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THE EFFECTS OF MONETARY POLICY ON U.S. AGRICULTURE

by

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The Effects of Monetary Policy on U.S. Agriculture

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Abstract

The effects of monetary policy on agriculture are discussed in the context of a fix-price, flex-price model of the economy. It is shown that the prices of auction-market goods such as agricultural commodities can overshoot their long-run equilibrium levels in response to changes in monetary policy. This is directly related to the stickiness of prices of other commodities, and is a generalization of the Dornbusch model of exchange-rate overshooting. Emprical evidence for both the United States and Australia supports this assumption that different prices have different adjustment speeds.

A small-scale, quarterly econometric model of the U.S. economy is described. The model includes an agricultural sector with flexible prices, a non-agricultural sector with sticky prices, and a small international sector. Emphasis is on the inclusion of policy variables, both macroeconomic and agricultural-sector specific, and on the linkages between sectors.

Simulation experiments designed to examine the effects of monetary policy are then discussed. The experiments are conducted using the econometric model, maintaining the fix-price, flex-price distinction. Assuming a continuation of the programs in the U.S. 1981 Farm Bill, the behavior of the agricultural sector under alternative growth rates of the money supply is examined. These are obtained by varying the extent to which the Federal Reserve is assumed to monetize the Federal deficit. The results show substantial adverse effects on prices, farm incomes, and government outlays following a shift to a regime of expansionary fiscal policy with tight money. The paper concludes with a discussion of some policy implications and an examination of alternatives for the 1985 Farm Bill.

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Introduction

Since Schuh's famous paper, the effects on the agricultural sector of exchange rates and monetary policy have been a subject of much interest and controversy in agricultural economics. Increasing attention has been paid to the role played by shocks emanating from the monetary and financial sectors of the economy. The magnitude and duration of the effects of these shocks on the agricultural sector is still not resolved. For the U.S., some studies (e.g. Chambers and Just) find monetary factors to be important, while others (e.g. Batten and Belongia) disagree.

Part of the difficulty in reconciling the different conclusions available in the literature is that no common theoretical model underlies these studies. However, if monetary policies are to be considered important forces in determining agricultural market conditions, a theoretical framework must be developed in which this proposition can be evaluated. Otherwise, empirical analyses which purport to show significant real effects of exchange rates, inflation, etc., lack the theoretical background against which results can be judged.

In this paper, we discuss a model of price and exchange rate dynamics in which there are short-run effects of monetary policy. They take the form of relative price changes which benefit the agricultural sector during expansionary monetary policy regimes and which turn against the sector when money is tight. These results are based on the exchange rate overshooting model of Dornbusch, in which short-run exchange rate changes in response to money growth can exceed, or overshoot, their long-run equilibrium values. Unlike the Dornbusch model, in which all goods' prices are fixed, agricultural prices in our model are assumed to be flexible, and we focus on the importance of this assumption for the agricultural sector. The model is consistent with rational expectations and asset market equilibrium at every point in time, and with the long-run neutrality of money.

We adopt a "fix-price, flex-price" framework, to use the terms originating with Hicks. Prices of agricultural commodities, because those goods are homogeneous, frequently traded, and storable, are assumed to be flexible and governed by instantaneous commodity arbitrage. Nonagricultural goods, on the other hand, are more often differentiated products, with contracting, less rapidly disseminated information, and imperfect competition as possible causes of less rapid price adjustment. Price adjustment therefore occurs instantaneously in the flex-price agricultural markets, while fix-price, nonagricultural markets respond gradually to changes in aggregate demand.

The paper has two main sections. The first half focuses on some of the theoretical background and some empirical evidence on the stickiness of prices. First, a review of the model of agricultural price and exchange rate overshooting is given. Next, we consider the factors affecting the degree of overshooting and present some empirical evidence for the United States. Results are presented for Australia which are also suggestive of different speeds of adjustment between agricultural and nonagricultural prices.

The second half of the paper describes some simulation experiments using a structural model of the U.S. agricultural sector. In the interest of conserving space, only a brief overview of the model is given, but Figure 1 gives a representation of the model structure. The simulation experiments focus on the effects of monetary policy on the agricultural sector. The paper concludes with a discussion of the implications of the results for agricultural policy and suggestions for further research.

A Model of Overshooting of Agricultural Prices

The overshooting model was developed by Dornbusch to explain variability in flexible exchange rates. In his model, all goods prices were assumed to be sticky, adjusting less rapidly than the prices of assets (currencies and bonds). This causes short-run exchange rate changes in response to changes in the money supply which are greater than the long-run outcome.

A simple example illustrates the application of the concept of overshooting to food prices in a pure exchange economy. Consider two goods markets, say, food and widgets, and assume that there is a currency but the quantity of real balances demanded is perfectly inelastic. When a doubling of the money supply occurs in the presence of perfect price flexibility, doubling of the food and widget prices follows immediately and money is neutral. The doubling of the price level leaves the quantity of real money balances unchanged, and equilibrium quantities of food and widgets are also unaffected.

The flexibility of prices is the key. Now, assume that food is a flex-price good, while the price of widgets adjusts slowly over time in response to changes in aggregate demand. With short-run fixity in the price in the widget market, such an adjustment is prevented. If the food price alone doubles after a doubling of the money supply, there is excess demand for goods and excess supply of money balances. The continuing effort of moneyholders to rid themselves of excess money balances guarantees further food price increases. If the widget price gradually rises over time, initial relative prices can be restored.

Thus, what would be observed in this simple world is an overshooting of the food price in response to money growth, with the food price falling gradually back to its long-run equilibrium, while the widget price gradually rises to its long-run level. The longer it takes for the latter change to occur, the longer the food price will be above its eventual level. As long as there are no impediments to the eventual doubling of the widget price, the end result is that of the price flexibility case, with relative prices unchanged.

An important factor is omitted from this simple example, the interest elasticity of money demand. It was assumed that under no circumstances would individuals hold real money balances in excess of the initial stock. If the quantity of money demanded responds positively to decreases in the interest rate, however, the above result is not necessary. It is easy to see that, the greater the willingness of individuals to hold extra real balances, the less the effect of money supply changes on the food price in the short run. That is, the more interest elastic is money demand, the less will be the degree of overshooting.

However, the change in the interest rate brings capital markets into the picture. Departing from this simple model of a closed, exchange economy, let us introduce a world capital market and currencies. Assume that the home country in question is a small country and assume that uncovered interest parity holds, so that home and rest-of-world nominal interest rates differ only by expected depreciation in the value of the home currency. The domestic nominal interest rate can only change if there is an expected appreciation or depreciation of the currency at the same time.

Dornbusch used this setup to show that there would be exchange rate overshooting following a change in money growth, as long as the prices of sticky-price goods had not reached their new long-run equilibrium levels. He assumed that all goods were subject to this gradual price adjustment. Frankel and Hardouvelis observed that it is possible to substitute the prices of commodities for currency prices in Dornbusch's model, and found that asset market equilibrium conditions applied to the market for storable commodities guarantee the same outcome: nominal commodity prices overshoot their eventual levels in response to changes in money growth rates.

Stamoulis et. al. used the Frankel and Hardouvelis assumption that agricultural commodities are flexible-price goods, but kept the exchange rate in the model, as well. The law of one price was assumed to hold at all times for the agricultural commodity, so that its price was never out of line with rest-of-world prices, while gradual price adjustment again characterized nonagricultural prices. The model thereby differs from the Dornbusch model only in allowing some goods to have flexible prices.

The home country is assumed to be a small country in both agricultural commodity and capital markets. This and the law of one price assumption guarantees that the domestic nominal food price will follow exactly the same path as the value of the home currency, so that it overshoots its long-run equilibrium and that this condition persists as long as adjustment in remaining, sticky-price goods markets lags behind. Comparison of the path of adjustment resulting for flexible prices with the Dornbusch solution reveals that, as the number of flexible-price goods in the economy rises, the degree of overshooting is reduced. Thus, the results provide an intermediate case between complete flexibility of prices and the case of stickiness of all goods' prices. The appendix to this paper contains a short derivation and description of these results.

These results depend on few assumptions. The price of agricultural commodities must be free to adjust, as can the exchange rate, while nonagricultural commodities must be characterized by slower adjustment. The model does not require a violation of rationality on anyone's part, provided one adopts the view that there are good reasons for the existence of contracts, costly price adjustment, or other factors contributing to the stickiness of prices elsewhere in the economy. In fact, Dornbusch showed that overshooting is consistent with rational expectations at every point in time.

Also, there is no reliance on the substitution of other countries' agricultural products for the home country's exports; the law of one price was assumed to hold. To the extent that it is violated, say, because of price supports limiting the downward flexibility of prices, weak export markets can be expected to add to these relative price changes in the case of tight money.

In the fix-price, flex-price framework, the short-run effect of monetary policy thus shows up in relative price changes. An expansionary regime favors the agricultural sector in the short run, since relative prices favor agricultural producers, while tight money has the opposite effect, causing larger and quicker decreases in agricultural prices than in nonagricultural prices.

Evidence Concerning the Stickiness of Prices

Our version of the overshooting model depends on the assumption that the economy can be described by two types of goods, flex-price goods such as agricultural commodities and financial assets, and fix-price, or sticky price goods, such as many nonagricultural commodities. Evidence concerning the relative stickiness of nonagricultural prices comes mostly from ad hoc regressions in which price indices or their growth rates are linked to money growth rates and possibly some other causal factors such as income growth.[1] Based on quarterly data, the evidence is much stronger in favor of the relative stickiness of nonagricultural prices than it is for actual overshooting of agricultural prices. Money growth does appear to have a greater initial effect on agricultural prices, but the effect is probably not greater than one-for-one. We have not tested for overshooting of the exchange rate variable, but if the exchange rate does overshoot its long-run equilibrium, the same result need not apply to the price of agricultural commodities. This is the case if the law of one price does not hold instantaneously for agricultural commodities.

[1] See the papers by Gordon and Rotemberg for examples and Rausser et. al. for a review of this literature.

Results given in Stamoulis et. al. for the United States were based on the method used by Barro to construct an anticipated money growth variable. Regression of the growth rate of the U.S. Department of Agriculture's index of prices received by farmers on current anticipated money growth rates revealed an effect much larger than for the Consumer Price Index (CPI) or for the non-food CPI. The lagged dependent variable was found to have a larger and significant coefficient in the latter regressions, consistent with the gradual price adjustment assumption used above. Meanwhile, the coefficient on the lagged dependent variable was small and insignificant for the growth rate of the index of prices received by farmers. These results were consistent with those of Lombra and Mehra, who found that the cumulative effect of money growth is greatest in the consumer price index for food, but that it has larger initial effects, the less is the processing component in the food price index examined.

Depending on data and specifications used for estimation, results of tests of neutrality do appear to vary across studies. Similar regressions have been reported by Belongia and by Grennes and Lapp, and each study supported neutrality of money growth after intervals of one year or less. Using annual data, Grennes and Lapp found that, once real demand and supply forces were accounted for, there appeared to be no effect of inflation on real agricultural prices. Quarterly data were used by Belongia to test the money neutrality hypothesis. He found that the difference in growth rates between the GNP deflator for farm products and that for industrial commodities was not affected by unanticipated money growth after two quarters.

A test for differential effects of money growth on prices in different sectors was performed using Australian quarterly data for money, prices, and income. The following model was used:

$$\dot{P}_{it} = \alpha_0 + \sum_{t=0}^{K} \beta_i \dot{m}_{t-i} + \sum_{t=0}^{4} \gamma_i \dot{g}_i$$

where $\dot{P}_{it}$ is the rate of growth in time t of price index i, $\dot{m}_{t-i}$ is the growth rate of money in period t-i, and $\dot{g}_{t-i}$ is the corresponding growth rate in real income. The lag length, K, was allowed to be as large as 12 quarters for money growth, and a contemporaneous growth rate was always included. The income growth variable was assumed to enter with a four period lag in all models.[2] Each variable is seasonally adjusted, and quarterly dummy variables were also included.

These regressions were run for growth rates of four different price indices-- the Consumer Price Index (DCPI), the Consumer Price Index for Non-Food Items, (DCPINF), the Consumer Price Index for Food Items (DCPIF), and the Index of Prices Received by Farmers (DIPRF). For each set, the model with the highest $\bar{R}^2$ was selected.

Two hypotheses were tested for each model. One was for money neutrality, checking whether the sum of the coefficients on money growth equals one. The other test was for whether the sum of the coefficients on the income variable was equal to zero. Regression results along with results for the two tests are given in Table 1.

The columns of the Table marked F_m and F_g give the values of the F statistic for testing the hypothesis of money neutrality and for the significance of the income growth variables, respectively. The terms in parentheses are the probabilities of obtaining larger F-values under the null hypotheses.

As Table 1 shows, there is a significant difference in the number of lags included in the best model for the prices received by farmers variable compared with the best models for the other price indexes. The F-test also indicates that the hypothesis of neutrality cannot be rejected for this model, while it is rejected for the rest of the price indices, confirming the hypothesis of a fas-

[2] The inclusion of income growth as an explanatory variable can be justified following the reasoning provided by Dornbusch (1976).

ter response of agricultural markets to money growth changes. Further evidence concerning this hypothesis can also be found by observing that, apart from the CPIF index, the coefficients on the lagged dependent variable are larger and significant for CPIU and CPINF, compared to IPRF index, signifying a slower speed of adjustment to shocks. Income growth does not have an important effect in the two regressions for food price indices, but the sum of the coefficients on income growth is significantly different from zero in the other two.

The evidence presented in Table 1 using the reduced form model suggests a faster response of farm prices to changes in money growth than nonfarm prices, but no evidence of overshooting was found. The results also show that the index of retail food prices may not be a good proxy for farm prices, especially when questions of relative price variability are considered. The behavior of that index is closer to the behavior of the nonfood and general price indexes, probably due to its inclusion of marketing and processing inputs.

The lack of structure in these regressions, of course, prevents too much to be made of the results. In order to examine the particular channels through which monetary policy affects agriculture, and to examine the role of agricultural policy, a structural model is required. The next two sections of the paper describe an econometric model which was constructed for this purpose. The first section describes the structure of the agricultural sector of the model, and the next gives a brief description of the nonagricultural sector and the results of a simulation experiment.

Structure of the Agricultural Economy

The agricultural sector is specified as a series of supply and demand equations with market prices playing the key equilibrating role. The agricultural sector is composed of two blocks of crop equations and three blocks of livestock equations. As shown in Figure 1, these blocks are related to the international and macroeconomy sectors through a number of linkages. These consist of variables from the nonagricultural components of the model, such as interest and exchange rates, that affect the agricultural sector. A more general treatment of the linkages between the sectors incorporates feedback effects as well. These were not included in the simulation results reported in this paper, so the agricultural sector can be thought of as a satellite model.

Each grain block includes behavioral equations for acreage planted, yield per planted acre, domestic utilization, and inventories. Production is computed as the product of acreage and yield. Domestic utilization is divided into two components: (1) livestock and residual demand and (2) industry or food demand. Inventories are either publicly controlled (government-owned stocks, inventories tied to outstanding Commodity Credit Corporation (CCC) loans, and stocks in the farmer-owned reserve) or privately owned. The privately held stocks and inventories under CCC loans are aggregated into a single inventory position. Farmer-owned reserve stocks and government-owned stocks are each modeled separately. This specification allows different rules governing the movement of the various types of stocks to be incorporated in policy experiments.

Since the planting decision is tied to the discrete choice of participation in farm programs, an appropriate specification must incorporate the trade-off between expected returns of all potential crop choices. Traditional acreage response equations included in past models do not fully incorporate these trade-offs. Acreage planted of each crop is presumed to depend on expected returns from noncompliance and compliance with acreage programs for the crop under consideration, the expected profitabilities form competing crops, and last years' acreage planted. The final variable is included since acreage planted is modeled as a partial adjustment process.

Crop production costs depend on inputs purchased from the nonfarm sector. Costs are a function of the wage rate paid for hired labor; the market interest rate paid for financing working capital, machinery, and buildings; prices paid for energy and fertilizer; and an index of nonfood prices. This cost measure enters the expected profit calculations for wheat and feed grains and provides a direct link with conditions in the general economy.

When farmers do not participate in government programs, profitability depends, among other variables, on anticipated output price. For estimation purposes, the expected output price was taken to be the March price for a September futures contract. For simulation purposes, these price expectations were assumed to be rational, and the March futures price used in the acreage and yield equations was set equal to the cash price observed in the third quarter of the simulation. Thus, the price "expectations" used in the simulations are those which bring forth a level of production just sufficient to create market conditions consistent with that price, and the need to simulate the relationship between cash and futures prices is avoided.

Domestic consumption is divided into food consumption and feed and other uses with separate demand equations for each component. Since most wheat that is fed goes to broilers, the feed demand for wheat is specified to be a function of own price and corn price, each relative to the price of broilers, and the number of broilers on feed. Domestic feed demand for feed grains is specified to be a function of the inventories of cattle on feed, pigs on feed, broilers on feed and the price of grains relative to the price of meat. As suggested by the theory of consumption, domestic per capita food demand for wheat is a function of the real price of wheat, an index of real food prices, and real per capita income. Food and industrial use of feed grains is modeled as a function of real feed grain prices, a trend variable representing technology and real income.

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

Quantity demanded by the private sector for stocks by both producers and users is motivated by transactions and precautionary motives. A large part is also due to the seasonality of production and to speculative motives. Speculative demand is influenced by the farm price relative to expected farm price. It is also presumed that the difference between the farm price and the loan rate, and public stocks have an influence. The market stock equation was modeled in price-dependent form.

Interest rates enter the stockholding equations in two ways-- the real interest rate and the government interest rate subsidy are both included as explanatory variables. In the private stock equations, it is expected that increased interest rates should have a negative effect due to the increased opportunity cost of holding idle inventories. As real interest rates rise, prices of wheat and feed grains fall since the opportunity costs of holding grain inventories has increased. Demand for stocks from the private sector is modeled in price dependent form.

Stocks demanded by the government sector include government-owned stocks and the farmer-owned reserve. To a large extent, government stocks are a residual with the government playing a passive role. Farmers place stocks with the government when the farm price is close to or below the loan price by defaulting on nonrecourse loans. They redeem loans only as the farm price moves above the loan price. As required by law, the government can only release its own stocks when prices are sufficiently above the loan price. In the case of the farmer-owned reserve, stocks flow out whenever market price approaches or exceeds the release price.

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

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

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

Placement of cattle on feed is expressed as a function of lagged cow inventories to reflect the availability of feeder calves and the expected profitability of cattle feeding. Profitability is influenced by the price of beef relative to feed costs. Feed costs for beef cows depend on the cost of feed grains, measured by the farm price of corn. Production of beef comes from gross number of placements of cattle on feed in previous periods, cull cows, and other nonfed cattle slaughter. Cull cows and other nonfed slaughter are modeled as the change in lagged cow inventories. The price of beef and the feed cost for beef may have two effects. In the short term, they encourage feeding of animals to heavier weights and withholding of heifers to increase the breeding stock. This gives rise to a negatively sloped short-run supply curve. In the longer term, the supply curve will be upward sloping as placements on feed from the higher breding inventories increase.

As with the cattle sector, the representation of the hog sector is highly aggregated. It allows for cyclical responses of pork production to changes in the final product price and costs. On the supply side, equations are given for the closing inventory of breeding sows, pig crop and production of pork. As with beef, the decision to retain breeding sows or send them for slaughter represents a series of decisions to retain or slaughter breeding sows and to feed pigs for slaughter or retain them to add to the breeding stock. At each period, these decisions are based on a comparison of the current value of pork to the expected returns from the sale of hogs in the future. The closing inventory of breeding sows is positively related to the price of hogs, negatively related to feed costs, and negatively related to the interest cost of holding inventories. The pig crop is a function of lagged breeding hog inventory and anticipated profitability from producing pork. Production of pork depends on previous pig crops and on liquidation of breeding inventories, which is measured by the previous period's change in the breeding inventory of hogs.

Production of broilers is modeled similarly to the beef and pork subcomponents. Equations with the same type of causal influences are specified for poultry production, broiler chicks hatched, and broiler hatchery supply flocks.

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

As is apparent from the discussion above, macroeconomic variables are incorporated into the agricultural sector in a number of places. Income and prices of nonfood items affect food demand, interest rates affect the willingness to hold stocks of either crops or livestock, and the exchange rate and rest-of-world prices and income affect the exports of feed grains and wheat from the U.S. We turn now to the simulation results to examine the extent to which variations in these macroeconomic variables induced by monetary policy affects variables in the agricultural sector.

Monetary Policy and the Agricultural Sector

The ad hoc regressions reported earlier provided some evidence concerning the effect of money growth on the rate of change of food and nonfood prices. However, this approach reveals nothing about the effects on real incomes in the agricultural sector, since agricultural output was not included and there is no evidence concerning consumption, inventory behavior, and exports. Enders and Falk and Huffman and Langley have estimated similar regressions with growth in output as dependent variables, focusing on whether unanticipated money growth has output effects. While this method does add some information to the price change regressions, it is still not amenable to policy analysis.

To investigate the effect of monetary policy on agricultural sector prices, quantities, and incomes, as well as to indicate its effects on government outlays for the feed grains and wheat programs, we used estimated equations for the above model using data through 1983. The starting point of the sample used for estimation varied with the stability of the equation over time and also depended on whether the dependent variable was quarterly or annual, but no sample data from before the 1960s were used.

We performed simulations for the 1984 to 1986 period using two different assumptions concerning the level of monetization of the U.S. federal budget deficit. The deficit was set at levels projected by the Congressional Budget Office for 1985 and 1986, while actual levels were used for 1984. All lagged variables were set at their actual levels, so the starting point reflects conditions in the U.S. during 1983.

A restrictive policy regime was created by allowing the money supply to grow at the rate of trend real GNP growth; the deficit was thus entirely bond-financed. An easy monetary policy regime was created by varying the level of monetization. We assumed an approximately 30 percent monetization, and increased bank reserves and the money supply by a corresponding amount.[3] All other exogenous variables were held constant between the two simulations.

The policy regimes of expansionary and tight monetary policy can be viewed as providing rough approximations to the environments of the early 1970s and early 1980s, respectively. Effectively, the monetary policies of the 1970s provided a subsidy to the agricultural sector. Conversely, the tight monetary policies of the 1980s can be viewed as a tax on export dependent,

[3] In a couple of quarters, 30 percent monetization resulted in such a large rate of money growth that this value was replaced by an average growth rate, so the average rate is lower than 30 percent for the period as a whole.

capital intensive sectors such as agriculture. A number of other events in the two periods, such as weather and oil-price shocks are not replicated, of course. The simulations are designed to hold other things constant and examine the effects of variations in money growth rates alone.

The nonagricultural sector was modeled using the fix-price assumption. The major components of the model are domestic aggregate demand (aggregate consumption, domestic investment, and a government finance sector), aggregate supply represented by nonfood price and wage equations, a monetary/financial sector, and a small international sector (imports and exports of nonagricultural goods and an exchange rate determination equation.) Prices and wages are assumed to adjust slowly to changes in aggregate excess demand. Prices are assumed to depend on wages adjusted for productivity, materials costs, the gap between actual and potential income. Inflationary expectations, approximated by expected money growth, also enter the price equation. Wages, in turn, depend on labor market pressure, changes in the consumer price index, and a minimum wage variable. Finally, the labor market pressure variable, the difference between actual and natural rates of unemployment, is a function of the income gap. The monetary/financial component consists of a money demand equation, a money supply process, and interest rate determination equations for short and long term rates.

The model contains no unusual variables or specification in most equations. Exceptions are equations for the short term interest rate and the exchange rate. The former includes two proxy variables designed to measure capital market pressure. The first of these, representing public sector demand for credit, is the ratio of government deficits to nonborrowed reserves. The private sector proxy variable is the ratio of disposable income to nonborrowed reserves.

The equation for the exchange rate is based on an asset market framework (Frankel). The basic assumptions underlying this framework are rational expectations, sticky prices of goods, and uncovered interest parity. The equation expresses the natural logarithm of a trade-weighted index of exchange rates as a function of U.S. and rest-of-world money supplies, incomes, inflation rates and interest rates. In addition, a variable similar to the proxies for capital market pressure in the interest rate equation is included, the ratio of nonmonetized U.S. federal deficits to nonborrowed reserves. Increases in this variable, representing increases in holdings of dollar denominated assets, lead to appreciation of the dollar.

These policy settings were used to simulate behavior of interest and exchange rates, growth in the price level, and income growth in the two monetary policy regimes, using the model outlined in the previous section. The results were then passed to the model of the agricultural sector described in the previous section. No attempts were made with these simulations to allow feedback effects, through the deficit, for instance, from the agricultural sector to the economy at large, or through any effects of changes in farm prices on the general price level.

Table 2 shows the paths for deficits and nonborrowed reserves for the two time periods. Based on its correspondence with the 1970s, the regime of easy money is designated as the subsidy scenario, while that of tight money is termed the tax scenario. The two regimes bracket recent growth rates of the money supply, with the subsidy scenario producing approximately 18 percent money growth while the tax scenario is characterized by annual money growth at the rate of 3 percent. Thus, the two regimes are somewhat extreme compared to actual money growth rates.

Table 3 reports the results from these simulations for the important macroeconomic variables which affect the agricultural sector. Real interest rates and the value of the dollar are much higher in the tight policy regime, while GNP and the price level are higher in the subsidy regime.

There is both a liquidity effect and an inflation premium effect in the interest rate equation due to different results for money growth between the two regimes. Real interest rates are substantially higher in the tight policy regime due to the lower level of nonborrowed reserves. There is not a one-for-one increase in short-run nominal interest rates following an increase in money growth rates, however, so nominal interest rates also are lower in the easier monetary policy regime. Since the focus was on quarterly movements in the variables in the agricultural sector, we have not yet tested the long-run neutrality of money growth in the model.

Low real interest rates and easy money have the expected effect on real GNP in the subsidy scenario. By the end of 12 quarters, this variable is 12.6 percent higher than in the tax scenario. Ceteris paribus, this higher income should cause the dollar to appreciate, but the effect is more than offset by the relative unattractiveness of dollar-denominated assets.

The net effect of lower income growth and high real interest rates is for the dollar to appreciate during the tax scenario. Thus, the trade-weighted index of the dollar's value is higher by more than 100 percent by the fourth quarter of 1986. Compared to 1983:4, this represents 20 percent appreciation during the tight monetary regime simulation and a near 90 percent devaluation with easy money. Finally, the effect on the price level is seen in Table 3 by the higher rate of inflation, nearly 8 percent higher by the end of the simulations.

International sector variables were held constant across the two regimes. Those which enter the model are rest-of-world real GNP, indices of the rest-of-world money supply and wholesale price index, and the rest-of-world production of wheat and feed grains. Growth rates for the 1981-1983 period were used as the basis for projecting these variables through 1986. To the extent that the world macroeconomic variables are related to those of the U.S., we have not captured what would actually happen under these two regimes. If one takes the view, for instance, that other countries' central banks react to U.S. monetary policy by attempting to manage the value of their currencies, it is likely that we have understated rest-of-world money growth for the easy monetary policy regime in the U.S., and vice-versa for the tight period. McKinnon's arguments on currency substitution and world liquidity support this view. While we have not run these simulations under alternative paths for rest-of-world macroeconomic variables, varying rest-of-world production of wheat does have the expected effects on demand for U.S. exports.[4]

Turning to the results for the agricultural sector, Table 4 gives the settings for the parameters of the wheat and feed grains programs. These policy settings are continuations of those legislated under the 1981 Farm Bill, with 1986 levels being continuations of 1985 settings. Recently, support prices were announced for 1986 which are below those we assumed. To the extent that other 1986 conditions resemble those we simulated, one can expect higher deficiency payments (target minus support prices) and higher government expenditures on these two programs than those we find in the simulation results. We did not examine alternative agricultural policy scenarios, so it is only macroeconomic policy which varies between the two simulations.

Simulations for the agricultural sector were conducted under two different government policies concerning stockholding. One simulation used an estimated behavioral equation for government stocks, which allowed market

[4] These alternative simulations showed that the *levels* of prices are affected in the two monetary policy regimes, but that the comparisons between the two results are not affected.

prices to fall well below support prices during the tight policy simulation. However, it seemed reasonable that participation rates for wheat and feed grains programs would approach 100 percent in such a period, especially if the policy was well anticipated. In that case, prices should not fall below the support rate, since participation carries the opportunity to sell to the government instead of the market. Thus, in a second simulation, we added an active stock policy regime by imposing a condition in our simulation program that the government buy up available market stocks, so long as the market price was below 90 percent of the support price. A corresponding reduction of government inventories was added in periods where the price was greater than 110 percent. This is in effect for the results reported in this paper.

Recall that acreages, yields, and thus production of both wheat and feed grains were estimated to be functions of expected real profits from participation and nonparticipation in government programs. Acreages and yields are not particularly responsive to conditions in the marketplace, mainly because of favorable settings on target prices. Both appear to be dominated by the favorability of agricultural policy, with actual market prices having less of an effect. Table 4 reports production figures from our simulations. Actual figures from 1983 are included for comparison.

Table 5 gives actual market prices for 1983 and those which resulted from each simulation for the 1984-1986 period. There are sizable differences in the nominal prices between the two simulations. Real prices are higher in the subsidy simulation for the first half of the period for feed grains and for the second half for wheat. When real prices are higher during the tax period, it is due to the support provided by government stock accumulation.

As can be seen from the results in Table 6, exports play an important role in transmitting the effects of monetary policy to the agricultural sector.

Domestic demand for wheat and feed grains is fairly inelastic, but exports are close to twice as large by the last quarter of 1986. Particularly in the case of wheat, which is more sensitive to exchange rate movements, the effect of an expansionary monetary policy and a cheap dollar shows up in increased exports.

Tables 7 and 8 give the total stocks of feed grains and wheat in all positions, along with the percentages in government-owned, farmer-owned reserve, and readily available (market and CCC non-government owned) stocks. Movements in inventories are a major determinant of real prices; all inventories have a depressing effect on price, but the size of these effects differs, reflecting the ease with which stocks of different types can reach the market. As one would expect, the total inventories of both feed grains and wheat are higher during the tax scenario.

The distribution across the three inventory positions differs, as well. Market stocks are lower due to the higher real interest rate during the tax scenario. At the same time, government-owned stocks rise due to the price support operations imposed during the simulations--keeping price above 90 percent of support requires the purchase of feed grains. This adds to the interest rate effect in reducing market stocks. The farmer owned reserve is also somewhat higher during this period.

The interest rate effect also causes market stocks of wheat to be lower during the tax period. In addition, price support operations again caused grain to move from market to government-owned positions. Cash price being near the support price also gave farmers incentives to participate in the farmer-owned reserve.

Tables 9 and 10 reveal that the livestock sector benefits from the same monetary policy that subsidizes the wheat and feed grains sectors. Table 9 gives prices for beef, pork, and broilers for each scenario, and Table 10 gives breeding inventories for these sectors. With the exception of poultry for the first few quarters of the simulation, real prices are higher throughout the subsidy scenario. Because of the more favorable profitability levels in that simulation, animals are retained for breeding purposes in all three livestock sectors, especially the hog and poultry sectors. A significant amount of liquidation occurs, in contrast, during the tax scenario, due largely to the high levels of real interest rates. Thus, while it would be expected that the higher grain prices of the subsidy scenario would hurt the livestock sector, this effect is more than offset by higher income and lower interest rates.

Table 11 reports the U.S. Treasury cost of the provisions of the 1981 Farm Bill and the settings of policy parameters in Table 4. The figures include both the direct outlays and the opportunity costs of intervention. The major components of the calculations include deficiency payments, carrying costs of government-held inventories, the cost of acquisition and release of government-owned inventories, and the opportunity cost of holding stocks. As can be seen in the Table, these costs are considerably higher during the tax scenario--the real cost of agricultural policy is as much as 45 times larger for some quarters (wheat for the third quarter of 1986.)

These large differences in costs are due mainly to deficiency payments incurred as a result of the low prices of the tax scenario, and also due to the cost of acquiring stocks to support the market price. Thus, it is apparent that one important effect of a tight monetary policy is on the public sector, rather than the wheat and feed grains sectors. If a policy of supporting prices by acquiring stocks is followed, much of the effect of low prices is shifted to the government.

This is especially true when farm incomes are examined. Table 12 gives net farm incomes for wheat and feed grains, along with income to the livestock sector. In computing the income measures for crops, no storage activity was considered; instead, total production is assumed to be sold in the harvest quarter for either the market or support price. Government payments are also included in these income measures. Costs are simply the variable per acre cost reported in Table 4, multiplied by the number of planted acres, plus storage costs associated with the farmer-owned reserve. Under the subsidy scenario, all computations are based on a 60 percent participation rate, while this is assumed to be 100 percent during the tax period. For the livestock sector, the retail price is used for meats, since the model does not at present include margins determination. This figure overstates income to the farm sector as a result.

As can be seen from the Table, income is generated during the harvest quarter, and in the remaining quarters, carrying cost charges are incurred for both grains sectors. The important quarters are those in which harvest occurs. We find that the third quarter real incomes for wheat and fourth quarter real incomes for feed grains are higher under the regime of tight money. The only exception is the fourth quarter of 1984, when they are virtually the same in the two scenarios. This is not surprising when the price support policy and the government expenditures on these programs are considered. The burden of low prices which would have occurred was felt by the public sector, not wheat and feed grains producers. This situation is reversed when government stocks are not used to support prices.

Throughout the simulations, on the other hand, livestock producers prefer the easy monetary policy. Even though this puts pressure on prices of feed, the combined effects of lower real interest rates and higher incomes dominate the income calculation.

Conclusions

In this paper, we took the overshooting model and the fix-price, flex-price characterization of the U.S. economy as the starting point for policy experiments to examine the effects of monetary policy on the agricultural sector. The results support the predictions of the simple overshooting model that monetary policy can have significant real effects in the agricultural sector. These results are also consistent with the experience of the agricultural sector since the early 1970s. Results for Australia also support the fix-price, flex-price characterization.

In the simulation experiments conducted, we considered the effects of a change in the degree of monetization of the federal deficit on the macroeconomy, the agricultural sector, and government expenditures on agricultural programs. We found substantial effects on income, real interest rates, and exchange rates, and on the rate of growth of the price level. Different levels of monetization of the deficit can be viewed as providing an indication of the tightness of monetary policy, since the level of government spending was held constant in the two scenarios. As these shocks to macroeconomic variables are passed through to the agricultural sector, there are significant responses in the grain and livestock sectors.

Grain prices fell with money growth rates, while more grain showed up in government stocks. The strong dollar led to the weakening of export markets, and high interest rates added to the problem by increasing the opportunity costs to private agents of holding grain stocks. Livestock producers also fared poorly during the tight money period as high real interest rates encouraged the reduction of inventories. As one might expect, the shock to livestock prices increases with the length of the production cycle.

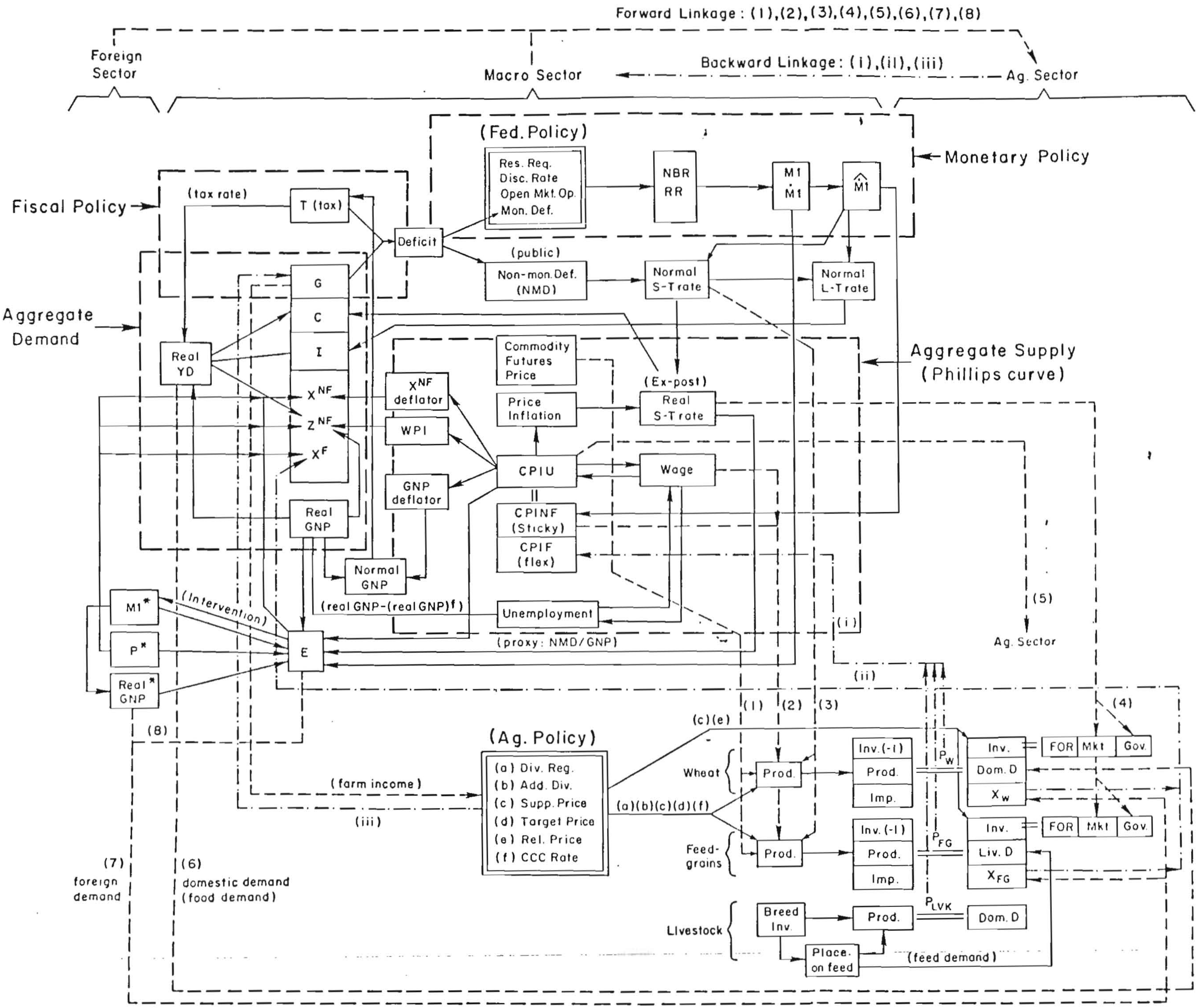
Analyses of conditions in the agricultural sector must, therefore, take into account not only real demand and supply forces directly related to the sector, but also the effects of monetary and fiscal policies operating through these forces. This paper has argued that the short-run effects of these policies are substantial. The long-run effects of these shocks can be argued to be neutral, and there is support in the literature for this using simple regressions involving the rate of change of price indices. The practical length of the short run, however, which one might define as the time period during which the kinds of external shocks examined above are of concern to agricultural policymakers, remains an open question. Using a model of the agricultural sector, we have found effects on breeding stocks and grain inventories which are likely to be felt for some time.

An important result of simulating the effects of a price support policy which transfers grain to government positions when prices are less than 90 percent of support prices is that the burden of lower prices is largely shifted from producers to taxpayers (as well as the livestock industry.) A policy of continuing to support the nominal price of grain, much as was the case in the early 1980s, can only lead to increasingly intolerable government expenditures and stockholding, and increasing support for production controls, another PIK program, or export subsidies.

The analysis of changes in agricultural policy parameters will be of particular interest given recent developments in the U.S. A new Farm Bill has been passed and support prices have been reduced considerably. One can therefore expect the substitution of exports and large deficiency payments for government stock-carrying.

In the context of the fix-price, flex-price specification we have advanced in this paper, analysis of different fiscal policies and varying the parameters of agricultural programs will help to indicate whether sector-specific policies can offset the large budget outlays which were legislated under the provisions of the 1981 Farm Bill. In addition, some of the long-run properties of the model will be explored.

Of particular interest will be a determination of the duration of the effects of changes in monetary policy in the agricultural sector. The length of time before money would be neutral in such a model of the agricultural sector has not been tested, nor has the simple overshooting hypothesis. Given the reasons which might exist for violations of the law of one price and the many ways monetary policy and exchange rates affect sectors such as agriculture (Nishiyama and Rausser), it is likely that the one-for-one movements in the exchange rate and agricultural prices will not occur, at least, not for sectors such as wheat and feed grains in the U.S.



Forward Linkage: (1),(2),(3),(4),(5),(6),(7),(8)
Foreign Sector
Macro Sector
Backward Linkage: (i),(ii),(iii)
Ag. Sector
(Fed. Policy)
Monetary Policy
Res. Req.
Disc. Rate
Open Mkt. Op.
Mon. Def.
NBR
RR
M1
M1
M̂1
Fiscal Policy
(tax rate)
T (tax)
Deficit
(public)
Non-mon. Def. (NMD)
Normal S-T rate
Normal L-T rate
Aggregate Demand
G
C
I
Real YD
X^{NF}
Z^{NF}
X^F
X^{NF} deflator
WPI
GNP deflator
Commodity Futures Price
Price Inflation
(Ex-post)
Real S-T rate
Aggregate Supply (Phillips curve)
CPIU
Wage
CPINF (Sticky)
CPIF (flex)
Real GNP
Normal GNP
(real GNP-(real GNP)f)
Unemployment
(proxy: NMD/GNP)
M1*
P*
Real* GNP
(Intervention)
E
(i)
(5)
Ag. Sector
(ii)
(8)
(1)
(2)
(3)
(4)
(c)(e)
(Ag. Policy)
(a) Div. Reg.
(b) Add. Div.
(c) Supp. Price
(d) Target Price
(e) Rel. Price
(f) CCC Rate
(farm income)
(iii)
(a)(b)(c)(d)(f)
Wheat
Prod.
Inv. (-1)
Prod.
Imp.
P_W
Inv.
Dom. D
X_W
FOR
Mkt
Gov.
Feed-grains
Prod.
Inv. (-1)
Prod.
Imp.
P_{FG}
Inv.
Liv. D
X_{FG}
FOR
Mkt
Gov.
Livestock
Breed Inv.
Prod.
P_{LVK}
Dom. D
Place on feed
(feed demand)
(7) foreign demand
(6) domestic demand (food demand)

TABLE 1

Summary of Regression Results for Different Price Indices

(Australian Data, 1971:1, 1983:4)

P_i	$P_{i,t-1}$	no. of lags	$\bar{R}2$	F_m	F_g	D.W
DCPI	0.571	9	0.647	38.553	6.064	2.16
	(0.163)			(0.0001)	(0.024)	
DCPINF	0.626	10	0.633	26.40	7.721	1.57
	(0.162)			(0.0001)	(0.012)	
DCPIF	-0.072	12	0.407	5.790	0.015	1.50
	(0.349)			(0.030)	(0.905)	
DIPRF	0.413	2	0.240	2.035	1.771	1.910
	(0.194)			(0.166)	(0.195)	

TABLE 2

Fiscal and Monetary Policy Under Subsidy and Tax Scenarios

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

TABLE 3

Major Macroeconomic and International Variables
Under Subsidy and Tax Scenarios

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

TABLE 4

Setting of Agricultural Policy Variables and Supply Response Under Subsidy and Tax Scenarios

	1983	1984	1985	1986
FEED GRAINS				
Setting of sector policy variables				
Diversion requirement (percent of base average)	20	10	10	10
Target price, corn (dollars per bushel)	2.86	3.03	3.03	3.03
Support price, CCC, corn (dollars per bushel)	2.55	2.65	2.55	2.55
Release price, FOR, corn (dollars per bushel)	4.21	4.21	4.21	4.21
Base acreage (million acres)	81.30	81.40	81.40	81.40
Acreage (million acres)				
Subsidy scenario	72.10	96.73	96.30	94.32
Tax scenario		96.21	96.42	95.75
Yields (bushels per acre)				
Subsidy scenario	64.66	90.39	94.03	95.97
Tax scenario		90.69	94.42	96.33
Production (million metric tons)				
Subsidy scenario	136.00	241.89	249.81	249.70
Tax scenario		241.43	251.05	254.09
Cost (variable costs including seed, chemicals, and labor; dollars per acre)				
Subsidy scenario	152.92	145.03	150.69	169.94
Tax scenario		146.18	145.71	169.57
WHEAT				
Setting of sector policy variables				
Diversion requirement (percent of base acreage)	20	30	30	30
Target price (dollars per bushel)	4.30	4.38	4.38	4.38
Support price, CCC (dollars per bushel)	3.55	3.65	3.30	3.30
Release price, FOR (dollars per bushel)	4.64	4.64	4.30	4.30
Base acreage (million acres)	90.90	94.00	93.90	43.90
Acreage (million acres)				
Subsidy scenario	76.40	67.51	69.12	70.42
Tax scenario		67.70	65.73	65.70
Yields (bushels per acre)				
Subsidy scenario	31.67	33.37	33.15	33.56
Tax scenario		33.37	33.16	33.61
Production (million bushels)				
Subsidy scenario	2,419.80	2,253.18	2,201.24	2,363.11
Tax scenario		2,259.23	2,179.75	2,207.84
Cost (variable costs including seed, chemicals, and labor; dollars per acre)				
Subsidy scenario	69.76	67.49	64.40	70.60
Tax scenario		[illegible]	[illegible]	[illegible]

TABLE 5

Feed Grain and Wheat Prices Under Subsidy and Tax Scenarios

	FEED GRAIN				WHEAT			
	Nominal prices[a]			Percentage difference between real prices: subsidy vs. tax scenario[b]	Nominal prices[a]			Percentage difference between real prices: subsidy vs. tax scenario[b]
	Subsidy scenario	Actual	Tax scenario		Subsidy scenario	Actual	Tax scenario	
	dollars per bushel			percent	dollars per bushel			percent
1983								
Quarter 1		2.54				3.61		
2		2.99				3.77		
3		3.21				3.53		
4		3.16				3.54		
1984								
Quarter 1	3.46 (1.12)[c]		3.45 (1.12)	0.00	3.55 (1.15)		3.55 (1.16)	- 0.86
2	3.68 (1.17)		3.58 (1.15)	1.74	3.31 (1.05)		3.36 (1.08)	- 2.78
3	3.89 (1.20)		3.73 (1.18)	1.69	3.25 (1.00)		3.33 (1.06)	- 4.76
4	2.92 (0.88)		2.63 (0.82)	7.32	3.60 (1.08)		3.63 (1.14)	- 5.26
1985								
Quarter 1	2.89 (0.85)		2.51 (0.78)	8.97	3.64 (1.06)		3.53 (1.10)	- 3.63
2	2.86 (0.82)		2.53 (0.78)	5.13	3.44 (0.99)		3.07 (0.94)	5.32
3	2.99 (0.84)		2.80 (0.86)	- 2.32	3.55 (1.00)		3.23 (0.98)	2.04
4	2.65 (0.73)		2.45 (0.74)	1.35	4.02 (1.10)		3.59 (1.09)	0.92
1986								
Quarter 1	2.69 (0.72)		2.77 (0.83)	-13.25	4.25 (1.14)		3.35 (1.01)	12.87
2	2.77 (0.73)		2.80 (0.84)	-12.05	4.26 (1.12)		2.90 (0.87)	28.74
3	2.93 (0.76)		2.75 (0.82)	- 7.32	4.43 (1.14)		3.13 (0.93)	22.58
4	2.60 (0.65)		2.32 (0.69)	- 5.80	5.24 (1.32)		3.28 (0.98)	34.69

[a]Price at farm, U. S. average.

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

[c]Figures in parentheses are real prices.

TABLE 6

Export and Major Domestic Demand Under Subsidy and Tax Scenarios

	FEED GRAIN						WHEAT					
	Export			Domestic demand			Export			Domestic demand		
	Subsidy scenario	Actual	Tax scenario	Subsidy scenario	Actual	Tax scenario	Subsidy scenario	Actual	Tax scenario	Subsidy scenario	Actual	Tax scenar
	million metric tons						million bushels					
1983												
Quarter 1		14.77			40.20			442.10			151.40	
2		8.30			24.40			228.30			96.80	
3		16.10			29.50			475.30			210.10	
4		15.70			49.30			362.60			160.70	
1984												
Quarter 1	12.34		12.25	39.31		39.31	346.39		345.54	127.30		127.3
2	6.65		6.56	23.23		23.19	213.59		211.78	71.08		71.2
3	14.49		14.12	29.87		29.83	489.47		482.84	191.78		191.9
4	13.64		13.19	47.71		47.63	343.01		329.00	128.62		129.2
1985												
Quarter 1	11.37		9.94	39.16		39.08	346.24		316.41	126.06		126.8
2	6.36		4.41	23.73		23.63	243.44		196.58	71.51		72.6
3	15.02		12.59	31.68		31.50	542.77		471.23	193.32		194.0
4	14.05		11.26	49.23		48.86	401.86		316.07	128.40		129.8
1986												
Quarter 1	13.98		9.63	41.50		40.88	410.98		291.96	126.37		127.7
2	10.07		5.08	26.45		25.54	328.91		167.60	71.35		72.9
3	19.42		13.10	34.82		33.50	639.17		448.39	195.00		195.5
4	19.33		11.16	51.96		50.26	504.95		295.97	128.80		130.8

TABLE 7

Total Feed Grain Stocks and Their Shares Across Various Components Under Subsidy and Tax Scenarios

	FEED GRAIN											
				Share of stocks						Share of reserved stocks		
	Total stocks (ending)			Market and CCC, nongovernment owned			Government held			Farmer owned		
	Subsidy scenario	Actual	Tax scenario	Subsidy scenario	Actual	Tax scenario	Subsidy scenario	Actual	Tax scenario	Subsidy scenario	Actual	Tax scenar[io]
	million metric tons			percent						percent		
1983												
Quarter 1		183.20			47.65			7.42			44.92	
2		145.60			33.37			9.62			57.01	
3		107.60			24.90			31.23			43.87	
4		154.70			49.83			23.46			26.70	
1984												
Quarter 1	97.49		97.58	68.44		68.22	0.02		0.02	31.54		31.7[illegible]
2	62.37		62.62	70.07		66.88	0.03		0.04	29.90		33.0[illegible]
3	26.62		27.31	100.00		84.64	0.00		0.00	0.00		15.3[illegible]
4	181.00		181.82	97.16		91.30	0.01		0.60	2.83		8.1[illegible]
1985												
Quarter 1	125.04		127.44	89.34		75.46	0.00		1.40	10.66		23.1[illegible]
2	89.75		94.30	77.47		54.52	0.02		2.88	22.51		42.6[illegible]
3	51.39		58.63	68.11		36.84	0.03		1.97	31.86		61.2[illegible]
4	211.73		223.49	55.42		32.27	33.44		48.55	11.14		19.1[illegible]
1986												
Quarter 1	150.90		167.70	61.87		8.46	17.09		64.98	21.04		26.9[illegible]
2	109.23		131.99	52.47		15.92	14.60		49.91	32.95		34.1[illegible]
3	63.13		93.50	52.96		13.80	0.04		42.70	47.00		43.4[illegible]
4	215.48		260.00	52.45		11.55	31.46		69.28	16.10		19.1[illegible]

TABLE 8

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

	WHEAT											
	Total stocks (ending)			Share of stocks						Share of reserved stocks		
				Market and CCC, nongovernment owned			Government held			Farmer owned		
	Subsidy scenario	Actual	Tax scenario	Subsidy scenario	Actual	Tax scenario	Subsidy scenario	Actual	Tax scenario	Subsidy scenario	Actual	Tax scenar
	million bushels			percent						percent		
1983												
Quarter 1		1,862.00			31.25			9.95			58.81	
2		1,515.10			17.33			12.67			70.00	
3		2,955.20			67.08			5.33			27.59	
4		2,326.40			62.68			7.12			30.20	
1984												
Quarter 1	1,766.06		1,766.84	47.37		47.37	10.14		10.14	42.49		42.4
2	1,431.91		1,435.11	30.53		18.86	14.63		26.71	54.84		54.4
3	2,731.51		2,750.44	63.97		58.38	7.90		14.12	28.13		27.5
4	2,174.23		2,210.89	64.84		60.78	1.43		6.65	33.74		32.5
1985												
Quarter 1	1,638.75		1,710.45	54.97		47.81	0.00		9.11	45.03		43.0
2	1,300.38		1,424.34	41.82		32.93	1.81		12.99	56.37		54.0
3	2,630.59		2,717.70	72.80		65.27	0.95		7.03	26.25		27.7
4	2,054.74		2,227.36	69.19		58.32	0.00		9.25	30.81		32.4
1986												
Quarter 1	1,478.67		1,770.44	59.24		44.99	0.00		12.28	40.76		42.7
2	1,077.62		1,519.72	48.94		0.00	0.00		47.08	51.06		52.9
3	2,416.56		2,877.11	80.76		47.39	0.00		25.12	19.24		27.4
4	1,766.70		2,420.21	80.09		49.15	0.00		18.51	19.90		32.3

TABLE 9

Livestock Prices Under Subsidy and Tax Scenarios

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

(Continued on next page.)

Table 9--continued.

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

[a]Average retail price (3 months); choice.

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

[c]Average retail price (3 months).

[d]Average retail price (3 months); four regions.

[e]Figures in parentheses are real prices.

TABLE 10

Livestock Breeding Inventories Under Subsidy and Tax Scenarios

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

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

[b]Breeding hog inventory, 10 states (Quarter 1 = March 1, Quarter 2 = June 1, Quarter 3 = September 1, Quarter 4 = December 1).

[c]Pullet chicks placed in broiler hatchery supply flocks.

TABLE 11

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

	FEED GRAIN				WHEAT			
	Total cost under:			Ratio of the tax scenario to the subsidy scenario	Total cost under:			Ratio of the tax scenario to the subsidy scenario
	Subsidy scenario	Actual	Tax scenario		Subsidy scenario	Actual	Tax scenario	
	million dollars				million dollars			
1983								
Quarter 1		606.34 (206.52)[a]				174.66 (59.49)		
2		568.81 (191.65)				204.10 (68.77)		
3		2,492.95 (831.54)[b]				1,505.66 (502.22)[b]		
4		787.16 (259.70)				162.40 (53.58)		
1984								
Quarter 1	-4,598.71 (-1,489.33)		-4,583.40 (-1,494.23)	1.00	183.35 (59.38)		182.77 (59.58)	1.00
2	126.75 (40.21)		133.09 (42.79)	1.06	255.11 (80.93)		911.55 (293.07)	3.62
3	45.13 (13.89)		60.69 (19.24)	1.39	1,516.33 (466.83)		2,386.38 (756.43)	1.62
4	423.81 (127.19)		2,614.24 (819.05)	6.44	-536.83 (-161.10)		-709.30 (-222.22)	1.38
Total	-4,003.02 (-1,308.04)		-1,775.38 (-613.15)		1,417.96 (446.04)		2,771.40 (886.86)	

(Continued on next page.)

TABLE 11--continued.

	FEED GRAIN				WHEAT			
	Total cost under:			Ratio of the tax scenario to the subsidy scenario	Total cost under:			Ratio of the tax scenario to the subsidy scenario
	Subsidy scenario	Actual	Tax scenario		Subsidy scenario	Actual	Tax scenario	
	million dollars				million dollars			
1985								
Quarter 1	44.55 (13.02)		196.04 (60.81)	4.67	-13.15 (-3.84)		163.71 (50.78)	-13.22
2	87.68 (25.15)		290.84 (89.44)	3.56	176.29 (50.56)		235.53 (72.43)	1.43
3	93.42 (26.24)		40.05 (12.22)	0.47	1,148.83 (322.65)		2,437.82 (743.80)	2.31
4	8,894.43 (2,444.39)		14,357.10 (4,349.86)	1.78	-10.82 (-2.97)		203.06 (61.52)	-20.71
Total	9,120.08 (2,508.80)		14,884.03 (4,512.33)		1,301.15 (366.40)		3,040.12 (928.53)	
1986								
Quarter 1	4,193.80 (-1,127.63)		1,363.03 (410.55)	-0.36	80.32 (21.60)		193.37 (58.25)	2.70
2	-715.62 (-188.73)		-3,601.78 (-1,080.06)	5.72	74.96 (19.77)		1,871.41 (561.18)	28.39
3	-1,592.27 (-411.26)		-2,007.21 (-599.76)	1.46	65.89 (17.02)		2,615.73 (781.59)	45.92
4	8,805.08 (2,214.58)		18,294.10 (5,456.85)	2.46	53.15 (13.37)		-616.65 (-183.91)	-13.76
Total	2,303.39 (486.96)		14,048.14 (4,187.58)		274.32 (71.76)		4,063.86 (1,217.08)	

[a]Figures in parentheses are real costs.

[b]Assume the participation rate = 100 percent.

TABLE 12

Net Farm Income for Feed Grains, Wheat, and Livestock Under Subsidy and Tax Scenarios

	FEED GRAIN				WHEAT				LIVESTOCK			
	Net farm income under: Subsidy scenario	Actual	Tax scenario	Percentage difference in real income: subsidy vs. tax scenario[a]	Net farm income under: Subsidy scenario	Actual	Tax scenario	Percentage difference in real income: subsidy vs. tax scenario[a]	Net farm income under: Subsidy scenario	Actual	Tax scenario	Percentage difference in real income: subsidy vs. tax scenario[a]
	million dollars			percent	million dollars			percent	million dollars			percent
1983												
Quarter 1		-151.80				-79.52				19,196.90		
		(-51.70)[b]				(-27.08)				(6,538.50)		
2		-209.67				-87.56				20,934.70		
		(-70.64)				(-29.50)				(7,053.50)		
3		3,747.04				7,214.67				20,545.30		
		(1,249.85)[c]				(2,406.50)[c]				(6,853.00)		
4		3,579.74				-61.87				17,460.10		
		(1,181.04)				(-20.41)				(5,760.50)		
1984												
Quarter 1	-140.43		-134.11	-4.03	-73.74		-70.39	-4.05	21,235.20		20,882.40	1.02
	(-45.48)		(-43.72)		(-23.88)		(-22.95)		(6,877.20)		(6,807.90)	
2	-105.40		-115.87	10.23	-74.79		-81.72	9.67	26,869.00		26,183.60	1.26
	(-33.44)		(-37.25)		(-23.73)		(-26.27)		(8,524.20)		(8,418.40)	
3	-48.76		-63.65	25.62	5,309.56		7,086.85	-27.23	30,528.00		29,098.50	1.90
	(-15.01)		(-20.18)		(1,634.64)		(2,246.37)		(9,398.60)		(9,223.60)	
4	11,898.20		11,320.80	0.01	-95.17		-99.20	8.11	31,790.30		29,603.60	2.86
	(3,570.59)		(3,546.83)		(-28.56)		(-31.08)		(9,540.10)		(9,274.90)	

(Continued on next page.)

TABLE 12--continued.

	FEED GRAIN				WHEAT				LIVESTOCK			
	Net farm income under:			Percent-age differ-ence in real income: subsidy vs. tax scenario[a]	Net farm income under:			Percent-age differ-ence in real income: subsidy vs. tax scenario[a]	Net farm income under:			Percent-age differ-ence in real income: subsidy vs. tax scenario[a]
	Subsidy scenario	Actual	Tax scenario		Subsidy scenario	Actual	Tax scenario		Subsidy scenario	Actual	Tax scenario	
	million dollars			percent	million dollars			percent	million dollars			percent
1985												
Quarter 1	-36.81		-80.90	57.13	-93.91		-95.42	7.26	34,298.60		30,921.30	4.53
	(-10.76)		(-25.10)		(-27.45)		(-29.60)		(10,025.70)		(9,591.60)	
2	-63.07		-126.32	53.44	-84.64		-83.98	6.04	37,235.80		32,729.00	6.11
	(-18.09)		(-38.85)		(-24.27)		(-25.83)		(10,679.80)		(10,064.90)	
3	-77.00		-161.05	56.00	5,128.05		6,029.14	-21.71	39,171.50		33,229.50	8.51
	(-21.62)		(-49.14)		(1,440.22)		(1,839.55)		(11,001.40)		(10,138.70)	
4	10,754.00		11,541.20	-15.48	-97.70		-117.57	24.62	38,709.80		31,229.70	12.43
	(2,955.43)		(3,496.68)		(-26.85)		(-35.62)		(10,638.30)		(4,461.80)	
1986												
Quarter 1	-106.99		-215.62	55.70	-95.87		-111.91	23.52	40,187.90		31,043.00	15.57
	(-28.77)		(-64.95)		(-25.78)		(-33.71)		(10,805.70)		(9,350.30)	
2	-131.29		-240.91	52.06	-87.10		-110.45	30.65	42,330.90		31,659.40	17.60
	(-34.63)		(-72.24)		(-22.97)		(-33.12)		(11,164.10)		(9,493.70)	
3	-138.64		-252.75	52.58	5,900.07		5,546.38	-8.05	44,846.20		31,937.80	21.38
	(-35.81)		(-75.52)		(1,523.90)		(1,657.27)		(11,583.10)		(9,543.10)	
4	8,927.52		9,169.19	-17.90	-82.74		-144.34	51.66	45,438.00		30,027.60	27.59
	(2,245.38)		(2,735.03)		(-20.81)		(-43.05)		(11,428.20)		(8,956.80)	

[a]Calculated by $(I_s - I_t)/I_t$ for $I_s, I_t > 0$ and $-(I_s - I_t)/I_t$ for $I_s, I_t < 0$.

[b]Figures in parentheses are real income.

[c]Assume the participation rate = 100 percent.

Appendix

Overshooting of Flexible Prices

The uncovered interest parity assumption requires that

$$i - i^* = x,$$

where i and i^* are domestic and rest-of-world nominal interest rates, respectively, and x denotes expected depreciation of the home currency. This expectation, in turn, is assumed to be a function of the extent to which the logarithm of the exchange rate (units of domestic currency per rest-of-world currency unit) deviates from its long-run equilibrium level

$$x = \vartheta(\overline{e} - e)$$

where ϑ is directly related to the flexibility of nonagricultural prices.

An equilibrium condition in the money market is expressed in natural logarithms:

$$m - q = \varphi y - \lambda i,$$

where m denotes the nominal money supply, q the price level, y income, and i the interest rate. All variables are in logs except for the interest rate. Purchasing power parity is assumed to hold for the agricultural commodity, so that, expressing prices in logs,

$$e = P_a - P^*_a .$$

Normalizing the world price to be one, this condition is equivalent to

$$e = P_a .$$

The logarithm of the domestic price index, q, which appears in the money market equilibrium condition, is assumed to be

$$q = \alpha P_n + (1 - \alpha) P_a$$

or

$$q = \alpha P_n + (1 - \alpha) e,$$

where P_n is the natural log of the fix-price good. The money market equilibrium condition can therefore be expressed as

$$m - \alpha P_n - (1 - \alpha) e = \varphi y - \lambda i.$$

Combining the uncovered interest parity assumption and the expected depreciation of the currency, the money market equilibrium condition becomes

$$m - \alpha P_n - (1 - \alpha) e = \varphi y - \lambda [\vartheta(\bar{e} - e) + i^*].$$

This expression summarizes equilibrium in financial asset markets.

A long-run version of the expression for asset market equilibrium, one in which money supply and income are taken to be at their long-run equilibrium levels, is

$$\bar{m} - \alpha \bar{P}_n - (1 - \alpha) \bar{e} = \varphi \bar{y} - \lambda i^*.$$

Note that expected depreciation of the currency is now zero.

Combining the last two expressions and expressing the nominal interest rate differential $i - i^*$ as expected depreciation of the home currency,

$$m - \alpha P_n - (1 - \alpha) e = - \lambda \vartheta (\bar{e} - e) + \bar{m} - \alpha \bar{P}_n - (1 - \alpha) \bar{e}.$$

Treating m = $\bar{m}$ and y = $\bar{y}$, we find that

$$e - \bar{e} = -\alpha[(1-\alpha) + \lambda\vartheta]^{-1} (P_n - \bar{P}_n).$$

The equilibrium exchange rate deviates from its long-run equilibrium rate ($\bar{e}$) by an amount proportional to the deviation of the price in the fix-price sector from its long-run equilibrium level. The proportion is increasing in α, the share of the fix-price good in the price index, and is decreasing in λ and ϑ.

Recall that we took P_a to be equal to the exchange rate by normalizing the rest-of-world price of agricultural commodities. This means that there is an equivalent amount of overshooting in domestic agricultural prices. The upshot of this result is that, as e and P_a overshoot their long-run equilibrium levels after money growth, relative prices will have turned in favor of the agricultural sector, since $P_a - P_n$ is larger than in equilibrium, and that they turn against the sector after contractions ($P_a - P_n$ is smaller than in equilibrium.) In this model, e and P_a remain out of long-run equilibrium as long as P_n has not fully adjusted to its new level.

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