demand exists (Lau, 1977), the general disappearance equation can be written as:

$$\left(\frac{D^c}{P^c}\right)_t = F_2\Big[\overset{(-)}{\left(\frac{P^c}{CPI}\right)_t}, \overset{(+)}{\left(\frac{P^L}{CPI}\right)_t}, \overset{(+)}{\left(\frac{RDPI}{USPOP}\right)_t}, Z_{2,t}\Big] \qquad (4.2)$$

where

D_t^c = the nominal value of aggregate demands 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.

$$\left(\frac{I^c}{P^c}\right)_t = F_3\Big[\overset{(-)}{\left(\frac{P^c}{CPI}\right)_t}, \overset{(-)}{V_t^a}, \overset{(+)}{L_t^c}, \overset{(+)}{S_t^c}, \overset{(+)}{\left(\frac{I^c}{P^c}\right)_{t-1}}, Z_{3,t}\Big] \qquad (4.3)$$

where

I_t^c = nominal value of crop inventories, and

L_t^c = index of loan rates,

Crop exports The real value of U.S. crop exports 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.

$$\left(\frac{X^c}{PX^c}\right)_t = F_4\Big[\underset{(-)}{\left(\frac{PX^c}{CPI^f}\right)_t},\ \underset{(+)}{e_t},\ \underset{(+)}{\left(\frac{Y}{POP}\right)_t^f},\ \underset{(-)}{S_t^{c,f}},\ Z_{4,t}\Big] \qquad (4.4)$$

where

X_t^c = nominal value of net crop exports by the U.S.,

PX_t^c = aggregate export price index of U.S. crop exports,

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

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

$S_t^{c,f}$ = 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-á-vis the dollar gives a more accurate representation of the overall competitive position of the dollar and eliminates the need for construction of a basket index of exchange rates (see Chambers, 1979).

In equation (4.1), the exchange rate is considered a separate regressor, instead of being multiplied with the export price index. The justification is, based on Orcutt's suggestions, that including the exchange rate as a separate regressor would simplify the estimation procedure by avoiding nonlinearity. Secondly, both fixed and flexible exchange rate regimes can be incorporated in the model. Thirdly, it does not rely upon the purchase power parity condition, since the law of one price may very well not hold at the aggregate level (see, e.g., Isard, 1977).

Crop input demand The demand for inputs used in crop production is specified as:

$$P_t^I = F_5[\overset{(-)}{Q_t^I}, \overset{(+)}{CPI_t}, \overset{(+)}{P_{t-1}^I}, Z_{5,t}] \qquad (4.5)$$

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:

$$\left(\frac{S^c}{P^c}\right)_t + \left(\frac{I^c}{P^c}\right)_{t-1} = \left(\frac{D^c}{P^c}\right)_t + \left(\frac{I^c}{P^c}\right)_t + \left(\frac{X^c}{PX^c}\right)_t \qquad (4.6)$$

where

$\left(\frac{S^c}{P^c}\right)_t + \left(\frac{I^c}{P^c}\right)_{t-1}$ = current production + lagged inventories = total supply, and

$(\frac{D^c}{P^c})_t + (\frac{I^c}{P^c})_t + (\frac{X^c}{PX^c})_t$ = 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 last year, the real price index of livestock products, the real price index of feed, and the real interest rate.

$$(\frac{S^L}{P^L})_t = F_7[\overset{(+)}{(\frac{P^L}{CPI})_{t-1}}, \overset{(-)}{(\frac{P^F}{CPI})_{t-1}}, \overset{(-)}{V^a_t}, \overset{(+)}{H_{t-1}}, Z_{7,t}] \tag{4.7}$$

where

S^L_t = the real value of aggregate supply of livestock and livestock products,

P^F_t = 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:

$$(\frac{D^L}{P^L})_t = F_8[\overset{(-)}{(\frac{P^L}{CPI})_t}, \overset{(+)}{(\frac{P^c}{CPI})_t}, \overset{(+)}{(\frac{RDPI}{USPOP})_t}, Z_{8,t}] \tag{4.8}$$

where

D^L_t = the real value of aggregate demand for livestock products.

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

$$P_t^F = F_9[\overset{(-)}{Q_t^F}, \overset{(+)}{CPI_t}, \overset{(-)}{P_{t-1}^F}, Z_{9,t}] \tag{4.9}$$

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:

$$(\frac{S^L}{P^L})_t = (\frac{D^L}{P^L})_t - (\frac{M^L}{PM^L})_t \tag{4.10}$$

where

M_t^L = the real value of U.S. net imports of livestock and livestock products, and

PM_t^L = the import price index of livestock and livestock products.

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

The total income from crop and livestock production in the farm sector is computed as:

$$Y_t^a = P_t^c \cdot (\frac{S^c}{P^c})_t + P_t^L \cdot (\frac{S^L}{P^L})_t \tag{4.11}$$

$$S_t^a = \frac{Y_t^a}{P_t^a} \qquad (4.12)$$

where

Y_t^a, S_t^a = nominal and real agricultural income, respectively, and

P_t^a = the index of agricultural prices.

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

$$i_t^a = F_{13}[\overset{(-)}{V_t^a}, \overset{(+)}{S_t^a}, Z_{13,t}] \qquad (4.13)$$

where

i_t^a = real agricultural investment.

The investment in the farm sector along with the investment in the general economy form the total investment, which is needed to complete the GNP identity.

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.

$$r_t^a = F_{14}[r_t, r_{t-1}, \ldots, r_{t-j}, Z_{14,t}] \qquad (4.14)$$

where

r_t is the nominal interest rate in the general economy.

<u>General economy</u>

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

The specification of the real value of domestic supply of manufactured goods is based on Gordon (1970) and Shei (1978).

$$\frac{\dot{P}^m}{P^m_{t-1}} = F_{15}[\overset{(+)}{(\frac{\dot{W}}{W_{t-1}})}, \overset{(-)}{(\frac{\dot{PR}}{PR_{t-1}})}, Z_{15,t}] \tag{4.15}$$

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, and

PR_t = the aggregate productivity index in the industrial sector,

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

The $\frac{\dot{PR}}{PR_{t-1}}$ 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 U.S. has been carried out at the Brookings Institution by, e.g., Gordon (1975), Schultze (1971), and Wacher (1976). The following specification of the wage rate equation is based on the discussion of Wacher's and Gordon's studies.

$$\frac{\dot{W}}{W_{t-1}} = F_{16}\Big[\big(\overset{(+)}{\frac{\dot{HPM}}{HPM_{t-1}}}\big),\ \overset{(-)}{U_t},\ Z_{16,t}\Big] \qquad (4.16)$$

where

HPM_t = high-powered money or monetary base,

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

U_t = the unemployment rate.

The above equation 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 rate of unemployment reflects the downward pressure of excess demand in the labor market on the wage rate.

The consumption function for this sector is:

$$\left(\frac{C^m}{P^m}\right)_t = F_{17}\Big[\overset{(-)}{\left(\frac{P^m}{CPI}\right)_t},\ \overset{(+)}{\left(\frac{RDPI}{USPOP}\right)_t},\ Z_{17,t}\Big] \qquad (4.17)$$

where

C^m_t = the nominal value of per capita consumption of industrial goods.

The net exports of industrial goods is specified as a function of the ratio of price indices of the U.S. export price to the general price level in the foreign countries, the exchange rate, the per capita real income in the ROW, and the lagged value of net exports of industrial goods.

$$\left(\frac{X^m}{PX^m}\right)_t = F_{18}\left[\overset{(-)}{\left(\frac{PX^m}{CPI^f}\right)_t},\ \overset{(+)}{e_t},\ \overset{(+)}{\left(\frac{Y}{POP}\right)_t^f},\ \overset{(+)}{\left(\frac{X^m}{PX^m}\right)_{t-1}},\ Z_{18,t}\right] \tag{4.18}$$

where

X_t^m = the nominal value of net exports of industrial goods, and

PX_t^m = the aggregate export price index of industrial goods.

The market equilibrium for the industrial good is

$$S_t^m = \left[USPOP_t \cdot \left(\frac{C^m}{P^m}\right)_t\right] + \left(\frac{X^m}{PX^m}\right)_t \tag{4.19}$$

where S_t^m = real value of output in the industrial sector.

The investment in the manufacturing sector is defined as:

$$i_t^m = F_{20}[\overset{(-)}{V_t},\ \overset{(+)}{S_t^m},\ Z_{20,t}] \tag{4.20}$$

where

i_t^m = the real value of industrial investment,

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.

<u>Money market</u> The monetary sector, from which the macrolinkages originate, is the nucleus part 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.

$$\left(\frac{M^d}{CPI}\right)_t = F_{21}\left[\overset{(+)}{S_t}, \overset{(-)}{r_t}, \overset{(-)}{\left(\frac{M^d}{CPI}\right)_{t-1}}, Z_{21,t}\right] \tag{4.21}$$

where

M_t^d = the nominal money balances, and

S_t = the real gross national product.

The above demand function 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, i.e., international reserves and domestic credit, which can be written as:

$$M_t^s = m \cdot (D_t + R_t) \tag{4.22}$$

where

M_t^s = the nominal stock of money supply,

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:

$$m[D_t + R_t] = CPI_t \cdot F_{21}[S_t, r_t, (\frac{M^d}{CPI})_{t-1}, Z_{21,t}]$$

or

$$[D_t + R_t] = CPI_t \cdot F_{23}[S_t, r_t, (\frac{M^d}{CPI})_{t-1}, Z_{23,t}] \qquad (4.23)$$

where it is assumed that the money multiplier is constant so that it can be subsumed into the functional form of F_{23}.

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, left the relative prices unchanged. But, under a floating exchange rate regime, different rates of inflation exist among countries. Furthermore, under a flexible exchange 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 a 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 further 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 to note is that the channels through which the economy is stimulated are rather 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, there was little effect on the agricultural commodity trade. However, an easy monetary policy did stimulate 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 have to 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 U.S. and world bouts of inflation and recession 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

$$X_t^c - M_t^L + X_t^m + CAP_t + R_t + SD_t = 0 \qquad (4.24)$$

where

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 into the model by following the simplified portfolio capital approach used by Freebairn, Rausser, and Gorter (1982).

$$CAP_t = F_{25}[\overset{(-)}{V_t}, \overset{(+)}{V_t^f}, Z_{25,t}] \qquad (4.25)$$

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 approach (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. Thus, before proceeding with the formulation of exchange rate determination, a brief review of the monetary approach to exchange rate determination is presented below.

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. Combining the money market equilibrium and purchasing power parity condition we get, $M = eP^* \cdot L(y,r)$.

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

$$g_M = g_e + g_{P^*} + N_y g_y + N_r g_r .$$

---

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

and rearranging the terms

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

where g_k denotes the growth rate of subscripted variable k, and N_y, N_r denotes 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, i.e., 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 U.S. dollar; and an increase in the rate of growth of interest rate will cause the U.S. dollar value to decline.

The above equation 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 money market in the ROW 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 income and interest rates in the ROW.

Solving the money market equilibriums of the U.S. and ROW, and the purchasing power parity equation for the exchange rate,

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

writing the above function as:

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

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

$$e_t = F_{26}[\overset{(+)}{M_t^s}, \overset{(-)}{M_t^{s,f}}, \overset{(-)}{S_t}, \overset{(+)}{Y_t^f}, \overset{(+)}{r_t}, \overset{(-)}{r_t^f}, Z_{26,t}]. \qquad (4.26)$$

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., $\frac{\partial e}{\partial M_t^s} > 0$, e increases, since e is defined as \$/SDR). On the other hand, an increase in the ROW money stock puts an upward pressure on the value of the dollar (decline in e, $\frac{\partial e}{\partial M_t^{s,f}} < 0$). Given that income elasticity of money (N_y^{US} or N_y^f) is positive, an increase in the U.S. income (ROW income) will increase (decrease) the value of the U.S. dollar, respectively ($\frac{\partial e}{\partial S_t} < 0$, $\frac{\partial e}{\partial Y_t^f} > 0$). Since the interest rate elasticity of money demand (N_r^{US} or N_y^f) is negative, an increase in the U.S. interest rate (ROW interest rate) will put downward (upward) pressure on the value of the U.S. dollar, respectively ($\frac{\partial e}{\partial r_t} > 0$, $\frac{\partial e}{\partial r_t^f} < 0$).

Since the data period is from 1950-1982, this study includes both fixed and flexible exchange rate regimes. Under the fixed exchange rate system, the explanatory variables of the exchange rate equation had no effect on the exchange rate. In view of this fact, the grafted polynomial technique developed by Fuller (1976) will be used to estimate the exchange rate equation under both fixed and flexible exchange rate systems. A detailed discussion of this technique is given in the next chapter.

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, and 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 two international price linkages--for the crop export price and manufactured goods export price--are developed (see Shei, 1978).

$$PX_t^c = e \cdot P_t^c(1 + b_t^c), \qquad (4.27)$$

$$PX_t^m = e \cdot P_t^m(1 + b_t^c) \qquad (4.28)$$

where

b_t^c, b_t^m = the adjustment factors reflecting the difference in commodity composition of domestic and (net) export price indices for crops and industrial products.

The rationale for the above two linkages is that even under unchanging exchange rates the indices of domestic and export prices of each sector do not move exactly together due to imperfect aggregation.

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

$$CPI_t = F_{29}[\overset{(+)}{(\frac{M^s}{S})_t}, \overset{(+)}{(\frac{M^s}{S})_{t-1}}, CPI_{t-1}, Z_{29,t}]. \tag{4.29}$$

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

$$S_t = C_t + i_t + G_t + X_t, \tag{4.30}$$

$$CPI \cdot C_t = D_t^c + D_t^L + C_t^m, \tag{4.31}$$

$$CPI \cdot i_t = P_t^a \cdot i_t^a + P_t^m \cdot i_t^m, \tag{4.32}$$

$$PX_t \cdot X_t = X_t^m + X_t^c - M_t^L, \tag{4.33}$$

$$RDPI_t = S_t - TD_t \tag{4.34}$$

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,

PX_t = the aggregate export price index of all the goods, 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 Figure 4.1. The model is capable of investigating the impacts of the U.S. monetary policies on the farm sector through exchange rates, interest rates, inflation, and income.

CHAPTER V. EMPIRICAL ANALYSIS AND MODEL VALIDATION

This chapter consists of discussion of the estimation techniques, the data base, operational definition of the variables, results of the estimation, and the validation of the model.

Estimation

The mathematical structure of the model presented in Chapter IV 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 simultaneous equations system with autocorrelated error terms can lead to a nonlinear system (see Judge et al., 1982). In view of the nonlinearity nature of the model, nonlinear three-stage least square (N3SLS) was used for the final estimation of the model. The computer program used for the estimation is SYSNLIN of SAS/ETS (SAS, 1982).

N3SLS estimation procedure is a straightforward generalization of the linear three-stage least squares estimator. Gallant (1977) describes the simultaneous system consisting of M nonlinear equations as

$$q_\alpha(y_t, x_t, \theta^*_\alpha) = e_{\alpha t}, \ \alpha = 1, 2, \ldots, M, \ t = 1, 2, \ldots, n,$$

where y is an M by 1 vector of endogenous variables, x is a k by 1 vector of exogenous variables, θ^*_α is a P_α by 1 vector of unknown parameters contained in the compact parameter space Θ_α, and

$$e_{\alpha t} = (e_{1t}, e_{2t}, \ldots, e_{Mt})'$$

is the tM by 1 vector of residuals for the M endogenous variables stacked together. The N3SLS estimates the parameters by minimizing the generalized sum of squares of the residuals.

Gallant shows, if the following assumptions are satisfied and each equation in the model is identified, the N3SLS estimator is strongly consistent, asymptotically normally distributed, and more efficient than the nonlinear two-stage least squares estimator (N2SLS).

The assumptions are:

1) The moment matrix of the instrumental variables $(\frac{1}{n})z'z$ converges to a positive definite matrix P; where z is a k by 1 vector of instrumental variables.

2) The errors $\{e_{\alpha t}\}$ are independently and identically distributed each having mean zero and positive definite variance-covariance matrix Σ.

3) Each parameter space H_α is compact.

4) The true parameter value θ^*_α is contained in an open sphere O_α which is, in turn, contained in H_α.

5) Each function $q_\alpha(y, x, \theta_\alpha)$ and its first and second order derivatives with respect to θ_α are continuous in θ_α for fixed (y, x).

The identification rule is defined as:

The structural equation

$$q_\alpha(y_t, x_t, \theta_\alpha) = e_{\alpha t}$$

from a system satisfying the above assumption is said to be identified by the instruments z_t if the only solution of the almost sure limit

$$\lim_{n\to\infty} \left(\frac{1}{n}\right) \sum_{t=1}^{n} z_t' \, q_\alpha(y_t, x_t, \theta_\alpha) = 0$$

is $\theta_\alpha = \theta^*_\alpha$.

A rigorous treatment of the assumptions, identification, efficiency tests, and estimation of N3SLS procedure can be found in Gallant (1977).

Before the final estimates were obtained by using N3SLS, considerable time was spent in estimating the model by using ordinary least squares (OLS), two-stage least squares (2SLS), and nonlinear two-stage least squares (N2SLS). OLS was applied to each behavioral equation of the model to check the a priori expected signs of the variables in each equation, to test the goodness of fit of each equation, and to identify any misspecification of the variables.

Considering the simultaneous nature of the model, the next step was to use system methods for the estimation. First, 2SLS was used to estimate the farm sector and the macroeconomy as two separate blocks to see how these two sectors perform individually. Then, both blocks were combined together as a single system and estimated by 2SLS. A comparison of 2SLS estimates with that of OLS estimates indicated substantial differences in the levels of estimated coefficients, implying that simultaneous equation bias in OLS estimates is significant for the hypothesized system.

Since the model is nonlinear in nature, N2SLS was applied to the entire model. N2SLS assumes that endogenous variables of an equation are correlated with the disturbance term, but the disturbance terms across equations are not correlated, i.e., there is no contemporaneous correlation. Therefore, N2SLS ignores information that may be available concerning the error covariances. Also, the N2SLS estimator does not consider information concerning the endogenous variables that appear in the system but not in the i-th equation. Thus, the estimations of the model by N2SLS will yield consistent but biased estimates.

N3SLS takes explicit account of the covariance matrix including the contemporaneous correlation of error terms across equations. Hence, N3SLS is called the full information method, and N3SLS estimates are consistent and asymptotically more efficient than N2SLS estimates. Therefore, N3SLS was preferred over N2SLS for the final estimation of the model.

Because of the space limitation, models estimated by using OLS, 2SLS, and N2SLS are not reported. Only the final form of the model that is estimated by N3SLS is shown in Table 5.1. The model consists of 33 equations including 19 behavioral relationships and 14 identities. Each equation has the estimated coefficients, t-statistics (parentheses), elasticities of major variables (brackets), R-square, and Durbin-Watson or H-statistic.[1] Several attempts were made, with little or no success,

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[1]The H-statistic replaces the Durbin-Watson statistic in the presence of a lagged dependent variable on the right-hand side of the equation. The H-statistic is tested as a standard normal deviate for first-order autocorrelation.

Table 5.1. Estimated model

Farm sector

Crop supply

$$\left(\frac{S^c}{P^c}\right)_t = 400.053 + 117.105 \left(\frac{P^c}{CPI}\right)_{t-1} - 256.643 \left(\frac{P^I}{CPI}\right)_{t-1} - 6.288\, V^a_t$$

(6.52) (2.51) [0.37] (-5.74) [-0.85] (-2.82) [-0.11]

$$- 147.05 \left(\frac{P^L}{CPI}\right)_{t-1} + 151.817 \left(\frac{P^S}{CPI}\right)_t - 0.873\, AD_t - 59.127\, D1$$

(-4.42) [-0.85] (4.90) [0.70] (-4.04) (-3.20)

$R^2 = 0.76$, $DW = 1.45$ (5.1)

Crop demand

$$\left(\frac{D^c}{P^c}\right)_t = 243.615 - 294.673 \left(\frac{P^c}{CPI}\right)_t + 0.931 \left(\frac{RDPI}{USPOP}\right)_t + 207.356 \left(\frac{P^L}{CPI}\right)_t$$

(4.53) (-6.12) [-0.47] (0.79) [0.16] (5.72) [1.47]

$R^2 = 0.637$, $DW = 0.97$ (5.2)

Crop inventories

$$\left(\frac{I^c}{P^c}\right)_t = 82.845 - 27.91 \left(\frac{P^c}{CPI}\right)_t - 1.666\, V^a_t + 0.543 \left(\frac{I^c}{P^c}\right)_{t-1} + 30.696\, D2$$

(5.97) (-3.86) [-0.32] (-2.94) [-0.06] (6.93) (5.84)

$R^2 = 0.806$, $H = 1.97$ (5.3)

Net crop exports

$$\left(\frac{X^c}{PX^c}\right)_t = -157.926 - 12.288 \left(\frac{PX^c}{CPI^f}\right)_t + 1.289\, e_t + 22.668 \left(\frac{Y}{POP}\right)^f_t$$

(-13.48) (-4.64) [-0.55] (10.48) [4.82] (6.76) [2.27]

$R^2 = 0.905$, $DW = 1.49$ (5.4)

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[a]Adjusted t-statistics; see text on page 74.

Table 5.1. continued

Crop input demand

$$P^I_t = \underset{(5.70)}{31.227} - \underset{(-4.02)}{0.285}\, Q^I_t + \underset{(9.01)}{3.268}\, CPI_t - \underset{(-7.15)}{2.995}\, CPI_{t-1} + \underset{(9.45)}{0.568}\, P^I_{t-1}$$

$$R^2 = 0.959,\ H = 2.31 \qquad (5.5)$$

Market equilibrium in the crop sector

$$\left(\frac{S^c}{P^c}\right)_t + \left(\frac{I^c}{P^c}\right)_{t-1} = \left(\frac{D^c}{P^c}\right)_t + \left(\frac{I^c}{P^c}\right)_t + \left(\frac{X^c}{PX^c}\right)_t \qquad (5.6)$$

Supply of livestock products

$$\left(\frac{S^L}{P^L}\right)_t = \underset{(0.41)}{7.999} + \underset{\substack{(5.14)\\ [0.22]}}{45.192} \left(\frac{P^L}{CPI}\right)_{t-1} - \underset{\substack{(-15.26)\\ [-0.52]}}{109.405} \left(\frac{P^F}{CPI}\right)_{t-1} - \underset{(-0.22)}{0.119}\, V^a_t$$

$$+ \underset{(20.15)}{2.974}\, H_{t-1} - \underset{(-3.86)}{11.932}\, D1$$

$$R^2 = 0.943,\ DW = 1.12 \qquad (5.7)$$

Domestic demand for livestock products

$$\left(\frac{D^L}{P^L}\right)_t = \underset{(8.78)}{165.876} - \underset{\substack{(-5.41)\\ [-0.64]}}{134.309} \left(\frac{P^L}{CPI}\right)_t + \underset{\substack{(14.32)\\ [0.71]}}{6.161} \left(\frac{RDPI}{USPOP}\right)_t + \underset{\substack{(2.39)\\ [0.20]}}{41.207} \left(\frac{P^c}{CPI}\right)_t$$

$$R^2 = 0.557,\ DW = 1.03 \qquad (5.8)$$

Feed demand

$$P^F_t = \underset{(8.78)}{165.876} - \underset{(-5.41)}{134.309}\, Q^F_t + \underset{(14.32)}{6.161}\, CPI_t + \underset{(2.39)}{41.207}\, CPI_{t-1}$$

$$R^2 = 0.909,\ DW = 0.53 \qquad (5.9)$$

Market equilibrium in the livestock sector

$$\left(\frac{S^L}{P^L}\right)_t = \left(\frac{D^L}{P^L}\right)_t - \left(\frac{M^L}{PM^L}\right)_t \qquad (5.10)$$

Table 5.1. continued

Total farm income

$$Y_t^a = P_t^c \cdot \left(\frac{S^c}{P^c}\right)_t + P_t^L \cdot \left(\frac{S^L}{P^L}\right)_t \qquad (5.11)$$

$$S_t^a = \frac{Y_t^a}{P_t^a} \qquad (5.12)$$

Agricultural investment

$$\underset{}{i_t^a} = \underset{(1.22)}{6.365} - \underset{\substack{(-2.53)\\ [-0.05]}}{0.921}\, V_t^a + \underset{\substack{(12.23)\\ [0.95]}}{0.137}\, S_t^a$$

$$R^2 = 0.826,\ DW = 0.68 \qquad (5.13)$$

Interest rate in the farm sector

$$r_t^a = \underset{(16.63)}{3.87} + \underset{(12.27)}{1.129}\, r_t - \underset{(-5.24)}{0.519}\, r_{t-1}$$

$$R^2 = 0.914,\ DW = 0.58 \qquad (5.14)$$

General economy

Supply function

$$\frac{\dot{P}^m}{P^m_{t-1}} = \underset{(-1.98)}{-0.019} + \underset{(11.47)}{1.515} \left(\frac{\dot{W}}{W_{t-1}}\right) - \underset{(-8.14)}{1.210} \left(\frac{\dot{PR}}{PR_{t-1}}\right)$$

$$R^2 = 0.723,\ DW = 1.37 \qquad (5.15)$$

Wage rate equation

$$\frac{\dot{W}}{W_{t-1}} = \underset{(2.71)}{-0.021} + \underset{(6.85)}{0.535} \left(\frac{H\dot{P}M}{HPM_{t-1}}\right) - \underset{(-1.65)}{0.002}\, U_t$$

$$R^2 = 0.51,\ DW = 1.22 \qquad (5.16)$$

Table 5.1. continued

Consumption function

$$\left(\frac{C^m}{P^m}\right)_t = 16.557 - 17.802 \left(\frac{P^m}{CPI}\right)_t + 0.750 \left(\frac{RDPI}{USPOP}\right)_t$$

(30.74) (-39.43) (93.59)
[-1.05] [1.12]

R^2 = 0.996, DW = 1.11 (5.17)

Net exports of manufactured goods

$$\left(\frac{X^m}{PX^m}\right)_t = 35.895 - 111.985 \left(\frac{PX^m}{CPI}\right)_t - 0.968\, e_t - 2.858\, PR_t$$

(0.31) (-4.62) (-1.47) (-6.82)

$$+ 43.580 \left[\left(\frac{RDPI}{USPOP}\right)_t / \left(\frac{Y}{POP}\right)_t^f\right] - 0.434 \left(\frac{X^m}{PX^m}\right)_{t-1}$$

(4.46) (5.56)

R^2 = 0.928, H = 1.42 (5.18)

Market equilibrium in the industrial sector

$$S_t^m = \left[USPOP_t \cdot \left(\frac{C^m}{P^m}\right)_t\right] + \left(\frac{X^m}{PX^m}\right)_t \quad (5.19)$$

Investment in the industrial sector

$$i_t^m = 32.076 - 16.03\, V_t + 0.164\, S_t^m$$

(0.51) (-2.78) (19.35)
[-0.03] [0.99]

R^2 = 0.911, DW = 1.03 (5.20)

Money demand

$$\left(\frac{HPM^d}{CPI}\right)_t = 181.877 - 17.799\, r_t + 0.032\, S_t + 0.465 \left(\frac{HPM}{CPI}\right)_{t-1}$$

(4.61) (-8.38) (7.23) (4.48)
[-0.36] [0.77]

R^2 = 0.91, H = 5.10 (5.21)

Table 5.1. continued

Money supply

$$M_t^s = m \cdot HPM_t = m \cdot (D_t + R_t) \qquad (5.22)$$

General price level

$$CPI_t = \underset{(-2.95)}{-6.972} + \underset{(5.43)}{1.334} \left(\frac{M^s}{S}\right)_t - \underset{(-5.16)}{1.316} \left(\frac{M^s}{S}\right)_{t-1} + \underset{(85.76)}{1.105}\, CPI_{t-1}$$

$$R^2 = 0.997,\ H = 1.79 \qquad (5.23)$$

Balance of payments identity

$$X_t^c - M_t^L + X_t^m + CAP_t + R_t + SD_t = 0 \qquad (5.24)$$

International capital flow

$$CAP_t = \underset{(-2.40)}{-4925.16} - \underset{(-3.96)}{2606.76}\, V_t + \underset{(7.35)}{5389.034}\, V_t^f$$

$$R^2 = 0.405,\ DW = 0.91 \qquad (5.25)$$

Exchange rate determination

$$e_t = \underset{\substack{(235.51)\\(83.27)^a}}{100.03} - \underset{\substack{(-10.96)\\(-3.88)^a}}{152.043}\, \delta_t + \underset{\substack{(3.69)\\(1.31)^a\\ [3.14]}}{0.00036}\, (\delta_t * M_t^s) - \underset{\substack{(-6.41)\\(-2.27)^a\\ [-2.87]}}{0.351}\, (\delta_t * M_t^{s,f})$$

$$- \underset{\substack{(-6.27)\\(-2.22)^a}}{0.005}\, (\delta_t * S_t) + \underset{\substack{(11.04)\\(3.90)^a}}{1.281}\, (\delta_t * Y_t^f) + \underset{\substack{(8.68)\\(3.07)^a}}{2.756}\, (\delta_t * r_t)$$

$$- \underset{\substack{(-8.61)\\(-3.04)^a}}{1.668}\, (\delta_t * r_t^f)$$

$$R^2 = 0.966,\ DW = 1.87 \qquad (5.26)$$

Table 5.1. continued

International price linkages	
$PX_t^c = e \cdot P_t^c (1 + b_t^c)$	(5.27)
$PX_t^m = e \cdot P_t^m (1 + b_t^c)$	(5.28)
Accounting identities	
$S_t = C_t + i_t + G_t + X_t$	(5.29)
$CPI \cdot C_t = D_t^c + D_t^L + C_t^m$	(5.30)
$CPI \cdot i_t = P_t^a \cdot i_t^a + P_t^m \cdot i_t^m$	(5.31)
$PX_t \cdot X_t = X_t^m + X_t^c - M_t^L$	(5.32)
$RDPI_t = S_t - TD_t$	(5.33)

to correct for the autocorrelation. Since the model was estimated by using a nonlinear estimation program, correction for the autocorrelation involved huge amounts of computer cost and also produced unsatisfactory results. In recognition of these problems, the original estimates are used for the analysis. Table 5.2 contains the variable names, descriptions, and data sources. The data period used for estimation is from 1950 to 1982.

The nominal value of domestic demand for crops and livestock products refers to both the expenditures on intermediate (indirect) demand and final demand for consumption. The nominal value of domestic consumption demand for industrial goods and services refers only to the final demand for direct consumption. The nominal value of domestic supply of crops and livestock products refers 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 consumption. In international commodity trade, the net concept is used. That is, the U.S. is usually a net exporter of crop products and a net importer of livestock products.

As is usually the case in empirical analysis, some of the _a priori_ specifications established in the theoretical model were abandoned; some variables were dropped and others added. The changes made in the theoretical model for the estimation are explained below. The estimates of each structural equation are discussed with respect to the estimated sign, and its own price and income elasticities. The model as a whole appears to fit quite well as evidenced by the associated R^2 statistics.

Table 5.2. Description of variables, units, and data sources

Variable	Description	Units	Sources[a]
List of endogenous variables			
S_t^c	Farm income: cash receipts from marketings	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 livestock 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)
D_t^c	Domestic disappearance of crop output	Million dollars	Calculated from the market equilibrium condition

[a]For complete reference, see the bibliography.

Table 5.2. continued

Variable	Description	Units	Sources[a]
$RDPI_t$	The aggregate nominal disposable income divided by the consumer price index	Million dollars in 1967 prices	Economic Report of the President, 1983
I_t^c	Nominal value of crops stored on and off farms	Million dollars	Economic Indicators of the Farm Sector Income and Balance Sheet--USDA, 1982
X_t^c	Nominal value of net exports of crops	Million dollars	U.S. Foreign Agricultural Trade Statistical Report--USDA (various issues)
PX_t^c	Export price index of crops = ag. export price index * $\left(\frac{\text{value of ag. exports}}{\text{value of crop exports}}\right)$ - export price index of livestock products * $\left(\frac{\text{value of livestock exports}}{\text{value of crop exports}}\right)$ (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	Index	IMF, IFS (International Financial Statistics, various issues)
S_t^L	Farm income: cash receipts from marketings of total livestock and products	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)

Table 5.2. continued

Variable	Description	Units	Sources[a]
D_t^L	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 nominal farm income	Million dollars	Calculated from the farm income identities
S_t^a	Real farm income	Million dollars in 1967 prices	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
C_t^m	Nominal value of per capita consumption of industrial goods	Million dollars	Economic Report of the President, 1983
X_t^m	Nominal value of net exports of industrial goods	Million dollars	U.S. Foreign Agricultural Trade Statistical Report--USDA (various issues)

Table 5.2. continued

Variable	Description	Units	Sources[a]
PX_t^m	Export price index of industrial goods = total commodity export price index * $(\frac{\text{value of commodity goods}}{\text{value of industrial goods}})$ - agricultural export price index * $(\frac{\text{value of agricultural exports}}{\text{value of industrial exports}})$ (see Shei, 1978)	Index, 1967=100	USDA (Agricultural Statistics, various issues)
S_t^m	Real value of output in the industrial sector	Million dollars in 1967 prices	Economic Report of the President, 1983
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
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
S_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

Table 5.2. continued

Variable	Description	Units	Sources[a]
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)
<u>List of exogenous variables</u>			
P_t^s	Support price index of major price support commodities weighted by production (see Egbert, 1969)	Index, 1967=100	Calculated
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

Table 5.2. continued

Variable	Description	Units	Sources[a]
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 last year	Index, 1967=100	USDA (Agricultural Statistics, various issues)
PM_t^L	Import price index of livestock and livestock products	Index, 1967=100	USDA (Agricultural Statistics, various issues)
M_t^L	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, 1983
R_t	Foreign exchange reserves	Million dollars	IMF, IFS (various issues)

Table 5.2. continued

Variable	Description	Units	Sources[a]
D_t	Net domestic money asset	Million dollars	IMF, IFS (various issues)
U_t	Total unemployment rate	Percent	Economic Report of the President, 1983
m_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)
$M_t^{s,f}$	Money supply in the world	Index, 1967=100	IMF, IFS, supplement on money, 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
TD_t	Taxes and other deductions	Million dollars in 1967 prices	Economic Report of the President, 1983

The final results of the structural equation estimations all have the correct sign and could be used for the simulation experiments.

Farm Sector

The estimated coefficients of the crop supply equation display expected signs. First, for the crop input prices, the index of prices paid by farmers was used in the estimation. 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 prices and also for crop output prices resulted in wrong signs. To overcome this problem, the index of prices paid by farmers for inputs of nonfarm origin was considered for the estimation; however, the data for this variable is available only from 1965 onwards and since the data period for this study is from 1950 to 1982, the index of price paid for nonfarm inputs could not be used. In view of this problem, the index of fertilizer price paid by farmers was used as a proxy for the crop input prices. The farm policy variables--support price and acreage diversion--have the right signs and are significant, and thus indicate the importance of the farm policy programs. Since there was no single aggregate variable to represent the weather condition across the country, the variable pasture condition was used for the weather index. However, it produced unsatisfactory results and, hence, was dropped from the equation. Results indicate that the output price elasticity of crop supply is inelastic at 0.37, which is very much 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 -0.85, which is almost identical to the elasticity 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 right sign and is significant at the one percent level. The elasticity of crop output with respect to the real interest rate is inelastic at -0.11.

The livestock product supply equation has the right signs for all the estimated coefficients. The output price elasticity of livestock product supply is 0.22, which is inelastic as obtained by other studies. For example, Tweeten and Quance (1969) and Griliches (1959) estimated the output price elasticity as 0.38 and 0.2 to 0.3, respectively. The input price variable, i.e., 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 -0.52. The real interest rate was retained in the livestock product supply equation, even though the t-ratios are less than that of the five percent probability level, because (1) the sign is theoretically correct and (2) the real interest rate is needed to capture the cost effect of interest rates in the livestock product supply.

Domestic crop demand 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; particularly, the cross-price effect of livestock products has the expected positive sign. The domestic livestock product 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 0.16, which is considerably less than the elasticity (0.67) estimated by Shei (1978). However, the income elasticity of livestock product demand is 0.71, almost equal to the elasticity (0.72) obtained by Shei (1978). The estimated coefficients for the income variable reflect the income effect of an expansionary monetary policy.

The 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 the crop inventories; thus, it captures the stock effect of higher interest rates leading to a reduction in the crop storage. Stock demand is own-price inelastic at -0.32, 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.

Following the discussion in Chapter IV, the crop exports are estimated with a separate exchange rate regressor. The estimated coefficients are consistent with prior expectations and statistically significant. The exchange rate appears to be a very important determinant of crop exports and they are exchange-rate elastic at 4.82. The magnitude of the exchange-rate elasticity of crop export demand is critical in determining the trade effect of the 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 the changes in crop exports. Comparing the price elasticity of export demand (-0.55) with that of other studies, it is smaller than that obtained by Tweeten (-6.4); however, it is very much in line with the elasticities estimated by Houthakker and Magee (-0.96), Clark (-0.38), and Hooper and Wilson (-0.88).

The estimated equations (5.5) and (5.9) are the crop input demand and feed demand relationships, respectively. Equation (5.5) relates the general price level changes to the crop supply through fertilizer price. Similarly, equation (5.9) 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 greater than one and, therefore, reflect the cost-price squeeze of inflation on the farm sector.

The agricultural investment relationship is shown in equation (5.13). Both real interest rates and real farm income have correct signs and are significant at the one 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.

Equation (5.14) 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 one percent level.

General Economy

The estimated coefficients of the industrial-goods price equation have the expected signs. In the wage-rate equation, a positive relationship between changes in the supply of high-powered money and changes in the wage-rate index of the Phillips curve type relationship is anticipated. 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.

In the consumption function, 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 less than the mpc found in other studies (for example, Dornbusch and Fischer (1981) estimated the mpc at 0.88) because the consumption expenditures include only the manufactured goods spendings and do not include the expenditures on the food items.

The estimated coefficients of the net imports of industrial goods have the right signs. The investment equation in the industrial sector produced similar results to that of Bischoff's (1971) study in terms of coefficients and elasticities.

The estimated results for the money demand function are consistent with prior expectations and significant. The long-run elasticities of demand for money with respect to changes in the interest rate and real income are -0.36 and 0.77, respectively, and 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 with respect to changes in the interest rate, and 0.7 with respect to changes in real income.

In the general price level equation, 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. The estimates in the capital flow equation indicate that changes in domestic and world real interest rates are significant causal variables, even though the equation has a low R^2.

The estimated results of exchange rate determination are presented in equation (5.26). Under a fixed exchange rate regime (1950-1971), movements in the exchange rate were not explained by the explanatory variables in the exchange rate equation. The explanatory variables in the exchange rate equation are crucial in determining the exchange rate under the flexible exchange rate regime. Therefore, it is not appropriate to estimate the exchange rate equation over the entire time period of the analysis. In recognition of this problem, as explained in Chapter IV, the grafted polynomial technique developed by Fuller (1976) is used to link the fixed and flexible exchange rate regimes in the estimation of the exchange rate equation. Before presenting the results of the estimation, the grafted polynomial technique is developed below.

To illustrate the use of grafted polynomials in the estimation of the exchange rate equation, 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 (1974-1980). These three segments are joined together by a grafted polynomial variable δ, as defined below:

$$\delta = 0, \text{ year} \leq 1971;$$

$$\delta = \text{year} - 1971, \ 1972 \leq \text{year} \leq 1973;$$

$$\delta = 3, \text{ year} > 1974.$$

In the first case of a 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. In the second case, the adjustment or transition period in 1972 and 1973 was considered because, even though the flexible exchange rate system was officially adopted in 1973, many countries started to revalue their currencies in terms of the U.S. dollar in 1972 to break away from the fixed exchange rate system. Finally, in the third case of a flexible exchange rate regime, monetary factors in the U.S. and ROW are the determinants of the exchange rate as formulated in equation (4.26) using a monetary approach to exchange rate determination. The grafted polynomial variable (δ) is defined such that when all the explanatory variables in equation (4.26) are multiplied by the δ, and also the δ is included as a separate regressor, the resulting equation (given below) explains the movements in the exchange rate only after 1971.

$$e_t = \Psi_{26,t}[\delta_t, \delta_t \cdot M_t^s, \delta_t \cdot M_t^{s,f}, \delta_t \cdot S_t, \delta_t \cdot Y_t^f, \delta_t \cdot r_t, \delta_t \cdot r_t^f, z_{26,t}]$$

Denbaly (1984), in his doctoral thesis, used a similar approach to endogenize the exchange rate. The estimated results of the above modified exchange rate equation meet the theoretical expectations given in Chapter IV. All the coefficients have the correct 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 are still statistically significant, except for the U.S. money supply variable. Therefore, the sign and magnitude of the estimate for the money supply variable is more important than the significant level per se.

The elasticity of the exchange rate with respect to the U.S. money supply is at 3.14. This implies that a one percent increase in the U.S.

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[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).

money supply will raise the value of the U.S. dollar price of the SDR by 3.14 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 III are captured quite well (refer to Figure 4.1). 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 affects 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 the 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 effect 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 the farm products through per capita real disposable income. An important point to note is that all the estimated coefficients of the variables involved in these four macro linkages have right signs.

Validation of the Model

In this section, the estimated structural equations and identities are used to test the overall ability of the model to replicate the observed values of the endogenous variables, and also to test the stability of the model. Since the model is to be used for multiplier and dynamic simulation analysis, a rigorous validation procedure is undertaken.

In the validation run, the structural form of the model is dynamically simulated over the entire study period. The simulation procedure is dynamic in the sense that solved values are used for lagged values of endogenous variables rather than the actual values for those variables. A dynamic simulation seems preferable since it allows the researcher to study the evolutionary character of the model over time. As the model is nonlinear, a nonlinear simulation procedure, SIMNLIN from SAS/ETS (SAS, 1982), is used to solve the model. The Gauss-Seidel solution method is used for the validation run and all future simulations. Before presenting the simulation results, some of the standard criteria that are often used in evaluating a simulation model are discussed below (see Pindyck and Rubinfeld (1981) for further details on evaluating the simulation model).

Root Mean Square Error (RMSE)

The RMSE of a simulated variable is defined as

$$\text{RMSE} = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2}$$

where Y_t^a = actual value of the variable Y_t,

Y_t^s = simulated value of Y_t, and

T = number of periods in the simulation.

In simple terms, the RMSE is a measure of the deviation of the simulated variable from its actual value. A priori, little information is gained from the examination of RMSE, as it is relatively meaningless without a knowledge of the average size of the variable in question.

Root Mean Square Percentage Error (RMSPE)

This is also a measure of the deviation of the simulated variable from its actual path but in percentage terms. Thus, RMSPE is defined as

$$\text{RMSPE} = \sqrt{\frac{1}{T}\sum\left(\frac{Y_t^s - Y_t^a}{Y_t^a}\right)^2}\ .$$

Theil's inequality coefficient (U)

A useful simulation statistic related to the RMSE and applied to the evaluation of simulation results is Theil's inequality coefficient, defined as

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s)^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^a)^2}}$$

The Theil inequality coefficient can be decomposed into three different components: bias (U^m), regression (U^s), and disturbance (U^c) proportions. These proportions can be derived with little algebra that

$$\frac{1}{T}\Sigma(Y_t^s - Y_t^a)^2 = (\overline{Y}^s - \overline{Y}^a)^2 + (\sigma_s - \sigma_a)^2 + 2(1 - \rho)\,\sigma_s\sigma_a$$

where $\overline{Y}^s$, $\overline{Y}^a$, σ_s, and σ_a are the means and standard deviations of the series Y_t^s and Y_t^a, respectively, and ρ is their correlation coefficient. We can define the proportions of inequality as

$$U^m = \frac{(\overline{Y}^s - \overline{Y}^a)^2}{\frac{1}{T}\Sigma(Y_t^s - Y_t^a)^2},$$

$$U^s = \frac{(\sigma_s - \sigma_a)^2}{\frac{1}{T}\Sigma(Y_t^s - Y_t^a)^2},$$

$$U^c = \frac{2(1 - \rho)\,(\sigma_s\,\sigma_a)}{\frac{1}{T}\Sigma(Y_t^s - Y_t^a)^2}.$$

The bias proportion U^m is an indication of systematic error, since it measures the extent to which the average values of the simulated and actual series deviate from each other. For better prediction of the actual values, U^m should be close to zero. The regression proportion U^s indicates the ability of the model to replicate the degree of variability in the variable of interest. If U^s is large, it means that the actual series has fluctuated considerably while the simulated series shows little fluctuation, or vice versa. The covariance proportion U^c measures the error remaining after deviations from average values and average variabilities have been accounted for. The perfect correlation of simulated values with actual values would imply the ideal distribution of inequality over the three sources as $U^m = U^s = 0$, and $U^c = 1$.

Turning point method

To be useful, econometric models should be able to predict or explain the fluctuation in the endogenous variables. A model could fit well in other respects and still fail to predict turning points in the system or only predict them with a lag. For this reason, several techniques known, in general, as turning point methods have been developed. By far the most common is the most simple, i.e., the number of turning points missed or the number of turning points accurately predicted.

Results of the model validation

The overall goodness of fit of the model is judged from the RMSE, RMSPE, Theil's inequality coefficient, and the ability of the model to predict the turning points. In general, the model performs very well in tracking the observed values. Table 5.3 presents RMSE and RMSPE for important endogenous variables. Table 5.4 reports Theil's forecast statistics for these endogenous variables. The observed and predicted values for key endogenous variables are plotted in Figures 5.1-5.20.

The RMSPE for the crop exports is by far the largest at 0.74. The next largest error is for the general economy interest rate at 0.21. For all but these two variables, the RMSPE are quite small (less than 0.2), which would imply the simulated values track the actual values fairly closely.

Theil's forecast error measures complement the RMSE and RMSPE in explaining the predictability of a simulation model. The value of bias for all the endogenous variables are close to zero except for two variables, viz, per capita consumption of industrial goods and real supply of industrial products. The values of regression for these two variables are quite small, which resulted in a better prediction of the actual values (see Figures 5.16 and 5.18). If the value of accuracy, U (Theil's inequality coefficient), is zero, $Y_t^s = Y_t^a$ for all t and there is a perfect fit. If U = 1, on the other hand, the predictive performance of the model is as bad as it possibly could be. When U = 1, simulated values are always zero when actual values are nonzero, or nonzero predictions have been made when actual values are zero, or simulated values are positive (negative) when actual values are negative (positive). As can be seen from Table 5.4, the values of Theil's inequality coefficient for all the endogenous variables are close to

Table 5.3. Root mean square and root mean square percent error from the dynamic simulation

Variable	RMSE	RMSPE
Real crop supply $(S^c/P^c)_t$	21.7035	0.1165
Domestic demand for real crop output $(D^c/P^c)_t$	20.9543	0.1266
Real crop inventories $(I^c/P^c)_t$	10.7641	0.1081
Real crop net exports $(X^c/PX^c)_t$	17.0323	0.7433
Crop price (P_t^c)	24.4866	0.1482
Fertilizer price (P_t^I)	17.3889	0.1152
Crop export price (PX_t^c)	27.0386	0.1456
Real livestock product supply $(S^L/P^L)_t$	11.5442	0.0497
Domestic demand for livestock products $(D^L/P^L)_t$	11.5423	0.0494
Livestock product price (P_t^L)	16.8657	0.1045
Feed price (P_t^F)	16.8897	0.1203
Real agricultural investment (i_t^a)	8.7688	0.1342
Interest rate in the farm sector (r_t^a)	1.3838	0.1561
Real farm income (S_t^a)	38.5518	0.0849
Real output in the industrial sector (S_t^m)	254.626	0.0305
Per capita consumption of industrial goods $(C^m/P^m)_t$	1.1757	0.0557
Manufactured goods price (P_t^m)	10.22	0.0822
Real investment in the industrial sector (i_t^m)	113.558	0.0861
Interest rate in the economy (r_t)	1.0630	0.2095
Consumer price index (CPI_t)	4.2563	0.0340
Exchange rate (e_t)	7.6446	0.0646
Real gross national product (S_t)	129.559	0.0147

Table 5.4. Theil's forecast error measures

Variable	Bias U^m	Regression U^s	Disturbance U^c	Accuracy (inequality coefficient) U
Real crop supply $(S^c/P^c)_t$	0.01	0.78	0.22	0.0006
Domestic demand for real crop output $(D^c/P^c)_t$	0.00	0.43	0.57	0.0008
Real crop inventories $(I^c/P^c)_t$	0.05	0.21	0.74	0.0010
Real crop net exports $(X^c/PX^c)_t$	0.03	0.11	0.86	0.0198
Crop price (P_t^c)	0.00	0.61	0.39	0.0010
Fertilizer price (P_t^I)	0.00	0.23	0.77	0.0009
Crop export price (PX_t^c)	0.00	0.51	0.49	0.0010
Real livestock product supply $(S^L/P^L)_t$	0.00	0.77	0.22	0.0002
Domestic demand for livestock products $(D^L/P^L)_t$	0.00	0.78	0.22	0.0002
Livestock product price (P_t^L)	0.00	0.41	0.59	0.0007
Feed price (P_t^F)	0.00	0.41	0.59	0.0009
Real agricultural investment (i_t^a)	0.00	0.55	0.45	0.0021
Interest rate in the farm sector (r_t^a)	0.01	0.69	0.30	0.0194
Real farm income (S_t^a)	0.00	0.88	0.12	0.0002
Real output in the industrial sector (S_t^m)	0.51	0.09	0.40	0.0000
Per capita consumption of industrial goods $(C^m/P^m)_t$	0.55	0.14	0.32	0.0031
Manufactured goods price (P_t^m)	0.18	0.61	0.22	0.0006
Real investment in the industrial sector (i_t^m)	0.05	0.03	0.93	0.0001
Interest rate in the economy (r_t)	0.10	0.77	0.13	0.0318
Consumer price index (CPI_t)	0.16	0.48	0.35	0.0003
Exchange rate (e_t)	0.00	0.89	0.11	0.0006
Real gross national products (S_t)	0.04	0.00	0.96	0.0000

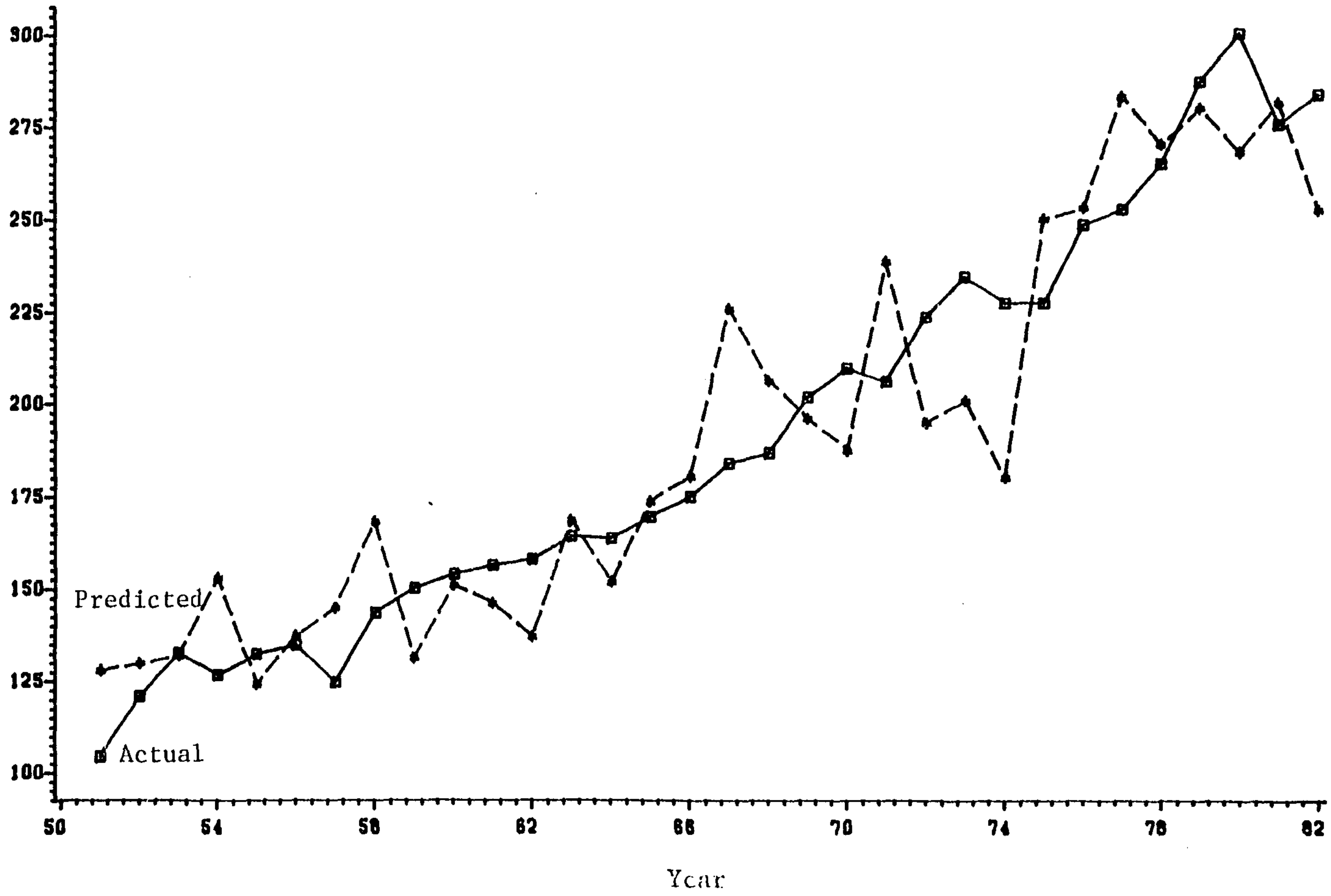

Figure 5.1. Predicted versus actual values of real crop supply (mil. dol. in 1967 prices)

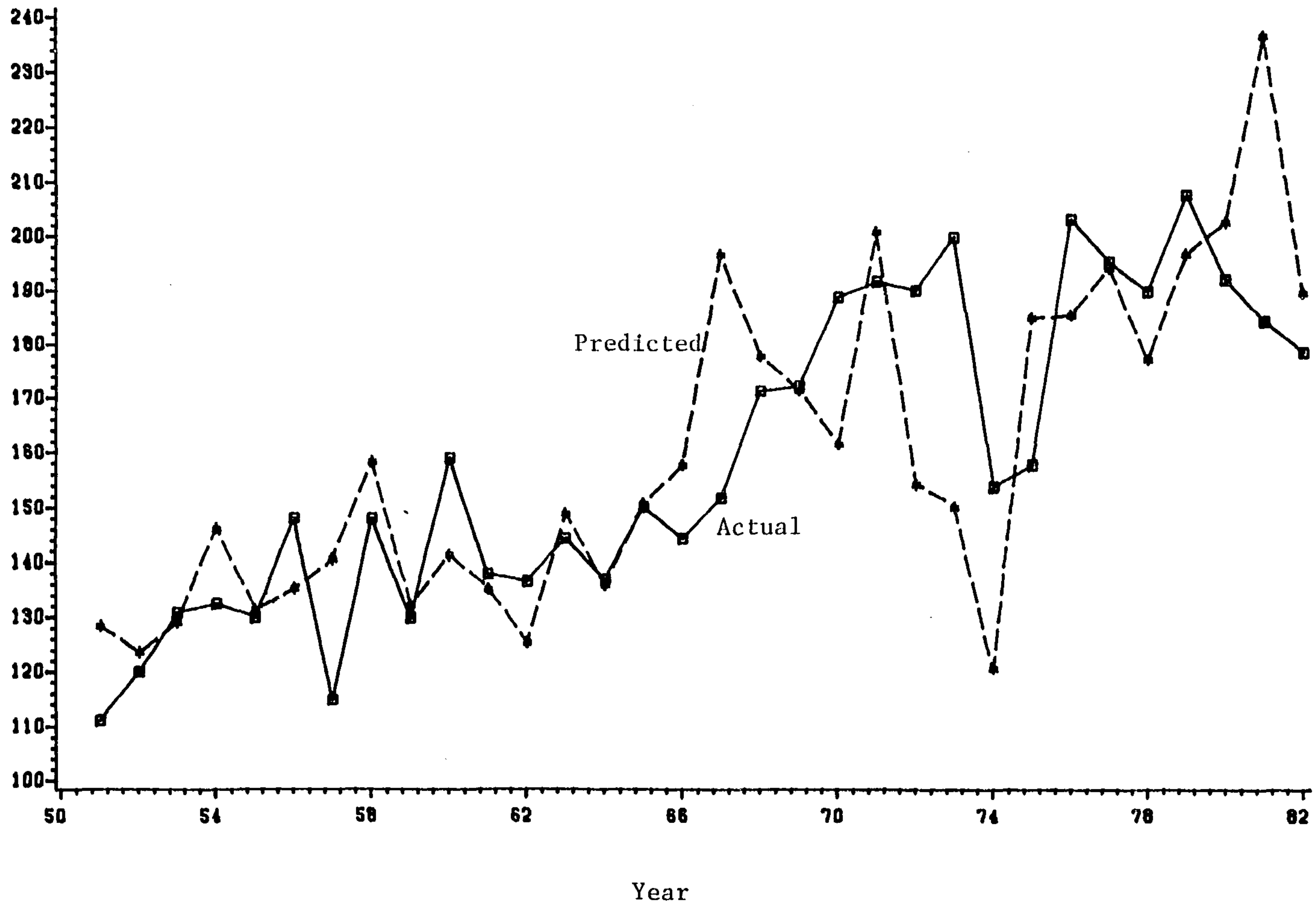

Figure 5.2. Predicted versus actual values of real domestic disappearance of crops (mil. dol. in 1967 prices)

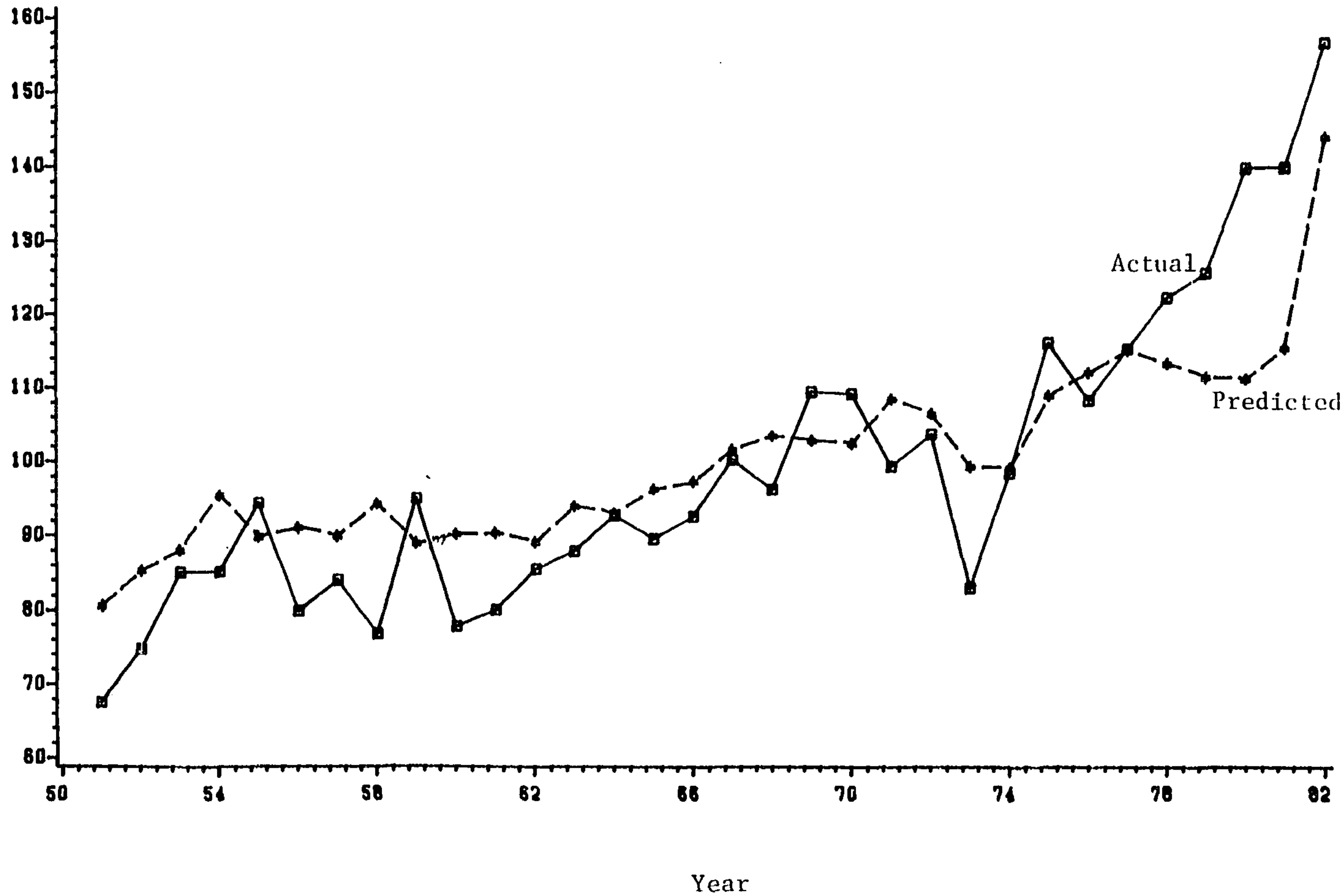

Figure 5.3. Predicted versus actual values of real crop inventories (mil. dol. in 1967 prices)

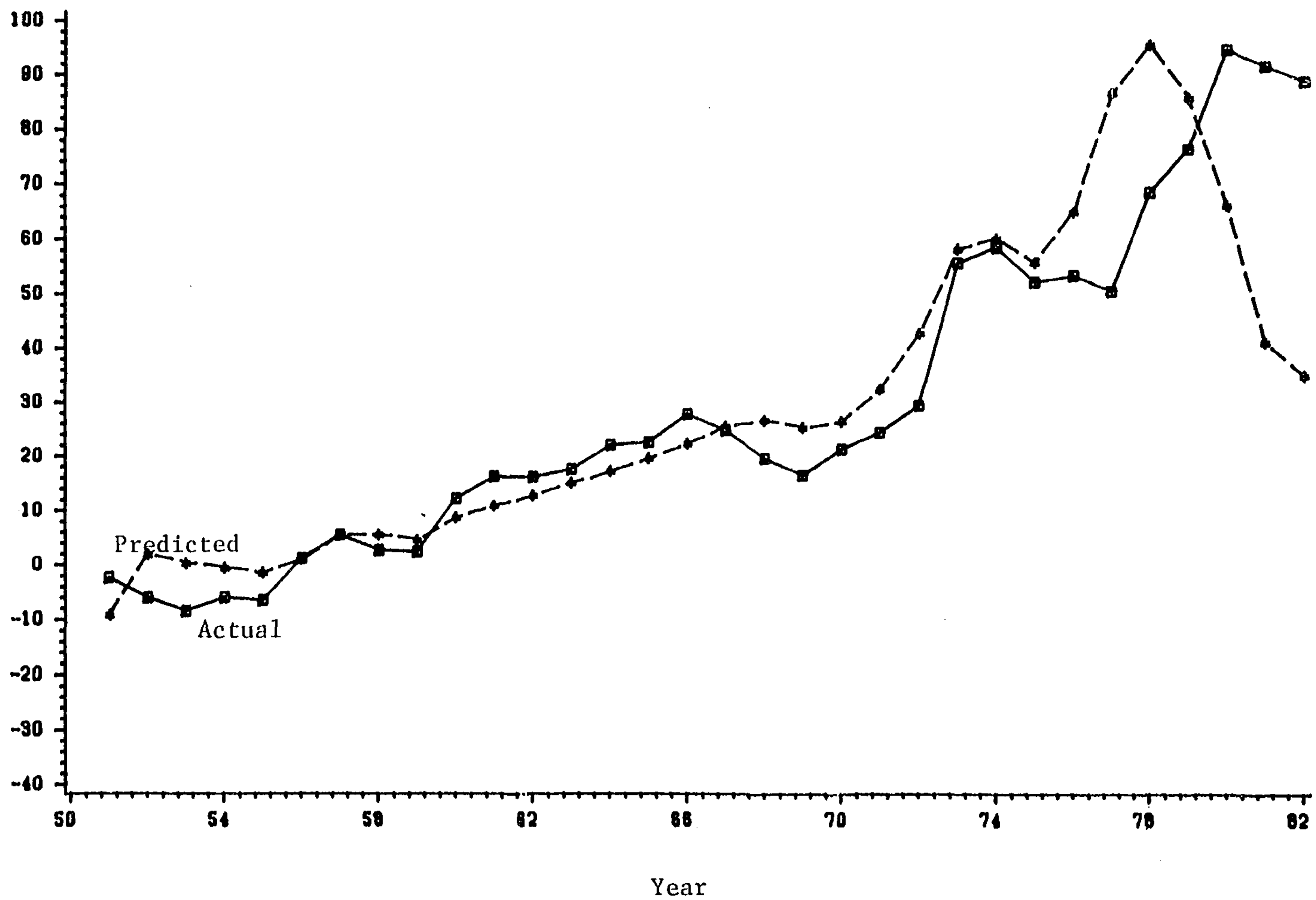

Figure 5.4. Predicted versus actual values of real net crop exports (mil. dol. in 1967 prices)

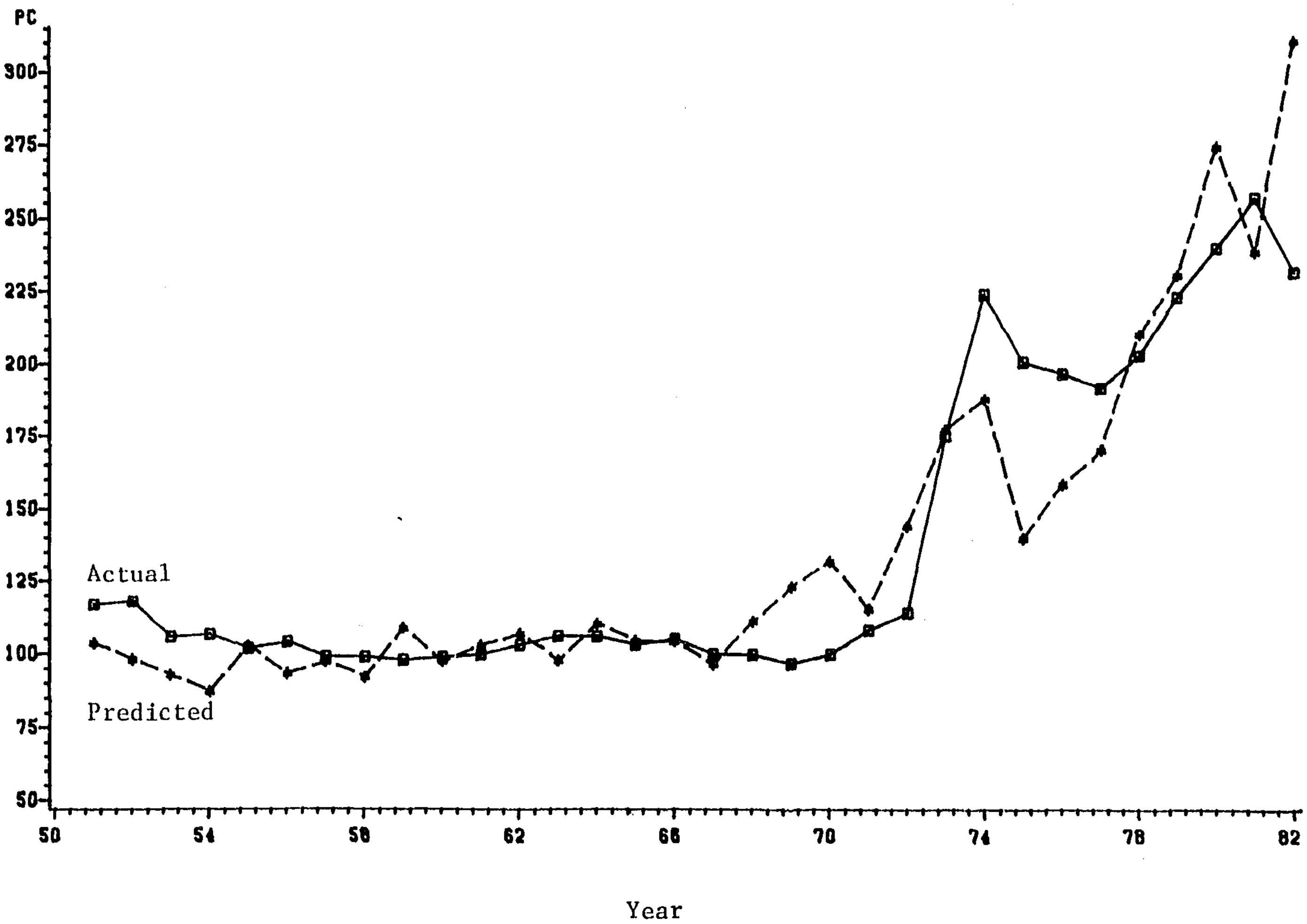

Figure 5.5. Predicted versus actual values of crop price (index, 1967=100)

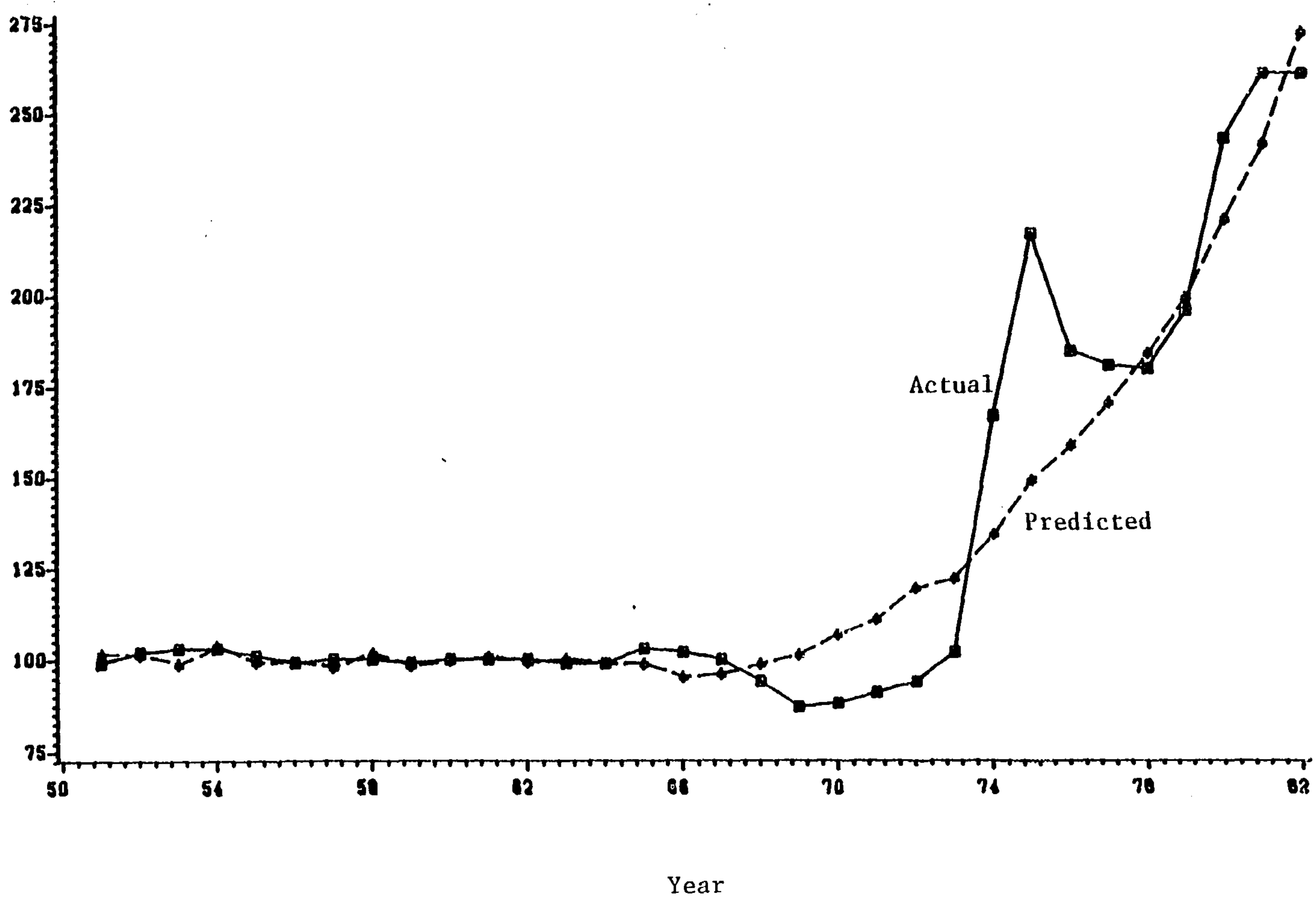

Figure 5.6. Predicted versus actual values of fertilizer price (index, 1967=100)

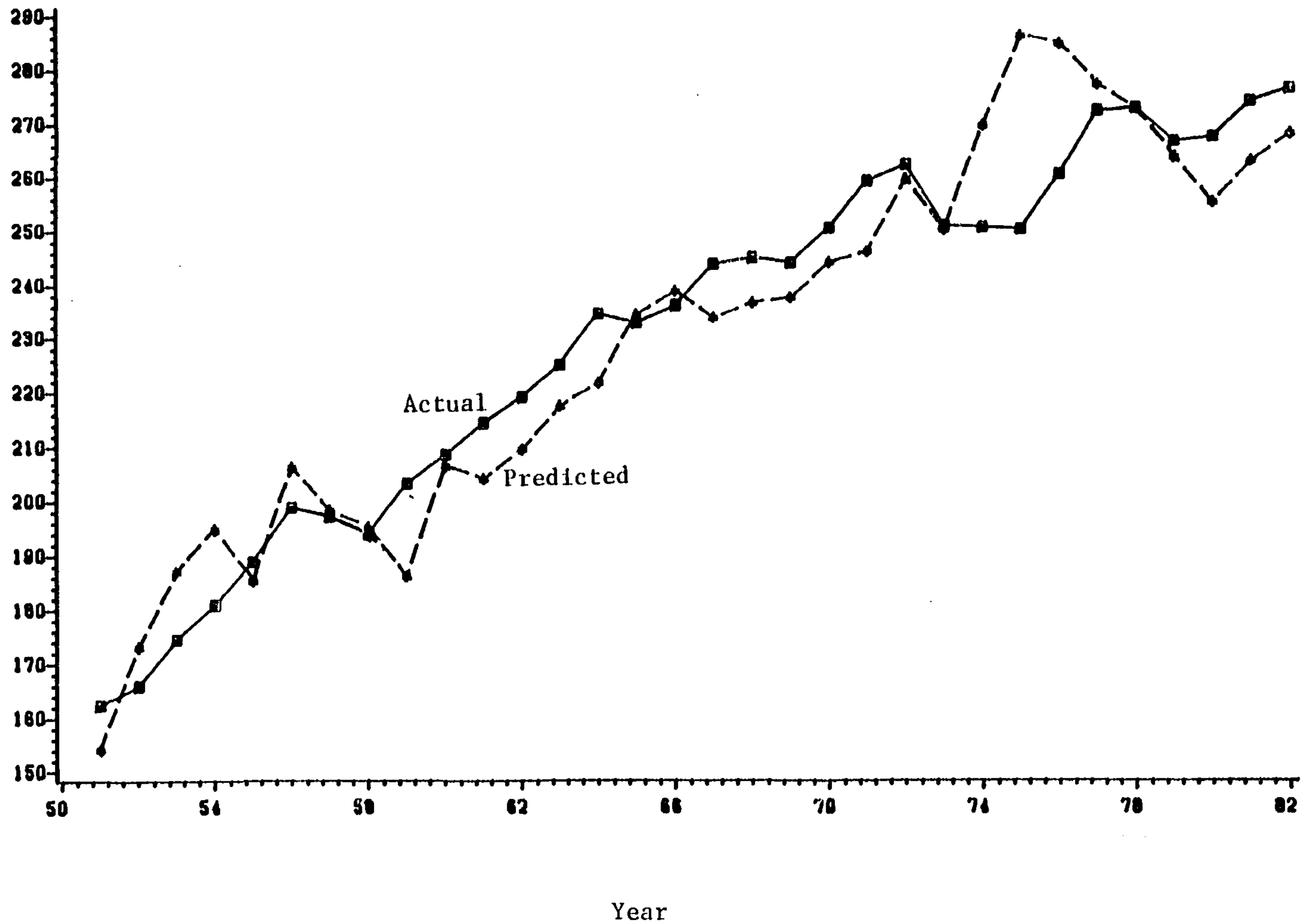

Figure 5.7. Predicted versus actual values of real livestock product supply (mil dol. in 1967 prices)

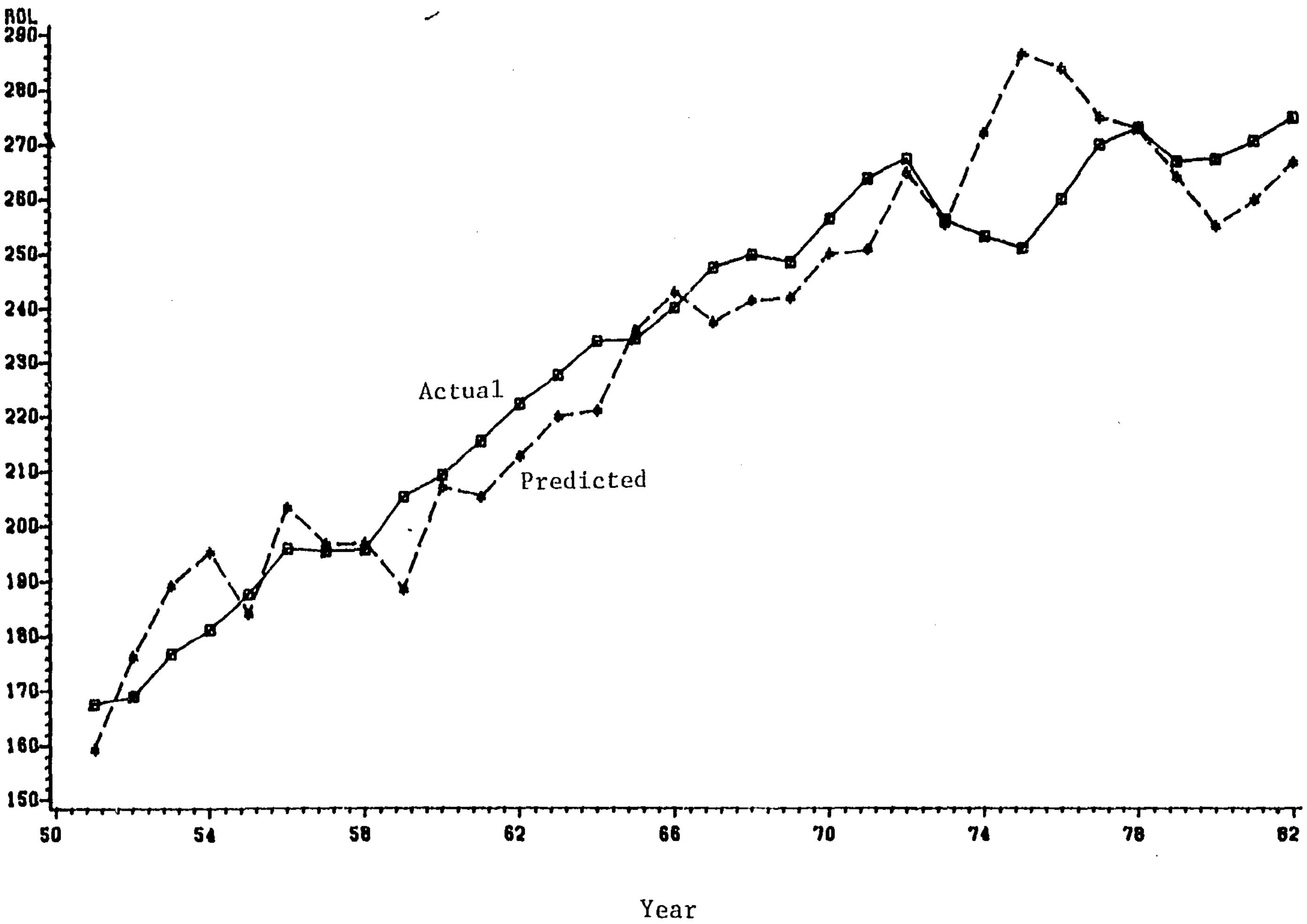

Figure 5.8. Predicted versus actual values of real livestock product demand (mil. dol. in 1967 prices)

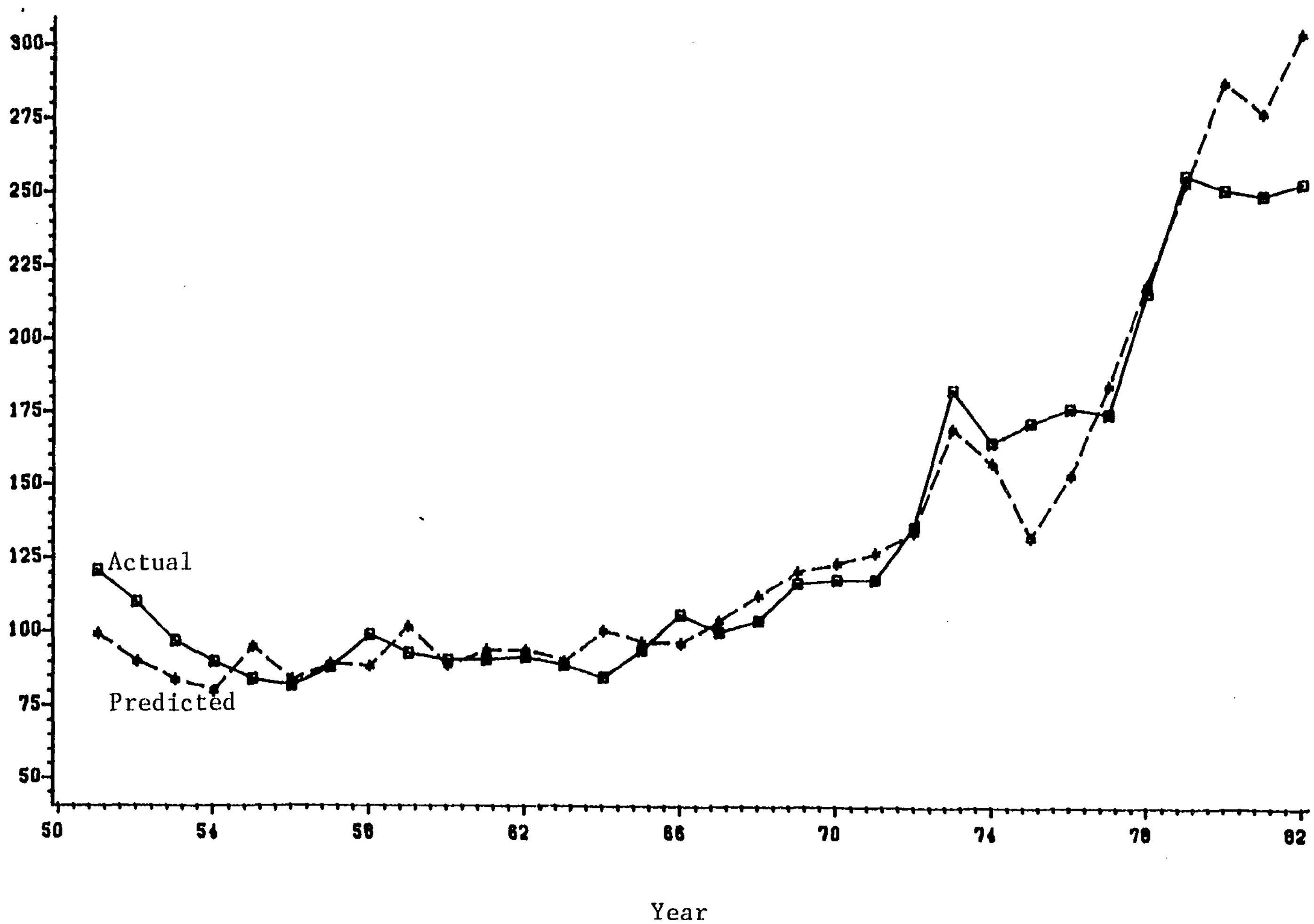

Figure 5.9. Predicted versus actual values of livestock product price (index, 1967=100)

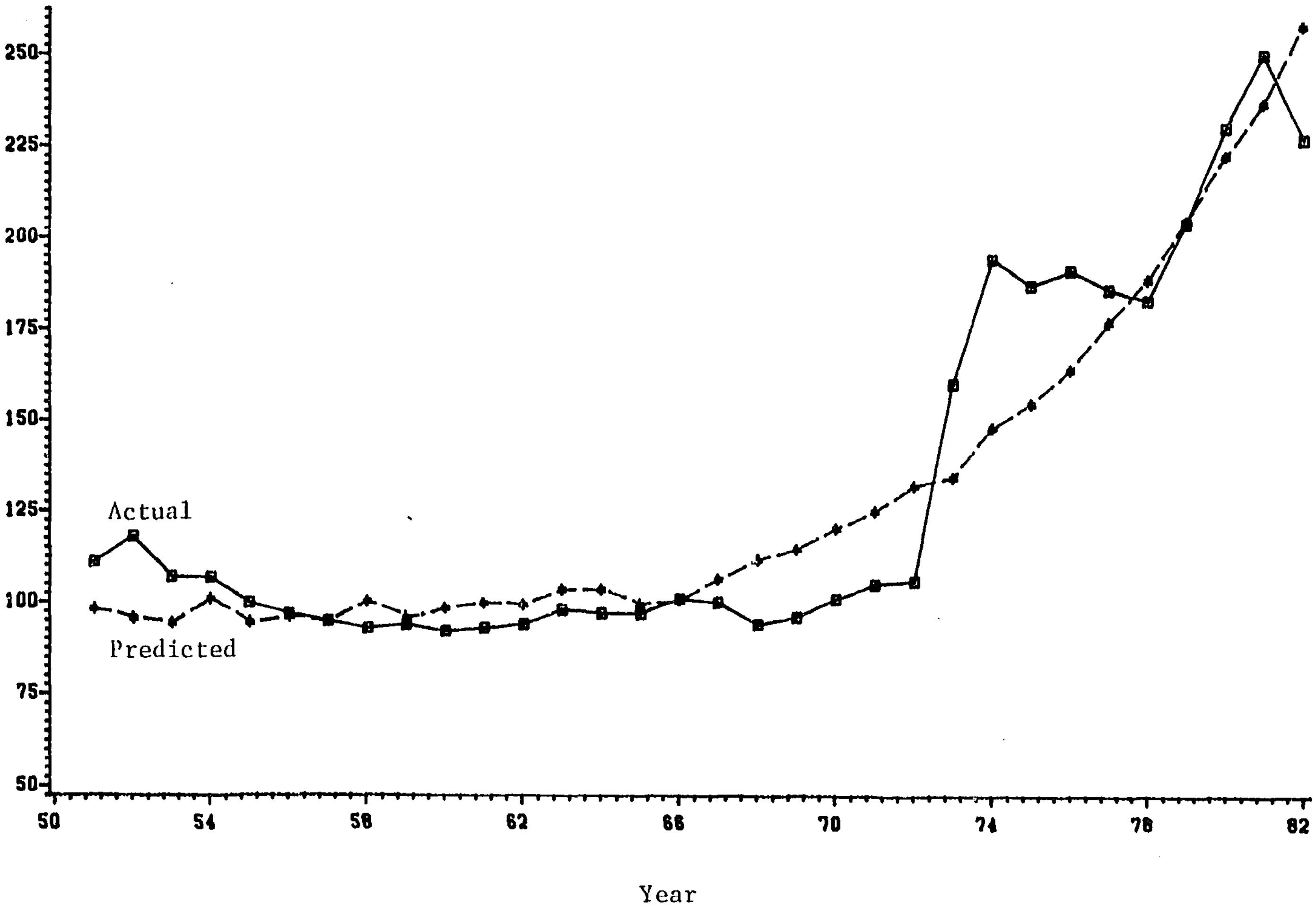

Figure 5.10. Predicted versus actual values of price of feed (index, 1967=100)

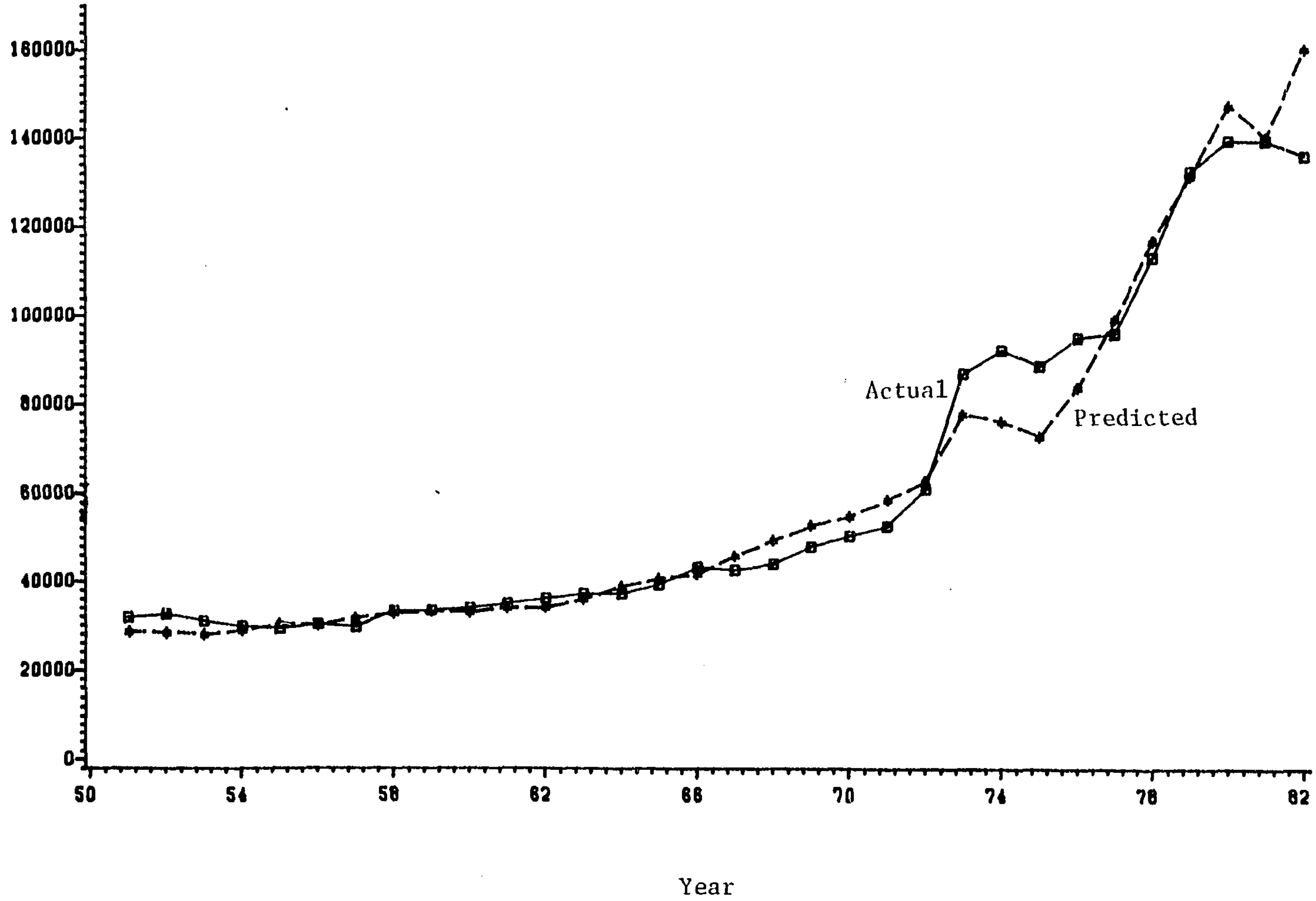

Figure 5.11. Predicted versus actual values of nominal farm income (mil. dol.)

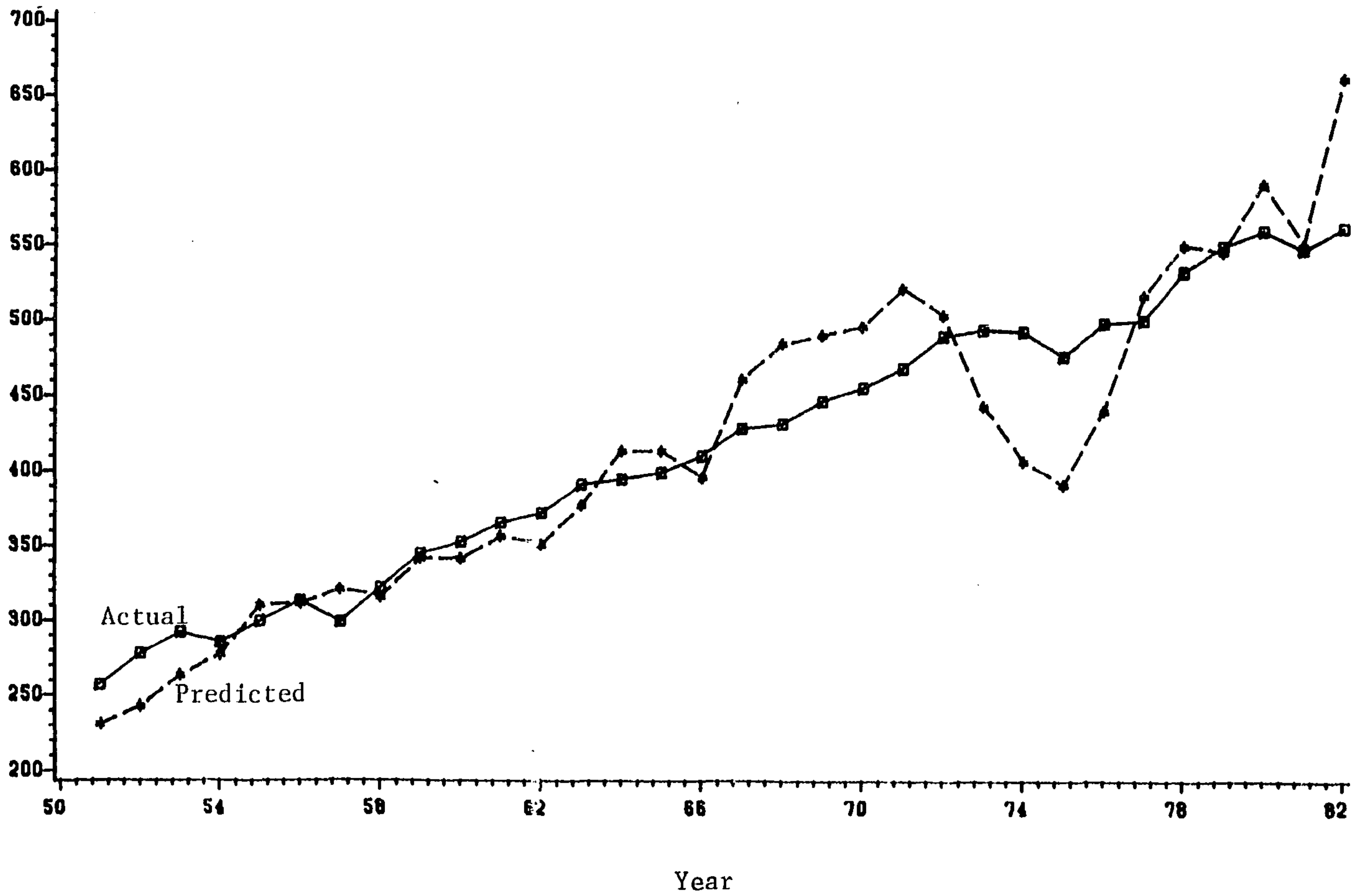

Figure 5.12. Predicted versus actual values of real farm income (mil. dol. in 1967 prices)

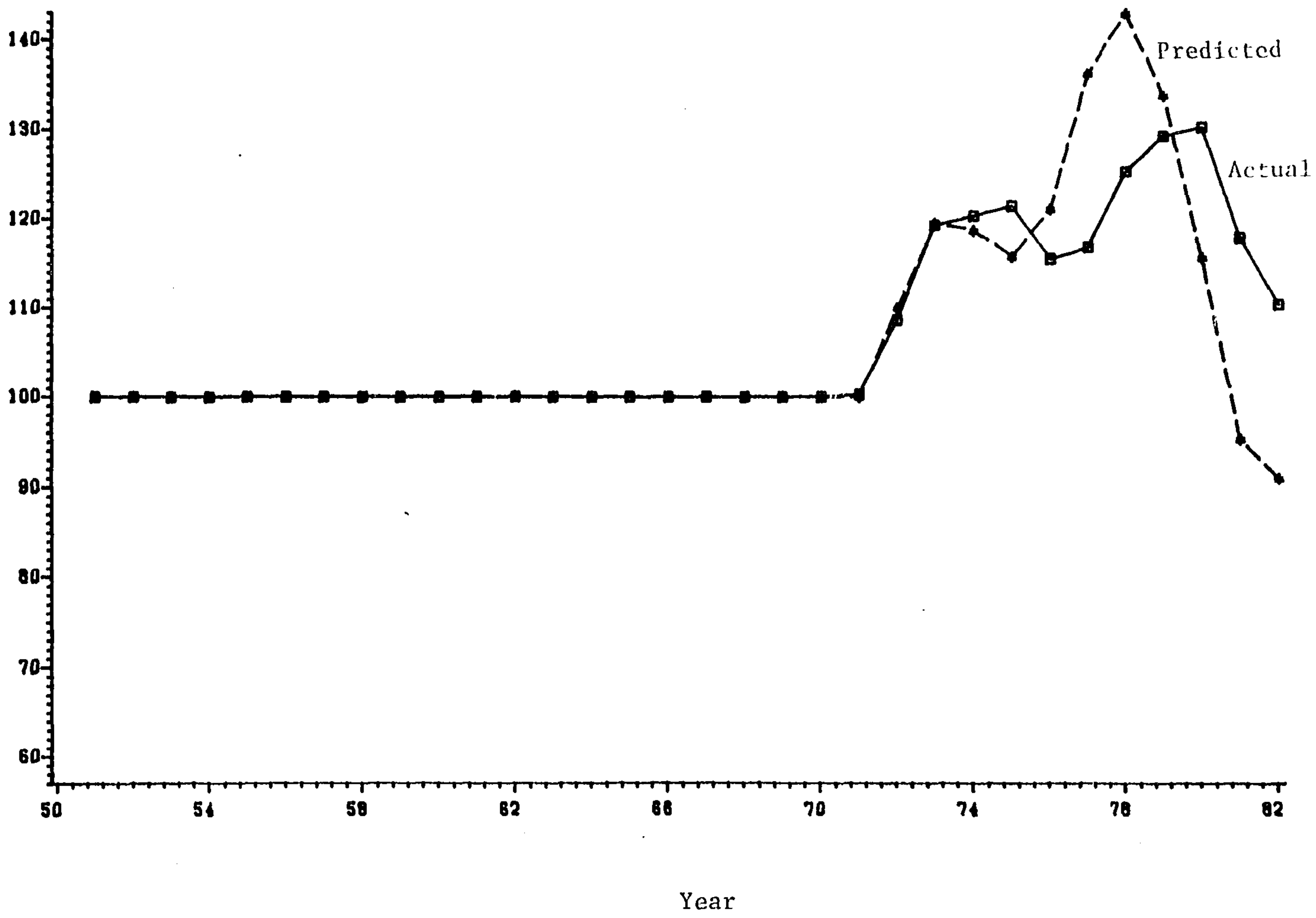

Figure 5.13. Predicted versus actual values of the exchange rate (U.S.$/SDR)

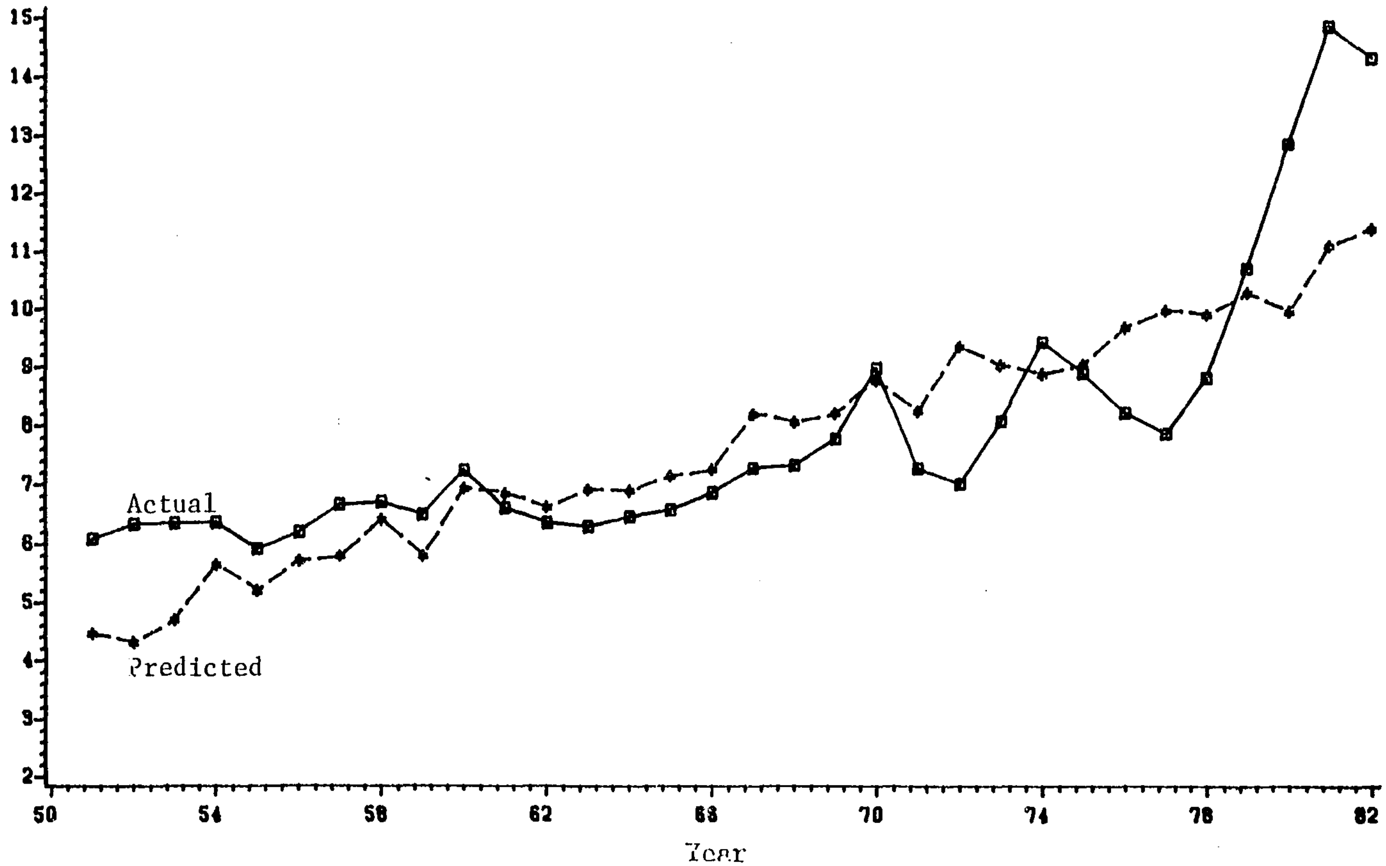

Figure 5.14. Predicted versus actual values of interest rate in the farm sector

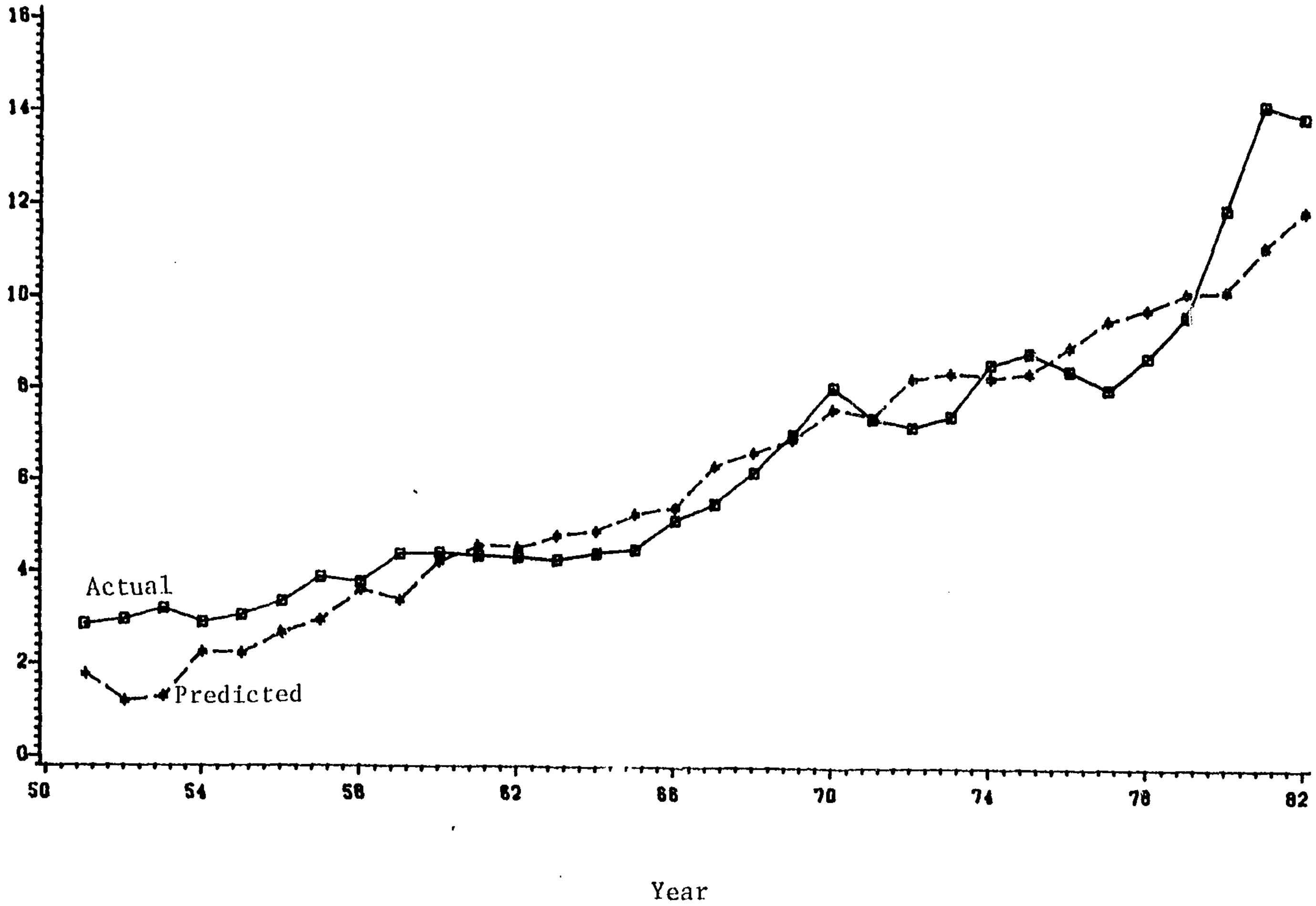

Figure 5.15. Predicted versus actual values of interest rate in the general economy

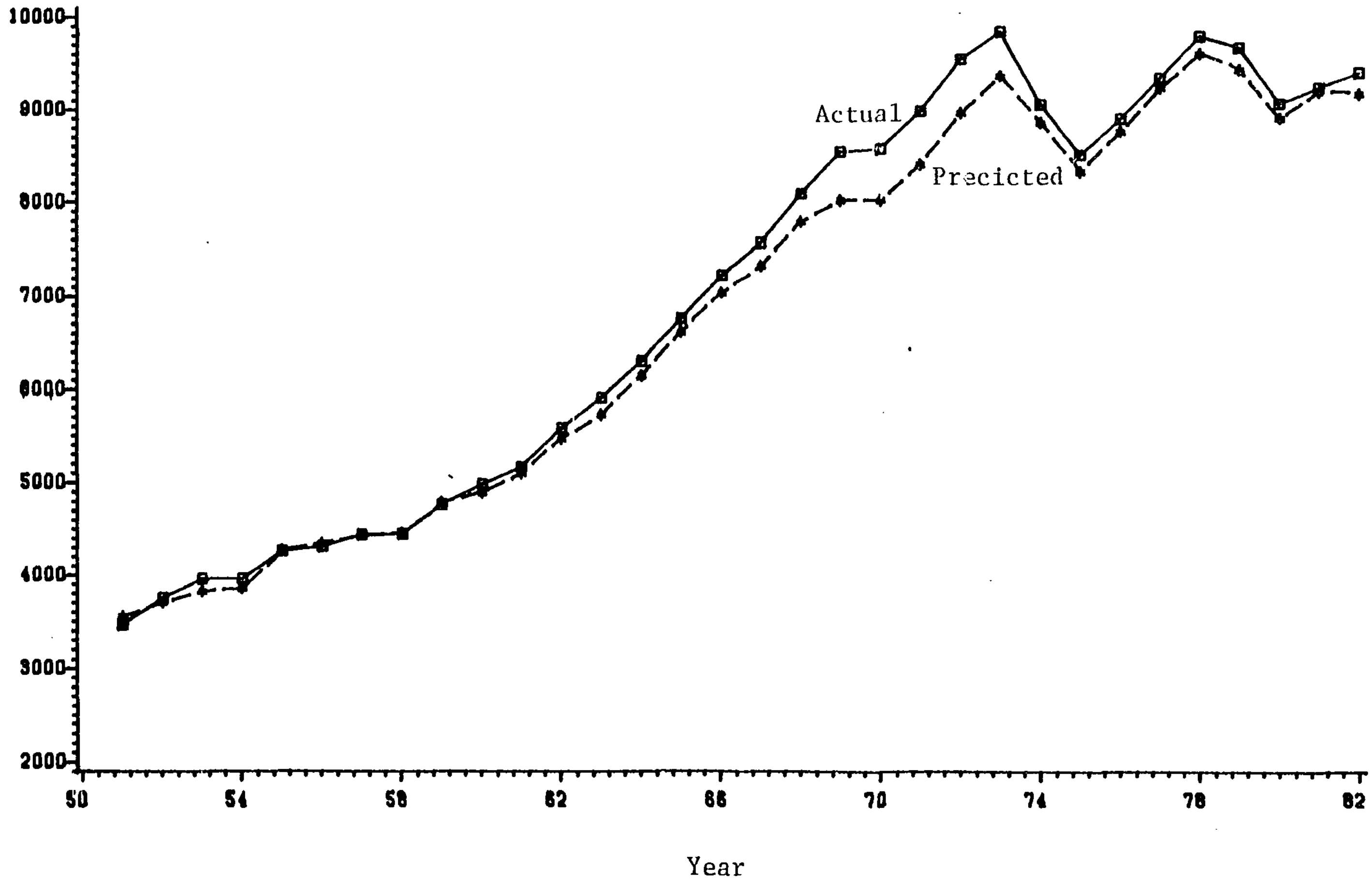

Figure 5.16. Predicted versus actual values of real output supply of manufactured goods (mil. dol. in 1967 prices)

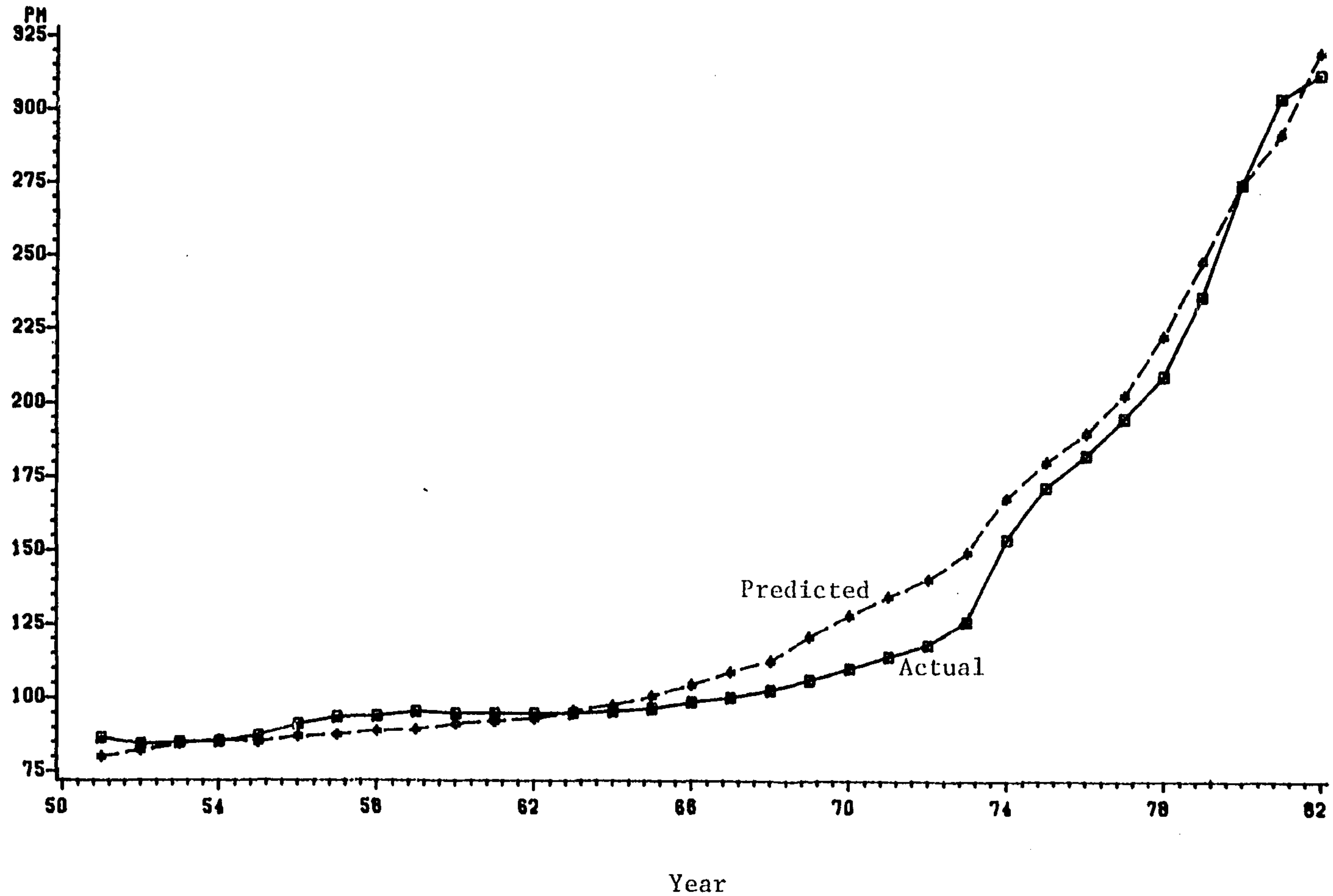

Figure 5.17. Predicted versus actual values of manufactured goods price (index, 1967=100)

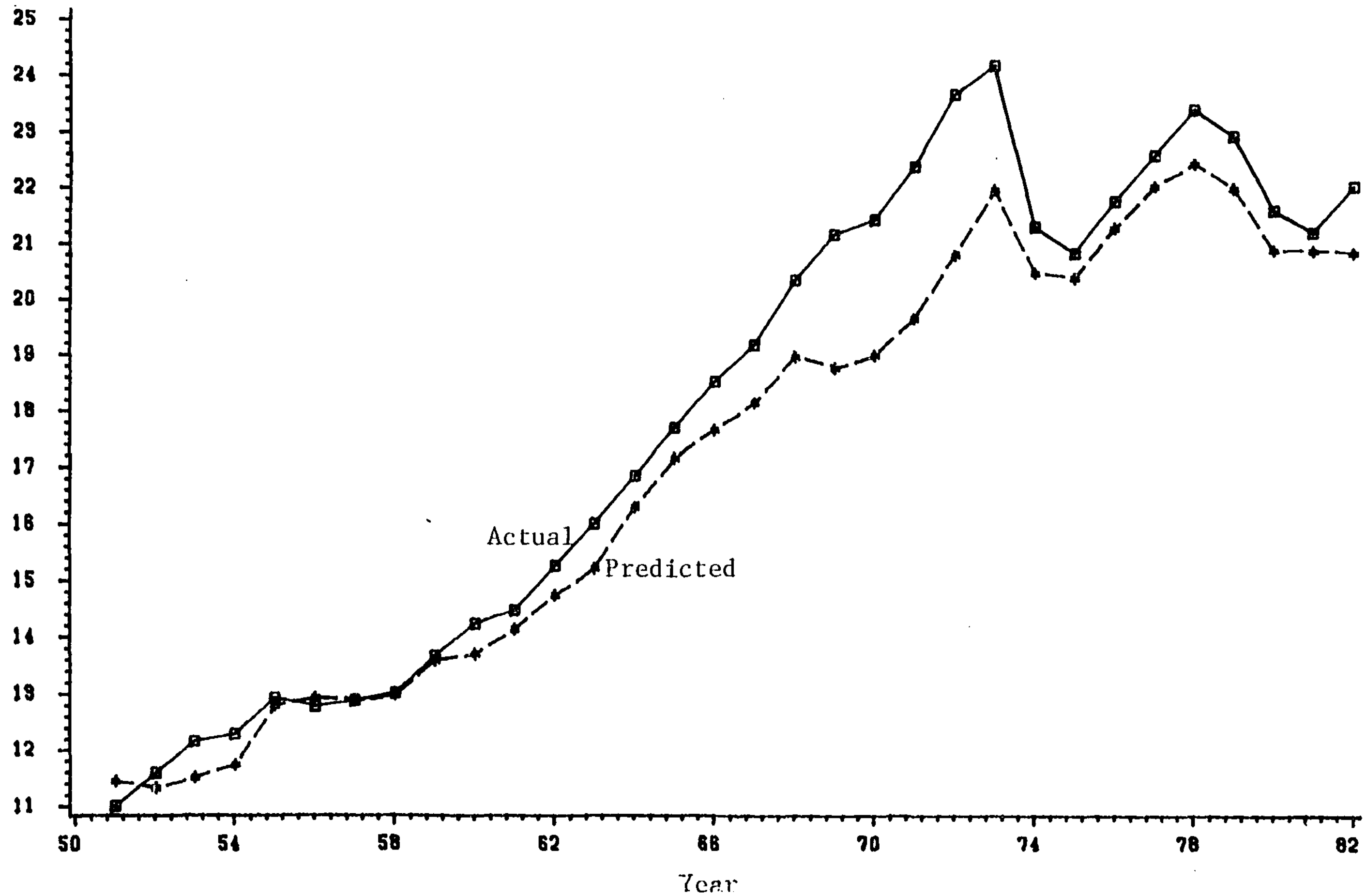

Figure 5.18. Predicted versus actual values of per capita real consumption of manufactured goods (thousand dol. in 1967 prices)

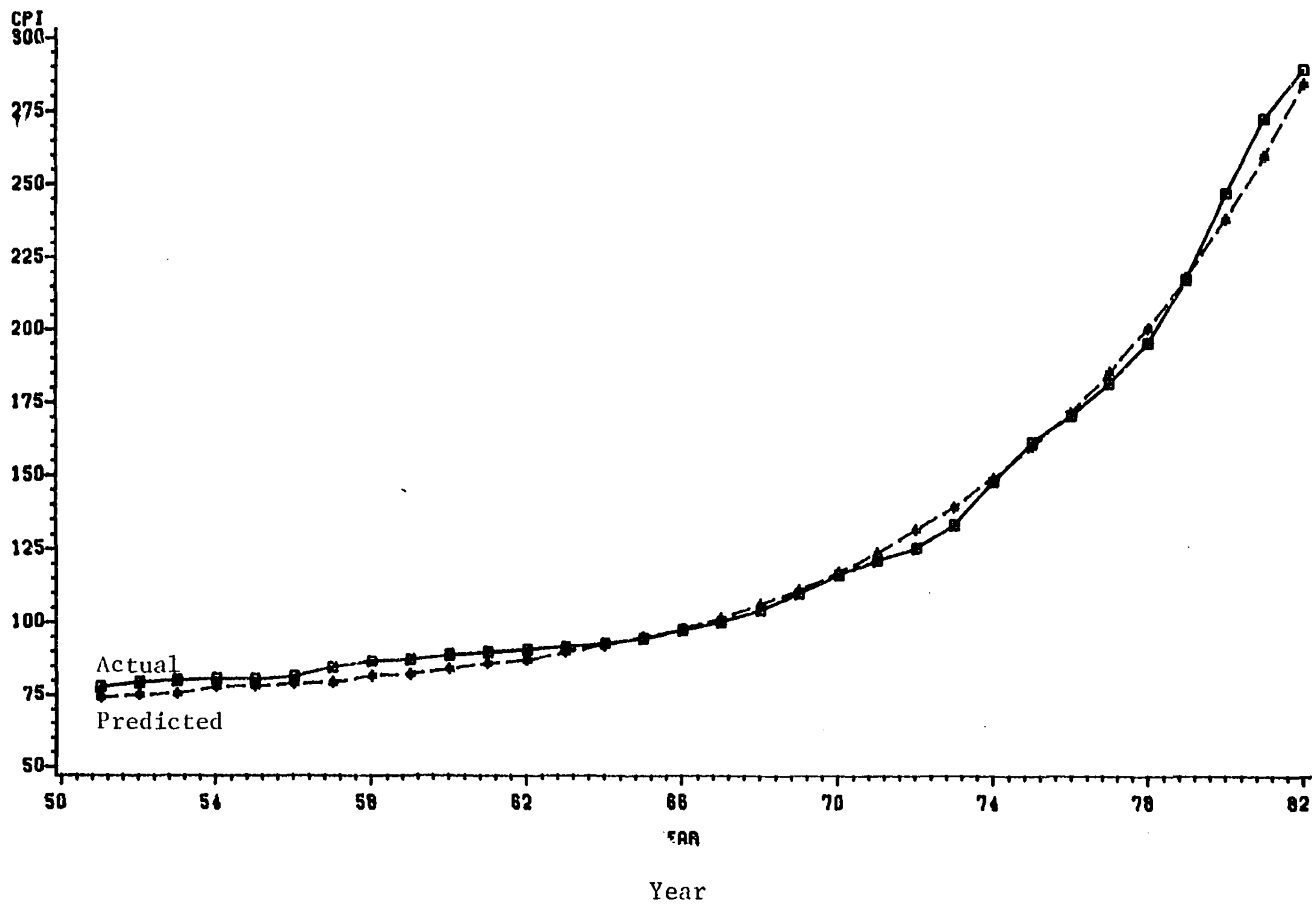

Figure 5.19. Predicted versus actual values of consumer price index (index, 1967=100)

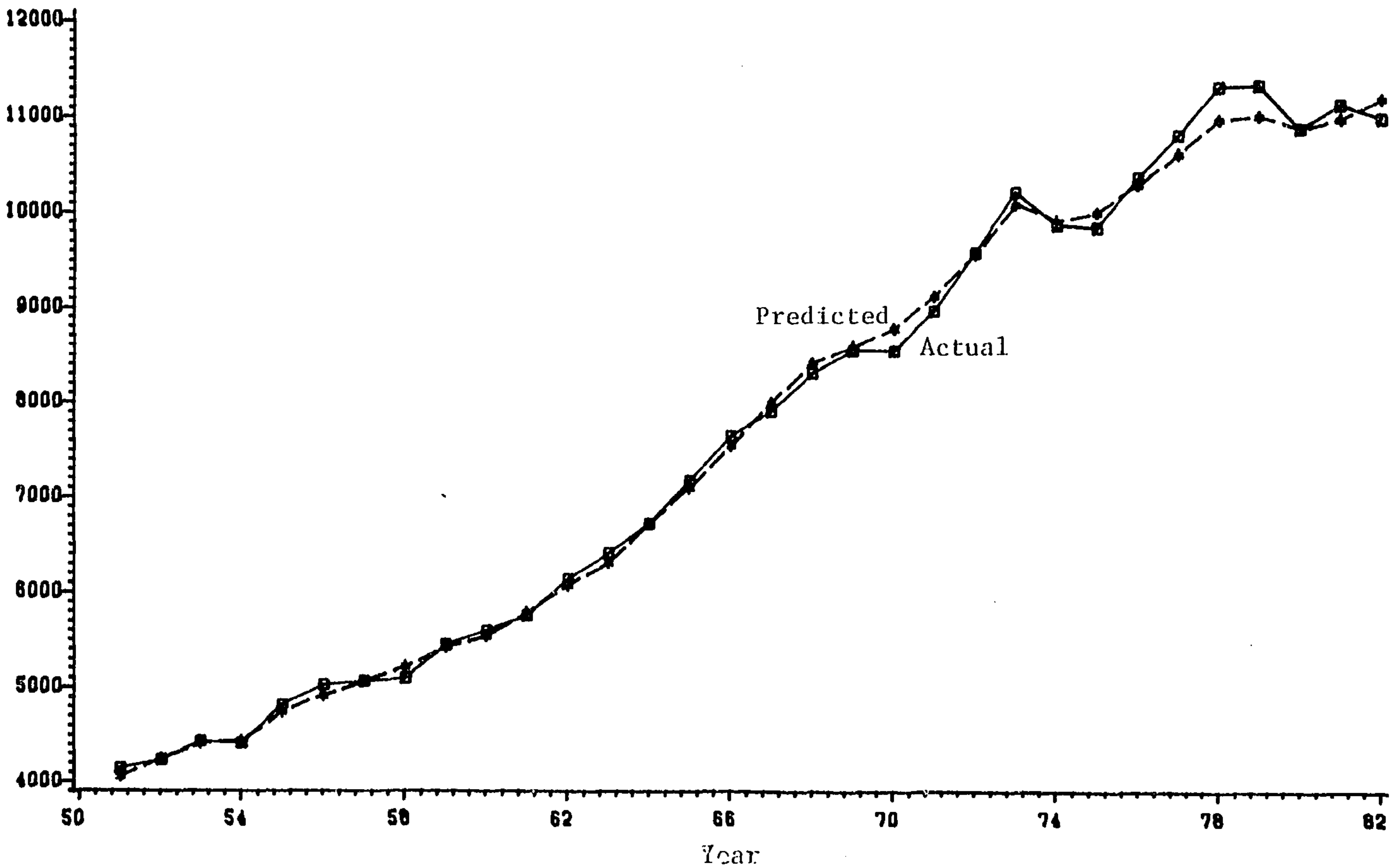

Figure 5.20. Predicted versus actual values of real gross national product (mil. dol. in 1967 prices)

zero, implying the model has performed remarkably well in simulating the actual values.

Let us examine the ability of the model to duplicate turning points or rapid changes in the actual data of some key endogenous variables. Looking at Figures 5.1 to 5.20, we observe that the simulated series do seem to reproduce the general long-run behavior of the actual series, although 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 the general economy; as a result, farm variables tend to have more short-run fluctuations than 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 difference 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 relatively performs 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 is predicted very well. The livestock product price performs extremely well barring a minor turning point error in 1975. A relatively poor job seems to have been done in tracking the net crop exports after 1977; it might be due to the high volatility of crop exports in those periods. Both nominal and real farm income have perfect fit except for the smaller differences in the mid-1970s.

Turning to the exchange rate variable, even though there is very minor deviation of simulated values from the actual values, all the turning points since the beginning of the floating exchange rate system are predicted quite well. Other endogenous variables in the nonfarm sector, such as industrial output supply, real gross national product, and the consumer price index, have performed remarkably well. In general, results suggest that some headway has been made in predicting the actual values by the construction of the econometric model.

The stability of the model is analyzed by calculating the characteristic roots from the characteristic equation that is derived from the model. If the model is large and nonlinear, calculating the characteristic roots becomes a cumbersome task. In such cases, the best one can do to determine whether or not the model is stable in the long term is to simulate the model over a long period of time (see Pindyck and Rubinfeld, 1981). Hence, a good fit of the model would imply the model is stable. Thus, the above dynamic historical simulation of the model over the entire period indicates the model is stable.

Other ways of testing the model stability is to perform a series of simulations, over different periods of time and using different time paths for the exogenous variables in the model. For the present case, the money supply growth rate in 1972 is exogenously increased by three percent to test the stability of the model. If the changes in the endogenous variables to 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 because that was the year the floating exchange rate regime was in effect; thus, we would expect the changes in the money supply growth rate to have effect on the endogenous variables, like crop exports, through the exchange rate. Given this shock, the simulation is rerun over the period of 1972 to 1982. Table 5.5 reports the base simulated values and the changes in the values of the key endogenous variables from the base solution due to the 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 will be on the consumer price index, interest rates, and exchange rates. The percentage change of consumer price index steadily declines from 0.69 percent to 0.10 percent from 1972 to 1982. The value of exchange rates ($/SDR) rises by 0.44 percent in 1972 and 1.83 percent in 1973, and then steadily decreases to 0.18 in 1982. The immediate effect of an increase in the rate of growth of the money supply is to lower interest rates by 8.58 percent in 1972; however, interest rates increase by 4.25 percent in 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

Table 5.5. Dynamic impact of an increase in the U.S. money supply growth rate by three percent in 1972

	Year	1972	1973	1974
Real crop supply	Base	195.14	201.22	180.65
mil. dol. (1967 prices)	Change	8.72	-14.41	3.57
	Percent change	4.47	-7.16	1.98
Domestic demand for	Base	154.30	150.25	120.59
crop output	Change	5.00	-11.04	1.24
mil. dol. (1967 prices)	Percent change	3.24	-7.35	1.03
Real crop inventories	Base	106.27	99.07	98.98
mil. dol. (1967 prices)	Change	3.29	-2.03	-0.09
	Percent change	3.09	-2.05	-0.09
Real crop net exports	Base	42.81	58.19	60.15
mil. dol. (1967 prices)	Change	0.43	1.96	0.39
	Percent change	1.00	3.36	0.65
Crop price index	Base	144.21	177.07	187.67
(1967=100)	Change	-0.42	5.84	-3.92
	Percent change	-0.29	3.30	-2.09
Fertilizer price	Base	119.53	122.21	134.20
index (1967=100)	Change	2.90	-0.49	-0.30
	Percent change	2.42	-0.40	-0.22
Real livestock	Base	259.50	250.09	269.58
product supply	Change	0.18	-2.22	3.15
mil. dol. (1967=100)	Percent change	0.07	-0.89	1.17
Domestic demand for	Base	264.77	255.46	272.22
livestock products	Change	0.18	-2.22	3.15
mil. dol. (1967=100)	Percent change	0.07	-0.89	1.17
Livestock product price	Base	134.04	169.79	157.67
index (1967=100)	Change	0.39	4.05	-4.59
	Percent change	0.29	2.39	-2.91
Feed price	Base	131.98	134.26	148.01
index (1967=100)	Change	2.87	-1.87	0.03
	Percent change	2.18	-1.39	0.02
Interest rate in the	Base	9.35	9.03	8.88
farm sector	Change	-0.79	0.79	-0.18
percent	Percent change	-8.49	8.74	-2.02

1975	1976	1977	1978	1979	1980	1981	1982
250.62	253.69	283.86	271.09	280.69	268.90	282.20	253.26
1.84	-0.32	0.54	-0.48	0.18	-0.32	-0.21	-0.18
0.73	-0.13	0.19	-0.18	0.07	-0.12	-0.07	-0.07
185.07	185.54	194.24	177.25	196.69	202.67	236.62	189.61
1.80	-2.35	0.31	-0.71	-0.08	-0.41	-0.35	-0.34
0.97	-1.27	0.16	-0.40	-0.04	-0.20	-0.15	-0.18
108.77	111.90	114.88	113.07	111.23	111.04	115.20	143.71
-0.17	-0.02	0.02	0.03	0.08	0.01	-0.05	-0.06
-0.15	-0.01	0.01	0.03	0.07	0.00	-0.04	-0.04
55.75	65.02	86.65	95.66	85.84	66.42	41.42	35.15
0.11	1.88	0.19	0.21	0.21	0.17	0.19	0.17
0.21	2.89	0.22	0.22	0.25	0.25	0.46	0.47
139.89	158.54	170.22	210.46	230.76	274.47	238.67	310.96
0.32	1.26	0.10	0.87	0.47	0.31	0.39	0.29
0.23	0.80	0.06	0.41	0.20	0.11	0.17	0.09
149.08	158.70	170.44	183.91	199.26	220.87	241.47	272.22
-0.23	0.34	0.24	0.25	0.25	0.27	0.31	0.33
-0.15	0.21	0.14	0.13	0.12	0.12	0.12	0.12
285.98	284.44	277.08	272.60	263.70	255.35	263.05	268.04
-1.35	0.58	-0.34	0.16	-0.02	0.02	0.02	0.02
-0.47	0.21	-0.12	0.06	-0.01	0.01	0.01	0.01
286.73	284.05	275.04	273.0	264.11	255.32	260.01	266.80
-1.35	0.58	-0.34	0.16	-0.02	0.02	0.02	0.02
-0.47	0.21	-0.12	0.06	-0.01	0.01	0.01	0.01
132.63	153.86	184.69	219.51	253.79	288.16	277.72	304.62
1.78	-0.14	0.65	0.21	0.38	0.26	0.29	0.26
1.34	-0.09	0.35	0.10	0.15	0.09	0.10	0.09
154.60	163.75	176.95	188.47	204.45	222.25	236.58	257.63
-0.01	0.50	0.10	0.16	0.16	0.19	0.22	0.23
-0.01	0.31	0.06	0.08	0.08	0.09	0.09	0.09
9.04	9.69	9.99	9.92	10.29	9.97	11.11	11.40
0.02	-0.05	0.02	0.01	0.01	0.01	0.01	0.01
0.20	-0.55	0.21	0.10	0.09	0.13	0.11	0.11

Table 5.5. continued

	Year	1972	1973	1974
Nominal farm income mil. dol.	Base	62924	78092	76406
	Change	1297.28	-831.42	-808.85
	Percent change	2.06	-1.07	-1.06
Real farm income mil. dol. (1967=100)	Base	503.39	442.95	407.07
	Change	10.38	-4.72	-4.31
	Percent change	2.06	-1.06	-1.06
Industrial goods price index (1967=100)	Base	140.34	149.25	167.70
	Change	3.28	0.05	0.06
	Percent change	2.33	0.04	0.04
Interest rate in the general economy percent	Base	8.24	8.36	8.26
	Change	-0.71	0.36	0.00
	Percent change	-8.58	4.25	0.00
Exchange rate U.S. $/SDR	Base	109.89	119.34	118.57
	Change	0.49	2.18	0.15
	Percent change	0.44	1.83	0.13
Consumer price index index (1967=100)	Base	131.58	138.94	149.19
	Change	0.91	0.19	0.17
	Percent change	0.69	0.14	0.11
Real gross national product mil. dol. (1967=100)	Base	9558.5	10079.3	9913.0
	Change	18.81	-22.91	-11.22
	Percent change	0.20	-0.23	-0.11

1975	1976	1977	1978	1979	1980	1981	1982
72989	83981	99491	116893	131698	147385	140408	160406
667.58	317.45	235.46	226.45	268.78	69.48	142.45	92.41
0.91	0.38	0.24	0.19	0.20	0.05	0.10	0.06
390.94	439.69	516.84	550.08	545.56	590.96	550.84	661.74
3.58	1.66	1.22	1.07	1.11	0.27	0.56	0.38
0.92	0.38	0.24	0.19	0.20	0.05	0.10	0.06
180.16	190.00	203.23	222.96	248.38	274.82	291.79	319.65
0.06	0.07	0.07	0.08	0.09	0.09	0.10	0.11
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
8.36	8.94	9.52	9.77	10.14	10.18	11.14	11.91
0.02	-0.01	0.02	0.02	0.02	0.02	0.02	0.02
0.20	-0.07	0.19	0.21	0.21	0.20	0.17	0.17
115.69	120.99	136.05	142.84	133.69	115.59	95.33	91.01
0.10	0.37	0.15	0.17	0.16	0.17	0.17	0.16
0.09	0.30	0.11	0.12	0.12	0.14	0.18	0.18
159.91	171.66	185.25	200.30	218.02	238.24	259.70	284.08
0.14	0.18	0.18	0.20	0.22	0.25	0.27	0.30
0.09	0.11	0.10	0.10	0.10	0.10	0.10	0.10
10002.5	10294.8	10610.8	10973.4	11008.0	10878.7	10982.5	11189.2
2.52	-4.72	-0.28	-0.37	0.12	-0.49	-0.31	-0.59
0.03	-0.05	-0.00	-0.00	0.00	-0.00	-0.00	-0.00

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.

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 the farm sector variables due to different monetary policies will be discussed in the next chapter. However, the important point to note at present is that the fluctuation response of the farm sector variables to the exogenous shock declines from 1972 to 1982. Since all the variables move back to their equilibrium values after the increase in the money stock growth rate, the model is stable.

In summary, the results suggest that the model does an excellent job of depicting the behavior of the endogenous variables of concern. The model appears to provide a good foundation upon which to base further empirical research. In the next chapters, dynamic properties of the overall system will be more closely investigated through simulation analysis. Several interesting policy questions will be evaluated empirically.

CHAPTER VI. DYNAMIC POLICY ANALYSIS

This chapter will investigate the impact of different monetary policies on U.S. agriculture using dynamic multiplier analysis. The comparison of the dynamic simulation results with and without a given event or policy shows the impact of such an event or policy. Two policy scenarios are examined. First, an expansionary monetary policy of sustained increase in the growth rate of money supply by three percent from 1972 to 1982 and, second, a contractionary policy of sustained decrease in the growth rate of money supply by three percent from 1972 to 1982, are investigated.

Before presenting the results of multiplier analysis, a few notes are necessary about selecting these policy scenarios. First, the changes in the monetary policies are evaluated only with 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 is altered by changing the growth rate of money supply rather than changing the level of money supply. This is done because when the Federal Reserve open market committee conducts the monetary policy, it would do so by changing the money supply growth rate rather than the level of money supply. Then, the money supply level corresponding to the increase (decrease) in the growth rate of money supply for easy (tight) monetary policy is incorporated in the simulation model to analyze the effects of changes in the monetary policies on the farm economy.

Since the money supply growth rate is altered every year from 1972 to 1982, simulation results will have compounding effects on the endogenous variables. That is, the consequent changes in the endogenous variables in any period will include the dynamic effects of the increase in the money supply of all previous periods. Table 6.1 reports the simulation results of the expansionary monetary policy for key endogenous variables.

As explained in the previous chapters, the money supply expansion appreciates (depreciates) the value of SDR (U.S. dollar). The value of the exchange rate in terms of SDR appreciates continually from 0.44 percent in 1972 to 13.99 percent in 1982, which implies the value of the U.S. dollar depreciates 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 declines by -8.58 percent in 1972 to -2.53 percent in 1982, whereas the consumer price index continues to rise from 0.70 percent in 1972 to 1.49 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 analyzed with the help of Figure 6.1. The depreciation of the dollar causes a higher demand for U.S. crop products by the rest of the world. Similarly, an increase in the income and decline in the interest rate causes domestic demand and inventory demand to shift up, respectively. Therefore, the aggregate demand curve shifts from D to D'. The aggregate supply curve shifts from S to S'

Table 6.1. Dynamic impact of a sustained increase in the U.S. money supply growth rate by three percent from 1972 to 1982

	Year	1972	1973	1974
Real crop supply mil. dol. (1967 prices)	Base	195.14	201.22	180.65
	Change	8.78	-5.99	-1.17
	Percent change	4.47	-2.30	-0.65
Domestic demand for crop output mil. dol. (1967 prices)	Base	154.30	150.25	120.59
	Change	5.00	-6.94	-6.90
	Percent change	3.24	-4.62	-5.72
Real crop inventories mil. dol. (1967 prices)	Base	106.27	99.07	98.98
	Change	3.29	1.03	0.61
	Percent change	3.09	1.04	0.61
Real crop net exports mil. dol. (1967 prices)	Base	42.81	58.19	60.15
	Change	0.43	3.21	6.16
	Percent change	1.00	5.51	10.25
Crop price index (1967=100)	Base	144.21	177.07	187.67
	Change	-0.42	3.82	4.34
	Percent change	-0.29	2.16	2.31
Fertilizer price index (1967=100)	Base	119.53	122.21	134.20
	Change	2.90	2.45	2.52
	Percent change	2.42	2.01	1.88
Real livestock product supply mil. dol. (1967=100)	Base	259.50	250.09	269.58
	Change	0.18	-2.04	1.23
	Percent change	0.07	-0.82	0.46
Domestic demand for livestock products mil. dol. (1967=100)	Base	264.77	255.46	272.22
	Change	0.18	-2.04	1.23
	Percent change	0.07	-0.80	0.45
Livestock product price index (1967=100)	Base	134.04	169.79	157.67
	Change	0.39	3.97	0.82
	Percent change	0.29	2.34	0.52
Feed price index (1967=100)	Base	131.98	134.26	148.01
	Change	2.87	1.05	1.41
	Percent change	2.18	0.78	0.95
Interest rate in the farm sector percent	Base	9.35	9.03	8.88
	Change	-0.79	-0.03	-0.24
	Percent change	-8.49	-0.35	-2.71

1975	1976	1977	1978	1979	1980	1981	1982
250.62	253.69	283.86	271.09	280.69	268.90	282.20	253.26
1.45	0.55	-1.64	0.69	5.55	0.64	0.82	1.04
0.58	0.22	-0.58	0.25	1.98	0.24	0.29	0.41
185.07	185.54	194.24	177.25	196.69	202.67	236.62	189.61
-4.97	-6.83	-8.55	-8.14	-7.63	-11.42	-12.14	-13.22
-2.69	-3.69	-4.40	-4.59	-3.88	-5.63	-5.13	-6.97
108.77	111.90	114.88	113.07	111.23	111.04	115.20	143.71
0.21	0.05	-2.11	-3.00	-1.09	-1.20	-1.57	-1.52
0.20	0.05	-1.83	-2.66	-0.98	-1.08	-1.36	-1.05
55.75	65.02	86.65	95.66	85.84	66.42	41.42	35.15
6.81	7.54	9.07	9.73	11.27	12.17	13.33	14.21
12.21	11.59	10.46	10.17	13.13	18.32	32.18	40.43
139.89	158.54	170.22	210.46	230.76	274.47	238.67	310.96
4.68	5.10	7.90	8.90	5.88	12.35	14.55	3.72
3.35	3.22	4.64	4.23	2.55	4.50	6.10	1.20
149.08	158.70	170.44	183.91	199.26	220.87	241.47	272.22
2.45	2.56	3.48	3.85	3.94	4.48	4.89	5.50
1.65	1.61	2.04	2.09	1.98	2.03	2.02	2.02
285.98	284.44	277.08	272.60	263.70	255.35	263.05	268.04
-0.16	0.48	0.19	0.62	0.65	0.28	0.48	0.56
-0.05	0.17	0.07	0.23	0.25	0.11	0.18	0.21
286.73	284.05	275.04	273.0	264.11	255.32	260.01	266.80
-0.16	0.48	0.19	0.62	0.65	0.28	0.48	0.56
-0.05	0.17	0.07	0.23	0.25	0.11	0.19	0.21
132.63	153.86	184.69	219.51	253.79	288.16	277.72	304.62
2.49	2.10	3.49	3.22	3.37	6.07	6.25	2.35
1.88	1.36	1.89	1.47	1.33	2.11	2.25	0.77
154.60	163.75	176.95	188.47	204.45	222.25	236.58	257.63
1.38	1.57	2.49	2.40	2.37	2.95	3.17	3.67
0.89	0.96	1.41	1.27	1.16	1.33	1.34	1.42
9.04	9.69	9.99	9.92	10.29	9.97	11.11	11.40
-0.23	-0.22	-0.21	-0.14	-0.22	-0.19	-0.20	-0.06
-2.58	-2.24	-2.06	-1.37	-2.14	-1.90	-1.77	-0.50

Table 6.1. continued

	Year	1972	1973	1974
Real farm income	Base	503.39	442.95	407.07
mil. dol. (1967=100)	Change	10.83	1.82	5.19
	Percent change	2.06	0.41	1.28
Industrial goods price	Base	140.34	149.25	167.70
index (1967=100)	Change	3.28	3.45	3.89
	Percent change	2.33	2.31	2.32
Interest rate in the	Base	8.24	8.36	8.26
general economy	Change	-0.71	-0.38	-0.39
percent	Percent change	-8.58	-4.50	-4.67
Exchange rate	Base	109.89	119.34	118.57
U.S. $/SDR	Change	0.49	3.29	5.54
	Percent change	0.44	2.76	4.67
Consumer price index	Base	131.58	138.94	149.19
index (1967=100)	Change	0.91	1.10	1.36
	Percent change	0.70	0.79	0.91

1975	1976	1977	1978	1979	1980	1981	1982
390.94	439.69	516.84	550.08	545.56	590.96	550.84	661.74
11.11	10.76	15.35	16.84	16.65	20.60	23.92	8.56
2.84	2.45	2.97	3.06	3.05	3.49	4.34	1.29
180.16	190.00	203.23	222.96	248.38	274.82	291.79	319.65
4.19	4.42	4.71	5.11	5.74	6.36	6.86	7.49
2.33	2.33	2.32	2.29	2.31	2.31	2.35	2.34
8.36	8.94	9.52	9.77	10.14	10.18	11.14	11.91
-0.38	-0.37	-0.41	-0.38	-0.34	-0.33	-0.33	-0.30
-4.58	-4.17	-4.31	-3.86	-3.30	-3.24	-2.91	-2.53
115.69	120.99	136.05	142.84	133.69	115.59	95.33	91.01
6.00	6.71	7.95	8.61	9.35	10.39	11.42	12.73
5.18	5.55	5.85	6.03	6.99	8.99	11.98	13.98
159.91	171.66	185.25	200.30	218.02	238.24	259.70	284.08
1.55	1.78	2.04	2.33	2.70	3.15	3.58	4.23
0.97	1.04	1.10	1.16	1.24	1.32	1.38	1.49

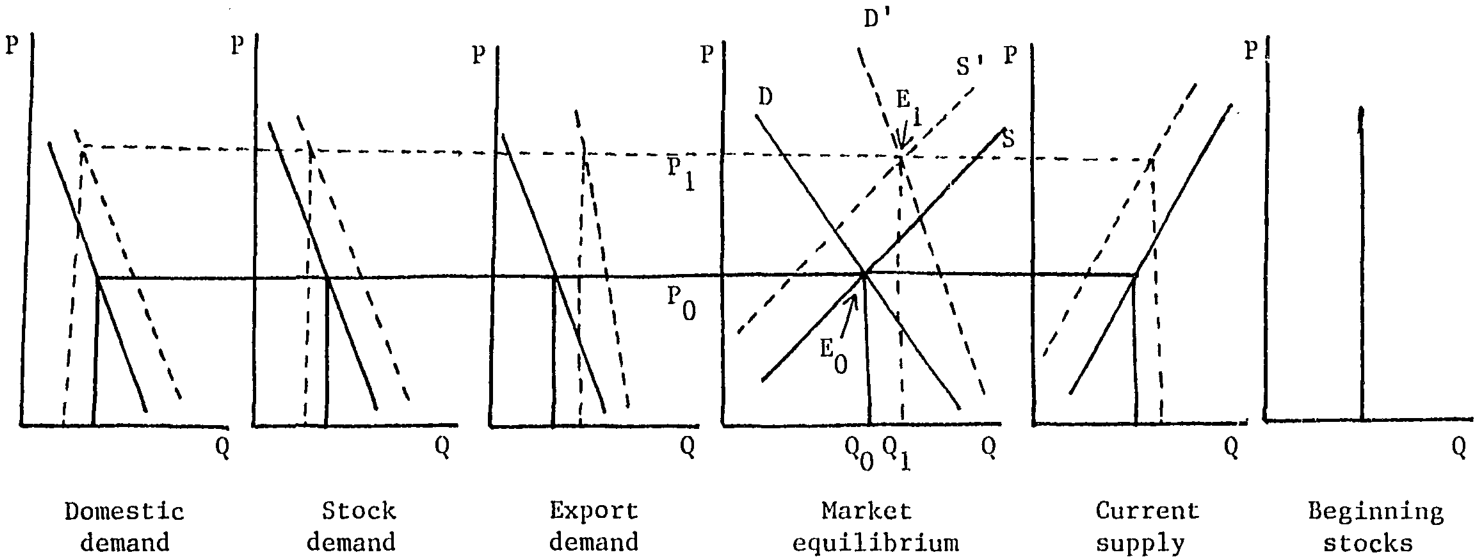

Figure 6.1. The effect of money supply increase on the crop sector

because the cost effect of an increase in the inflation dominates the cost effect of decline in the interest rate. Since graphical analysis does not permit to analyze the dynamic changes in the endogenous variables over time, the year 1982 is chosen to examine the 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 1982 and also prior to 1982. At this equilibrium, the crop price rises to P_1, i.e., by 1.20 percent (refer to Table 6.1). This rise in the crop price is caused by the increase in the aggregate crop demand and decrease in the supply schedules. The equilibrium quantity of net crop exports increases by 40.43 percent, which is the major driving force for the crop price increase. However, the equilibrium quantities of domestic demand and stock inventories decline by -6.97 percent and -1.05 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. For the same reason, the equilibrium quantity of crop supply increases by 0.41 percent.

Turning to the livestock sector, the percentage changes in the livestock product supply, demand, and prices in 1982 are 0.21, 0.21, and 0.77, respectively. Unlike in the case of domestic crop demand, the equilibrium quantity of livestock product demand increases. This is because the livestock commodity trade is assumed to be exogenous and, hence, there is no trade effect to raise the livestock product price. Therefore, the income effect of livestock product demand dominates the effect of price increase, i.e., there is no crowding out of domestic demand since the livestock product trade is predetermined.

Given these increases in the equilibrium quantities and prices in both the crop and livestock sector, we would anticipate the total farm income to rise. As can be seen from Table 6.1, the real farm income increases by 1.29 percent.

The long-run elasticities of key endogenous variables with respect to money supply increases are reported in Table 6.2. The long-run elasticities of crop price, exports, and domestic demand associated with a one percent increase in the money supply are elastic. The elasticities of crop price (1.13) and crop exports (4.83) are particularly interesting, because they provide evidence to Chambers and Just's argument that the effect of money supply changes on agricultural trade and prices would be magnified if a more complete set of linkages are specified, as has been done in this study, rather than specifying only the exchange rate linkage. Chambers and Just estimated that the long-run elasticities of corn, wheat, and soybean exports with respect to money supply are 2.23, 2.03, and 0.99, respectively, and the long-run price elasticities of corn, wheat, and soybeans with respect to money supply are 0.74, 1.76, and 1.17, respectively.

The elasticity of livestock product price with respect to money supply expansion is inelastic at 0.54. This inelastic response is

Table 6.2. Dynamic elasticities of sustained increase in the money supply growth rate by three percent

	Long-run elasticity[a]
Exchange rate (U.S. $/SDR)	2.26
Domestic interest rate	-1.46
Consumer price index (1967=100)	0.412
Real crop supply (mil. dol. in 1967 prices)	0.14
Real domestic demand for crop output (mil. dol. in 1967 prices)	-1.46
Real crop inventories (mil. dol. in 1967 prices)	-0.53
Real crop net exports (mil. dol. in 1967 prices)	4.83
Crop price index (1967=100)	1.13
Real livestock product supply (mil. dol. in 1967 prices)	0.03
Real domestic demand for livestock products (mil. dol. in 1967 prices)	0.03
Livestock product price (1967=100)	0.54
Real farm income (mil. dol. in 1967 prices)	0.90

[a]Calculated as average changes of the variable in interest divided by average changes of the money supply, and evaluated at the means over the period 1972-1982.

anticipated because, as explained above, the livestock commodity trade is exogenous and, hence, there is no trade effect. Therefore, the increase in the livestock product price is only due to the changes in the domestic market.

Another interesting result is the long-run elasticity of real farm income is 0.9, which implies that the changes in the monetary policies have significant effect on the farm economy. Furthermore, from the above results, it is clear that an expansionary monetary policy favors the agricultural sector by increasing farm prices and income.

The second policy scenario examines the effect of a contractionary monetary policy of decreasing the money supply growth rate by three percent from 1972 to 1982. Table 6.3 reports the dynamic simulation results of this policy.

The reduction in the level of money supply increases the value of the dollar. The trade effect of this higher value of the dollar makes the U.S. farm products more expensive in the foreign market leading to a decline in the exports. The net crop exports in 1982 decrease by 42.74 percent. The reduced demand for U.S. products from abroad is the major driving force for the crop price to decline by 4.89 percent in 1982. Because of this lower crop price, the equilibrium quantity of domestic demand and stock demand increases by 6.77 percent and 0.82 percent, respectively.

Turning to the livestock sector, a similar depressing effect is apparent. The livestock product price, equilibrium quantities of livestock product demand, and supply decline by 2.14, 0.23, and 0.22 percent.

Table 6.3. Dynamic impact of a sustained decrease in the U.S. money supply growth rate by three percent from 1972 to 1982

	Year	1972	1973	1974
Real crop supply mil. dol. (1967 prices)	Base	195.14	201.22	180.65
	Change	-8.77	6.02	0.54
	Percent change	-4.49	2.99	0.30
Domestic demand for crop output mil. dol. (1967 prices)	Base	154.30	150.25	120.59
	Change	-5.07	6.67	6.45
	Percent change	-3.28	4.44	5.35
Real crop inventories mil. dol. (1967 prices)	Base	106.27	99.07	98.98
	Change	-3.30	-0.84	-0.61
	Percent change	-3.11	-0.85	-0.62
Real crop net exports mil. dol. (1967 prices)	Base	42.81	58.19	60.15
	Change	-0.40	-3.11	-6.14
	Percent change	-0.93	-5.35	-10.21
Crop price index (1967=100)	Base	144.21	177.07	187.67
	Change	0.40	-7.14	-3.86
	Percent change	0.27	-4.03	-2.05
Fertilizer price index (1967=100)	Base	119.53	122.21	134.20
	Change	-2.88	-2.39	-2.54
	Percent change	-2.41	-1.96	-1.89
Real livestock product supply mil. dol. (1967=100)	Base	259.50	250.09	269.58
	Change	-0.18	2.06	-1.35
	Percent change	-0.07	0.82	-0.50
Domestic demand for livestock products mil. dol. (1967=100)	Base	264.77	255.46	272.22
	Change	-0.18	2.06	-1.35
	Percent change	-0.07	0.81	-0.50
Livestock product price index (1967=100)	Base	134.04	169.79	157.67
	Change	-0.39	-5.18	-0.55
	Percent change	-0.29	-3.05	-0.35
Feed price index (1967=100)	Base	131.98	134.26	148.01
	Change	-2.86	-0.99	-1.45
	Percent change	-2.17	-0.74	-0.98
Interest rate in the farm sector percent	Base	9.35	9.03	8.88
	Change	0.80	0.05	0.24
	Percent change	8.57	0.60	2.73

1975	1976	1977	1978	1979	1980	1981	1982
250.62	253.69	283.86	271.09	280.69	268.90	282.20	253.26
-1.30	0.38	-4.07	-3.55	-3.68	-1.14	-0.75	-1.82
-0.52	0.15	-1.43	-1.31	-1.31	-0.43	-0.27	-0.72
185.07	185.54	194.24	177.25	196.69	202.67	236.62	189.61
5.01	5.87	5.67	6.70	7.62	10.13	11.67	12.84
2.71	3.17	2.92	3.78	3.87	5.00	4.93	6.77
108.77	111.90	114.88	113.07	111.23	111.04	115.20	143.71
-0.20	0.20	-0.53	-0.83	-0.96	-0.09	0.82	1.18
-0.18	0.18	-0.46	-0.74	-0.87	-0.08	0.71	0.82
55.75	65.02	86.65	95.66	85.84	66.42	41.42	35.15
-6.73	-5.89	-9.01	-9.94	-11.16	-12.15	-13.32	-15.02
-12.07	-9.06	-10.40	-10.40	-13.00	-18.30	-32.16	-42.74
139.89	158.54	170.22	210.46	230.76	274.47	238.67	310.96
-4.77	-4.28	-4.21	-5.17	-5.93	-10.85	-13.84	-15.20
-3.41	-2.70	-2.47	-2.45	-2.57	-3.95	-5.80	-4.89
149.08	158.70	170.44	183.91	199.26	220.87	241.47	272.22
-2.44	-2.23	-2.48	-2.79	-3.38	-4.12	-4.64	-5.49
-1.64	-1.40	-1.46	-1.52	-1.70	-1.87	-1.92	-2.02
285.98	284.44	277.08	272.60	263.70	255.35	263.05	268.04
0.28	-0.52	-0.48	-0.37	-0.46	-0.33	-0.38	-0.60
0.10	-0.18	-0.17	-0.14	-0.18	-0.13	-0.14	-0.22
286.73	284.05	275.04	273.95	264.11	255.32	260.01	266.81
0.28	-0.52	-0.48	-0.37	-0.46	-0.33	-0.38	-0.60
0.10	-0.18	-0.17	-0.14	-0.18	-0.13	-0.15	-0.23
132.63	153.86	184.69	219.51	253.79	288.16	277.72	304.62
-2.65	-1.56	-2.34	-3.12	-3.68	-5.48	-6.21	-6.52
-1.99	-1.01	-1.27	-1.42	-1.45	-1.90	-2.24	-2.14
154.60	163.75	176.95	188.47	204.45	222.25	236.58	257.63
-1.35	-1.24	-1.68	-1.91	-2.39	-2.90	-3.11	-3.78
-0.88	-0.76	-0.95	-1.01	-1.17	-1.31	-1.32	-1.47
9.04	9.69	9.99	9.93	10.29	9.97	11.11	11.40
0.24	0.16	0.25	0.24	0.24	0.19	0.20	0.17
2.62	1.64	2.54	2.41	2.36	1.94	1.81	1.53

Table 6.3. continued

	Year	1972	1973	1974
Real farm income mil. dol. (1967=100)	Base	503.39	442.95	407.07
	Change	-10.53	-7.78	-5.10
	Percent change	-2.09	-1.76	-1.25
Industrial goods price index (1967=100)	Base	140.34	149.25	167.70
	Change	-3.28	-3.45	-3.88
	Percent change	-2.33	-2.31	-2.32
Interest rate in the general economy percent	Base	8.24	8.36	8.26
	Change	0.71	0.38	0.39
	Percent change	8.66	4.51	4.70
Exchange rate U.S. $/SDR	Base	109.89	119.34	118.57
	Change	-0.46	-3.23	-5.48
	Percent change	-0.42	-2.70	-4.62
Consumer price index index (1967=100)	Base	131.58	138.94	149.19
	Change	-0.91	-1.06	-1.34
	Percent change	-0.69	-0.76	-0.90

1975	1976	1977	1978	1979	1980	1981	1982
390.94	439.69	516.84	550.08	545.56	590.96	550.84	661.74
-11.20	-8.10	-13.54	-14.40	-14.82	-18.89	-22.80	-26.06
-2.87	-1.84	-2.62	-2.62	-2.72	-3.20	-4.14	-3.94
180.16	190.00	203.23	222.96	248.38	274.82	291.79	319.65
-4.19	-4.42	-4.71	-5.11	-5.74	-6.34	-6.86	-7.49
-2.33	-2.33	-2.32	-2.29	-2.31	-2.31	-2.35	-2.34
8.36	8.94	9.52	9.77	10.14	10.18	11.14	11.91
0.39	0.35	0.36	0.35	0.34	0.34	0.33	0.32
4.64	3.95	3.73	3.55	3.38	3.32	2.98	2.70
115.69	120.99	136.05	142.84	133.69	115.59	95.33	91.01
-5.91	-6.44	-7.44	-8.28	-9.28	-10.29	-11.32	-12.69
-5.11	-5.33	-5.47	-5.80	-6.94	-8.91	-11.87	-13.94
159.91	171.66	185.25	200.30	218.02	238.24	259.70	284.08
-1.53	-1.75	-2.01	-2.29	-2.66	-3.10	-3.53	-4.09
-1.0	-1.02	-1.08	-1.14	-1.22	-1.30	-1.36	-1.44

More importantly, as we expect, the real farm income declines by 3.94 percent in 1982. From these results, it is clear 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 the above simulation analysis, several things are quite apparent. First, most importantly, the exchange rate has significant effects on the farm commodity trade. The upward pressure on the U.S. dollar seriously affects the competitive position of U.S. exports in the international markets. For sectors, like agriculture, that are heavily dependent on the export market, the results could be disastrous, as experienced in recent years. Furthermore, the effects of the exchange rate spill-over to the domestic market because agricultural commodity exports largely determine the farm prices which have significant influence on domestic demand, stock inventories, and production levels.

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

Third, lower inflation might seem to help the farm sector through lower input prices. However, a closer examination of a contractionary monetary policy aimed at lower inflation reveals that there is a downward pressure on the farm prices and incomes. This is because such a policy action, in addition to lowering the inflation, causes the value 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 Starleaf, Meyers, and Womack's argument that farmers are hurt by deflation.

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

Finally, most importantly for the study at hand, specification of a complete set of linkages between the general economy and the agriculture sector captures more fully the effect of money supply change on the farm sector. This type of specification seems to have been ignored by most preivous empirical studies.

The chief implication for policy purposes of the precedings analysis is that macroeonomic factors are important for U.S. agriculture. Therefore, the nonagricultural phenomena, such as the exchange rate, can and do have significant influence on the farm economy. Agriculture in the United States is both export sensitive and capital intensive, so the combined effects of a strong value of the dollar, high real interest rate, lower inflation, and slow economic growth are devastating. Furthermore, the evidence indicates that policy actions that are usually seen as benevolent, or inflationary fighting, may well be seriously injuring the overall position of agriculture relative to other sectors. Therefore, the effects of monetary factors are too large to be ignored; macroeconomic developments need to be seriously considered in the evaluation and selection of agricultural policies.

CHAPTER VII. SUMMARY AND CONCLUSIONS

Since the appearance of Schuh's article on the relationship between exchange rates and U.S. agriculture, there have been several attempts to investigate the effect of monetary factors on U.S. agriculture. However, much of the literature on the area of macroeconomics of agriculture mainly focused on the exchange rate linkage; relatively little attention has been given to other macro-interconnections such as the interest rate, inflation, and income linkages. The general concern of this study is to examine the effect of changes in the monetary policies on agriculture in a general equilibrium framework through the exchange rate, the interest rate, inflation, and income linkages. Emphasis was placed on agricultural products. Each of the primary objectives outlined in Chapter I was accomplished.

The first objective, to develop a general equilibrium macroeconomic model to capture all the possible interrelationships between the farm and nonfarm sector, was accomplished through an extensive review of literature on the following: the effects of monetary factors on agriculture, previous farm sector models, and exchange rate determination. The transmission mechanisms between the general economy and agriculture were illustrated in Chapter III. The theoretical model was constructed in Chapter IV, in which the relevant variables were specified.

The second objective, to examine the effects of changes in the U.S. monetary policy on crop prices, supply, demand, exports, inventory, livestock product prices, supply, demand, and farm incomes, was accomplished by econometrically estimating the structural equations in Chapter V and performing simulation experiments in Chapter VI. The sample period of the study is 1950-1982. Since the model was nonlinear and simultaneous, nonlinear three-stage least squares from SAS/ETS was used to estimate the model. The estimated coefficients have good statistical properties. In particular, all the coefficients related to the four macrolinkages are consistent with *a priori* expectations. The dynamic historical simulation over the entire study period to test the validity of the model proved satisfactory, and tracked the turning points of the endogenous variables very well. One period, exogenous shock of money supply increase in 1971, showed the convergence of equilibrium values, indicating the model was stable.

Finally, the third objective, to draw policy implications from the empirical findings, was also accomplished in Chapter VI through comparison of simulation results of an expansionary monetary policy (three percent increase in the growth rate of money supply from 1972 to 1982) and a contractionary monetary policy (three percent decrease in the growth rate of money supply from 1972 to 1982) to base simulation results of actual money supply growth.

Conclusions and Implications

The empirical findings with respect to the effects of U.S. monetary policy on the farm sector and the simulation experiments with the model can be summarized as follows:

1. All the estimated coefficients of the variables related to the macrolinkages have right signs and most of them are statistically significant and, thus, provide evidence for the hypothesis that macroeconomic developments are very important for U.S. agriculture.

2. Considering the significance of the exchange rate to the U.S. commodity trade, this study endogenizes the exchange rate using a monetary approach to exchange rate determination. All the explanatory variables (money supplies, real incomes, and interest rates of both the U.S. and 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 U.S. and ROW.

3. The simulation experiements suggest that the exchange rate has a significant impact on the U.S. crop exports. Furthermore, this trade effect spills over to the domestic market through crop prices. For example, the easy monetary policy increases the U.S. crop exports by depreciating the value of the U.S. dollar. These increased crop exports tend to crowd out the domestic demand and inventories because of the higher crop prices resulting from the larger export demand.

4. The effect of the 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 alarming budget deficit, is quite 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, i.e., lower inflation might seem to benefit the farm sector because of the lower farm input prices. But, a closer examination of such a contractionary monetary policy reveals that there is a downward pressure on the farm prices and incomes. This is because the reduction in the level of money supply, in addition to lowering inflation, causes the value of the dollar and the interest rate to rise and income to fall. These latter three changes do not seem to favor the farming industry. Hence, a tight monetary policy aimed at lower inflation would hurt the farmers rather than help them. Thus, the results in this study provide evidence to Starleaf, Meyers, and Womack's hypothesis that farmers are not benefited by the deflation.

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

7. The magnitude of the effect of an expansionary monetary policy suggests that such policy action has a positive impact on the farm sector. An expansion in the level of money supply increases the farm prices and incomes through the above mentioned four macrolinkages. 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 the preceding analysis is that the performance of U.S. agriculture largely depends on the macroeconomic developments, since the agricultural sector is closely related to and integrated with the general economy. Therefore, the nonagricultural phenomenon, such as the exchange rate, is likely to have significant impact on the farm sector. Since U.S. agriculture is heavily dependent on the nonfarm sector, 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. These results are particularly important in light of recent attempts to tighten the U.S. money supply. Furthermore, 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 estimates of the structural equations. Although the model deals with aggregate data, the empirical results are encouraging and suggest the feasibility of estimating the effects of changes in the monetary policies on the farm sector in a general equilibrium model. This study should probably be best regarded as an empirical exercise based on a well-established theoretical model, an approach which seems to be potentially interesting and fruitful for U.S. agricultural sector analysis. However, several aspects of the empirical implementation of the model merit improvement in future research, as discussed below.

1. In this study, 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 are not examined in this study. Since a significant portion of farm incomes come from nonfarm employment, adding the labor market would be a major improvement.

2. Since the factor market is not endogenized, this study does not take into account the total cost of production, and the impact of monetary policy is examined only on the total farm income, not on the real farm income. Hence, endogenizing the factor market would allow the researcher to analyze the impact of monetary policy on net farm income, which would be more accurate for policy analysis. However, we have to note that this study does examine the effect of monetary policy on farm production, demand, exports, and inventory stocks.

3. The crop sector includes exports and inventory stock markets, in addition to domestic demand and supply. But, the livestock sector does not include exports and inventory markets. Addition of these two markets in the livestock sector would give a better picture to analyze the impact of monetary policy on the farm sector.

4. This study has set up theoretical foundations to investigate the effect of monetary policies on the farm sector. Further simpler

extension would be to use the model to examine the effect of fiscal policies on the agricultural sector.

5. As explained earlier, this study uses aggregate data and, hence, the model could be used to analyze the effect of macro policies on aggregate variables, such as crop price, farm income, etc. However, the model can be disaggregated to include important crops and livestock products. Such disaggregation would lead to more accurate analysis of macro policies on the individual farm products. Obviously, such a task is far larger than the scope of one thesis. However, such an extension on a large-scale project would be very useful for agricultural policy decisions.

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