AN ASSESSMENT OF THE IMPACT ON AGRICULTURAL PRICES AND OUTPUT OF ANTICIPATED VERSUS UNANTICIPATED MONETARY VARIABILITY

by

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(ABSTRACT)

The effects of anticipated versus unanticipated money growth on total, nonfarm, and farm real gross domestic product, real net farm income, real prices received by farmers for crops and livestock, and the real value of agricultural exports are evaluated. The distinction between anticipated and unanticipated components of money growth is motivated by the new classical rational expectations assertion that anticipated money growth is discounted by agents and has no real effects, while unanticipated money may have real impacts. The differentiation of money growth into anticipated and unanticipated components follows a rational expectations scheme using Granger causality tests. The money growth equation and the output, real price, and agricultural export equations are estimated by a two-step estimation procedure.

The regression results for total and nonfarm real gross domestic product and real net farm income indicate an influence from both anticipated and unanticipated components of money. On the other hand, real farm gross domestic product

appears to be affected by only unanticipated components of money. The regression results for prices received by farmers for crops and livestock, and the real value of agricultural exports indicate little influence from either anticipated or unanticipated components of money. In sum, the results suggest that neither anticipated nor unanticipated money is always neutral, but only limited evidence is found of monetary impacts specifically on agriculture.

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CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION

This study investigates the impact of the anticipated versus unanticipated components of money growth on United States agriculture. Though the impact of macroeconomic factors on agriculture is now widely recognized(e.g. Schuh and Orden 1985 and Barnett, Bessler, and Thompson 1982) little research has been undertaken to distinguish the effects of anticipated movements in policy variables from those that arise from unanticipated macroeconomic shocks. This distinction has substantial policy implications. To illustrate, the assertion that systematically "tight" monetary policy will dampen agricultural exports must rest on real impacts of anticipated policy. If only unanticipated shocks matter, systematically tight monetary policy may not affect agriculture, while instability created by monetary shocks may be of serious concern.

To a large extent, the focus of this study on the effects on agriculture of anticipated versus unanticipated movements of the money supply arises as a result of models of the formation of individual expectations and the role of information. This modeling has been central to macroeconomic theory developments during the last two decades. Initially, this modeling proceeded under various ad hoc assumptions. Representative of the ad hoc rules is the hypothesis of adaptive expectations introduced by Cagan(1956).

Adaptive expectations postulate that individuals use information on past forecasting errors to revise current expectations. To illustrate with respect to the price level P_t, this hypothesis is written as:

$$ {}_{t-1}P^e_t - {}_{t-2}P^e_{t-1} = \alpha(P_{t-1} - {}_{t-2}P^e_{t-1}), $$

where P_{t-1} is the actual price level, and ${}_{t-1}P^e_t$ is agent's expectation of P_t at time t-1. This equation states that the change in expected price level is proportional to the forecast error between the actual and expected price level. This equation shows the ability of individuals to learn from past errors (Frish 1983). An alternative way of expressing the hypothesis of adaptive expectations is:

$$ {}_{t-1}P^e_t = \alpha P_{t-1} + (1-\alpha)\,{}_{t-2}P^e_{t-1}. $$

The equation now states that the expected price level is a weighted average of the actual past price level and the past expected price level.

The concept of adaptive expectations has several discernible difficulties. First, no economic theory gives criteria to explain the magnitude of α. Second, adjustment of expectations is very slow, that is, individuals take actions to amend their expectations rule only after recognizing forecast errors. Hence, using adaptive expectations agents can make systematic mistakes in their forecasts. Finally, an adaptive expectations scheme uses only it's own history to forecast a certain variable. Therefore, the adaptive expectations hypothesis may waste information, if there is information besides own history that helps to predict that variable.

In formulating a more comprehensive model of expectations it is crucial that the expectations rule does not make systematic errors and uses all information available. This does not imply that an expectation rule will always forecast accurately.

To overcome some of the difficulties of adaptive expectations, Muth(1961) proposed an alternative approach to the problem of modeling individual expectations. Muth starts from the assumption, "that expectations of firms (or, more generally, the subjective probability distribution of outcomes) tend to be distributed, for the same information set, around the prediction of theory (or, the objective probability distribution of outcomes)" (Muth 1961). Muth's hypothesis asserts that there exists a relevant economic theory and the forecasts derived from this theory are the best possible.

Muth's paper introduced the notion of rational expectations. In an economic model with endogenous variables, exogenous variables, and predetermined variables, rational expectations estimates are the unbiased estimates of endogenous variables in which all information concerning the values of the exogenous and predetermined variables is known and used for the prediction (Frish 1983).

Letting P_t^e and P_t be, respectively, agent's expected and the actual price level in period t and (I_{t-1}) be the information available at the end of period t-1, rational expectations implies two assumptions:

$$E(P_t | I_{t-1}) = P_t^e$$

$$P_t - P_t^e = P_t - E(P_t | I_{t-1}) = \varepsilon_t,$$

where ε_t is a random variable with $E(\varepsilon_t)=0$ and $E(\varepsilon_i \varepsilon_j)=0$ for all i=j. Rational expectations forecasts depend on the amount of relevant information (I_{t-1}) available. Rational expectations does not imply perfect foresight.

The application of rational expectations to a macroeconomic model has important implications concerning the ability of a government or a central bank to conduct economic policy. As will be discussed in Chapter 2, the assumption of rational expectations leads to the neutrality of anticipated monetary and fiscal policy in an equilibrium model with flexible prices. Introduction of rational expectations and incomplete information to a macroeconomic model provides one way to represent the agents' dynamic expectations formation. Rational expectations schemes utilize all information available and do not carry previous forecast errors, therefore the forecasts from rational expectations are optimal.

1.2 OBJECTIVES

The goal of this research is to investigate the impact of anticipated versus unanticipated monetary policy on relative prices received by agricultural producers and on the levels of agricultural output,income, and exports. The two specific objectives are:

1. To determine the relative impact of monetary policy on aggregate output compared to its impact on agriculture?

Empirical macroeconomic studies have focused on the effects of monetary policy on aggregate output. Specific outcomes of these studies, however, may be associated with several alternative impacts among sectors. In particular, neutrality with respect to aggregate output might arise from uniform neutrality among sectors or from nonneutral but offsetting sectoral impacts. Likewise, positive monetary impacts on aggregate output could be associated with neutral, or even adverse, impacts among specific sectors.

To investigate these relationships, models developed to measure effects of anticipated versus unanticipated money growth on agriculture will also be utilized to test for monetary effects on aggregate output. Comparison of these outcomes will help clarify the relative monetary impact on agriculture.

2. To determine whether there is a preponderance of evidence suggesting monetary impacts on agriculture and, if so, to determine whether the evidence favors the proposition that only unanticipated monetary shocks affect agriculture or the alternative proposition that anticipated monetary policies also have real effects?

To explore these questions parameters of several variants of an empirical model will be estimated as a basis for policy inference. These models will differ with respect to i) dependent variable utilized to measure monetary impacts on the agriculture sector and ii) the lag length over which money is estimated to have real impacts on the sector.

1.3 HYPOTHESES

The hypotheses to be tested are based on the two objectives of the study. Since the key issue is the effects of anticipated versus unanticipated monetary policy, the hypotheses are stated in terms of this distinction.

1. The real value of farm output is neutral to anticipated growth of U.S.money, but unanticipated money growth has a positive effect on the real value of farm output.

2. Real net farm income is neutral to anticipated growth of U.S. money, but unanticipated money growth has a positive effect on the real net farm income.

3. Real prices received by farmers are neutral to anticipated growth of U.S. money, but unanticipated money growth has a positive effect on these real prices.

4. The real value of traded farm products (U.S. exports) is neutral to anticipated growth of U.S. money, but unanticipated money growth has a positive effects on the real value agricultural exports.

1.4 ORGANIZATION OF THE STUDY

The organization of this thesis is as follows. Theoretical and empirical considerations with respect to the impacts of anticipated versus unanticipated money growth are discussed in Chapter 2. The new classical rational expectations hypothesis that only unanticipated money has real effects is shown mathematically in a rational expectations equilibrium model and the policy implications of this hypothesis are considered. Some issues related to empirical testing of the new classical hypothesis are then addressed. These include the specification of the money growth equation to distinguish between the anticipated and unanticipated components of money growth, the form of the output equations utilized to test for monetary impacts on the economy, the identification of specific monetary impacts, and alternative approaches to estimation. Chapter 2 concludes with a review of recent studies in which the effects of anticipated and unanticipated money growth on the aggregate economy have been evaluated. Studies that have evaluated these impacts specifically on agriculture are also reviewed.

Chapter 3 presents empirical findings based on the considerations discussed in Chapter 2. As a first step, money growth is differentiated into anticipated and unanticipated components using Granger causality tests. These components are then utilized as explanatory variables to detect monetary impacts on farm and nonfarm output measures, and on farm income, relative prices and agriculture exports. To preview the results, at least some monetary influences are detected on real total, nonfarm and farm gross domestic product, and on real net farm income. However, little monetary influence is detected on real prices received by farmers for crops or livestock or on the real value of agricultural exports.

The findings of this study are summarized and compared to previous studies in Chapter 4.

CHAPTER 2 LITERATURE REVIEW

2.1 INTRODUCTION

Modeling the role of information and expectations formation has been one of the most important tasks of economics. In this chapter, the rational expectations approach is developed and econometric tests of rational expectations in economic models are introduced.

In Section 2.2, rational expectations are embodied in a stochastic general equilibrium model in mathematical terms. It is shown that rational expectations resolve the discrepancy between past empirical findings that money has real effects and the new classical assertion of neutrality of anticipated monetary policy. Issues related to empirical testing of the new classical assertion are discussed in Section 2.3 and empirical tests of neutrality of money based on applications of rational expectations to macroeconomics are discussed. In Section 2.4 past applications of these tests to agricultural prices and output are reviewed. A brief summary of the chapter is presented in Section 2.5.

2.2 THE ROLE OF MONEY IN MODERN CLASSICAL MACROECONOMICS

The notion that a dichotomy exists between real economic variables, such as real output, unemployment and relative prices, and nominal economic variables, such as the quantity of money and the general price level, has been the essential feature of the classical school of macroeconomics. In this view, real variables, such as a relative price, are determined by demand and supply of specific commodities not by monetary phenomena. Aggregate demand and supply of an industry are, in turn, functions of relative prices among industries and other real factors, not of the general price level.

Despite the classical theory, a substantial body of empirical evidence has been presented that suggests a correlation between real and nominal economic variables. The most prominent example is the familiar modified Phillips curve which shows a tradeoff between the inflation rate and the level of unemployment or real output.

In addition to the Phillips curve, Glejer (1965) demonstrates a positive relationship between relative price variability and the rate of inflation in a cross-section of countries. Similarly, Vining and Elwertowski (1976) describe a positive relationship between relative price variability and the rate of inflation instability over time in the United

States. Fischer (1981) also reports a relation between the inflation rate and the variance of relative prices.

Empirical evidence showing relationships between real variables and the price level raises an important question: can such empirical findings can be explained in the context of classical theory?

One approach to this question is to introduce informational and adjustment frictions while retaining the basic classical notion. A simple model along these lines has been suggested by Phelps (1970). Phelps models the economy as a group of islands between which information does not flow instantaneously. Suppliers are located in a large number of scattered, competitive markets. Demand for goods in each period is distributed unevenly over markets. Shifts in demand lead to relative price movements.

In the setting described above, even rational agents, whose decisions depend on only relative prices, cannot perfectly distinguish movements in the general price level from relative price movements. Informational discrepancies arise as follows. Agents in a typical market have perfect information on aggregate variables up to and including the last period and on the current prices in their own market. However, they do not observe the current general price level or the current local prices in other markets. To learn the price on an adjacent island, an economic agent must spend one period traveling to obtain the information. But in such a setting, by applying rational expectations the unobservable general price level can be forecast, without making systematic mistakes. The rational expectations hypothesis asserts that the unobservable subjective expectation of individuals are exactly the true mathematical conditional expectations (Begg 1982).

Along the line of the Phelps (1970) model, Cukierman (1982) has suggested a model in which demand and supply on market j at time t assume the log linear forms:

$$(1)\quad Y_t^d(j) = -\psi(j)[P_t(j)-E(Q_t|I_{t-1})]+\alpha[X_t-E(Q_t|I_{t-1})] + \omega_t^d(j),$$

$$(2)\quad Y_t^s(j) = S_t\gamma(j)[P_t(j)-E(Q_t|I_{t-1})]+\omega_t^s(j),$$

where $Y_t^d(j)$ and $Y_t^s(j)$ are, respectively, the logarithms of output demanded and supplied on market j, $P_t(j)$ is the logarithm of the local price of market j, Q_t is the general price level, I_t is the information set of agents on market j at time t, X_t is the logarithm of the quantity of money, S_t is the economy wide level of productivity and $\omega_t^d(j)$ and $\omega_t^s(j)$ are, respectively, random specific shocks to demand and supply in market j. $E(Q_t|I_t(j))$ is the expected general price level as perceived by agents in market j.

In the Cukierman model, equation (1) states that demand in market j depends on the perceived relative price in this market, on perceived real money balance, and on a market-specific demand shock. The elasticity of demand in market j with respect to the relative price as perceived by agents in this market is $\psi(j)$, and α is the elasticity of the demand with respect to real money balances. Equation (2) states that supply on market j depends on economy-wide productivity, on the relative price perceived by individuals in the market, and on a market-specific supply shock. The elasticity of supply in market j with respect to the relative price as perceived in this market is $\gamma(j)$. The money supply and the economy-wide productivity shocks are random shocks whose first differences have known distributions.

(3) $\Delta X_t \sim N(\delta, \sigma_x)$,

where

$$\Delta X_t \equiv X_t - X_{t-1} = \delta + \varepsilon_t$$

(4) $\Delta S_t \sim N(0, \sigma_u)$,

where

$$\Delta S_t \equiv S_t - S_{t-1} = U_t.$$

Both ε_t and U_t are identically and independently distributed. The random shocks ε_t, U_t, and $\omega_t(j)$ are not observed separately by agents. ΔX_t and ΔS_t are independent of ω_t^d and ω_t^s but may be mutually correlated with a correlation coefficient ρ.

To obtain an equilibrium under the assumption that markets clear, one can solve (1) and (2) for equilibrium prices using signal extraction and the method of undetermined coefficients.

First, using (3) and (4), equations (1) and (2) may be rewritten as:

$$(1') \quad Y_t^d(j) = -\psi(j)[P_t(j)-E(Q_t|I_{t-1}\&u)]+\alpha[X_{t-1}+\delta+\varepsilon_t- E(Q_t|I_{t-1})]+\omega_t^d(j),$$

$$(2') \quad Y_t^s(j) = S_{t-1}+U_t+\gamma(j)[P_t(j)-E(Q_t|I_{t-1})]+\&Ome._t^s(j).$$

Setting equation (1') and (2') equal in equilibrium:

$$(5) \quad P_t(j) = [1-\alpha\lambda(j)]E[Q_t|I_t(j)]+\lambda(j)[\alpha(X_{t-1}+\delta)-S_{t-1}]+ \lambda(j)[\alpha\varepsilon_t-U_t+\omega_t(j)],$$

where

$$\lambda(j) \equiv 1/[\psi(j)+\gamma(j)]$$

and

$$\omega_t \equiv \omega_t^d(j)-\omega_t^s(j).$$

Now, let us assume $Q \equiv \Sigma u(j)P(j)$, where $u(j)$ is weight of market j, and no market is too large. A linear function for $P_t(j)$ can be represented by the exogenous variables of the equilibrium system. That is:

$$(6) \quad P_t(j)=\pi_0+\pi_1 X_{t-1}+\pi_2 S_{t-1}+ \pi_3 \varepsilon_t+\pi_4 U_t+\pi_5 \omega_t(j).$$

Summing up $P_t(j)$ with it's weight over markets:

$$(6') \quad \Sigma u(j)P_t(j)=Q_t=\pi_0+\pi_1 X_{t-1}+ \pi_2 S_{t-1}+\pi_3 \varepsilon_t+\pi_4 U_t.$$

The $\pi_5\omega_t(j)$ disappears in equation (6') because local shocks cancel out upon summation.

Taking an expectation operator to both sides of equation (6'), one finds:

$$(7) \quad E(Q_t|I_t(j)) = \pi_0+\pi_1 X_{t-1}+\pi_2 S_{t-1}+\pi_3 E[\varepsilon_t|I_t(j)] +\pi_4 E[U_t|I_t(j)].$$

The $E[\varepsilon_t|I_t(j)]$ and $E[U_t|I_t(j)]$ are rationally expected conditional on the informational contents of local market, $\alpha\varepsilon_t-U_t+\omega_t(j)$. By using signal extraction, agents can estimate the unobserved variables in a manner that is optimal (Sargent 1979):

$$E[\varepsilon_t|I_t(j)] = [(\alpha\sigma_\varepsilon^2-\alpha\rho\sigma_\varepsilon\sigma_u)/(\sigma_a^2+\sigma_\omega^2)] \; [\alpha\varepsilon_t-U_t+\omega_t(j)],$$

where

$$\sigma_a^2 = \alpha^2\sigma_\varepsilon^2+\sigma_u^2-2\alpha\rho\sigma_\varepsilon\sigma_u,$$

$$E[U_t | I_t(j)] = [(\sigma_u^2 - \alpha\rho\sigma_\varepsilon\sigma_u)/(\sigma_a^2+\sigma_\omega^2)] \; [\alpha\varepsilon_t - U_t + \omega_t(j)].$$

Substituting these results into equation (7):

$$E[Q_t | I_t(j)] = \pi_0 + \pi_1 X_{t-1} + \pi_2 S_{t-1} + \pi_3 \; P[\alpha\varepsilon_1 - \&_t + \omega_2(j)]$$
$$+ \pi_4 q(\alpha\varepsilon_t U_t + \omega_\varepsilon(j)),$$

where

$$P = (\alpha\sigma_\varepsilon^2 - \rho\sigma_\varepsilon\sigma_u)/(\sigma_a^2+\sigma_\omega^2)$$

and

$$q = (\sigma_a^2 - \alpha\rho\sigma_\varepsilon\sigma_{t-1})/(\sigma_a^2+\sigma_\varepsilon^2)$$

Again substituting this result into equation (5):

$$P_t(j) = (1-\alpha\lambda(j))\{\pi_0 + \pi_1 X_{t-1} + \pi_2 S_{t-1} + \pi_3 P(\alpha\varepsilon_t - U_t + \omega_t(j))$$
$$+ \pi_4 q(\alpha\varepsilon_t - U_t + \omega_t(j)) + \lambda \qquad (j)(\alpha X_{t-1} + \alpha\delta - \delta_{t-1})$$
$$+ \lambda(j)(\alpha\varepsilon_t - U_t + \varepsilon_t(j))$$

(8) $$Q_t \equiv \Sigma U(j) P_t(j) = \Sigma u(j)(1-\alpha\lambda(j))\pi_0 + \alpha\Sigma u(j)\lambda(j)\delta$$
$$+ \Sigma u(j)[(1-\alpha\lambda(j))\pi_1 \alpha\lambda(j)] X_{t-1}$$
$$+ \Sigma u(j)[(1-\alpha\lambda(j))\pi_2 - \lambda(j)] S_{t-1}$$
$$+ \Sigma u(j)[\lambda(j) + (1-\alpha\lambda(j)) P\pi_3 - q\pi_4)]\varepsilon_t$$
$$- \Sigma u(j)[\lambda(j) + (1-\alpha\lambda(j))(P\pi_3 - q\pi_4)] U_t$$

Comparing the coefficients of equation (8) and equation (6'):

$$\pi_0 = \delta,$$

$\pi_1=1,$

$\pi_2=-1/\alpha,$

$\pi_3=\alpha\Sigma u(j)\lambda(j)/(\theta+\xi),$

and

$\pi_4=-\Sigma u(j)\lambda(j)/(\theta+\xi)$

where

$\theta\equiv\sigma_\omega^2/(\sigma_a^2+\sigma_\omega^2)$

and

$\xi\equiv\alpha\Sigma u(j)\lambda(j)(1-\theta).$

Substituting these solutions for π's into equation (6) and (6'), the following results are obtained:

$$(9)\quad P_t(j) = X_{t-1}+\delta-(1/\alpha)S_{t-1}+[\theta\lambda(j)+(1-\theta)\Sigma u(j)\lambda(j)]\,[\alpha\varepsilon_t-U_t+\omega_t(j)]/(\theta+\xi),$$

$$(10)\quad Q_t = X_{t-1}+\delta-(1/\alpha)S_{t-1}+\,[\Sigma u(j)\lambda(j)/\theta+\xi](\alpha\varepsilon_t-U_t).$$

Subtracting equation (10) from (9):

$$(11)\quad P_t(j)-Q_t = \{\theta(\lambda(j)-\Sigma u(j)\lambda(j)\}(\alpha\varepsilon_t-U_t)/(\theta+\xi).\\ +[\theta\lambda(j)+(1-\theta)\Sigma u(j)\lambda(j)]\omega_t(j)/\,(\theta+\xi)$$

As shown by equation (11), the relative price in the stochastic equilibrium model with rational expectations is a weighted sum of the aggregate unanticipated shock, $a\varepsilon_t - U_t$, and market specific shock, $\omega_t(j)$.

The hypothesis expressed by equation (11) is that only the unanticipated part of money growth and the economy-wide productivity shock affect relative price relationships. The anticipated components of money and the level of productivity, respectively $X_{t-1}+\delta$ and S_{t-1}, affect local prices and the general price level in the same proportion. Therefore, anticipated components of these variable do not affect relative prices. This outcome has very important economic interpretations concerning whether anticipated policies affect the real economy, or whether only unanticipated policy shocks have real impacts.

As illustrated in the above model, the central policy implications of a stochastic equilibrium models with rational expectations are as follows. Anticipated changes in money supply have the same effects on prices in individual markets and the general price level so real economic activities are not affected. This is the usual classical assertion. An unanticipated monetary shock, sudden change in productivity level, and local excess demand affect the level of economic activity. The real effects which come from an unanticipated monetary shock results solely from the incompleteness of agents' information sets. An unanticipated monetary shock has a positive correlation with relative prices. This correlationship results from the fact that agents can not completely differentiate changes in relative prices level from change in the general price level because of lack of information.

Not surprisingly, given the confusion element associated with unanticipated monetary shocks in a stochastic equilibrium model it can be shown that a perfectly anticipated monetary policy is optimal, in the sense that the variance of economic output around its full information level is minimized by such a policy. The full information output level is derived from optimizing decisions of agents whose information set includes observations of the current price level so confusion between relative and nominal price changes is avoided. In a stochastic environment this does not mean output is constant, rather the economy responds naturally to real supply and demand disturbances.

The distinction between anticipated and unanticipated monetary policy in the stochastic equilibrium model plays a crucial role in the new classical view of macroeconomics. A deterministic monetary policy is optimal in this view in the sense that a constant rate of money growth does not confuse the agents of the economy. The changes in relative prices from unanticipated monetary shocks come from agents' confusion. This confusion would be eliminated if there were no monetary shocks.

The proposition that only unanticipated monetary policy has real effects has substantive implications for evaluation of macroeconomics impacts on specific sectors, such as agriculture, as well. If only unanticipated shocks matter, then the stability of monetary policy is of concern to agriculture but the level at which stability is attained of less consequence.

2.3 MACROECONOMIC TESTS OF ANTICIPATED MONEY NEUTRALITY

The new classical proposition is that deterministic monetary policy is optimal because unanticipated money causes fluctuations in output around the natural rate. To test this proposition, the explanatory power of the anticipated and unanticipated components of money supply with respect to real economic variables are investigated. First, for this purpose, anticipated and unanticipated components of money supply are differentiated. Second, the actual explanatory power of each component of money is examined.

2.3.1 MONEY GROWTH EQUATION

To test the hypothesis of neutrality of anticipated money growth, it is necessary first to distinguish the unanticipated components from the anticipated components of observed change in the money supply. Let anticipated money growth at time t, M_t^e, be the one period ahead forecast of money growth conditional on all informations which is available at the end of period t-1. That is:

(1) $M_t^e = E_{t-1}M_t$,

Unanticipated money growth at time t, UM_t, is then the forecast error from the actual money growth, M_t:

(2) $UM_t \equiv M_t - E_{t-1}M_t$,

The specification of a money growth equation quantifies the notion of anticipated money growth and unanticipated money growth. From equation (1) and (2)

(3) $M_t \equiv E_{t-1}M_t + UM_t$.

This money growth equation must be specified explicitly in order to test an hypothesis about whether anticipated money has real effects on the economy.

One of the earliest studies to test the neutrality hypothesis was Barro (1977). In his analysis, the dependent variable of the money growth equation is the logarithmic first order difference of the annual average of the M1 concept of money stock. The independent variables used to forecast the expected money growth are two lagged values of the dependent variable, a current measure of real federal expenditures relative to normal, $FEDV_t$, (i.e. the logarithmic federal expenditure less an exponentially declining distributed lag of federal expenditure), and a lagged unemployment variable,U. According to Barro, the federal spending variable is included to capture the revenue motive for money creation, and the unemployment variable is included to reflect the counter-cyclical policy response to the level of economic activity. Specifically, the form of the money growth equation is:

$$(4) \quad M_t = \alpha_0+\alpha_1 M_{t-1}+\alpha_2 M_{t-2}+\alpha FEDV_t+\alpha_4 \log[U/1-U]_{t-1}+\varepsilon_t,$$

where

$$M_t=\log(M1_t/M1_{t-1}).$$

There are two things to note about Barro's specification of money growth. First, the money growth equation is specified to represent the behavior of the monetary authority. In this regard, Blinder (1980) reasons that it may be more relevant to include an interest rate variable instead of an unemployment variable. Blinder justifies this specification on the basis that the interest rate rather than the unemployment rate has been the primary focus of the monetary authority.

The second important feature of Barro's specification is that it includes a variable measuring the current value of federal spending as part of the information set from which money growth is forecast. This may be a misspecification of the money growth equation in the sense of rational expectations. Rational expectations implies optimal use of all information available at a moment in time to forecast future unknown variables. Agents of a economy forecast money supply at time t in terms of information available at time t-1. Perhaps the federal spending variable should enter the equation only in the form of $E_{t-1}FEDV_t$, because $FEDV_t$ is not in the information set at time t-1 . As long as perfect forecasts of the federal spending variable are impossible, Barro's money growth equation does not provide a clear division between anticipated components and unanticipated components of money growth, because it contains forecasting error for the federal spending variable. There exists a strong possibility that by using a variable which becomes available after agent's forecasts are made Barro's equation forecasts better than agents are actually able to forecast.

As an alternative to Barro's approach to specification of the money growth equation, Mishkin(1982) uses multivariate Granger causality tests to evaluate the predictive content of information contained in the past history of variables other than lags of money growth itself. On the basis of these causality tests, Mishkin specifies a quarterly money growth equation in which the dependent variable is the first order difference of quarterly average M1, and the independent variables are four lagged dependent variables, four lagged interest rate variables, TBR (average 3-month Treasury bill rate), and four lagged values of the high employment surplus, SURP. Notice that Mishkin's atheoretical statistical specification of the money growth equation contains an interest rate variable, as was suggested by Blinder from the view point of monetary authority reaction to the economy's performance.

Comparing the forecasting equations of the two preceding studies, one finds that Mishkin's ordinary least squares (OLS) estimate of the money growth equation shows a poor fit of money growth compare to Barro's equation. This suggests that Barro's equation does forecast better than agents are able to at time t-1 because of inclusion of FEDV in his specification. However a poor fit also raises the question of whether the econometrician has forecast as well as rational agents: whether his statistical specification has captured all of the information agents use. If Mishkin's specification does not forecast money growth as well as rational agents, then the money shocks he utilize will be larger than those actually occurring in the economy.

2.3.2 OUTPUT AND UNEMPLOYMENT EQUATIONS

Having separated money growth into anticipated and unanticipated components, macroeconomic tests for neutrality of anticipated money growth have been carried out by estimating equations for output or unemployment. Difference in the specification of these equations allow a variety of hypothesis tests. Therefore the specification of these equations is a crucial part of an empirical study.

Barro(1980) measures the effects of monetary expansion on output and the unemployment rate by the impact of current and lagged values of unanticipated money on these dependent variables. Unanticipated money is the components which cannot be forecast by his money growth equation, that is the residuals of the money growth equation. The unanticipated components of money growth is equivalent to M_t minus $\hat{M}_t$, where M_t is a first order difference of logarithmic M1 concept of money stock, and $\hat{M}_t$ comes from equation (4). The unemployment equation is then:

$$(5) \quad \log[U/1-U]_t = a_0+a_1(M_t-\hat{M}_t)+a_2(M_{t-1}-\hat{M}_{t-1})+a_3(G/Y)_t+\varepsilon_t^u$$

where G is federal purchase and Y is GNP. Likewise an output equation can be specified as:

$$(6) \quad \log Y_t = b_0+b_1(M_t-\hat{M}_t)+b_2(M_{t-1}-\hat{M}_{t-1})+b_3\log(G_t)+b_4T+\varepsilon_t^y$$

where T is time trend. Here both error terms are assumed to be distributed normally, identically and independently.

Both the unemployment and output equations above are restricted so that only the unanticipated components of money may affect real economic variables. The specification of these equations also has imposed that the residuals generated from the money growth equation are used as explanatory variables in the unemployment and output equations.

In an alternative approach, Leiderman (1980) treats anticipated and unanticipated money explicitly in the output equation. If we assume that actual money growth may affect the output level, that is, if we abandon the hypothesis of neutrality of anticipated money, Barro's equation (6) can be rewritten allowing different parameters for anticipated and unanticipated money components:

$$(7)\quad \log Y_t = b_0+b_{11}M_t-b_{12}\hat{M}_t+b_4M_{t-1}-b_{22}\hat{M}_{t-1}+b_3\log(G_t)+b_4T+\varepsilon_t^y$$

Equation (7) can be rewritten once more by imposing the parameters from equation (4). This imposes a rationality assumption which means that economic agents' anticipations of money growth are formed by exploiting the stochastic structure governing monetary policy. Using equation (4) and $M_t \equiv \hat{M}_t+\varepsilon_t$;

$$\log Y_t = f_0+f_1M_{t-1}+f_2M_{t-2}+f_3M_{t-3}+f_4FEDV_t+f_5FEDV_{t-1} +f_6\log[U/1-U]_{t-1}+f_7\log[U/1-U]_{t-2}+b_3\log(G_t)+b_4 T+b_{11}\varepsilon_t+\varepsilon_t^y \quad (8)$$

where

$$\begin{aligned} f_0&=b_0+\alpha_0(b_{11}-b_{12}-b_{22}) \\ f_1&=\alpha_0(b_{11}-b_{21})+b_{21} \\ f_2&=\alpha_2(b_{11}-b_{12})-\alpha_1 b_{22} \\ f_3&=-\alpha_2 b_{22} \\ f_4&=\alpha_3(b_{11}-b_{12}) \\ f_5&=-\alpha_3 b_{22} \\ f_6&=\alpha_4(b_{11}-b_{12}) \\ f_7&=\alpha_4 b_{22} \end{aligned} \quad (9)$$

Equation (8) with nonlinear restrictions, (9), is a form of equation (7) with rational expectations. Imposing these restrictions implies that the current level of the money supply is expected rationally.

2.3.3 OBSERVATIONAL EQUIVALENCE

One issue that must be addressed in empirical studies is whether the effects of anticipated versus unanticipated money can be unambiguously identified in the econometric model. Sargent (1976) suggested that every structural model has a unique reduced form ,but different structural models can have same reduced forms, which are observationally equivalent. Therefore, it is not possible to choose the real structural model from the reduced forms.

To illustrate, consider Barro's output equation, equation (6). In equation (6), only unanticipated in money growth affect the level of output, therefore, the equation appears to reflect the classical theory of neutrality of money. However, one can substitute for $\hat{M}_t$ and $\hat{M}_{t-1}$ in equation (6) using the estimation of equation (4). Then, equation (6) appears to show the effects on output of actual amount of money growth:

$$(10)\quad \log Y_t = b_0 - \alpha_0(b_1+b_2) + b_1M_t + (b_2-\alpha_1 b_1)M_{t-1} - (\alpha b_1 - \alpha b_2)M_{t-2} - \alpha_2 b_2 M_{t-3} - \alpha_3 b_1 FEDV_t - \alpha_3 b_2 FEDV_{t-1} - \alpha_4 b_1 \log[U/1-U]_{t-1} - \alpha_4 b_2 \log[U/1-U]_{t-2} + b_3 \log(G_t) + b_4 T + \varepsilon_t^Y$$

This failure to distinguish between models is what Sargent means by "observational equivalence".

McCallum (1979) suggested that the observational equivalence dilemma can be resolved, because equation (10) has still classical nature and places testable restrictions on parameters. Hence a likelihood ratio test between the constrained form of equation (10), and an unconstrained equation, with same independent variables provides a means of distinguishing between models.

For this purpose, relevant parameters of equation (10) must be identified. To illustrate, consider 4 possible cases. In case 1, the money growth equation contains only lagged monetary variables while the output equation has more lagged monetary variables than the money growth equation. To illustrate, suppose the money growth equation is:

$$M_t=\alpha_0 M_{t-1}+U_t,$$

and the output equation with two monetary shock variables is:

$$Y_t= \beta_0(M_t-E_{t-1}M_t)+\beta_1(M_{t-1}-E_{t-2}M_{t-1})+\delta_0 E_{t-1}M_t+\delta_1 E_{t-1}M_{t-1}+u_t,$$

where

$$E_{t-1}M_t=\alpha_0 M_{t-1}$$

and

$$E_{t-2}M_{t-1} = \alpha_0 M_{t-2}.$$

The output equation can be rewritten as:

$$Y_t = \beta_0 M_t-[(\beta_0-\delta_0)\alpha_0-\beta_1]M_{t-1} -(\beta_1-\delta_1)\alpha_0 M_{t-2}+\varepsilon_t.$$

Comparing the parameters with those of the unconstrained output equation,

$$Y_t=a_0M_t+a_1M_{t-1}+a_2M_{t-2}+\varepsilon_t,$$

We have:

$$a_0=\beta_0,$$

$$a_1=-(\beta_0-\delta_0)\alpha_0+\beta_1,$$

and

$$a_2=-(\beta_1-\delta_1)\alpha_0.$$

Here β_1, δ_0 and δ_1 are not identified even though the a_i's and α are known. That is the classical model places no testable restrictions on the parameters of the unconstrained output equation. This makes the test of neutrality of anticipated money impossible.

Now consider a second case, in which the money growth equation contains at least one explanatory variable which is not in the output equation. To illustrate, consider simple money growth and output equations:

$$M_t=\alpha_0M_{t-1}+\alpha_1R_{t-1}+U_t$$

$$Y_t=\beta_0(M_t-E_{t-1}M_t)+\delta_0 E_{t-1}M_t+\varepsilon_t$$

where R_t is, say, the interest rate and $E_{t-1}M_t=\alpha_0 M_{t-1}+\alpha_1 R_{t-1}$. In this case, output depends on current anticipated and unanticipated money. The output equation can be rewritten as:

$$Y_t=\beta_0 M_t-(\beta_0-\delta_0)\alpha_0 M_{t-1}-(\beta_0-\delta_0)\alpha_1 R_{t-1}+\varepsilon_t \text{ .sk}$$

Now consider an unconstrained equation:

$$Y_t=a_0 M_t+a_1 M_{t-1}+a_2 R_{t-1}+\varepsilon_t.$$

Comparing the parameters of the constrained and unconstrained equations:

$$a_0=\beta_0,$$

$$a_1=-(\beta_0+\delta_0)\alpha_0,$$

and

$$a_2=-(\beta_0-\delta_0)\alpha_1.$$

In this case, β_0 and δ_0 are identified given the a_i's ($i=0,1,2$) and α_j's ($j=0,1$).

The preceding case had two restrictions: the variable R_{t-1} appeared only in the money growth equation and output depended only on current monetary variables. If the money growth equation contains an explanatory variable excluded from the output equation, but the output equation depends on current and lagged money, again the system is identified.

To illustrate, consider the same money growth equation as in the preceding case and an output equation:

$$Y_t = \beta_0(M_t - E_{t-1}M_t) + \beta_1(M_{t-1} - E_{t-2}M_{t-1}) + \delta_0 E_{t-1}M_t + \delta_1 E_{t-2}M_{t-1} + \varepsilon_t.$$

The final form of output equation is:

$$Y_t = \beta_0 M_t - (\alpha_0\beta_0 + \beta_1 + \alpha_0\delta_0)\, M_{t-1} - (\beta_1 - \delta_1)\alpha_0 M_{t-2} - (\beta_0 - \delta_0)\alpha_1 R_{t-1} - (\beta_1 - \delta_1)\alpha_1\, R_{t-2} + \varepsilon_t$$

Again, comparing the parameters of the constrained equation with those of an unconstrained equation:

$$Y_t = a_0 M_t + a_1 M_{t-1} + a_2 M_{t-2} + a_3 R_{t-1} + a_4 R_{t-2} + \varepsilon_t,$$

one obtains:

$a_0 = \beta_0,$

$a_1 = -\alpha_0\beta_0 - \beta_1 + \alpha_0\delta_0,$

$a_2 = -(\beta_1 + \delta_1)\delta_0,$

$a_3 = -(\beta_0 - \delta_0)\alpha_1,$

and

$a_4 = -(\beta_1 - \delta_1)\alpha_1.$

All parameters are identified again and the hypothesis $\delta_0=\delta_1=0$ is testable.

A final case provides alternative condition for identification. In this case, the number of lags in the money growth equation exceeds the number of monetary shocks in the output equation (Mishkin 1983). For example, consider the following money growth and output equations:

$$M_t=\alpha_0 M_t+\alpha_1 M_{t-1}+U_t$$

$$Y_t=\beta_0(M_t-E_{t-1}M_t)+\ \delta_0 E_{t-1}M_t+\varepsilon_t,$$

where

$$E_{t-1}M_t=\alpha_0 M_{t-1}+\alpha_1 M_{t-2}.$$

Therefore:

$$Y_t=\beta_0 M_t-(\beta_0-\delta_0)\alpha_0\ M_{t-1}+(\beta_0+\delta_0)\alpha_1 M_{t-2}+\varepsilon_t.$$

Comparing the parameters with those of the unconstrained equation from case 1:

$$a_0=\beta_0,$$

$$a_1=-(\beta_0-\delta_0)\alpha_0,$$

$$a_2=(\beta_0+\delta_0)\alpha_1$$

Again, the parameters β_0 and δ_0 of the output equation can be identified.

Only if the parameters of an equation like (7) are identified, can the observational equivalence problem be avoided and the impacts of anticipated versus unanticipated money be isolated. As illustrated herein, two conditions lead to identification and one or the other is required in building empirical money growth and output equations.

2.3.4 ESTIMATION

There have been two basic approaches to estimating the money growth and output or unemployment equations required to test for the real effects of anticipated versus unanticipated money. The first approach is a two-step estimation procedure. In this approach, the money growth equation is estimated first and then an output or unemployment equation is considered. The second approach employs a joint estimation method. Parameters of the money growth equation and the output or the unemployment equations are estimated simultaneously. The latter approach requires nonlinear estimation, and there are two ways to estimate parameters; full information maximum likelihood estimation (for example, see Leiderman 1980) and nonlinear least squares estimation (for example, see Mishkin 1982, 1983).

i) The two-step estimation method

Using this method, parameters of the money growth and output or unemployment equations are estimated separately. In the first step, a money growth equation is estimated over a sample period. The form of the money growth equation is:

$$(11) \quad M_t = Z_t \gamma + U_t,$$

where Z_t is a vector of information available at period t-1, and γ is a coefficient vector of Z_t. Anticipated money growth is represented by:

$$(12) \quad AM_t = Z_t \hat{\gamma},$$

where $\hat{\gamma}$ is the ordinary least squares estimator of γ. The unanticipated component of money growth is obtained from the difference between actual money growth and estimated money growth.

In the second step, the unanticipated component of money growth from equation (11) is used to estimate parameters of an output or unemployment equation. That is:

$$(13) \quad Y_t = a_1 UM_t + a_2 UM_{t-1} + a_3 AM_t + a_4 AM_{t-1} + \varepsilon_t,$$

where

$$UM_t=M_t-Z_t\hat{\gamma}.$$

Again, equation (13) is estimated by ordinary least squares (OLS) with respect to UM_t, UM_{t-1}, AM_t and AM_{t-1}.

The two-step estimation procedure has the advantage that it's application is very simple and intuitively explicit. This approach was used by Barro(1980). However, there are several statistical problems with this approach.

First, tests of neutrality of anticipated money growth using the two-step estimation procedure utilize the OLS residuals of the money growth equation in the output equation as the measure of unanticipated money. This embodies, without being explicit, the assumption of rationality of economic agents in forming and using their monetary expectations. The two-step approach provides no basis for a test of the hypothesis of such rationality. The two-step procedure also embodies the hypothesis of structural neutrality which is tested explicitly. To see this, consider a general specification of the output equation, such as:

$$(14)\quad Y_t = a_0+a_1(M_t-Z_t\gamma^*)+ a_2(M_{t-1}-Z_{t-1}\gamma^*)+a_3Z_t\gamma^*+ a_4Z_{t-1}\gamma^*+\varepsilon_t.$$

Two-step estimation of the output equation imposes the rationality assumption by using the unanticipated components of money from $M_t-Z_t\hat{\gamma}$ and substituting into equation (13).

The rationality assumption represents that $\hat{\gamma}$ in equation (12) equal to γ^* in equation (14). Therefore, the result from the hypothesis test of $a_3=a_4=0$ encompasses the joint hypothesis of rational expectation and structural neutrality.

Second, the two-step estimation procedure ignores the uncertainty in estimating γ, therefore, this results in inconsistent estimates of the standard errors of the parameters and, hence, test statistics that do not have the assumed F - distribution (Mishkin 1983). Using equation (11) and (12), in terms of the true underlying model equation (13) is:

$$(15) \quad Y_t=a_1UM_t+a_2UM_{t-1}+ a_3AM_t+a_4AM_{t-1}+m,$$

where m_t is equal to $(a_1-a_3)(U_t-UM_t)+(a_2-a_4)(U_{t-1}-UM_{t-1})+\varepsilon^Y_t$. The covariance matrix of m_t, $E(m_t m_t')$, is $\sigma_\varepsilon+\sigma_u$ SS', where $S=Z_t(Z_t'Z_t)^{-1}Z_t'(a_1- a_3) -Z_{t-1}(Z_t'Z_t)^{-1}Z_t(a_2-a_4)$. This matrix is not spherical so that the estimated standard errors from OLS regression on equation (14) cannot be correct (for more details, see Pagan 1984).

ii) Joint estimation method

The objections to the two-step procedure are overcome by joint estimation of the parameters of the money growth and output equations. In the latter approach the results from the money growth equation (12) are not substituted into the output equation (13) recursively. Rather all parameters are estimated jointly.

The joint estimation approach has several advantages compare to the two-step procedure. First, the joint estimation procedure does not impose the rationality hypothesis implicitly; rather it provides basis for a test of this hypotheses. This is because the joint estimation method allows the possibility of different parameters of M in the money growth and output equations.

Second, the problem of the two-step estimation procedure is that $\hat{\gamma}$ expected to minimize the mean squared error of the money growth equation was used rather than γ^* which minimizes the mean squared error of the output equation. The joint estimation procedure does not suffer from this problem, because γ^* minimizing the mean-squared forecasting error is used to separate monetary components in the output equation (Mishkin 1983).

Third, this method results in asymtotically more favorable estimates of standard errors because the information about the joint distribution of the errors is utilized.

Mishkin(1982) constructs a likelihood ratio test between the constrained and unconstrained systems for the rationality and neutrality tests. The rational expectation hypothesis can hold whether the neutrality hypothesis holds or not. Therefore, in the first test the sum of squared residuals

(SSR) for a constrained system, equations (11) and (14) imposing $\gamma=\gamma^*$, and SSR for unconstrained system, equations (11) and (14) without constraints, are estimated.

For the structural neutrality hypothesis test, the unconstrained system of equation (11) and (14) with $\gamma=\gamma^*$ is estimated, because the structural neutrality hypothesis is meaningless without the assumption of rational expectations. The constrained system is estimated with equation (12) and

$$(16) \quad Y_t=a_0+a_1(M_t-Z_t\gamma^*)+ a_2(M_{t-1}-Z_{t-1}\gamma^*)+\varepsilon_t.$$

The results of hypothesis tests is obtained from the estimation of SSR's of both constrained and unconstrained systems.

To test the validity of the constraints imposed under either of these tests, the likelihood ratio test statistic is

$$2n[\log(SSR^c)-\log(SSR^u)],$$

where n is the number of observations, and superscript c and u denote constrained and unconstrained model, respectively. The test statistic is asymtotically distributed as $\chi^2(q)$, where q is the number of restrictions. This likelihood ratio statistic may be devised to correct for substantial difference in the degree of freedom in estimate constrained and unconstrained equations as a result of using nonlinear generalized least squares.

2.3.5 OUTCOMES OF THE TESTS

The results from Barro's test(1980), which used the two-step estimation procedure indicate that the anticipated components of money do not affect output or employment. Leiderman's (1980) joint estimation using full information maximum likelihood estimation with Barro's specification of money growth and output equations also favors the neutrality hypothesis. However, joint estimation using nonlinear generalized least squares (Mishkin 1982) suggests that the anticipated components of money does affect the real economic variables. Mishkin used a much longer lag structure for unanticipated and anticipated money in his output equation. It is the longer lag structure that makes the crucial difference in his result compared to tests by Barro and Leiderman. Mishkin justifies the long lag structure as appropriate for correct test statistics, because including irrelevant variables reduces only the power of the tests, but omitting significant variables leads estimates to be biased and yields incorrect test statistics.

Besides the above studies, there have been a number of other studies in which the effects of anticipated versus unanticipated money growth have been evaluated. In extension of Mishkin's work, Hoffman and Schlagenhauf (1982) investigate the monetary neutrality and rationality proposition across six developed countries. Their evidences cast serious doubt on the neutrality of anticipated money and provides some empirical support for the macroeconomic policy implication that anticipated change in the money supply affect real economic activity. Hoffman and Schlagenhauf provide additional evidence about the importance of Mishkin's proposition that different numbers of monetary lags in the output equation lead to different result with respect to neutrality hypothesis tests. For a lag length of seven quarters, the neutrality hypothesis is rejected for all countries except Canada and the United States. When the lag length is extended to eleven periods, the neutrality hypothesis is rejected for all countries except Canada.

Makin (1982) uses an ARIMA model to make the distinction between anticipated and unanticipated money, and uses an inflation uncertainty variable as an explanatory variable in the output and unemployment equations. Makin's method is similar to Barro's in the sense that differentiated components of money are directly substituted into real economic activity equations . Like Barro, Makin does not provide any basis for a rationality hypothesis test. Makin's money growth equation contains variables which are not in the output and unemployment equations, therefore all parameters in the output and unemployment equations are identified. Makin's evidence suggests that only anticipated money and inflation uncertainty affect the output and unemployment growth rate.

Merrick (1983) asserts that financial market information may be useful in the construction of more efficient measures of money-growth expectations. Including such information, which is not used in the output equation, in forecasting money growth also helps to identify parameters in the output equations. Merrick's study suggests the significance of anticipated money growth and the independent significance of the nominal interest rate for real GNP. These results tend to indicate that anticipated movements in nominal variables have short-run real effect.

Finally, McGee and Stasiak (1985) use a trivariate autoregressive representation which provides a natural dichotomy between anticipated and unanticipated effects of money on output. They present evidence about effects of anticipted money growth on real GNP growth in the shout-run from tests of restriction on the vector autoregressive model. Like Barro,their results support the noneffectiveness of anticipated monetary policy.

2.4 AGRICULTURAL TESTS OF ANTICIPATED MONEY NEUTRALITY

In this study, the focus is on the effects of anticipated versus unanticipated money on the agricultural sector. To date there has been little research to differentiate between these impacts. Those few studies that have been undertaken vary widely in methodology and focus. Belongia and King (1982) reports evidence of positive impacts of unanticipated money shocks on the spread between wholesale and retail food prices. These impacts persist for less than three months. Tests for the neutrality of anticipated monetary policy are not reported. In a later paper, Belongia (1985) reports preliminary estimates suggesting no effect of anticipated money growth on the relative price of farm products. Enders and Falk (1984), using the Barro and Rush distinction between anticipated and unanticipated money, present evidence that only monetary shocks affect pork output. Azzam and Pagoulatos (1985) find the Enders and Falk results quite sensitive to sampling period. Bond, Vlastuin and Crowley (1983) find evidence that both anticipated world money supply and monetary shocks have positive effects on the relative price of traded food commodities. Parameters of their model are estimated using quarterly data over the relatively brief period from the first quarter of 1975 through the third quarter of 1982.

2.5 SUMMARY

In a stochastic equilibrium model unanticipated increases in money supply cause changes in absolute price in all markets.

Even agents with rational expectations are unable to differentiate between absolute and relative price change under the assumption of a one-period information lag between markets. As a result, monetary shocks may have real effects that are not optimal with full information. Anticipated monetary changes, in contrast, do not affect real economic variables. These results have the new classical school of macroeconomics to assert that output is affected only by unanticipated monetary policy and that deterministic, stable money supply rules are optimal.

There have been many empirical studies to test the assertion that only unanticipated money has real effects on the economy. The results of these empirical studies have been quite mixed. Barro's specification of money growth and output equations favors the neutrality of anticipated money. In contrast, Mishkin's specification with long lags of monetary variables in the output equation favors the nonneutrality of anticipated money. Similarly mixed results characterizes tests of the new classical hypothesis with respect to monetary effects on agriculture, though fewer empirical studies have been conducted with respect to sectoral, as opposed to aggregate, impacts.

CHAPTER 3 MEASUREMENT OF THE IMPACT OF MONEY ON AGRICULTURE

3.1 INTRODUCTION

In this chapter the hypothesis that only unanticipated money growth affects real economic variables is tested with particular focus on the agricultural sector. The two-step procedure described in the previous chapter is utilized despite its inherent limitations relative to joint nonlinear estimation. In Section 3.2, money growth is divided into anticipated and unanticipated components by estimating a money growth equation. Estimation of the money growth equation proceeds from an identification of its explanatory variables. The resulting anticipated and unanticipated money components are then used in Section 3.3 as independent variables in equations for real economic measures. The analysis focuses on the explanatory power of each component of money growth in these equations. First, monetary impacts on real total gross domestic product and real nonfarm gross domestic product are compared to monetary impacts on real farm gross domestic product. Second, monetary impacts on agriculture are evaluated further by examining the effects on real net farm income, a real index of prices received for crops, a real index of prices received for livestock, and the real value of agricultural exports. After presentation of the empirical models of for each of these variables, the chapter concludes with a summary of the results and a discussion of their implications.

3.2 THE MONEY GROWTH EQUATION

In order to test empirically the hypothesis of neutrality of anticipated money it is necessary to differentiate between anticipated and unanticipated components of monetary movements. The first step of this analysis is to specify a money growth equation. The rational expectations theory implies that the anticipated component of money growth is an optimal one-period ahead forecast, conditional on available information.

Two procedures are available to specify the money growth equation. The first procedure is to base the money growth equation on macroeconomic variables postulated theoretically to have a systematic relationship with money growth. This would be similar to building a reaction function for the monetary authority. Economic theory has often been considered a useful guide to building such econometric models.

Nevertheless, formulating an equation to distinguish between anticipated and unanticipated money based on economic theory may not be appropriate. First, economic theory may not be very valuable in generating an accurate model of expectation formation. It is difficult on theoretical grounds to exclude any piece of information available at time t-1 from the information set useful to predict a policy variable. Further, theoretical specifications of monetary authority behavior are generally based on the premise that anticipated monetary policy has impacts on the real economy. That, of course, is the basic hypothesis to be tested in this analysis.

An alternative procedure for specifying the money growth equation is an atheoretical statistical approach. The explanatory variables of the money growth equation are selected based on the Granger causality concept (Mishkin 1982). The variable X is said to Granger cause another variable Y, if Y can be predicted better from past values of X and Y than from past values of Y alone (Granger 1969).

In this study, Granger causality tests are employed to carry out the specification of the money growth equation. The idea of Granger causality is to minimize the variance of linear predictors, which is equivalent to the ordinary least squares estimation. The money growth variable is regressed on its own lagged variables to remove any serial correlation, and a wide range of other macroeconomic variables. Only variables with a certain marginal significance are included in the final money growth equation.

Specifically, for the money growth equation in this study, the money growth variable M1 is regressed on its own lagged values, and lags of the inflation rate (CPI), the unemployment rate (UE), the interest rate on three-month maturity Treasury bills (TBR), the growth rate of the high employment surplus (HES), the growth rate of the federal government surplus (FGS), and the growth rate of the U.S. balance of payments on current account (BOP).

Before estimating the money growth equation, the data set of every variable should be stationary, that is, no explosive fluctuations or trend should remain in the data. An initial plot of the raw M1 data looks much like a logarithmic function. Therefore, a logarithmic transformation of M1 data was utilized. Log of M1 data contains a strong linear trend. One way of taking the trend out is to regress the log of M1 on a linear trend, and then use the residuals of the regression as a concept of money growth. Another way to remove the linear trend is to take the first difference of the log of M1 data. This also gives a stationary data set. In this study, the first order difference of log M1 is used. A benefit of using first order difference of log M1 is that the variable is represented as a growth rate.

Examination of the other six variables in the initial money growth equation suggested that the first order difference of logarithmic transformation gives stationary data for the consumer price index, the treasury-bill rate, and the unemployment rate. Transformation into growth rates, $(X_t-X_{t-1})/X_{t-1}$, give a stationary data set for the balance of payment on current account, the federal government surplus, and the high employment surplus. These latter series contained negative values so log transformation was precluded.

The equation to distinguish between anticipated and unanticipated money growth was estimated based on the transformed data from first quarter of 1960 through third quarter of 1983. The initial equation included four lags of each variable. The initial equation was:

$$(1)\ M1_t = \text{constant} + \Sigma a_i M1_{t-i} + \Sigma b_i CPI_{t-i} + \Sigma\ c_i TBR_{t-i} + \Sigma d_i UE_{t-i} + \Sigma e_i BOP_{t-i} + \Sigma f_i\ FGS_{t-i} + \Sigma g_i HES_{t-i} + u_t,$$

R^2=0.59, R^2=0.41, D-W=1.99, Q(27)=17.94.

The estimated parameters, t-statistics, and hypothesis tests are shown in Table 3-1.

For the estimated money growth equation, the joint significance test (F-test) under the null hypotheses that parameters of each explanatory variable are equal to zero results in rejection of the null hypotheses at the 5-precent significance level for lags of money and the treasury bill rate. The test statistics for these variables are, respectively, $F(4,61)=4.37$ and $F(4,61)=8.09$.

TABLE 3-1. PARAMETER ESTIMATES OF THE INITIAL MONEY GROWTH EQUATION

	M1		CPI		TBR		UE		BOP		AGS		HES	
LAG	COEFF	T-STAT	COEFF.	T-STAT	COEFF.	T-STAT	COEFF	T-STAT	COEFF.	T-STAT	COEFF.	T-STAT	COEFF.	T-STAT
1	0.33	2.56	0.002	0.01	-0.04	-5.30	-0.05	-2.28	0.0001	0.28	-0.0001	-0.66	0.0001	0.33
2	0.31	2.23	0.45	2.08	-0.004	-0.40	0.02	0.88	0.0005	2.11	-0.0002	-0.95	-0.0003	-1.18
3	-0.03	-0.18	-0.40	-1.78	-0.003	-0.33	0.02	0.97	-0.003	-1.19	0.00004	0.23	0.0003	1.09
4	0.03	0.24	0.13	0.63	-0.006	-0.71	-0.04	-2.08	-0.0002	-0.71	-0.0001	-0.64	-0.0005	-1.68

LABEL	F-STATISTIC F(4,61)	SIGNIFICANCE LEVEL
M1	5.18	0.001
CPI	1.59	0.19
TBR	8.32	0.00002
UE	2.07	0.10
BOP	1.59	0.19
FGS	0.45	0.77
HES	2.18	0.08

The joint significance tests can be sensitive to the variables in the equation. To check the robustness of the above results, regressing a money growth equation excluding variables one-by-one generally supports the above Granger causality test results. Regressing the equation without either M1 lags or TBR lags decreases both the R^2 and corrected R^2 noticeably. This suggests the explanatory power of these two variables.

Further, from the above test results, only lags of M1 and TBR passed the 5-percent significance level test, so only these two variables are taken as a base for forecasting M_t However, if a less conservative test criterion, such as the 10-percent significance level, is used, then lagged UE and HES would also be included with lagged M1 and TBR in the final money growth equation. However, regressing M1 on its own lagged values and lags of TBR, UE, and HES yields insignificant UE's. Therefore, UE's causal relation to M1 is suspicious. Excluding HES does not deteriorate the fit much, which shows a limited explanatory power of this variable. Hence, the final money growth equation to be utilized herein is:

$$(2)\ M1_t = 0.005 + \Sigma\alpha_i M_{t-i} + \Sigma\beta_i TBR_{t-i} + u_t,$$

$R^2=0.40$, $R^2=0.34$, D-W=2.00, Q(27)=19.25.

The parameter estimates and t-statistics for the final equation are shown in Table 3-2. Lagged M1 variables and lagged Treasury-bill rate variables passed the 5-percent joint significance test. The Durbin-Watson statistic is biased toward 2.0 in the presence of the lagged dependent variables. The Q statistic is an alternative measure of the serial correlation. Too large a value of the Q-statistic suggests the existence of serial correlation. The Q-statistic for the estimated money growth equation suggests there is no serial correlation.

The regression results indicate positive, persistent effects of past money variables and a strong procyclical response against the interest rate (i.e. an increase in the nominal interest rate causes the monetary authority to contract). This has an interesting interpretation if it represents monetary policy. The level of interest rates has been a primary concern of the monetary authorities (Blinder 1982) so it is not surprising that interest rates enter the estimated equation. However the empirical results do not match the usual suggestion that tight money causes high interest rates, so if interest rates rise, the monetary authority would respond by increasing the money supply. Rather the results suggest that high nominal interest rates conveyed

TABLE 3-2. PARAMETER ESTIMATES OF THE FINAL MONEY GROWTH EQUATION

	M1		TBR	
LAG	COEFFICIENT	T-STATISTIC	COEFFICIENT	T-STATISTIC
1	0.27	2.67	-0.04	-5.45
2	0.26	2.42	-0.003	0.33
3	0.14	2.28	-0.002	0.03
4	0.01	1.24	-0.001	0.16

LABEL	F-STATISTIC, F(4,81)	SIGNIFICANCE LEVEL
M1	7.03	0.7×10^{-4}
TBR	9.33	0.3×10^{-5}

an inflation premium to which monetary authority respond by reducing money growth.

There is one final conceptual problem in estimating anticipated money by the regression method utilized herein. The problem is that the parameters are estimated using information from the whole sample period. At any moment in time not all of this information was available to agents in the economy.

One way to avoid the preceding problem is to estimate money growth equations with only past information and update the regressions after each period. Barro(1975) has shown that such an approach does not alter his tests of the neutrality hypothesis with respect to unemployment, output, and the price level, and this approach was not pursuited in this study.

3.3 MONETARY IMPACTS ON TOTAL, NONFARM, AND FARM GROSS DOMESTIC PRODUCT

3.3.1 INTRODUCTION

The new classical assertion concerning the neutrality of money is that the unanticipated components of money affects the cyclical components of real output, while the anticipated components have no real effects. Under investigation in this study is whether these assertions apply specifically to the U.S. agricultural sector. Since past studies focusing on the aggregate economy have yielded conflicting empirical results, it will be useful to reestimate these impacts based on the money equation specified in this study and to compare these impacts to estimated impacts on agriculture. In addition, past studies suggest that differences with respect to lag length of the money variables included in the analysis may affect conclusions relative to money's impact. Hence, it will be useful to test the robustness of the analyses of monetary impacts on agriculture with respect to lag length.

3.3.2 IMPACTS ON REAL TOTAL GROSS DOMESTIC PRODUCT

To evaluate monetary impacts on the general United States economy the total output measure, the first order log difference of real total gross domestic product deflated by the GNP deflator (TGDP), was regressed on the current and 8 lags of unanticipated and anticipated money. The sample period was the first quarter of 1965 through the third quarter of 1983. The first order log differences form for the output variable gives stationary data. The estimated equation is:

$$(3)\ TGDP_t = -0.002 + \Sigma\alpha_j AM_{t-j} + \Sigma\beta_j UM1_{t-j} + u_t,$$

$$R^2=0.60, \quad \bar{R}^2=0.46, \quad D\text{-}W=1.85, \quad Q(27)=48.72,$$

where AM1 stands for anticipated money (i.e. the one-step ahead expected values from the money growth equation), and UM1 stands for unanticipated money (i.e. the residuals from the money growth equation). The estimated parameters, their t-statistics, and hypothesis tests are reported in Table 3-3.

The joint significance test for the 9 unanticipated monetary shocks, for which the test statistic is $F(9,54)=7.11$, suggests rejection of the null hypothesis that all coefficients of unanticipated money variables are equal to zero, (i.e. β_j's=0; i=1 ... 8). The null hypothesis is rejected at the 5-percent significance level and even at the 1-percent level. The joint significance test for the 9 anticipated money variables, for which the test statistic is $F(9,54)=1.16$, fails to reject the null hypothesis at the 5-percent significance level. From these two tests, the conclusion that only anticipated money is neutral with respect to total gross domestic product receives empirical support. Thus, these test results confirm the new classical macroeconomic assertion that anticipated changes in aggregate

TABLE 3-3. EFFECTS OF ANTICIPATED AND UNANTICIPATED MONEY ON REAL TOTAL GROSS DOMESTIC PRODUCT

8 LAG MODEL

AM1			UM1		
LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC
0	0.43	1.24	0	0.68	3.37
1	-0.34	-0.83	1	-0.56	-2.66
2	0.57	1.35	2	0.95	4.62
3	-0.10	-0.22	3	-0.48	-2.30
4	0.85	1.78	4	-0.15	-0.69
5	-0.67	-1.43	5	-0.68	-3.15
6	0.43	0.97	6	-0.17	-0.76
7	-0.36	-0.87	7	-0.52	-2.25
8	-0.22	-0.60	8	-0.40	-1.75

16 LAG MODEL

AM1			UM1		
LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC
0	0.59	1.74	0	0.79	4.01
1	0.07	0.17	1	-0.67	-3.49
2	0.71	1.68	2	0.76	3.92
3	0.01	0.03	3	-0.47	-2.49
4	1.10	2.35	4	-0.05	-0.22
5	-0.95	-2.08	5	-0.58	-2.60
6	0.58	1.26	6	-0.06	-0.27
7	0.08	0.19	7	-0.43	-1.93
8	-0.25	-0.57	8	-0.47	-2.10
9	-0.65	-1.47	9	-0.46	-2.11
10	-0.0001	-0.0001	10	0.31	1.41
11	-0.55	-1.23	11	0.31	1.43
12	0.21	0.47	12	-0.41	-1.89
13	-0.37	-0.85	13	-0.17	-0.72
14	1.22	2.74	14	0.29	0.89
15	-1.17	-2.69	15	-0.96	-2.98
16	0.17	0.43	16	-0.51	-1.62

HYPOTHESIS	F-STATISTIC	SIGNIFICANCE LEVEL
α J'S=0(J=0...8)	F(9,54) = 1.16	0.34
β J'S=0(J=0...8)	F(9,54) = 7.11	0.11×10^{-5}
α J'S=0(J=0...16)	F(17,38) = 2.81	0.004
β J'S=0(J=0...16)	F(17,38) = 6.37	0.11×10^{-5}

demand policy will have no impact on the real output in the economy, while unanticipated changes will have real effects.

As discussed earlier, Mishkin asserts that longer lags of anticipated and unanticipated money variables--current and 20 quarterly lags of each--favors nonneutrality of anticipated components of money. Therefore, to test the robustness of the results from the 8-lag model, an additional 8 lags are allowed in the following regression:

$$(4)\ TGDP_t = -0.006 + \Sigma\alpha_j AM_{t-j} + \Sigma\beta_j UM1_{t-j} + u_t,$$

$$R^2=0.81, \quad \bar{R}^2=0.64, \quad D\text{-}W=1.94, \quad Q(27)=41.76,$$

The parameter estimates, their t-statistics, and hypothesis tests are also reported in Table 3-3. The joint significance tests for anticipated and unanticipated money are, respectively, $F(17,38)=6.37$ and $F(17,38)=2.81$. The null hypothesis is rejected at the 1-percent significance level in both cases. Neither anticipated nor unanticipated money appears neutral with respect to total gross domestic product. As in the study by Mishkin, allowing a longer lag length changes the hypothesis test results and leads to results that contradict the new classical assertion. Increasing the lag length also increases the corrected R^2 by a large amount. This suggests that the additional lags have strong explanatory power. From this result, it appears that Barro's equations with short lags are under specified, and may result in biased estimates and test results as Mishkin has argued.

3.3.3 IMPACTS ON REAL NONFARM GROSS DOMESTIC PRODUCT

The impacts of unanticipated and anticipated money on aggregate output was examined in the last subsection. The impacts of anticipated and unanticipated money on output of the nonfarm sector alone are now examined. The gross domestic product of the nonfarm sector in first order log difference form and deflated by the GNP deflator is used as the measure of nonfarm output (NFGDP).

Regressing the real nonfarm gross domestic product on current and 8 lags of anticipated and unanticipated money yields an equation:

$$(5)\ NFGDP_t = -0.004 + \Sigma\alpha_j AM_{t-j} + \Sigma\beta_j UM1_{t-j} + u_t,$$

$$R^2=0.60, \quad \bar{R}^2=0.47, \quad D\text{-}W=1.90, \quad Q(27)=50.13.$$

The estimated parameters, their t-statistics, and hypothesis tests are reported in the Table 3-4. The anticipated and unanticipated money variables are again from the money equation in Section 3.2. The joint significance test for the α_j's, for which the test statistic is F(9,53)=1.16, fails to reject the null hypothesis at either the 5- or 10-percent significance level. The joint significance of the β_j's, for which the test statistic is F(9,53)=7.03, results in rejection of null hypothesis that unanticipated components of money is neutral at the 1-percent significance level. The tests results confirm the new classical rational expectations assumption as in 8-lag model of total real gross domestic product.

Again, allowing 8 more lags of unanticipated and anticipated money results in an equation:

$$(6)\ NFGDP_t = -0.004 + \Sigma\alpha_j AM_{t-j} + \Sigma\beta_j UM1_{t-j} + u_t,$$

$$R^2=0.81, \quad \bar{R}^2=0.64, \quad D\text{-}W=1.87, \quad Q(21)=40.19.$$

The estimated parameters, their t-statistics, and hypothesis tests are also reported in Table 3-4. The test statistics of the joint significance tests of α's and β's, respectively,

TABLE 3-4. EFFECTS OF ANTICIPATED AND UNANTICIPATED MONEY ON REAL NONFARM GROSS DOMESTIC PRODUCT

8 LAG MODEL

AM1			UM1		
LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC
0	0.42	1.23	0	0.58	2.90
1	-0.17	-0.42	1	-0.55	-2.65
2	-0.54	1.36	2	0.97	4.81
3	-0.17	-0.35	3	-0.56	-2.72
4	0.82	1.75	4	-0.21	-1.01
5	-0.73	-1.58	5	-0.55	-2.59
6	0.44	1.01	6	-0.16	-0.73
7	-0.28	-0.68	7	-0.52	-2.29
8	-0.17	-0.48	8	-0.37	-1.64

16 LAG MODEL

AM1			UM1		
LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC
0	0.48	1.41	0	0.72	4.01
1	0.22	0.57	1	-0.63	-3.30
2	0.61	1.47	2	0.80	4.19
3	-0.02	-0.05	3	-0.54	-2.83
4	1.03	2.24	4	-0.13	-0.58
5	-1.04	-2.27	5	0.49	-2.22
6	0.62	1.37	6	-0.04	-0.20
7	0.04	0.10	7	-0.44	-1.99
8	-0.14	-0.33	8	-0.45	-2.05
9	-0.85	-1.90	9	-0.48	-2.19
10	0.04	0.09	10	0.36	1.65
11	-0.55	-1.22	11	0.28	1.30
12	0.29	0.66	12	-0.41	-1.86
13	-0.30	-0.68	13	-0.20	-0.86
14	1.24	2.81	14	0.38	1.20
15	-1.15	-2.66	15	-0.94	-2.93
16	-0.12	-0.30	16	-0.44	-1.41

HYPOTHESIS	F-STATISTIC	SIGNIFICANCE LEVEL
αJ'S=0(J=0...8)	F(9,53) = 1.16	0.34
βJ'S=0(J=0...8)	F(9,53) = 7.03	0.13×10^{-5}
αJ'S=0(J=0...16)	F(17,37) = 2.85	0.004
βJ'S=0(J=0...16)	F(17,37) = 6.43	0.12×10^{-5}

are $F(17,37)=2.85$ and $F(17,37)=6.43$. Therefore, the hypothesis tests reject the null hypotheses, α_j's=0 and β_j's=0. That is, in the long-run model, both anticipated and unanticipated money appear to affect GDP growth of the nonfarm sector. The results indicate that the inclusion of longer lags increases the corrected R^2, which means the additional variables have strong explanatory power. In other words, anticipated and unanticipated money have rather long and continuous impact on nonfarm real output.

3.3.4 IMPACTS ON REAL FARM GROSS DOMESTIC PRODUCT

Comparing the preceding results indicates that monetary impacts on the total economy are strengthened when the nonfarm sector is considered alone. In this subsection, monetary impacts on agricultural output are investigated. As a measure of agricultural output, gross domestic product of the farm sector deflated by GNP deflator and in first order log difference form is used.

Regressing farm output on only unanticipated and anticipated components of money results in a severe serial correlation problem. To correct the serial correlation problem a moving average of error terms generated from an initial regression on the anticipated and unanticipated money variables are used as additional explanatory variables in a final equation. This procedure is also followed in all subsequent equations when the Durbin-Watson statistic indicates the existence of serial correlation.

For real farm gross domestic product correcting for serial correlation, the final estimated equation is:

$$(7)\ FGDP_t = -0.02 + \Sigma\alpha_j AM_{t-j} + \Sigma\beta_j UM1_{t-j} + \Sigma\rho_{t-i}\varepsilon_{t-i} + u_t,$$

$R^2=0.51$, $R^2=0.28$, D-W=2.10, Q(24)=16.91.

The estimated parameters, t-statistics, and hypothesis tests are reported in Table 3-5. The joint significance test for the α's, for which the test statistic is F(9,47)=1.50, fails to reject the null hypothesis even at the 10-percent significance level. Anticipated money appears to be neutral with respect to farm sector real gross domestic product.

The joint significance test of β's , for which test statistic is F(9,47)=2.60, rejects the null hypothesis at the 5-percent significance level. That is, unanticipated money is not neutral to farm output.

Allowing 8 more lags of unanticipated and anticipated money in equation (7) yields following regression results:

$$(8)\ FGDP_t = -0.07 + \Sigma\alpha_j AM_{t-j} + \Sigma\beta_j UM1_{t-j} + \Sigma\rho_{t-i} + u_{t-i},$$

TABLE 3-5. EFFECTS OF ANTICIPATED AND UNANTICIPATED MONEY ON FARM REAL GROSS DOMESTIC PRODUCT

8 LAG MODEL

AM1			UM1			ERRORS		
LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC
0	1.77	0.90	0	2.94	2.66	1	0.27	1.87
1	-5.40	-2.37	1	-1.52	-1.26	2	0.03	0.19
2	-0.23	-0.10	2	-0.31	-0.27	3	-0.07	-0.41
3	1.65	0.66	3	2.21	2.02	4	-0.37	-2.23
4	2.12	0.87	4	1.59	1.45			
5	1.90	0.78	5	-3.63	-3.27			
6	2.12	0.94	6	0.18	0.16			
7	-1.63	-0.76	7	-0.46	-0.39			
8	-1.04	-0.55	8	-1.44	-1.23			

16 LAG MODEL

AM1			UM1			ERRORS		
LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC
0	3.72	1.49	0	2.87	2.14	1	0.26	1.43
1	-4.85	-1.73	1	-2.42	-1.65	2	0.08	0.35
2	0.93	0.31	2	-1.14	-0.81	3	-0.11	-0.52
3	1.60	0.50	3	1.97	1.49	4	-0.34	-1.63
4	2.45	0.76	4	2.44	1.59			
5	2.61	0.82	5	-2.93	-1.91			
6	0.89	-0.29	6	-0.67	-0.44			
7	1.56	0.51	7	-0.16	-0.10			
8	-3.25	-1.09	8	-1.51	-1.00			
9	4.55	1.50	9	-0.54	-0.36			
10	-1.75	-0.58	10	-1.89	-1.26			
11	-0.75	-0.24	11	0.90	0.62			
12	-1.96	-0.62	12	0.10	0.66			
13	-1.98	-0.65	13	0.55	0.32			
14	1.97	0.65	14	-0.85	-0.36			
15	-0.55	-0.19	15	-2.72	-1.23			
16	1.20	0.46	16	-1.94	-0.91			

HYPOTHESIS	F-STATISTIC	SIGNIFICANCE LEVEL
α J'S=0(J=0...8)	F(9,47) = 1.50	0.17
β J'S=0(J=0...8)	F(9,47) = 2.60	0.02
α J'S=0(J=0...16)	F(17,31) = 0.87	0.61
β J'S=0(J=0...16)	F(17,31) = 1.31	0.25

R^2=0.63, $\bar{R}^2$=0.18, D-W=2.03, Q(24)=14.26,

and parameters and t-statistics also shown in Table 3-5.

The joint significance tests for coefficients of $AM1_{t-j}$ and UM_{t-j} (j=1 ... 16) are, respectively, F(17,31)=0.87 and F(17,31)=1.31. Both tests fail to reject the null hypotheses even at the 10-percent significance level. As the low corrected R^2 indicates, the additional variables do not have much explanatory power. The farm output equation seems over-specified with current and 16 lags of unanticipated and anticipated money.

Both equations (7) and (8) show a worse fit than those for TGDP and NFGDP as the corrected R^2's of the equations indicate. That is, both monetary variables seem to have less explanatory power than in the total output and nonfarm sector output equations. Thus, only very limited evidence is found of monetary impacts on real farm gross domestic product from either anticipated or unanticipated money growth.

3.4 FURTHER ANALYSIS OF MONETARY IMPACTS ON THE FARM SECTOR

In the last section, the monetary impacts on the total output of the economy, the output of the nonfarm sector and the output of the farm sector were investigated. Additional attention is directed in this section toward the farm sector. Effects of anticipated and unanticipated money growth on four aggregate agricultural variables are examined. These are real net farm income, real prices received by farmers for crops, real prices received by farmer for livestock, and the real value of agricultural exports.

3.4.1 THE IMPACTS ON REAL NET FARM INCOME

A second measure of agricultural economic activity is net real farm income. To examine the effects of money growth on thes variable, first order log differences of total net farm income deflated by the GNP deflator are regressed on current and lagged unanticipated and anticipated money. The sample period is the first quarter of 1960 through the third quarter of 1983.

First, real farm income is regressed on the current and 8 lags of anticipated and unanticipated. The resulting equation is:

(9) $FI_t = 0.01 + \Sigma\alpha_j AM1_{t-j} + \Sigma\beta_j UM1_{t-j} + u_t,$

$R^2=0.44$, $\bar{R}^2=0.28$, D-W=1.86, Q(24)=17.38.

The parameter estimates, their t-statistics, and hypothesis tests are shown in Table 3-6.

The joint significance test statistics for the α_j's and β_j's are, respectively, F(9,63)=2.77, and F(9,63)=1.94. The former rejects the null hypothesis, α_j's=0, at the 5-percent significance level, while the latter marginally fails to reject the null hypothesis, β_j's=0, at this significance level.

Second, regressing FI on current and 16 lags of anticipated and unanticipated money and correcting for serial correlation, yields the following regression results:

(10) $FI_t = -0.04 + \Sigma\alpha_j AM1_{t-j} + \Sigma\beta_j UM1_{t-j} + \Sigma\rho_i \varepsilon_{t-i} + u_{t.},$

$R^2=0.70$, $\bar{R}^2=0.32$, D-W=1.89, Q(24)=18.87.

The parameters, their t-statistics, and hypothesis tests also reported in Table 3-6. The joint significance test statis

TABLE 3-6. EFFECTS OF ANTICIPATED AND UNANTICIPATED MONEY ON REAL FARM INCOME

8 LAG MODEL

AM1			UM1		
LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC
0	-1.60	-0.34	0	8.17	2.93
1	-4.24	-0.76	1	0.31	0.11
2	-8.52	-1.49	2	-0.27	-0.94
3	15.45	2.41	3	3.67	1.29
4	0.58	0.92	4	0.25	0.85
5	-2.13	-0.35	5	-7.79	-2.64
6	6.56	1.13	6	-0.98	-0.33
7	-15.00	-2.66	7	-2.01	-0.64
8	7.27	1.48	8	-0.25	-0.78

16 LAG MODEL

AM1			UM1			ERRORS		
LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC
0	1.60	0.26	0	6.96	1.91	1	0.29	1.62
1	-6.46	-0.86	1	-1.08	-0.28	2	-0.06	-0.27
2	-6.33	-0.80	2	-1.69	-0.45	3	-0.17	-0.80
3	12.89	1.52	3	3.03	0.85	4	-0.06	-0.31
4	1.08	-0.13	4	2.88	0.68			
5	7.61	0.90	5	-4.86	-1.15			
6	-6.91	-0.82	6	-6.08	-1.48			
7	-1.96	-0.23	7	-2.85	-0.69			
8	-2.11	-0.25	8	1.09	0.27			
9	10.77	1.26	9	5.16	1.28			
10	-9.75	-1.10	10	-11.79	-2.82			
11	-2.76	-0.31	11	4.75	1.07			
12	12.60	1.47	12	2.76	0.61			
13	-11.08	-1.30	13	-1.21	-0.25			
14	9.88	1.16	14	-2.86	-0.47			
15	-11.08	-1.28	15	-7.23	-1.22			
16	3.45	0.46	16	6.46	1.10			

	HYPOTHESIS	F-STATISTIC	SIGNIFICANCE LEVEL
α	J'S=0(J=0...8)	F(9,63) = 2.77	0.009
β	J'S=0(J=0...8)	F(9,63) = 1.94	0.06
α	J'S=0(J=0...16)	F(17,31) = 1.41	0.20
β	J'S=0(J=0...16)	F(17,31) = 1.53	0.15

tics for parameters of AM1 and UM1 are, respectively, $F(17,31)=1.41$ and $F(17,31)=1.53$. Both the joint significance test for parameters of AM1 and UM1 fail to reject the null hypothesis that all the parameters are equal to zero at the 5-percent significance level. The additional 8 lags in the farm income equation improves the regression results-- in terms of corrected R^2 only slightly. The highest corrected R^2 of 0.37 is obtained when FI_t is regressed on current and 12 lags of AM1 and UM1. This results are not shown in the table but in this case the joint significance test statistics for α_j's and β_j's are, respectively, $F(13.51)=1.99$ and $F(13,51)=2.47$ which are significant at the 0.04 and 0.05 percent, respectively.

3.4.2 THE IMPACTS ON REAL PRICES RECEIVED BY FARMERS FOR CROPS

In this subsection and the one that follows attention is directed toward prices rather than output or income. The sample period is again the first quarter of 1960 through the third quarter of 1983. To examine the monetary impacts on real agricultural price, real prices received by farmer for crops deflated by the GNP deflator and in first order log difference form (PC) is regressed on current and 8 lags of anticipated and unanticipated money. The estimated parameters, their t-statistics, and hypothesis tests are reported in Table 3-7. The 8-lag equation is:

$$(11)\ PC_t = -0.05 + \Sigma\alpha_j UM1_{t-j} + \Sigma\beta_j AM1_{t-j} + u_t,$$

R^2=0.23, $\bar{R}^2$=0.01, D-W=1.92, Q(27)=15.52.

The regression results indicate a very low corrected R^2, which means the independent variables have little explanatory power. The joint significance test for the α_j's fails to reject the null hypothesis, α_j's=0, at the 5-percent significance level. The joint significance test for the β_j's also fails to reject the null hypothesis β_j's=0 at the 5-percent significance level. The statistic is F(9, 63)=0.91. That is, both anticipated and unanticipated money appear neutral with respect to real prices received by farmers for crops.

Allowing 8 more lags each in AM1 and UM1 yields parameter estimates, their t-statistics, and hypothesis test also shown in the Table 3-7 and the following regression results:

$$(12)\ PC_t = -0.14 + \Sigma\alpha_j AM1_{t-j} + \Sigma\beta_j UM1_{t-j} + u_t,$$

TABLE 3-7. EFFECTS OF ANTICIPATED AND UNANTICIPATED MONEY ON REAL PRICES RECEIVED BY FARMERS FOR CROPS

8 LAG MODEL

AM1			UM1		
LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC
0	1.38	0.69	0	1.58	1.34
1	-4.11	-1.73	1	0.97	0.80
2	1.93	0.80	2	0.97	0.81
3	-1.44	-0.53	3	0.06	0.05
4	0.55	0.21	4	-0.67	-0.54
5	2.06	0.79	5	-1.37	-1.10
6	-0.54	-0.22	6	0.46	0.37
7	3.79	1.59	7	-1.03	-0.77
8	0.06	0.03	8	-1.68	-1.26

16 LAG MODEL

AM1			UM1		
LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC
0	2.87	1.12	0	2.04	1.49
1	-3.78	-1.28	1	-0.70	-0.49
2	4.98	1.56	2	-0.07	-0.05
3	-1.18	-0.34	3	0.12	-0.08
4	3.56	1.01	4	-1.53	-0.91
5	0.69	0.20	5	-1.76	-1.05
6	0.10	0.03	6	2.68	1.60
7	6.22	1.84	7	0.15	0.09
8	-0.52	-0.15	8	-2.91	-1.75
9	1.38	0.41	9	-0.69	-0.42
10	1.63	0.48	10	2.30	1.37
11	-0.42	-0.12	11	1.56	0.96
12	-3.85	-1.15	12	-2.22	-1.36
13	-0.79	-0.24	13	0.90	0.49
14	3.07	0.91	14	2.77	1.13
15	-1.73	-0.53	15	-3.49	-1.43
16	-2.99	-1.02	16	-4.50	-1.89

HYPOTHESIS	F-STATISTIC	SIGNIFICANCE LEVEL
αJ'S=0(J=0...8)	F(9,63) = 1.00	0.45
βJ'S=0(J=0...8)	F(9,63) = 0.91	0.53
αJ'S=0(J=0...16)	F(17,39) = 1.11	0.38
βJ'S=0(J=0...16)	F(17,39) = 0.98	0.50

R^2=0.48, $\bar{R}^2$=0.02, D-W=2.00, Q(24)=19.33.

The additional lagged variables do not change the outcomes of the joint significance tests for the α_j's (j=0 ... 16) and the β_j's (j=0 ... 16) nor raise the corrected R^2. The test statistic for the α_j's was F(17,39)=1.11. The null hypothesis, α_j's=0, is not rejected at the 5-percent significance level. The test statistic for the β_j's was F(17,39)=0.98, therefore, the null hypothesis, β_j's=0, is not rejected, either at this significance level.

3.4.3. THE IMPACTS ON REAL PRICES RECEIVED BY FARMERS FOR LIVESTOCK

In this subsection, the effects of money growth on the real prices received by farmers for livestock(PL) are tested. The price variable is again deflated by the GNP deflator and in first order log difference form.

Regressing the real prices for livestock on current and 8 lags of anticipated and unanticipated money and correcting for serial correlation, yields parameter estimates and their t-statistics and hypothesis tests in Table 3-8 and the following regression results:

$$(13)\ PL_t = -0.08 + \Sigma\alpha_j AM1_{t-j} + \Sigma\beta_j UM1_{t-j} + \Sigma\rho_i\varepsilon_{t-i} + u_t,$$

TABLE 3-8. EFFECTS OF ANTICIPATED AND UNANTICIPATED MONEY ON REAL PRICES RECEIVED BY FARMERS FOR LIVESTOCK

8 LAG MODEL

AM1			UM1			ERRORS		
LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC
0	2.57	1.10	0	1.51	1.28	1	-0.001	-0.01
1	-2.60	-0.97	1	-0.85	-0.69	2	0.18	1.19
2	2.87	1.03	2	1.25	1.03	3	-0.12	-0.79
3	-0.19	-0.06	3	0.51	0.42	4	-0.02	-0.14
4	3.35	1.15	4	0.31	0.25			
5	-1.53	-0.55	5	-1.61	1.25			
6	-0.32	-0.13	6	0.94	0.72			
7	0.32	0.13	7	-0.65	-0.48			
8	-2.03	-0.97	8	-1.59	-1.18			

16 LAG MODEL

AM1			UM1			ERRORS		
LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC
0	5.49	2.24	0	2.35	1.89	1	-0.11	-0.60
1	-1.51	-0.54	1	-1.93	-1.44	2	0.15	0.77
2	4.89	1.58	2	-0.68	-0.52	3	-0.19	-0.97
3	-1.32	-0.40	3	0.26	0.20	4	-0.01	-0.05
4	4.51	1.37	4	1.79	1.15			
5	-1.39	-0.44	5	-1.21	-0.78			
6	-0.26	-0.08	6	1.31	0.86			
7	2.18	0.71	7	0.51	0.33			
8	-2.25	-0.75	8	-2.08	-1.38			
9	-0.01	-0.002	9	-1.57	-1.04			
10	-1.20	-0.39	10	-0.14	-0.09			
11	1.21	0.39	11	0.55	0.37			
12	-3.46	-1.12	12	-2.10	-1.39			
13	-5.09	-1.69	13	-1.70	-0.99			
14	4.14	1.35	14	0.57	0.25			
15	-1.47	-0.49	15	-1.49	-0.66			
16	2.31	0.88	16	-6.86	-3.20			

HYPOTHESIS	F-STATISTIC	SIGNIFICANCE LEVEL
αJ'S=0(J=0...8)	F(9,55) = 0.69	0.71
βJ'S=0(J=0...8)	F(9,55) = 0.65	0.75
αJ'S=0(J=0...16)	F(17,31) = 1.62	0.12
βJ'S=0(J=0...16)	F(17,31) = 1.35	0.23

R^2=0.23, $\bar{R}^2$=-0.07, D-W=2.00, Q(24)=34.66.

The joint significance test for α_j's (j=0 ... 8) fails to reject null hypothesis that anticipated money is neutral to PL at the 5-percent significance level. The joint significance test for the β_j's (j=0 ... 8) also fails to reject the null hypothesis, β_j's=0, at the 5 percent significance level. The test statistic was F(9,55)=0.65. That is, unanticipated money growth appears to have no impact on real prices of livestock. Among the explanatory power of the independent variables is low, as shown by the corrected R^2. If conclusion is drawn from the above tests, then it would be that money growth does not affect real price for livestock.

Allowing 16 lags in AM1 and UM1 does not improve the regression results from the 8-lag model. The regression results are:

$$(14)\ PL_t = -0.11 + \Sigma\alpha_j AM1_{t-j} + \Sigma\beta_j UM1_{t-j} + \Sigma\rho_i \varepsilon_{t-i} + u_t,$$

R^2=0.60, $\bar{R}^2$=0.12, D-W=1.97, Q(27)=15.13, with parameter estimates, t-statistics, and hypothesis tests shown in Table 3-8. The additional variables do not change the either joint significance tests for the α_j's=0 (j=0 ... 16) or the β_j's=0 (j=0 ... 16) at the 5-percent significance level, though the significance level of each F-statistic rises substantially. The test statistics are, respectively, F(17,31)=1.62 and F(17,31)=1.35. Regressing PL on other lags of UM1 and AM1, for example, 4 lags or 12 lags, did not improve the regression results and did not change the hypotheses test results. Neither anticipated nor unanticipated money seems to have explanatory power for real prices received by farmers for livestock.

3.4.4 THE IMPACTS ON THE REAL VALUE OF AGRICULTURAL EXPORTS

In this subsection, an agricultural trade variable is examined to determine whether it is affected by U.S. domestic money growth. The monetary impact on agricultural exports for end use deflated by the GNP deflator and in first order log difference form (AEX) is the dependent variable.

Regressing real agricultural exports for end use on current and 8 lags of anticipated and unanticipated money growth and correcting for serial correlation, results in the equation:

$$(15)\ AEX_t = -0.11 + \Sigma\alpha_j AM1_{t-j} + \Sigma\beta_j UM1_{t-j} + \Sigma\rho_i\varepsilon_{t-i} + u_t,$$

$$R^2=0.34, \quad \bar{R}^2=0.07, \quad D\text{-}W=2.00, \quad Q(24)=14.49.$$

The estimated parameters, their t-statistics, and hypothesis tests are reported in Table 3-9. The joint significance test for parameters of the anticipated money variables fails to reject the null hypothesis, α_j's=0, at the 10-percent significance level. The test statistic is $F(9,55)=0.89$. The same test for parameters of the unanticipated money variables fails to reject the null hypothesis, β_j's=0, at the 10-percent significance level. The test statistic is $F(9,55)=0.84$. From these results, it appears that real agricultural exports for end use are not affected by either domestic monetary shocks or money supply expectations.

Regressing AEX on current and 16 lags of anticipated and unanticipated money growth, and again correcting for serial correlation, yields parameters estimates, t-statistics, and hypothesis tests also reported in Table 3-9. The regression results are:

$$(16)\ AEX_t = -0.37 + \Sigma\alpha_j AM1_{t-j} + \Sigma\beta_j UM1_{t-j} + \Sigma\rho_i\varepsilon_{t-i} + u_t,$$

TABLE 3-9. EFFECTS OF ANTICIPATED AND UNANTICIPATED MONEY ON THE REAL VALUE OF AGRICULTURAL EXPORTS

8 LAG MODEL

AM1			UM1			ERRORS		
LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC
0	-5.39	-1.23	0	-0.51	-0.21	1	-0.46	-3.21
1	-0.86	-0.17	1	2.71	1.09	2	0.09	0.53
2	-2.19	-0.42	2	-2.22	-0.92	3	-0.06	-0.34
3	4.14	0.73	3	-1.24	-0.50	4	-0.03	-0.21
4	-1.28	-0.23	4	1.58	0.62			
5	5.50	1.02	5	-2.73	-1.06			
6	-1.42	-0.28	6	-2.65	-1.02			
7	6.52	1.33		0.84	0.31			
8	2.05	0.49	8	-3.89	-1.45			

16 LAG MODEL

AM1			UM1			ERRORS		
LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC	LAG	COEFFICIENT	T-STATISTIC
0	-4.93	-0.91	0	-3.03	-1.02	1	-0.64	-3.16
1	-1.60	-0.26	1	0.63	0.21	2	0.38	1.55
2	4.40	0.67	2	-2.44	-0.82	3	-0.39	-1.69
3	4.46	0.65	3	-4.93	-1.76	4	-0.15	-0.79
4	1.98	0.29	4	-1.08	-0.30			
5	8.96	1.32	5	-2.98	-0.86			
6	0.69	0.10	6	-0.25	-0.75			
7	7.94	1.21	7	0.93	0.28			
8	2.48	0.38	8	-6.64	-2.01			
9	7.60	1.16	9	4.86	1.49			
10	-10.62	-1.58	10	-0.81	-0.25			
11	15.30	2.29	11	0.57	0.18			
12	-14.49	-2.21	12	0.98	0.30			
13	8.34	1.29	13	-0.67	-0.18			
14	0.64	0.97	14	0.48	0.99			
15	2.90	0.44	15	3.32	0.68			
16	-8.18	-1.42	16	-10.09	-2.15			

HYPOTHESIS	F-STATISTIC	SIGNIFICANCE LEVEL
α J'S=0(J=0...8)	F(9,55) = 0.88	0.55
β J'S=0(J=0...8)	F(9,55) = 0.89	0.54
α J'S=0(J=0...16)	F(17,31) = 1.28	0.26
β J'S=0(J=0...16)	F(17,31) = 1.11	0.39

R^2=0.60, $\bar{R}^2$=0.11, D-W=1.98, Q(24)=14.09.

This specification only improves the corrected R^2 slightly, and does not change the outcomes of the hypothesis tests. For test of α_j's=0 (j=0 ... 16) and β_j's=0 (j=0 ... 16) the test statistics are, respectively, F(17,31)=1.28 and F(17,31)=1.11. Both tests fail to reject the null hypothesis. Neither anticipated nor unanticipated money appears to have much explanatory power for AEX movements.

3.5 SUMMARY AND CONCLUSIONS

In this chapter the hypothesis that only unanticipated components of money affect real economic variables was tested with respect to aggregate real gross domestic product, nonfarm real gross domestic product, farm real gross domestic product, real net farm income, real prices received by farmers for corps and livestock, and the real value of agricultural exports for end use.

The regressions for aggregate gross domestic product (TGDP) and nonfarm gross domestic product (NFGDP) with current and 8 lags of unanticipated and anticipated money favor neutrality of the anticipated components of money. However, these equations may be under specified, therefore, estimators could be biased and variances could be inefficient. Allowing 8 more lags of each money variable raises bot corrected R^2's and changes the hypothesis test results: both components of money affect real total gross domestic output and real non-farm gross domestic output. The regression for farm gross domestic product (FGDP) with current and 8 lags of unanticipated and anticipated money favors neutrality of the anticipated components of money. Additional lags of money do not improve the regression result for FGDP and neither component of money has significant effects in the long-lag model. Real total gross domestic product, which is the sum of real non-farm and farm gross domestic product, shows similar results as NFGDP because FGDP is only a small portion of TGDP. The influence of nonfarm sector output dominates the influence of farm sector output.

Among farm sector variables, the regression for farm income (FI) with current and 8 lags of anticipated and unanticipated money favors nonneutrality of anticipated money and, marginally, neutrality of unanticipated money. These results are inconsistent with the new classical rational expectations hypothesis. Adding 4 more lags of each money components, resulted in the highest corrected R^2 and hypothesis tests which shows nonneutrality of both anticipated and unanticipated components of money.

For prices received for crops and livestock (PC and PL) and for the real value of agricultural exports for end use (AEX) neither monetary components appear to have significant impacts in either short-lag or long-lag models. These results raise some questions about previous examinations of the impacts of total money growth on agricultural prices (e.g. Barnet, Bessler, and Thompson) and about the assertion that monetary policy has a pronounced effect on agriculture through its effects on the exchange rate prices and international trade (e.g. Schuh and Orden). The absence of effects of unanticipated money on relative agricultural prices also seems contrary to the new classical rational expectations assertion. Under this assertion unanticipated money is likely to affect relative prices when sectors differ in supply and demand price elasticities, as shown Chapter 2.

The choice of lag length for the money variables turns out to be crucial because many of the results are sensitive to lag length specification. In particular, the 8-lag model for NFGDP -- the same lag length as used by Barro and Rush -- favors the new classical rational expectations assertion that anticipated demand policy has no real effects on economic activity. However, inclusion of additional variable in the NFGDP equation lead to rejection of the new classical rational expectations assertion. For FGDP and FI rather short-lag models were optimal in terms of corrected R^2: for FGDP current and 8 lags of money growth and for FI current and 12 lags. More lags in FGDP and FI can not be justified. Results from the 8-lag model for FGDP favor the neutrality of anticipated money and nonneutrality of unanticipated money. Results from the 12-lag model for FI show strong monetary impacts from both anticipated and unanticipated money.

In sum, the results presented in this chapter seem to suggest that both anticipated and unanticipated money affect the real output of the U.S. nonfarm sector. Therefore, systematic changes in monetary policy are effective. Only unanticipated money has real impacts on output of the farm sector, but real net farm income appears to be affected by both anticipated and unanticipated money. Real prices received by farmers seem to be free from any monetary influence. Finally, the real value of agricultural exports does not appear to be affected by changes in the domestic money supply.

CHAPTER 4 SUMMARY AND CONCLUSIONS

4.1 SUMMARY

This study was motivated by a substantial body of literature which suggests nonneutral monetary impacts on the agricultural sector. The study drew on the new classical rational expectations assertion that in a setting of incomplete information unexpected changes in money supply disturb agents' forecasts and, therefore, may have real effects on economic activity. Expected changes in the money supply, in contrast, are discounted by agents and have no real effects.

To formulate a model of expectations about money growth, a rational expectations scheme is employed. The rational expectations scheme is optimal in the sense that it uses all available information and does not make systematic forecasting error.

To differentiate the anticipated and unanticipated components of money growth in the empirical analysis herein, Granger causality tests were utilized. The Granger causality tests select the variables which might be used by agents in forming their expectations. The money supply growth variable was regressed on its 4 own lags and 4 lags of the inflation rate, the unemployment rate, the interest rate on 3-month maturity Treasury bills, the high employment government surplus, the actual federal government surplus, and the U.S. balance of payments on current account. Among these variables, F-tests indicated that only money growth lags and lags of the interest rate variable were significant at the 5-percent level. Therefore, the ordinary least squares estimates of money growth regressed on lagged money and lagged interest rate variables were used to represent agents' rational forecasts.

The two objectives of this study were to examine the relative impacts of monetary policy on aggregate output compared to its impacts on agriculture and to examine in detail the monetary impacts on the agricultural sector. To accomplish these objectives, monetary impacts were assessed on real total, nonfarm and farm gross domestic product and on real net farm income, real prices received by farmers for corps, real prices received by farmers for livestock, and the real value of agricultural exports. A two-step estimation procedure was utilized in estimating the coefficients of the output and price equations. The two-step estimation procedure has the advantage that its application is very simple and conceptually explicit. Each dependent variable was expressed in growth-rate form and each equation included both anticipated and unanticipated money variables. Thus, the impacts of the anticipated and unanticipated components of money growth are investigated in the presence of the other.

An important aspect of this study was to determine the effect of alternative lag lengths on the estimated real effects of anticipated and unanticipated money. The optimal lag length was evaluated using the corrected R^2 criterion. The empirical results indicate that the output equations are often sensitive to differences in lag length.

The regression results for real total and nonfarm gross domestic product and real net farm income indicate an influence from both anticipated and unanticipated money. On the other hand, real farm gross domestic product appears to be affected by only unanticipated components of money. The regression results for prices received by farmers for crops and livestock and for agricultural exports indicate little impact from either anticipated or unanticipated components of money growth.

4.2 CONCLUSIONS

In this study the analysis of monetary impacts on agriculture was extended to investigate the effects of anticipated versus unanticipated money growth. Differentiating money growth into anticipated and unanticipated components is motivated largely by the claim of neutrality of anticipated money in flexible price, rational expectations equilibrium models.

The empirical results reported herein suggest that money is not always neutral. In short-lag models real total, nonfarm and farm gross domestic product and farm income appear to be affected by only unanticipated money growth. These results would support the new classical rational expectations assertion that anticipated money growth has no real effects. However, both anticipated and unanticipated money growth appear to have a significant effect on total and nonfarm gross domestic product in 16-lag models, and on real net farm income in a 12-lag model. Because these latter models provide higher corrected R^2's compare to short-lag models, and because of concerns about short-lag models raised earlier by Mishkin, the latter models provide the primary basis for conclusions drawn in this study. For real total and nonfarm gross domestic product and real net farm income the results reject the new classical rational expectations assertion that only unanticipated money growth has real effects.

The results in the study for real prices received by farmers for crops and livestock and the real value of agricultural exports, in contrast, do not suggest any monetary impacts. These results are robust in the sense of being independent of lag-length specifications. As noted earlier, absence of impacts from either anticipated or unanticipated money on relative agricultural prices or the real value of agricultural exports is somewhat surprising given the emphasis placed on macroeconomic impacts on agriculture in many recent studies. By way of comparison, among those few studies that have made a distinction between anticipated and unanticipated money growth, Belongia's results (1985) which indicate no monetary impacts on relative farm price support results of this study. Bond, Vlastuin, and Crowley (1983), however, found strong impacts of both anticipated and unanticipated world money growth on real and nominal traded primary commodity prices. Enders and Falk (1983) found monetary impacts on the pork industry that support the new classical rational expectations assertion that only unanticipated money has real impacts.

As the empirical results indicate, the results of this study are quite mixed. That is, output and income measures show some monetary impacts but real prices and agricultural exports measures do not. In sum, only limited evidence of monetary impacts specially on agriculture is found.

4.3 SUGGESTIONS FOR FURTHER RESEARCH

This study has investigated monetary impacts on aggregate agricultural variables. Three aspects of this study could be pursuited in further analysis.

First, some additional sectoral variables could be evaluated. In this study, real farm gross domestic product, real net farm income, real prices received by farmers for crops and livestock, and the real value of agricultural exports were examined. The output and income variables indicated the influence of unanticipated components of money but the real prices and export value variables do not. Therefore, more agricultural variables, some additional aggregate variables and other less aggregate variables, could be investigated to provide additional evidence of monetary impacts on the agricultural sector.

Second, this research could be extended by use of different estimation methods and alternative tests for selection of optimal lag-length specification. It has been shown in Chapter 2 that a two-step estimation method has some statistical problems. To test the robustness of the results presented in this study it would be useful to utilize the joint nonlinear econometric method, even though Mishkin (1982) confirmed the robustness of the two-step estimation results.

Third, the research reported herein could be extended by building structural output and price equations. The output and price equations of this study contain only the anticipated and unanticipated monetary variables as regressors. The output equations ignore the structure of the economy and other influences on growth rates of the dependent variables. It would be worth looking at the monetary impacts on agricultural variables in the presence of primary state variables which describe the structure of the economy and these alternative influences.

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