A SURVEY OF MACROECONOMICS AND AGRICULTURE

BY

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SECTION I. Introduction

In 1973, the Bretton-Woods Agreement collapsed and the U.S. dollar was allowed to float. Since then, agricultural economists have paid considerable attention to the relationship between agriculture and the macroeconomy. Indeed, the magnitude of macroeconomic policy impacts on agriculture have been among the most important and hotly disputed issues in agricultural economics during the past decade (Schuh 1974, 1976; Chambers 1981; Rausser 1985; Orden 1986III).

This paper undertakes a critical survey of previous literature on the macroeconomics of agriculture. The main controversies will be outlined and priorities for future research will be discussed. How agricultural variables are related to macroeconomic variables, and how government policies affect those variables under different theoretical models, will receive most attention.

In Section II, the important role of agriculture in the macroeconomy will be stressed by looking at key summary statistics. Then, the major issues and controversies that have arisen in the literature will be surveyed. Section III then provides a brief sketch of the macroeconomic environment facing agriculture. The mechanisms through which macroeconomic events get transferred to agriculture will be given particular attention. In Section IV, the current status of macroeconomic theory will be outlined through a selective review of the general macroeconomics literature.

Implications for the effects that monetary and fiscal policies might have on aggregate macroeconomic indicators will be provided. In Section V, the implications of alternative macroeconomic theories for how macroeconomic policies affect agriculture will be discussed. The impact of farm policies and variables on the macroeconomy will also be considered. Finally, Section VI will discuss future research directions and conclude the study with a brief summary of findings.

SECTION II. Issues and Controversies

Economic indicators of U.S. agriculture have fluctuated remarkably in the past two decades (see figure 1). Between 1971 and 1973, the real price of farm products grew over 19.4% per year on average and real net farm income increased 45% per year. Over the same period, the annual increase in the value of real farm exports was almost 42.5%. However, all of these indicators declined between 1974 and 1977 and then fluctuated throughout the rest of the decade.

Agriculture experienced a prolonged recession in the early 1980's. Between 1979 and 1983, the real price of farm products decreased by an average of 6.17% per year and real net farm income dropped by 15% per year. Furthermore, the real value of farm exports fell by 8.4% per year between 1980 and 1986.

U.S. macroeconomic indicators have also been volatile throughout the 1970's and 1980's (see figure 2). The U.S. inflation rate accelerated by an average of 28.5% per year from 1972 to 1975, but declined by 22.1% per year from 1981 to 1986. The rate of interest remained relatively low in the early 1970's but has been high during the 1980's. Between 1969 and 1973, the multilateral trade weighted value of the U.S. dollar fell consistently by 5.1% per year on average but increased by an average of 10.6% per year between 1980 and 1985.

Traditionally, agricultural economists have devoted most of their attention to microeconomic issues because the classical

FIGURE 1

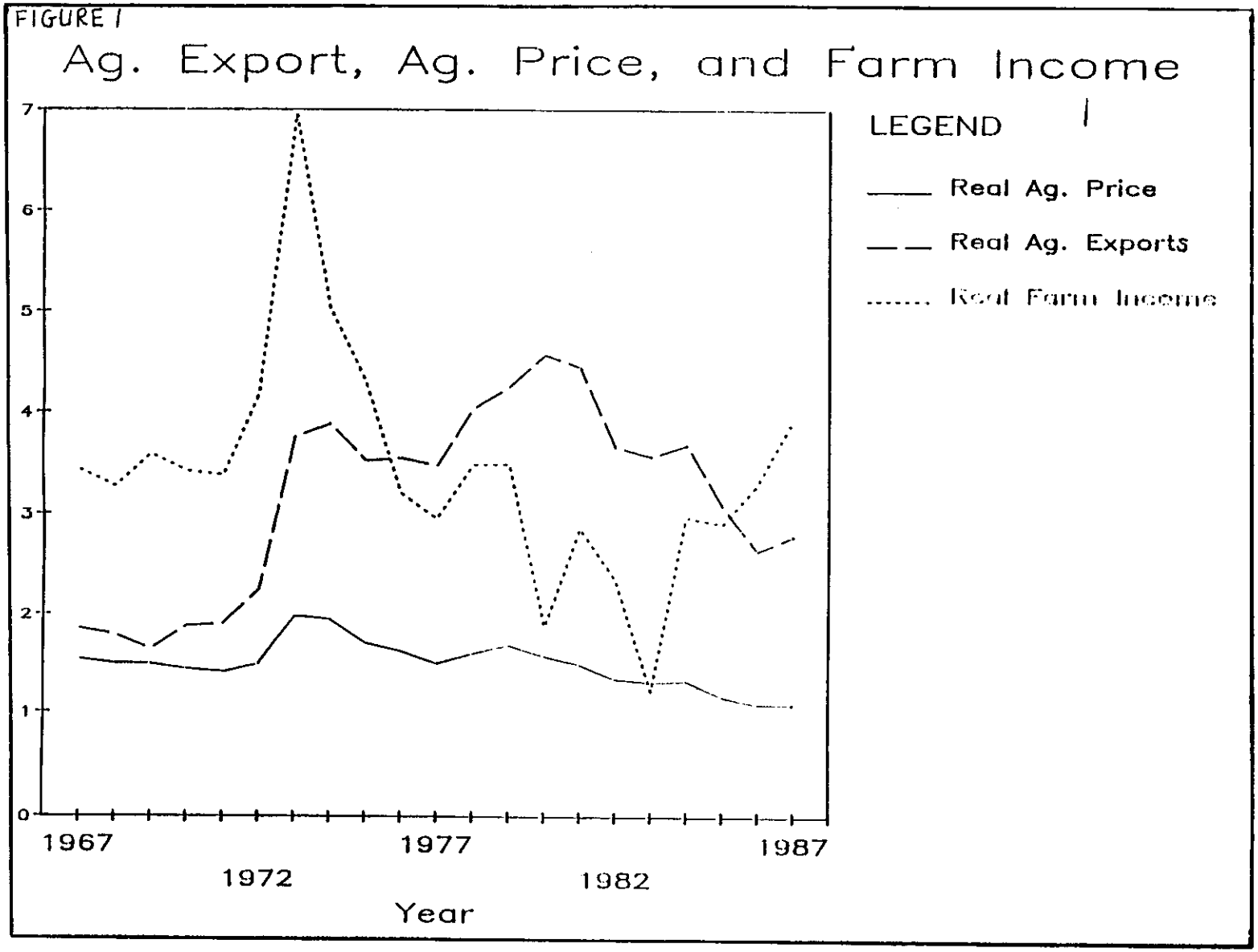
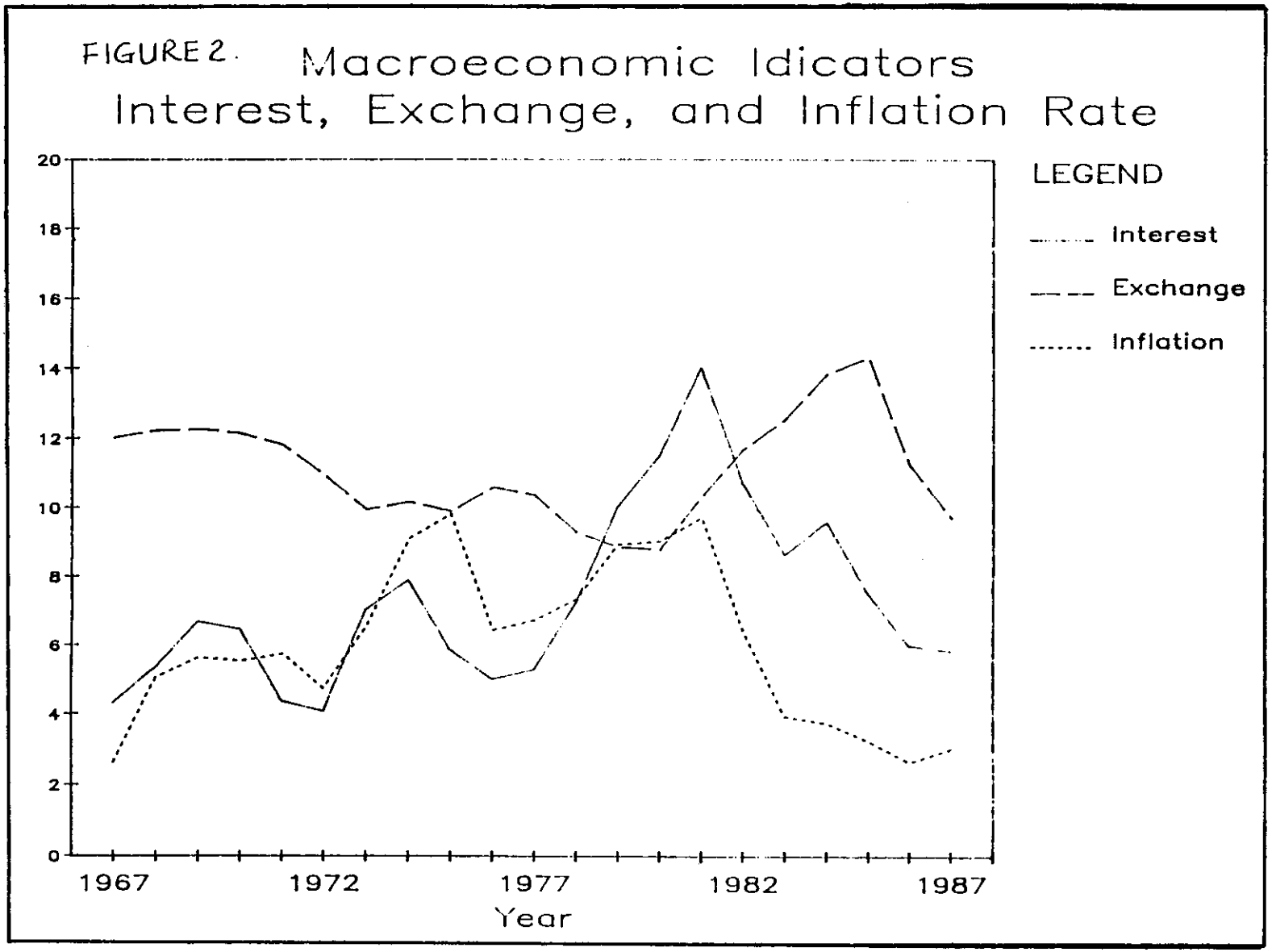

Ag. Export, Ag. Price, and Farm Income
LEGEND
Real Ag. Price
Real Ag. Exports
Real Farm Income
7
6
5
4
3
2
1
0
1967
1972
1977
1982
1987
Year

FIGURE 2.


Macroeconomic Idicators
Interest, Exchange, and Inflation Rate
LEGEND
Interest
Exchange
Inflation
20
18
16
14
12
10
8
6
4
2
0
1967
1972
1977
1982
1987
Year

economic paradigm applies to agricultural markets better than anywhere else (Frankel 1984). But, there is a growing belief that economic fluctuations in agriculture can be traced mainly to macroeconomic events. Though some early literature focused on this topic (Schultz 1945; Hathaway 1957, 1959; Firch 1964), it was Schuh (1974) who focused the profession's attention on this new dimension of agricultural economics. Schuh, in his famous paper on the exchange rate and agriculture, argued for the important role of a macroeconomic variable, the exchange rate, in causing economic fluctuations in agriculture.

Schuh's work was immediately controversial and become an important area of research in agricultural economics. Some scholars challenged Schuh's contention that fluctuations in the exchange rate have significant impacts on agriculture. For example, Kost (1976), using a single good partial equilibrium model, asserted that the magnitude of the exchange rate impact depends on the size of the trade sector and on the elasticities of export supply and import demand. He insisted that the proportional changes in export quantity and price will be smaller than the proportional change in the exchange rate because of low supply and demand elasticity. Vellianitis-Fidas (1976) provided empirical support for Kost's argument. Chambers and Just (1979) extended Kost's basic model, by allowing for cross price elasticities between goods. They found that Kost's argument is not valid in this case. Orden (1986:I) also rejected the Kost argument using a generalized framework that included income effects. Both papers

found the elasticity of agricultural price with respect to a change in the exchange rate would not necessary be restricted in the closed interval between -1 and 0, as claimed in Kost's paper.

Numerous empirical studies have also been undertaken. Johnson, Grennes, and Thursby (1977), Collins, Meyers and Bredahl (1980), and Batten and Bellongia (1986) all found evidence to support Kost's result that exchange rate fluctuations are relatively unimportant. On the other hand, Chambers and Just (1981), and Longmire and Morey (1982) found important exchange rate effects. The difference in the data and models used in these studies could be important reasons for the difference in the results. However, it is certain that the controversies on the issue of exchange rate effects on agriculture have not been fully resolved. Recently, Just and Chambers (1987) raised the question again in considering whether the falling value of the U.S. dollar since 1985 could help the depressed agricultural economy.

Not surprisingly, there is also disagreement on how inflation impacts on agriculture relative to nonagricultural sectors. Tweeten (1980:I) argued that general inflation contributes to the "cost-price" squeeze: the declining ratio of prices received to prices paid by farmers. Applying Okun's hypothesis on the heterogeneity of market types, Rausser (1985) asserted that money supply growth leads not only to general inflation, but also a (short run) increase in agricultural prices relative to most nonagricultural prices. Rausser found a positive correlation between inflation and farm prices (and income).

Belongia and King (1983), and Orden (1986:III), however, disagree and found support for the general neutrality of money; a change in money stock changes all nominal prices by the same proportion, leaving relative prices unaffected.

Between 1981 and 1985, interest rates on long term loans rose to 11-15%, compared to 7-8% in the 1970's. Over the same period, farm land prices decreased by an average of 6.7% per year, the largest fall in the last 50 years. During this time, U.S. agriculture also became more capital intensive compared to the 1970's (USDA, selected issues). The capital-output ratio in agriculture jumped up by 11.5% on average in the 1981-1985 period compared to 6.4% growth in the 1971-1975 period. Total debt loads of U.S. farmers increased over three times from 59.5 billion dollars in 1971 to 182 billion dollars in 1981. In 1981, U.S. farmers paid 19.9 billion dollars for interest on borrowed money, five times more than the 3.6 billion dollars spent in 1970. As a result, the interest rate has had much more effect recently than it had previously. Some agricultural economists have tried to connect the financial crisis of the U.S. farm sector in early 1980's to the high interest rate environment occurring at that time (ERS:USDA 1982; Thompson 1986). Though relatively few studies on this subject have been done, disagreement exists on the effects of interest rate changes on agriculture. Schwartz (1986) found negative impacts of interest rate changes on agricultural exports and prices while Chambers (1981) found no significant impact.

Traditionally, agricultural economists have tried to link

the cyclical fluctuations in the macroeconomy to the agricultural sector. Schultz (1945) and Brandow (1977) believed that changes in the level of macroeconomic activity were a major cause of instability in agriculture. Schultz claimed that agricultural production usually occurred at full capacity due to high fixed costs and low mobility of labor. Hence, agriculture is not very responsive to external shocks, and changes in national income shift the demand but not the supply of farm products. Firch (1977) and Thompson (1986) found support for this model, but Gardner (1981) found no impact of business fluctuations on farm prices. Although the issue of business cycle impacts on agriculture is not new, most of the work has been done in the context of partial equilibrium models.

Thus far, this paper has been concerned with mechanisms through which macroeconomic events get transferred to agriculture. More recently, agricultural economists have became concerned directly with how monetary and fiscal policies affect agriculture, through their influence on the exchange rate, inflation, interest rates, and business fluctuations. The conventional view is that tight monetary policy increases interest rates and the value of the dollar, thereby decreasing the relative price of agricultural products. Loose monetary policy has the reverse effect. (Schuh 1974; Chambers 1984; Rausser 1985). On the other hand, there is the neutrality hypothesis that monetary policy doesn't have any impacts on relative prices. With complete price flexibility, anticipated monetary disturbances can only have the same effect on

all nominal variables. The general price level follows the rate of money growth but relative prices are not affected by the monetary disturbances. There is research supporting the neutrality of money in agriculture (Batten and Belongia 1984, 1986).

The effects of fiscal policy on agriculture have received less attention compared to monetary policy. Recently, a number of agricultural economists have tried to relate the depressed farm economy in the early 1980's to the growing federal budget deficit (Rausser 1985; Just and Chambers 1987). It is argued that the fiscal deficit bids up interest rates and exchange rates, thereby decreasing exports of agricultural products. However, there is also a neutrality argument for fiscal policy: real economic variables are not affected by the method of financing federal expenditures. This hypothesis, known as the Ricardian proposition, states that shifts between taxes and government borrowing affects the timing of tax collection, but not aggregate wealth since households save the full amount of their extra income to pay for higher future taxes required to repay currents debts. Thus, deficits do not alter the real economy in the case of lump sum taxes (Crouch 1972; Barro 1974, 1987). There is research supporting fiscal neutrality in the agricultural economy (Batten and Belongia 1986).

Events in the macroeconomy clearly may have an effect on agriculture but some researchers have also been concerned with the effect of agricultural instability on macroeconomic indicators. Just (1977:I) argued that agricultural price changes may affect

inflation, that agricultural trade may affect the exchange rate, and that agricultural instability may affect general economic instability. However Hughes and Penson (1980) denied any impact of agricultural variables on the general economy.

The issues raised in this section can be summarized as four linkages drawn in figure 3 and discussed through the remainder of this paper.

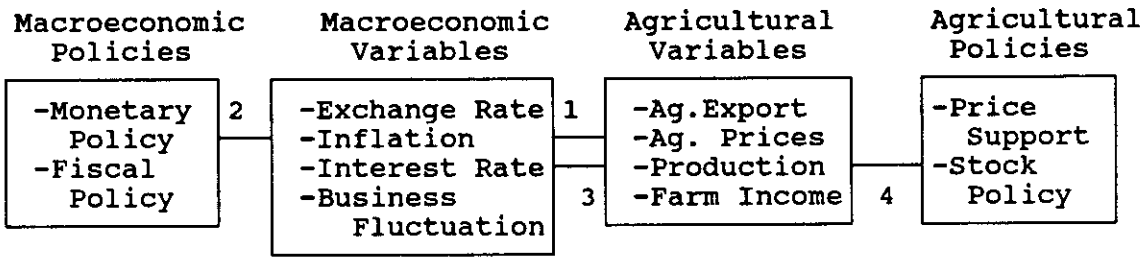


Figure 3. Forward and backward linkages between the macroeconomy and agriculture

SECTION III. The Macroeconomic Environment Facing Agriculture

The macroeconomic environment facing agriculture consists of four mechanisms through which events and policies in the macroeconomy may be transferred to agriculture. These are the exchange rate, the interest rate, the rate of inflation, and the demand effect of business cycle fluctuations. In this section, these mechanisms are examined by treating them as exogenous, and asking what effect changes have on the agricultural sector. The approach is partial equilibrium in the sense that the financial and factor markets are treated exogenously. In a general equilibrium approach, discussed in Section V, these markets would be endogenous.

From the literature, two types of partial equilibrium approaches can be distinguished: single-good partial equilibrium models and multi-good partial equilibrium models. Both partial equilibrium models only deal with variables related to goods markets and the exchange rate, the inflation rate, the interest rate, and income flows, are treated exogenously. The multi-good partial equilibrium model considers the interaction between various types of goods; tradable goods versus non tradable goods, goods with fixed prices versus goods with flexible price, etc. The single-good partial equilibrium model only deals with a single good. The remainder of this chapter will be devoted to a discussion of the issues and controversies raised in Section II, based on these partial equilibrium models.

1. The exchange rate and agriculture

Since Schuh (1974, 1976) first asserted that changes in the exchange rate have significant impacts on agriculture, many agricultural economists have examined this view. They have tried to identify causality from the exchange rate to agriculture and measure the magnitude of the impact. However the early works were mainly partial equilibrium, where changes in the exchange rate were taken as exogenous. Furthermore, the early works considered the goods markets only, and failed to examine financial flows. Kost (1976) responded to Schuh's proposition as follows:

> Economists have given substantially less thought to the price and quantity effect of exchange rate policy on a particular agricultural commodity. ..... This misspecification of theory has led many people to conclude that the exchange rate is an important structural variable that has been omitted from many analyses of the agricultural situation. They have also come to believe that the dollar devaluations contributed significantly to the increase in foreign demand for U.S. agricultural products (Kost 1976, p.99)

Kost focuses on a homogeneous good, say the i-th good, traded between two countries without any commercial policy. Assuming no transportation costs, the price of the i-th good expressed in importer's currency (p^*_i) and the price of the good expressed in exporter's currency (p_i) are linked by the exchange rate (e):

$$(1) \qquad p^*_i = ep_i.$$

A devaluation by the exporter decreases the foreign price p^*_i for any given value of p_i, increasing foreign demand and decreasing

foreign supply. Thereby exports (q_i) and price in the exporting country (p_i) both rise (see figure 4). However, the proportional changes in price and quantity will be smaller than the proportional change in the exchange rate in this one good partial equilibrium model. To measure the effect, let

(2) $M_i = f(p^*_i)$ $\quad df/dp^*_i < 0,$

(3) $X_i = g(p_i)$ $\quad dg/dp_i > 0,$

(4) $M_i = X_i = q_i$

be the import demand of good i (M_i), the export supply of good i (X_i), and a market equilibrium condition. Differentiating (2) and (3) and using the equilibrium condition (4), we get (see appendix 1 for details)

(5) $$E_{pi} = \frac{dp_i}{de}\frac{e}{p_i} = \frac{-E^*_{ii}}{E^*_{ii} - E_{ii}}$$ (the exchange rate elasticity of the i-th good price)

where

(6) $$E^*_{ii} = \frac{df}{dp^*_i}\frac{p^*_i}{q_i}$$ (the elasticity of import demand for good i with respect to own price, p_i)

(7) $$E_{ii} = \frac{dg}{dp_i}\frac{p_i}{q_i}$$ (the elasticity of excess supply for good i with respect to own price, p_i)

From (5), it is clear that E_{pi} is confined to the closed interval [0, -1] since $E^*_{ii} < 0$ and $E_{ii} > 0$. Thus, the maximum price rise for the traded good will be the same percentage as the devaluation. The maximum occurs when the export supply curve is perfectly inelastic ($E_{ii} = 0$). As illustrated in figure 5, a devaluation would then shift the import demand curve upward, and the percentage change in price is exactly equal to the percentage change in the exchange rate. Alternatively, a change in the

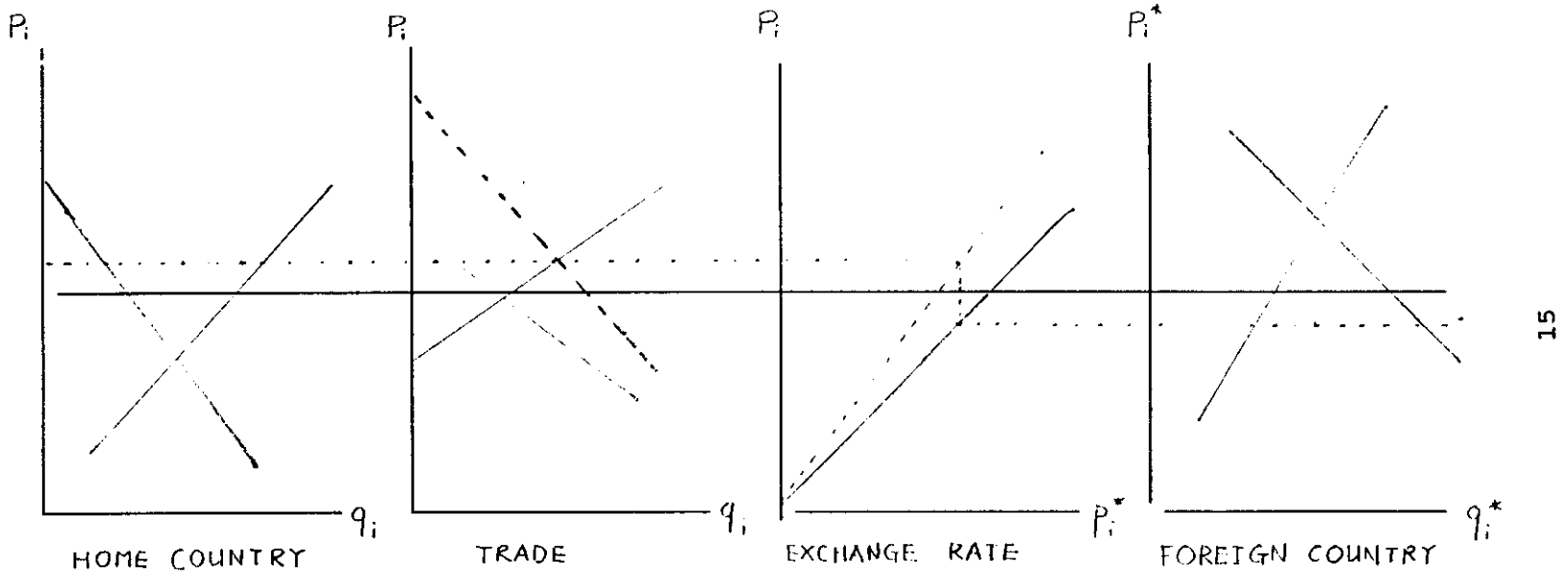


Figure 4. EFFECTS OF A DEVALUATION IN AN ONE GOOD PARTIAL EQUILIBRIUM MODEL

exchange rate doesn't have any impact in the case of a perfectly elastic excess supply curve ($E_{ii} = \infty$). As shown in figure 6, all adjustment comes in terms of an increase in exports.

The exchange rate elasticity of exports of good i in equilibrium is

$$(8)\quad E_{qi} = \frac{dq_i}{de}\,\frac{e}{q_i} = \frac{dp_i}{de}\,\frac{e}{p_i}\,\frac{dX_i}{dp_i}\,\frac{p_i}{X_i} = E_{pi}\,E_{ii}.$$

Since $-1 < E_{pi} < 0$, it is also clear that $-E_{ii} < E_{qi} < 0$. The maximum amount of increase in the quantity traded will depend on the elasticity of excess supply. Empirical support for these results can be found in Johnson, Grennes, and Thursby (1977), Collins, Myers, and Bredahl (1980), and Gardner (1981). Starleaf (1982) found -1.33 for the exchange rate elasticity of farm output price for the years 1968-81, and -.8 for the same years with 1973 removed.

Chambers and Just (1979) criticized the single-good partial equilibrium approach by emphasizing cross price effects between the agricultural good and other goods. Orden (1983) is also skeptical of the single-good partial equilibrium approach. He states that:

> ....to justify the partial equilibrium analysis...., it must be assumed that there are no other traded goods, or alternatively, that all cross-price effects between other traded goods and the supply and demand for i-th good in each country are zero. In addition, it must be assumed that the nominal prices of any nontraded goods with cross price effects in the i-th market are held fixed. (p.23)

Chambers and Just (1979) adopted a multi-good partial equilibrium approach. Their approach is quite similar to the single-good partial equilibrium approach, except for the inclusion of n goods

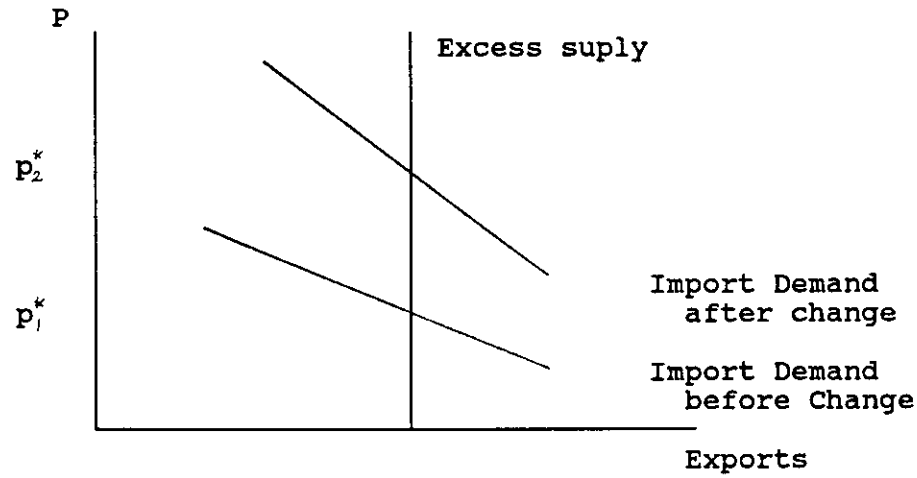


Figure 5. Effect of devaluation when the export supply curve is perfectly inelastic ($E_{ii} = 0$)

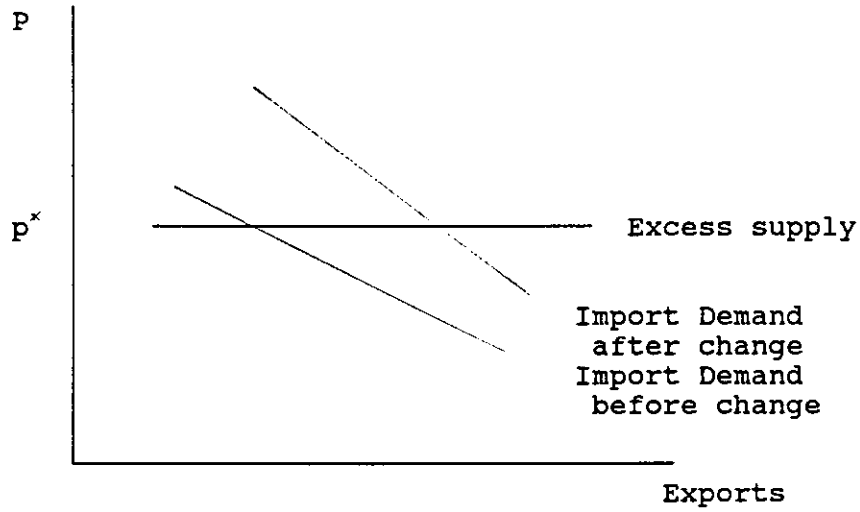


Figure 6. Effect of devaluation when the excess supply curve is perfectly elastic ($E_{ii} = \infty$)

in the model. The import demand equation (2) becomes

$$(9)\quad M_i = f(p^*_1, p^*_2, \ldots\ldots\ldots, p^*_n, Y)$$

$$df/dp^*_i < 0,$$

and the export supply (3) becomes

$$(10)\quad X_i = g(p_1, p_2, \ldots\ldots\ldots, p_n)$$

$$dg/dp_i > 0,$$

where Y is income for the importing country. Assuming dY = 0, the exchange rate elasticity of the price of the i-th good in the multi-good equilibrium model can be obtained by differentiation (see appendix 2 for a derivation).

$$(11)\quad E^m_{pi} = \frac{dp_i}{de}\frac{e}{p_i} = E_{pi} + \frac{E_{pi}}{E^*_{ii}} \sum_{j \neq i} [E^*_{ij}\ (1 + E^m_{ij}) - Eij\ E^m_{pj}]$$

where E^*_{ij} and E_{ij} are elasticities of import demand and export supply for good i with respect to the j-th good price, and E^m_{pj} is the exchange rate elasticity of the j-th good price in the multi-good approach.

By imposing the condition that the export supply function is homogeneous of degree zero in prices, and the import demand function is homogeneous of degree zero in prices and income,

$$(12)\quad E^*_{ii} + \sum_{j \neq i} E^*_{ij} + E^*_y = 0$$

$$(13)\quad E_{ii} + \sum_{j \neq i} E_{ij} = 0$$

where E^*_y is the income elasticity of import demand for good i.

Equation (11) can be written as

$$(14)\quad E^{m}_{pi} = E_{pi} - \frac{\sum_{j \neq i} (E^{*}_{ij} - E_{ij}) E^{m}_{pj} - (E^{*}_{y} + E^{*}_{ii})}{E^{*}_{ii} - E_{ii}} .$$

Examining (11) and (14), the magnitude of E^{m}_{pi} is indeterminate since the second element of right hand side cannot be signed. Chambers and Just concluded that, " ..... there is no a priori reason to restrict E^{m}_{pi} to the closed interval [0, -1]."

To show that the elasticity constraint by single good equilibrium approach is not correct, Chambers and Just considered a special case of zero cross price elasticity of import demand, $E^{*}_{ij} = 0$. Then, $E^{*}_{y} = 0$, and (11) becomes

$$(15)\quad E^{m}_{pi} = E_{pi} + \frac{\sum_{j \neq i} E_{ij} E^{m}_{pj}}{E^{*}_{ii} - E_{ii}} .$$

If devaluation is inflationary for supply substitutes, $E^{m}_{pj} < 0$, then the second element on the right hand side of (15) becomes negative. Therefore, $|E^{m}_{pi}| > |E_{pi}|$, and the exchange rate elasticity of price in the multi-good partial equilibrium model could be larger than that in the single-good model. Chambers and Just again criticized the single good partial equilibrium approach by saying that, ".... the associated argument that the percentage change in price is less than the percentage exchange rate movement is invalid." They later supported their argument with empirical

work (Chambers and Just, 1981). However, Longmire and Morey (1982), in their empirical application of a multi-good partial equilibrium model, found the exchange rate elasticity of agricultural price does not exceed the unitary range in absolute value when the assumption of zero cross price elasticities is relaxed.

The conflicting results make the issue of exchange rate impacts on agricultural prices an unresolved puzzle. Pagoulatos and Canler (1982) criticized both partial equilibrium approaches and argued for the endogeneity of the exchange rate. Three different approaches for exchange rate determination were compared. The elasticity approach concentrates on the goods market and considers the flow of goods, services, and assets as the determinants for the exchange rate. Orden (83, 86:I) emphasized the role of the income transfers in this context. The portfolio approach assumes imperfect substitution between foreign and domestic bonds which enter into the exchange rate equation. Van duyne (1979) applied this approach to estimate the effect of the 1973 commodity price shocks on general inflation. The monetarist approach, a special case of the asset approach, assumes perfect substitution between bonds and ignores assets as substitutes for money. Relative money growth, relative GNP growth, relative interest rates, and differences in inflationary expectations between countries are important determinants in this approach. Chambers and Just (1986) treated prices, and the trade balance as determinants of the exchange rate. Schwartz (1986) believed that

differential inflation and interest rates among countries were two main reasons for exchange rate variations. All of these approaches are in a general equilibrium framework.

Though the primary concern over exchange rates has been their impact on agricultural prices, some agricultural economists have also been concerned with other impacts of the exchange rate on agriculture. Schuh (1974, 1981:I, 1983) argued thet the exchange rate would affect food prices relative to other prices, the amount of land used, employment in agriculture, farm incomes, and productivity. He also argued that an increase in the exchange rate would increase agricultural factor prices relative to output prices, agricultural imports, and farm migrations. Schuh (1981:I, 1983) also confirmed the negative impact of exchange rate changes on agricultural income and inventories. Johnson, Grennes, and Thursby (1977) supported Schuh's original work empirically by finding an exchange rate effect on land prices. They also found the exchange rate elasticity of land price keeps to the closed interval [-1, 0]. Gardner (1981) found that the exchange rate elasticity of land price is bounded by unity. Chambers and Just (1981) agreed with the negative relationship between agricultural income and exchange rate changes. Finally, Schuh (1976) describes the increase in world trade volume with the change in the U.S. exchange rate system from fixed to flexible.

2. Inflation and agriculture

The relationship between agricultural prices and a change in the general price level was given considerable attention after the U.S. economy experienced a major inflation beginning in 1973. Tweeten (1980:I) formulated and tested the proposition that general inflation contributes to the "cost-price" squeeze in agriculture. He found that the "general increment in overall price level increases nominal farm product prices and farm demand in proportion to the general price level but leaves real farm demand and hence real demand price unchanged." He also found that " national inflation moved upward the supply curve through prices paid by farmers proportionately more than it moved the demand curve and prices received by farmers." The estimated change in the ratio of prices received to prices paid by farmers caused by inflation in Tweeten's paper was .76 in the short run. The hypothesis of a cost-price squeeze is also supported by Penn (1979). However, Schluter and Lee (1981) rejected the "cost-price" squeeze and did not find any real impact of general inflation on agriculture in their empirical work. Gardner (1981) also detected an insignificant impact of general inflation on the price of farm land, wages, input prices, and output prices. Feldstein (1980) argued that inflation would be neutral against factor market effects, unless there exist any distortions in the market, such as a capital income tax. Starleaf (1982) and Starleaf, Meyers, and Womack (1985) found that anticipated inflation causes an increase

in agricultural prices relative to nonagricultural prices rather than a cost price squeeze. Heien (1977) adopted the multi-good partial equilibrium approach. Considering the cross price interaction between substitutes, he found that the price of agricultural commodities decreases more than the decline in the general price level.

Ruttan (1979) tried to link productivity growth in agriculture to general price level changes. Examining U.S. data, he claimed that general price inflation dampens productivity growth in the agricultural sector. However, Johnson (1980) and Lee (1980) found no impact on agricultural productivity from a change in the general price level.

There also are other issues surrounding the impacts of inflation on agriculture. Vining and Elwortowski (1976), and Park (1978), establish the positive correlation between general price inflation and relative price dispersion. Firch (1977) found that real farm prices and incomes are more variable when the general price level is more variable. Robinson (1979) asserted that inflation has contributed to a greater degree of inequality among regions, types, and income classes of farms. Hoover (1979) criticized the use of partial equilibrium approaches for analyzing inflation and agriculture. He argued that inflation is a monetary phenomenon and, hence, ignoring other macroeconomic variables in a partial equilibrium model is not acceptable. He stated that:

> ..... I reviewed a considerable amount of the literature and was depressed with how little I found that is useful to an understanding of inflation in the farming sector. ..... Most of the papers that purport to analyze infla-

> tion's impact on agriculture use no macro variables. They simply build in the historical drift in real product prices to inflation. ..... Since inflation appears to be an important and persistent phenomenon this appears to be an area in which we should launch new studies. (p.914)

3. Interest rates and agriculture

Agriculture has become a more capital intensive sector in recent decades, and farmers are now relying more on debt financing than in the past. Thus, the interest rate has become one of the most important factors affecting agriculture. Chambers (1984) briefly mentioned the direct impact of interest rates on agriculture. He argued that an interest rate increase causes farm stocks to be released to the market, since interest costs are an important component of the total costs of carrying stocks. Therefore, the price of agricultural products will fall. Thompson (1986) argued that increases in real interest rates were the major factor causing land price falls in the 1980's. Schuh (1981:I) and Rausser (1985) added the indirect impact of interest rate changes on agriculture through the exchange rate to the direct impact. The decline in the price of agricultural commodities will be aggravated when high interest rates induce capital inflows from abroad which bid up the value of dollar.

4. Business cycle fluctuations and Agriculture

Traditionally, agricultural economists tend to link

instability in the agricultural sector to fluctuations in general macroeconomic activity. Most the papers found on this subject were written before 1981 and used a partial equilibrium approach. Schultz (1945) argued that fluctuations in national income are an important factor causing instability in agricultural prices and the farm economy. High fixed costs for farm production, immobility of excess labor, new technology and land development, and maladjustment in farming were possible candidates for the lack of adjustment in agricultural resources. As a result, demand shifts for farm products induced by changes in national incomes make agricultural prices very unstable. Schultz's explanations received mixed reviews within the profession. Firch (1964, 1977) and Brandow (1977) supported the proposition, and Starleaf (1982) estimated 2.74 for the elasticity of farm output prices with respect to a change in real nonfarm output. However, Gardner (1976, 1981) found no evidence supporting any significant impact on farm prices and incomes from a change in national income levels. Heien (1977) in his empirical work with a multi- good partial equilibrium model found a link between national income and agricultural prices in the short run, but not in the long run. Hathaway (1957, 1959) supported the correlation between business cycle fluctuations and agriculture. He argued that nonfarm economic activity affects agriculture by passing through input price changes. Johnson (1958, 1960) gave a different explanation for the irresponsive supply of farm products. Asset fixity (the difference in salvage and acquisition values of assets) and

specialization of farm production activity were his main explanations for the low elasticity of agricultural supply.

SECTION IV. Monetary Policy, Fiscal Policy and Macroeconomic Theory

During the 1950s and 1960s, the Keynesian synthesis dominated developments in macroeconomic theory and policy. However, the combined recessions and inflations of the 1970's dissolved the Keynesian consensus. As a result, macroeconomics was thrown into disarray (Grossman, 1980; Fusfeld, 1982; Barro, 1984). Bell and Kristol (1981) refer to this disarray as a "crisis in economic theory".

The crisis in macroeconomic theory has spilled over into studies on how macroeconomic events affect agriculture. If there is no consensus on how macroeconomic policies affect aggregate economic activity, then there is little hope of agreement on how these policies affect a particular sector of the economy.

In this section, the current status of macroeconomic theory will be summarized. The implications the competing theories have for the effects of monetary and fiscal policy on economic performance will be given particular attention.

1. The Keynesian Paradigm

Keynesian macroeconomics explains the existence of business cycles in terms of aggregate demand. As illustrated in figure 7, employment (or total output) of the economy depends on aggregate spending, consisting of consumer spending, business investment and

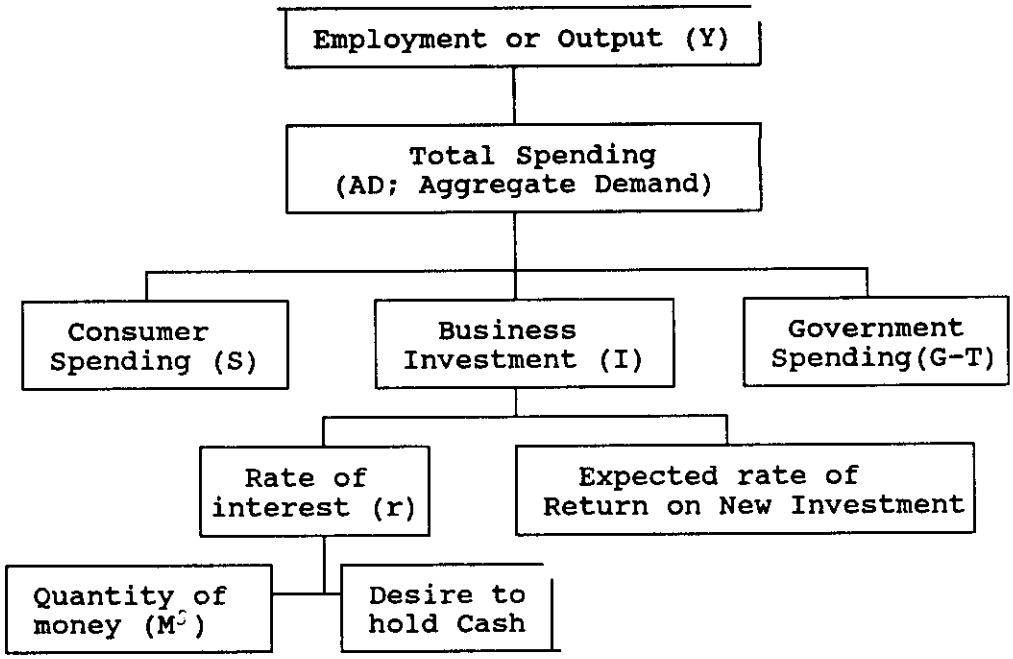


Figure 7. Schematic Diagram of Keynesian Theory (Fusfeld 1982, p.103)

the government sector. Too little demand will result in falling output and employment (recession). Inflation, on the other hand, will be caused by too much spending. The level of investment spending depends on the expected return on the new investment relative to the interest rate.

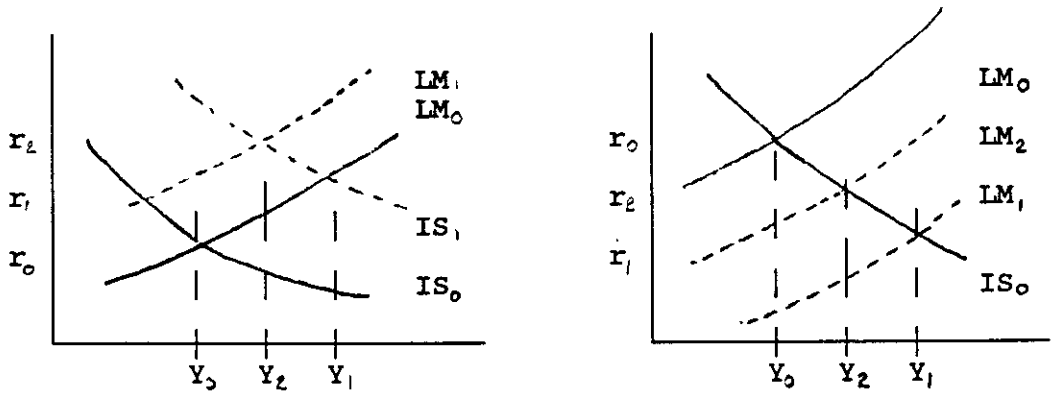
The agents in a Keynesian world live with imperfect foresight regarding the future. As a result, workers (firms) are constrained in the market with an excess supply of labor (goods). Prices and wages tend to be sticky and markets are not cleared by a flexible price mechanism. The output of the economy depends solely on aggregate demand and the supply side plays only a passive role. There is a positive multiplier connecting autonomous shifts in aggregate demand to output fluctuations. When the economy is operating at the maximum level of aggregate supply for the society, no further expansion of employment will be possible by increasing aggregate demand. The level of employment at that point is defined as full employment.

Keynesian macroeconomics cannot explain simultaneous inflation and unemployment. When the price level increased rapidly during the 1958-59 recession, A.W. Phillips (1958) attempted to explain this phenomenon as "structural unemployment": persistent unemployment even while prices are rising. He extended the Keynesian model by showing the tradeoff between unemployment and prices (negatively sloped Phillips curve). The Keynesian economy could be at less than full employment in the short run and involuntary unemployment exists because of sticky prices. In the

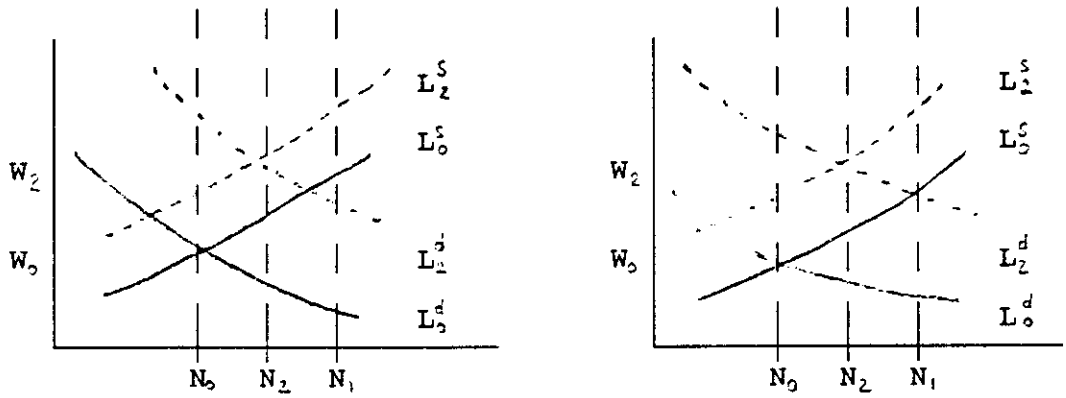
Keynesian model, government policies (monetary or fiscal or both) can be used to stimulate aggregate demand in a recession.

As shown in figure 8, expansionary fiscal policy (increases in government spending or a tax cut) shifts out the IS curve from IS_0 to IS_1, changing equilibrium output on the demand side of the economy to Y_1. This causes a demand curve shift in the goods market and an increase in the price level. The real amount of money stock (M^s/P) decreases by the increase in price level, making the LM curve move up toward LM_1. The interest rate increases from r_0 to r_2 and investment drops, pulling the output level back to Y_2. In the labor market, the demand for labor shifts upward proportional to the increase in the price level. However the labor supply moves up less than proportionally to the price increases. Overall, fiscal policy influences both real and nominal variables.

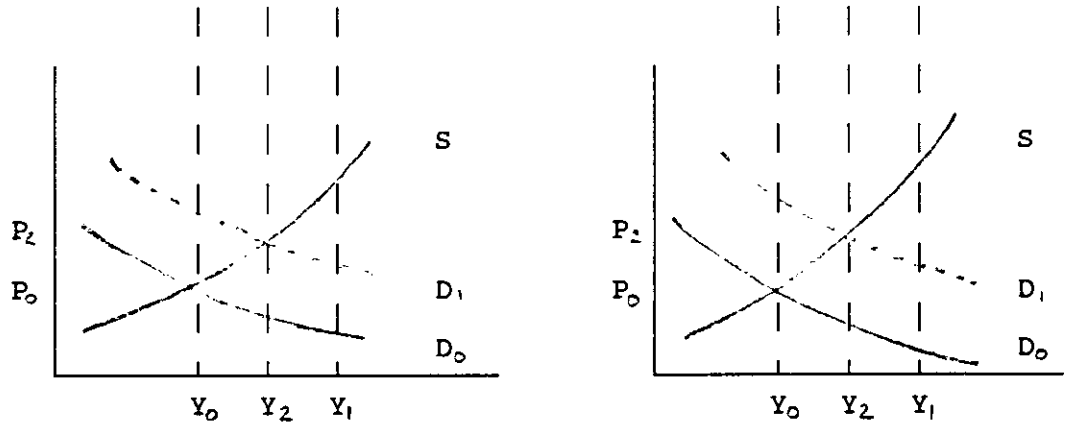
Expansionary monetary policy will bring interest rates down and shift the LM curve from LM_0 to LM_1, as shown in figure 9. The lower interest rate will stimulate additional investment, increasing equilibrium demand-side output to Y_1. This causes a demand shift in the goods market to D_1, generating excess demand for goods at the initial price level P_0. Thus, the price level will increase to balance supply and demand. The real amount of money stock (M^s/P) falls as a result of the price increase and this increases interest rates, pulling the LM curve back to LM_2. The higher interest rate will reduce investment and hence output level from Y_1 to Y_2. Again, both labor demand and supply shift out. Overall, expansionary monetary policy has both real and nominal



Goods and Money Market



Labor Market



Goods Market

Figure 8. Fiscal Policy in a Keynesian Economy

Figure 9. Monetary Policy in a Keynesian Economy

effects.

In summary, the Keynesian model exhibits nonmarket clearing (or disequilibrium) due to a stickiness or slow adjustment process in the labor market. Both monetary and fiscal policies have real effects, and hence government intervention can have an important influence on economic performance.

2. The Neoclassical Paradigm

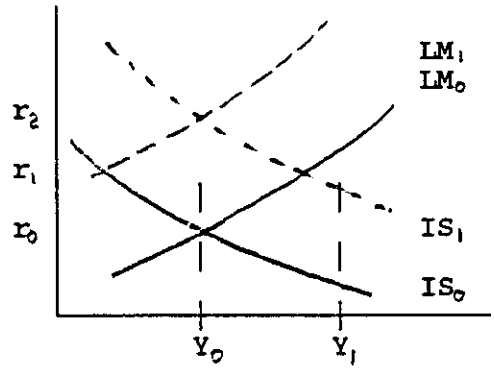
In the neoclassical macroeconomic model, agents utilize all the available information to form their expectations about future events. No money illusion occurs and the long-run Phillips curve is vertical. There is no trade off between unemployment and inflation. There will be a natural rate of employment and output. Money plays no role in determining the values of real variables, but only helps to determine the values of nominal variables. Therefore, inflation is a monetary phenomenon and adjusts proportionally to the rate of money supply growth. All nominal variables respond proportionally to a money supply shock and hence relative prices remain unchanged (the Neutrality of money). Neoclassical economists are pessimistic about the Keynesian belief that monetary policy can have important real effects on the economy.

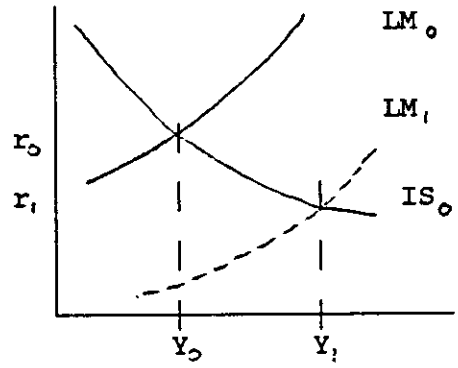
As shown in figure 10, the IS curve shifts up to IS_1 with expansionary fiscal policy. At the initial price level P_0, equilibrium output demanded rises to Y_1. This is shown as a shift

in the demand curve to D_1 in the goods market generating, an excess demand gap of $Y_1 - Y_0$ which forces prices to rise. However the price increase is fully anticipated by agents, and output stays at the natural rate, Y_0. In the financial market, the price increase reduces the real level of money stock (M^s/p) and, hence, moves the LM curve up to LM_1. This raises interest rates further to r_2 and reduces investment, which results in a decline in income to the original level, Y_0. Overall, fiscal policy affects only nominal variables but not real variables, thus leaving the equilibrium of the economy unaffected. The general price level,the nominal wage, and the rate of interest for the economy are increased by the same proportion. But real income, the level of employment, and the real wage rate remain at the original level.

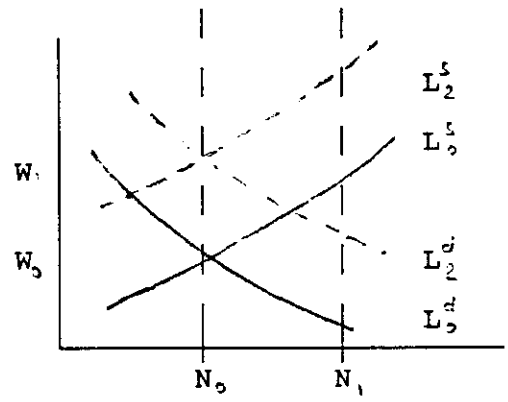
Expansionary monetary policy shifts the LM curve from LM_0 to LM_1 as shown in figure 11. This forces the interest rate down which encourages investment. Equilibrium output demanded rises to Y_1 with the additional investment, which drives the demand curve up to D_1. This produces an excess demand gap of Y_1-Y_0; so the price level begins to rise. As the price level increases, the demand and the supply of labor shift out by same proportion, thus leaving equilibrium in the labor market undisturbed at the natural level. In the financial market, the increased price level reduces the real stock of money supply (M^s/p) and hence, reduces the LM curve back to its original position. Again, monetary policy doesn't affect real variables.

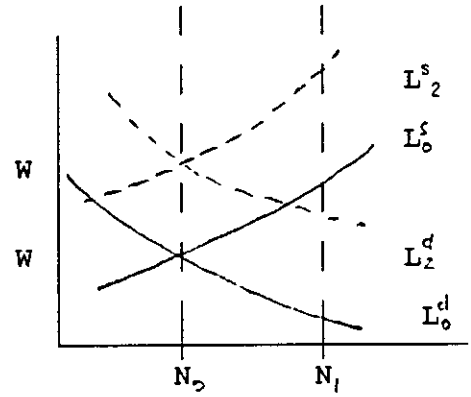
As discussed, systematic monetary and fiscal policies can



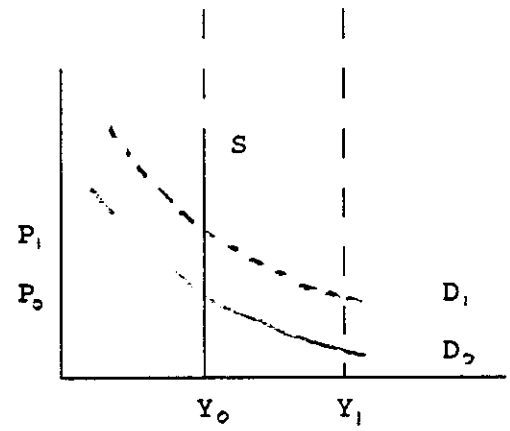


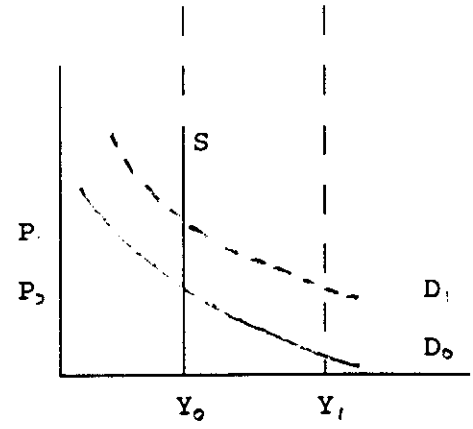
Goods and Money Market





Labor Market





Goods Market

Figure 10. Fiscal Policy in a Neoclassical Economy

Figure 11. Monetary Policy in a Neoclassical Economy

change the general price level but have no real effect on the economy. However an unanticipated policy shock may have real impacts. Friedman (1968) argued that monetary policy has a far more pervasive effect on economic activity than does fiscal policy in the short run, but denies the active use of the monetary policy to prevent inflation or underemployment. He supported a gradual and steady increase in the money supply at a fixed percent annually as an aid to economic growth. Friedman and the monetarists also contend that government spending designed to prevent recessions is a significant cause of inflation.

In summary, the neoclassical economy can be represented by market clearing (or equilibrium) with price and wage flexibility. Both monetary and fiscal policies don't have real impacts in the classical economy.

3. The Neo-Keynesian Paradigm

Andrews and Rausser (1986) described the evolution of the Neo-Keynesian paradigm as follows;

> Traditional Keynesians in a quandary to develop a rival to the natural rate hypothesis, turned to the fixed-flex -price model first proposed by Means and expanded it to explain how stagflation can be generated from exogenous supply shocks. These modifications of the traditional Keynesian sticky price model have converged into a compet -ing paradigm known as the Neo-Keynesian school. (p.414)

The main characteristic of the Neo-Keynesian paradigm is the heterogeneity in the economy. It contains both Walrasian auction markets (flexible price sector) and nonclearing customer markets

(fixed price sector). Though the Neokeynesian view does not deny money neutrality and the natural rate of employment in the long run, the emphasis is placed on the short run responses to a shock to the economy (Frankel, 84; Rausser, 85; Stamoulis, Chalfant and, Rausser, 85; Andrews and Rausser, 86). During the transition period, there will be a macroeconomic externality when the price of the flexible sector overshoots beyond its long run equilibrium level, due to rigidities in customer markets. The rate of temporary overshooting depends on the size of the auction sector and the speed of the transmission. Both price and the output will fluctuate over the short run business cycle. The Phillips curve could be vertical in the long run, but the trade off between the price level and output is allowed, at least in the short run (Taylor 1979, 1980).

Although the reasons for the short run sticky price in the economy are not completely understood, some justifications are made based on the optimizing behavior of agents. Search costs (or information costs) due to the imperfect information (Okun 1975), transaction costs (or management costs) due to price setting and delivery lags (Blinder 1982; Carton 1978, 1979, 1980), implicit wage contracts due to the uncertain environment (Taylor 1979, 1980), and asymmetric information (Stiglitz 1984) are the various candidates for Neokeynesian microfoundations.

Due to the heterogeneity of markets, both monetary and fiscal policies lead to changes in the relative price between the auction and the customer market, even under rational expectations.

Real output, employment, and the rate of interest will also be affected by the differential price movement to any economic shock. Prices in the flexible price sectors will overshoot their long run equilibrium values.

In summary, the Neo-Keynesian economy can be described as a hybrid of the disequilibrium approach of the Keynesian model with the equilibrium of the new classical model. Both quantity rationed customer markets (fixed price) and auction markets (flexible price) exist and produce real policy impacts in the short run.

4. Estimation of Policy Impacts

As discussed above, wide disagreement exists among macroeconomists. Numerous scholars have tried to test empirically the different propositions resulting from different theories. Initially, simultaneous equation models were used in empirical macroeconomics. These models tend to be large scale, taking account of many behavioral relations between macro variables. Numerous a priori restrictions are used to identify the parameters of the behavioral equations. Zero restrictions are often used to exclude or exogenize a variable from a specific equation. Usually, the policy regimes of the government enter exogenously into the model. Restrictions on the lag structure and the error structure (recursive or uncorrelated error terms) are also used. The predictive power of the model depends on the credibility of the restrictions. The problems associated with this type of modeling

are now well known. The traditional model might be appropriate when the system is in an equilibrium, but cannot capture the dynamic evolution of the economy during the adjustment from one equilibrium to another.

Rational expectations models interpret the rules of government behavior as part of the environment. Any changes in policy regime will change the expectations of agents, which will affect their decision rules and hence the structure of the economy. Therefore, the traditional simultaneous equation model will not be valid for policy analysis, since any policy shock would change the parameters of the behavioral equations. However, rational expectations models have not been successful for large scale macroeconomic forecasting.

Resistance to the use of a priori restrictions and the poor empirical performance of traditional macroeconomic models have lead some economists to turn their attention to unconstrained vector autoregressions (VARs). Sims (1980,1986) originally applied the method to the problem of modeling the effects of government policy. The restrictions used in this approach are based on statistical properties of the data. Economic theory has a role in selecting variables initially but not in restricting specific parameters. Thus, VAR models tend to be small scale. Once the variables are selected, they are all treated as endogenous. The dynamic responses of the economy to a specific policy shock is identified by the coefficients of the moving-average representation of the VAR.

Sims applied the VAR approach to test competing

macroeconomic theories. The Phillips curve "wage equation" was rejected and unemployment was not found to be important in the wage equation. Money supply effects were important for both nominal variables (price and import prices) and real variables (real wage, unemployment, and output investment). The effects of a money shock were persistent, and the short run output effects are tied to the long run price effects through the money shock.

The VAR approach has been criticised on a number of grounds. First, the selection of the variables are arbitrary, depending on the researcher's interests. Therefore, the results from the VAR approach are not directly connected to the optimal behavior of agents. Rather they reveal the statistical relations between the selected variables at a macro level. Second, a loss of information occurs since the VAR model tends to be small scale. The exclusion of important macroeconomic variables could result in biased estimation of some parameters. Third, when the variables are contemporaneously correlated, the arbitrary ordering plays an important role in the decomposition of the forecast error variances. Different orderings may results in very different results. Fourth, in the case of unprecedented large movements in policy instruments, it is doubtful that the linear structure of the model would remain fixed.

In this section, three different macroeconomic theories and their policy implications were explored. The traditional Keynesian theory is represented by disequilibria with sticky prices (slow adjustment). The Neoclassical model is represented by market

clearing with flexible prices (quick adjustment). Finally, the Neo-Keynesian model has both sticky and flexible prices.

SECTION V. Monetary Policy, Fiscal Policy, and Agriculture

Controversies surrounding competing macroeconomic theories have spilled over into research on the effects of macroeconomic policies on agriculture. The implications each of these theories has for linkages between agriculture and the macroeconomy are quite different and are discussed in this section.

1. Macroeconomic policy impact on Agriculture

In the case of the Keynesian model, macroeconomic policies have effects on real farm variables, through their effects on exchange rates, inflation, interest rates, and business fluctuations. However, the direction of effects on farm variables remains controversial. Tight monetary policy or a government deficit will cause the price level to fall and interest rates to rise. There is a belief that these changes will induce capital inflows from abroad, which in turn will bid up the value of dollar. The strong dollar makes agricultural exports more expensive and the high interest rate makes storage of farm products costly. A decrease in prices, exports, production, and income for agriculture will then occur (Schuh 1981,1983; McCalla 1982; Pagoulatos and Canler 1983; Schwartz 1986). Alternatively, it is believed that those changes will improve the farm economy by decreasing the cost of agricultural production without decreasing farm prices (Just and Chambers 1987). The rationale for this approach is that farm

programs fix prices received by farmers. In either case, macroeconomic policies have real impacts on the farm economy, but the direction of the impacts is an empirical question.

In the Neoclassical approach, Macroeconomic policies cannot have any real impacts on agricultural variables since they do not have any real effects. All of the macroeconomic variables and agricultural prices adjust to a policy shock by the same proportion. Orden (1983) constructed a Neoclassical trade model and found money neutrality under flexible exchange rates; "a monetary expansion is completely offset by proportionate uniform changes in domestic prices and the exchange rate under a flexible exchange rate system." Frankel (1986), and Stamoulis, Chalfant, and Rausser (1987) constructed theoretical models to compare impacts of monetary policy on agriculture under Neoclassical assumptions, with those under Neo-Keynesian assumptions. Comparative static results showed no real impact of monetary policy on interest rates, exchange rates, and agricultural prices under the flexibility assumption.

In the Neo-Keynesian approach, macroeconomic policies have real impacts on agriculture in the short run. Frankel, and Stamoulis, Chalafant, and Rausser emphasized the real impact of monetary policy on agricultural prices. Unanticipated growth in the money stock is followed by an inflation which causes a short run decline in interest rates and exchange rate. Agricultural prices will increase more than proportionately to the change in the money supply and they overshoot their long run equilibrium.

The short run monetary effects will disappear as prices of nonagricultural goods rise to their long run equilibrium over time. Initial relative prices are eventually restored and long run neutrality holds. The same results are also derived by Chambers (1984). Chambers (1985) and Bredahl (1985) related the differential price adjustment to the stylized facts that U.S. agriculture has (a) highly inelastic demand and supply, (b) low income elasticities of demand, (c) high competition, (d) rapid technological change, (e) asset fixity, (f) variability in supply due to weather, and (g) foreign agricultural policy.

The conflicting implications of different theories means that the effects of monetary policy on agriculture becomes an empirical question. Chambers (1981), and Chambers and Just (1982) found support for the Keynesian view by finding increased agricultural exports and prices as a result of monetary expansion. Inflation and exchange rates were found to be important transfer mechanisms. Hughes and Penson (1980) built a large scale simultaneous equations model which supported the real impact of monetary policy on agriculture under the Keynesian paradigm. Among the linkages in the economy, the negative impact of inflation on agricultural prices, demand, and income, and the positive impact of general income level changes on agricultural production expenses were significant. The cost price squeeze makes farmers better off economically with a tight monetary policy scenario which slows inflation and income growth. Orden (1986:III), using a VAR model, found support for the cost-price squeeze effect of an autonomous

inflation but he could not relate this to monetary policy.

Belongia and King (1983), and Belongia (1985) rejected the Keynesian view empirically. The neutrality of money on relative price changes is found using causality tests with monthly and quarterly U.S. data. Batten and Belongia (1984, 1986) also rejected monetary policy impacts on agriculture through the exchange rate. Monetary disturbances didn't have any impact on the real exchange rate. Denbaly and Williams (1988) supported the Neoclassical results differently. With annual data from 1960 to 1980, a weak link between the money stock and the exchange rate is found, but the exchange rate impacts on prices and exports of the agricultural commodities are found to be insignificant (-.18 for the price elasticity and .39 for the elasticity of exports). Bessler (1984) found money neutrality in a VAR application to Brazilian data. Orden (1986:III) also used a VAR approach and found no monetary policy impacts on agriculture. Autonomous shocks in real financial variables (interest rates, the exchange rate, and inflation) had greater effect on agricultural prices and exports, but anticipated monetary policy didn't have any impact on real financial variables.

On the other hand, Shei and Thompson (1981) found support for the Neokeynesian hypothesis of differential price adjustments. A growth in the money supply caused inflation, which caused agricultural prices to increase more then industrial prices. The same results are also found by Rausser (1985), and Rausser, Chalfant, Love, and Stamoulis (1986). Using simultaneous equation

models, they found that growth in the supply of mone
general price and income levels, and decreased the real
rate and the exchange rate. Stamoulis, Chalfant, and
(1987), using simple causality tests, supported the Neo-Keynes
paradigm. A monetary shock resulted in rapid adjustment of agricultural prices and slow adjustment of other prices. However, all the real effects remained short run and disappeared as prices of other goods adjusted over time to the monetary shock. They also found that the degree of overshooting depends on the degree of rigidity in the economy. Chambers (1984), with a VAR approach, supported the hypothesis that short run relative price changes are affected by unanticipated money changes. Contractionary monetary policy decreases exports, relative prices, and incomes of the agricultural sector. Devados and Myers (1987) also applied the VAR approach and found support for the Neo-Keynesian hypothesis of flexible agricultural prices and inflexible non-agricultural prices. Though their approach is identical to Bessler, monetary shocks were found to increase agricultural prices relative to non-agricultural prices using U.S. data.

There is less research on the effects of fiscal policy on agriculture. Belongia and Stone (1985) empirically tested and supported the Neoclassical view. They found an impact of exchange rate changes on agricultural exports, but couldn't find any significant impact of the federal deficit on exchange rates or interest rates. Batten and Belongia (1986) also supported the Neoclassical view. However, Rausser (1985), and Rausser, Chalfant,

Love, and Stamoulis (1986) supported the Neo-Keynesian approach. The federal deficit had the same effect on agriculture as tight monetary policy in the short run.

2. Impacts of agricultural sector policy on the macroeconomy

Arzac and Wilkinson (1979) have claimed that agricultural sector policies are not effective in influencing agricultural prices and production. However, other scholars disagree. Penn (1979) argued for the impact of sector policies on the general price level through cost of production effects and Lamm (1979) found that agricultural price supports caused food price inflation. Lamm (1980) also found a negative impact of price supports on farm income. Belongia and King (1983) found that price controls are responsible for decreases in agricultural prices. Rausser (1985), and Rausser, Chalfant, Love, and Stamoulis (1986) detected empirically that agricultural price supports increase downward rigidity in agricultural prices which leads an over-allocation of resources into the agricultural sector through overshooting. Sector policies dominated macroeconomic policies in the long run since macroeconomic policies are neutral over the longer time horizon. But macro policies dominate sector policies in the short run because of overshooting. They suggested a flexible sector policy to reduce overshooting.

In studying the effects of the agricultural sector on the macroeconomy (backward linkages), Just (1977:I) described three

mechanisms through which these effects could occur; impacts of agricultural trade on the exchange rate, impacts of agricultural prices on inflation, and impacts of instability in agriculture on instability in general economy. Ruttan (1979) believed that fluctuations in agricultural productivity are a factor causing inflation. However, Penn (1979) denied any impact of agricultural price movements on inflation.

Empirically, Vining and Elwertovski (1976) found a positive correlation between agricultural prices and the general price level. Rausser (1985) found a positive response of the general price level to changes in agricultural prices, with a two quarter lag. However, Hughes and Penson (1980), and Lamm (1980), did not find any significant impact of agricultural variables on the general economy. Using Granger causality tests on monthly data from 1970 to 1978, Barnett, Bessler, and Thompson (1983) found that the supply of money caused changes in agricultural prices, but not vice-versa. Orden (1986:III) supported these results with a VAR application.

Although agricultural sector policies seem to have real impacts on agricultural variables, whether agricultural variables have impacts on the macro economy is still controversial.

SECTION VI. Summary and Conclusions

Agricultural economists have gradually turned their attention to relationships between macroeconomics and agriculture. Four macroeconomic variables are considered as major mechanisms through which macroeconomic events get transferred to agriculture. An increase in the exchange rate or interest rate appeared to depress the farm economy, though the magnitude of the impacts remains in question. Exchange rate and interest rate increases also decrease agricultural prices, storage, production and income, and increase costs of production. Whether inflation will improve the farm economy or result in a cost price squeeze in agriculture is controversial. Whether general income growth will improve or worsen prosperity of the farm economy is also controversial. Interactions between different mechanisms makes it even more difficult to measure and compare the impact of each mechanism on agriculture. Further research will be needed to resolve the controversies.

Controversies surrounding macroeconomic theories are mostly to blame for the different theories on how macroeconomic policies impact on agriculture. Macroeconomic policies in a Keynesian model have effects on real farm variables through their effects on real macroeconomic variables. In a Neoclassical model, macroeconomic policies don't have real effects on farm variables since they don't have any effect on real macroeconomic variables. In the Neo-Keynesian model, macroeconomic policies have real effect only in

the short run and are neutral in the long run. Therefore, a consensus on how macroeconomic policies affect macroeconomic variables will be key to resolving the controversies on how these policies affect agriculture.

Numerous empirical studies have been done to test the controversies, but a consensus has not been reached yet. The Neo-Keynesian model seems more general than other two models by allowing the differential price adjustment and this model deserves additional study. However, use of the traditional simultaneous equation methods reduces the flexibility of the Neo-Keynesian model by treating the differential price adjustment exogenously. The VAR approach is used in a few papers to find the relationship between variables on a purely statistical basis. Though the dynamic nature of the VAR approach allows the differential price adjustment to be endogenized, the time series approach lacks explanatory power for agent behavior.

The empirical studies have also shown the wide differences in interpreting the relationships between macroeconomic variables and agricultural variables. The use of different indices (Belongia 1986; Batten and Belongia 1986; Chambers 1981) and different model specifications (Orden 1986:III) could be responsible for the different interpretations. Different ordering of variables (Orden 1989), different lag selections (Sanders 1988), and stationarity of data (Engle and Granger 1987) in the VAR approach might also be responsible to some extent.

Although agricultural sector policies seem to have real

impacts on agricultural variables, there is no strong evidence that agricultural variables affect macroeconomic variables.

Based on these findings, a few suggestions are made for future study. First, a useful model must include the important macroeconomic factors in a general equilibrium framework. Second, different assumptions and theories must be tested appropriately within the model. Third, the model should consider the dynamics of policy effects. The length and structure of lags have to be determined endogenously within the model. Fourth, the appropriate indices for a variable have to be obtained based on their performance in the model. Finally, more consideration of the issue of fiscal policy impacts on agriculture are needed.

Appendix 1.

At Equilibrium,

$$f(p^*_i;\ p^*_1,\ p^*_2,\ \ldots\ldots,\ p^*_{i-1},\ p^*_{i+1},\ \ldots\ldots,\ p^*_n)$$

$$= g(p_i\ ;\ p_1,\ p_2,\ \ldots\ldots,\ p_{i-1},\ p_{i+1},\ \ldots\ldots\ ,\ p_n)$$

$$= q_i\ .$$

By differentiation with respect to exchange rate e, we get

$$\frac{df}{dp^*_i}\frac{dp^*_i}{de} = \frac{dg}{dp_i}\frac{dp_i}{de}\ .$$

Since

$$\frac{dp^*_i}{de} \quad \frac{d(ep_i)}{de} = \frac{dp_i}{de}\,e + p_i\ ,$$

$$\frac{df}{dp^*_i}\left(\frac{dp_i}{de}\,e + p_i\right) = \frac{dg}{dp_i}\frac{dp_i}{de}\ .$$

Hence

$$\frac{df}{dp^*_i}\ p_i = \frac{dp_i}{de}\left(\frac{dg}{dp_i} - \frac{df}{dp^*_i}\,e\right)\ .$$

And

$$\frac{dp_i}{de} = \frac{(df/dp^*_i)\ p_i}{dg/dp_i\ -(df/dp^*_i)\ e} \qquad < 0$$

since $dg/dp_i > 0$, $df/dp^*_i < 0$.

Therefore,

$$E_{pi} = \frac{dp_i}{de}\frac{e}{p_i} = \frac{(df/dp^*_i)\ e}{dg/dp_i\ -(df/dp^*_i)\ e}$$

$$= \frac{(df/dp^*_i)\ p^*_i/q}{(dg/dp_i)p_i/q\ -\ (df/dp^*_i)p^*_i/q}$$

$$= \frac{E^*_{ii}}{E_{ii} - E^*_{ii}}$$

,which is equation (5).

Appendix 2.

At Equilibrium,

$$f(p^*_i,\ p^*_1,\ p^*_2,\ \cdots\cdots,\ p^*_{i-1},\ p^*_{i+1},\ \cdots\cdots,\ p^*_n)$$

$$= g(p_i,\ p_1,\ p_2,\ \cdots\cdots,\ p_{i-1},\ p_{i+1},\ \cdots\cdots,\ p_n)$$

$$= q_i \ .$$

By differentiation with respect to exchange rate e, we get

$$\sum_{j=1}^{n} \frac{df}{dp^*_j} \frac{dp^*_j}{de} = \sum_{j=i}^{n} \frac{dg}{dp_j} \frac{dp_j}{de} \ .$$

Since

$$\frac{dp^*_j}{de} \quad \frac{d(ep_j)}{de} = \frac{dp_j}{de} e + p_j \ ,$$

$$\sum_{j=i}^{n} \frac{df}{dp^*_j} \left(\frac{dp_j}{de} e + p_j\right) = \sum_{j=i}^{n} \frac{dg}{dp_j} \frac{dp_j}{de} \ .$$

Rearranging then yields

$$\frac{dp_i}{de} \left[\frac{dg}{dp_i} - \frac{df}{dp^*_i} \right] = \sum_{j\neq i} \frac{df}{dp^*_j} \left(\frac{dp_j}{de} e + p_j\right) + \frac{df}{dp^*_j} p_i - \sum_{j\neq i} \frac{dg}{dp_j} \frac{dp_j}{de} \ .$$

And multiplying by e/p_i makes

$$E^m_{pi} = \frac{dp_i}{de} \frac{e}{p_i} = \frac{1}{\Phi_i} \frac{e}{p_i} \frac{df}{dp^*_j} p_i + \frac{1}{\Phi_i} \frac{e}{p_i} \sum_{j\neq i} \left[\frac{df}{dp^*_j} \frac{dp_j}{de} e + \frac{df}{dp^*_j} p_j - \frac{dg}{dp_j} \frac{dp_j}{de}\right]$$

$$= \frac{df}{dp^*_i} \frac{e}{\Phi_i} + \frac{1}{\Phi_i} \frac{q_i}{p_i} \sum_{j\neq i} \left[\frac{df}{dp^*_j} \frac{e}{q_i} p_j \frac{e}{p_j} \frac{dp_j}{de} + \frac{df}{dp^*_j} \frac{p_j}{q_i} e - \frac{dg}{dp_j} \frac{p_j}{q_i} \frac{e}{p_j} \frac{dp_j}{de} \right] .$$

$$\text{where } \Phi_i = \frac{dg}{dp_i} - \frac{df}{dp^*_i} e$$

Using equation (5) and

$$\frac{1}{\Phi_i}\frac{qi}{pi} = \frac{1}{\Phi_i}\frac{df}{dp^*_i} e \frac{1}{e}\frac{1}{df/dp^*_i}\frac{q_i}{p_i}$$

$$= E_{pi} / E^*_{ii} \ ,$$

equation (11) will be derived.

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