A Study of Macro Rational Expectations
Hypothesis Tests on Commodity Markets

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Abstract

Empirical tests of the Macro Rational Expectation (MRE) hypothesis on three U.S. commodity markets-- beef, pork, and chicken--are conducted. The test procedure uses a joint nonlinear estimation of real output and money forecasting equations. The results reveal that the MRE hypothesis is strongly rejected. The chief conclusion of this study is that the anticipated monetary policy does matter in effecting the output in these three markets. The reason for the nonneutrality of the anticipated monetary policy in the livestock markets is that the output prices are freely flexible, whereas the input prices are not freely flexible because of U.S. government price support programs.

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I. Introduction

Since Lucas' 1972 pioneering article on the neutrality of money, numerous theoretical and empirical studies have examined what Modigliani (1977) termed as the Macro Rational Expectations (MRE) hypothesis at both the aggregate and sectoral levels. While most of the studies examined only the neutrality proposition of the MRE hypothesis, Mishkin (1982a) elucidated that the MRE hypothesis test can be decomposed into the rationality and neutrality tests. The theoretical results of the neutrality models as originally developed by Lucas (1972) and Barro (1976) imply that only the unanticipated, not the anticipated, component of monetary policy has impacts on real economic variables (Lucas, 1972 and 1973; Barro, 1976).

The theoretical underpinnings of the models developed by Lucas and Barro were based on microfoundations, and the neutrality results depend crucially on the assumptions of, among others, perfectly flexible input and output prices, and rational expectations by the agents.[1] However, most modern economies are comprised of markets in which output and/or input prices are not freely flexible because of labor contracts, sales contracts, price-fixing policies by the government, etc. Gordon (1980) asserts that the neutrality of anticipated monetary policy would be valid if the market prices are freely flexible, but the presence of administered prices and imperfect flexibility of prices would invalidate the hypothesis.

Other theoretical studies in this area incorporated nominal price rigidities in the analyses to illustrate the nonneutrality of the anticipated monetary policy in the modern economies. For example, Fischer (1977), in a landmark study, developed a model with nominal wage stickiness and multiperiod wage contracts to demonstrate the nonneutral effects of anticipated monetary policy on real output. In a related study, Phelps and Taylor (1977), by using a model with nominal output price rigidities, provided theoretical supports for the ineffectiveness of the anticipated monetary policy. Blinder and Mankiw (1984) illustrated that the impacts of monetary policy will vary across the markets depending on the nature of wage and price rigidities. Gauger (1984) more specifically showed that the anticipated money supply growth will have a positive (negative) effect on real variables if output prices are relatively more (less) flexible than input prices. From the preceding discussion, it is obvious that considerable controversy over the neutrality hypothesis exists in the literature, and, as noted by Levi and Shapiro (1987), this hypothesis is not universally accepted.

Empirical testing of the monetary neutrality hypothesis at the aggregate level was extensive in the literature. For example, Barro (1977) and Barro and Rush (1980), using aggregate data, concluded that the systematic movements in monetary policy do not affect real macroeconomic variables.[2] On the other hand, Mishkin (1982a) found that the movements in the anticipated monetary policy do affect real macroeconomic variables; moreover, contrary to the MRE hypothesis, the impacts of the unanticipated money supply growth on the real economic variables are not larger than those of the anticipated money supply growth (p. 47). Mishkin (1982b) also found that if GNP growth or inflation is used as the aggregate demand policy variable, then the MRE hypothesis is again not supported.

Empirical testing of the monetary neutrality proposition at the disaggregate or sectoral level also received considerable attention, because the theoretical underpinnings of this proposition as indicated by the models of Lucas and Barro were built upon supply and demand functions of large numbers of disaggregate markets. Moreover, empirical testing of the MRE hypothesis at the disaggregate level is needed because, as elucidated by Blinder and Mankiw (1984), aggregate level tests can obscure the true impacts of the anticipated monetary policy in a specific sector. This is because the aggregate level test results may net out the differing impacts of the anticipated monetary policy at the disaggregate levels. Gauger (1984) found evidence of nonneutral effects of the perceived money supply growth in the manufacturing industries.[3] However, studies that focused on the disaggregate level tests investigated only the neutrality hypothesis and did not examine the rationality hypothesis, and also they considered only the manufacturing sectors. Agricultural markets received scant attention even though they provide interesting cases for testing the MRE hypothesis because many of the agricultural markets in the U.S. are inundated with government price fixing policies such as price support programs which restrict price movements of many commodities.

In this study three U.S. livestock markets--beef, pork, and chicken-- are chosen for testing the MRE hypothesis. These livestock markets are chosen because of their special features in that the prices received by the producers for outputs are more flexible than the prices paid by the producers for inputs.[4] This is because the output markets in the livestock sector are primarily auction markets with perfectly flexible output prices, whereas the input markets such as feed grain and wheat markets are governed by the government price support policies which imparts rigidity to the input prices. In determining the real output responses to monetary policy shocks, one needs to focus on the relative movements of the output and input prices.[5] Thus the relevant issue is whether the output prices are relatively more flexible or less flexible than the input prices. Because of the differing flexibilities of output and input prices in the livestock sector, which contradict the perfectly flexible price assumption used in the MRE hypothesis model, it is worth testing the MRE hypothesis on the beef, pork, and chicken markets. Furthermore, tests of the rationality hypothesis in these markets will provide additional insights into the expectation behaviors of the livestock producers.

Section II describes the model and briefly outlines the methodology used in testing the MRE hypothesis. Section III discusses the money forecasting equation and the special characteristics of the livestock markets and presents the empirical results of the MRE hypothesis tests of the beef, pork, and chicken markets. The final section ends with brief concluding remarks.

II. Model and Test Procedures

The framework for testing the MRE hypothesis involves estimation of systems of money forecasting equation and reduced form output equations. The specification used to forecast the money supply growth is given by the following equation:

$$M_t = X_{t-1} \gamma + u_t \qquad (1)$$

where M_t is the actual money supply growth in t, X_{t-1} is the vector of macroeconomic variables pertinent to forecasting M_t, γ is the corresponding coefficient vector, and u_t is the disturbance term which is assumed to be generated by a temporally independent white noise process and thus uncorrelated with X_{t-1}. The money forecasting equation is used to decompose the actual money supply growth into the anticipated (systematic) and unanticipated (unsystematic) components. The anticipated money supply growth, M_t^a, is the expected value of M_t conditional on information available at t-1. Thus, M_t^a is equal to $X_{t-1}\,\gamma$. The unanticipated money supply growth is equal to $M_t - X_{t-1}\,\gamma$.

The market specific output equation is given by

$$LG_{jt} = \delta_j + \sum_{i=0}^{n} \beta_{ji}\,(M_{t-i} - X_{t-1-i}\,\gamma) + \sum_{k=1}^{m} \theta_{jk}\,Z_{jkt} + v_{jt} \qquad (2)$$

where LG_{jt} is the growth rate of real output[6] (the subscript j refers to the beef, pork, or chicken market), n is the number of lags of unanticipated money supply growth, Z_{jkt} is the k^{th} exogenous variable relevant to determining LG_{jt}, δ_j is the intercept term, β_{ji} (i = 0,1, ..., n) and θ_{jk} (k = 1, ..., m) are the coefficients, and v_{jt} is the random term.

To test the MRE hypothesis, equation (2) is modified to incorporate the anticipated money supply growth as

$$LG_{jt} = \delta_j + \sum_{i=0}^{n} \beta_{ji}\,(M_{t-i} - X_{t-1-i}\,\gamma^*) + \sum_{i=0}^{n} \alpha_{ji}\,(X_{t-1-i}\,\gamma^*) + \sum_{k=1}^{m} \theta_{jk}\,Z_{jkt} + v_{jt} \qquad (3)$$

where $\gamma = \gamma^*$ and α_{ji} (i = 0,1, ...,n) are the coefficients of the anticipated money growth. Equations (1) and (2) constitute the most constrained system, whereas equations (1) and (3) with $\gamma = \gamma^*$ not imposed constitute the most unconstrained system of the model.

Previous studies by Barro (1977) and by Barro and Rush (1980) used a two-step procedure to test the money neutrality proposition. In this procedure, the money forecasting equation is estimated by using ordinary least squares (OLS), and the predicted and residual series from this regression are used, respectively, as the perceived and unperceived money supply growth in the output equation which is also estimated by OLS. Mishkin (1982a) notes that the two-step procedure ignores possible covariances between the parameters across the money growth and output equations. If the covariances between these parameters are nonzero, then the estimates obtained from the two-step procedure are not efficient, and the test statistics are also invalid. Furthermore, the two-step procedure does not allow one to explicitly test the rationality proposition.

While earlier studies used the two-step procedure, Mishkin (1982a) was the first to develop a concrete methodology, which he termed as the joint estimation procedure, for testing the MRE hypothesis. This procedure, unlike the two-step procedure, can be used to test both the neutrality and rationality propositions. Mishkin (1983) provides a more detailed discussion of the methodology by clearly documenting the estimation procedures and various steps involved in testing the MRE hypothesis. In the current study, Mishkin's joint estimation procedure is used. This procedure estimates the money forecasting equation and the output equation as a joint nonlinear system. Because this procedure allows for covariances between parameters across equations (i.e., "information crossovers" between the forecast and output equations), the estimates of γ, β, and α are efficient, and the test statistics are also valid.

Tests of joint hypothesis, i.e., joint tests of the rationality and the neutrality propositions are conducted by constructing a likelihood ratio statistic from the constrained (1) and (2) system and the unconstrained (1) and (3) system with $\gamma = \gamma^*$ not imposed. Tests of monetary neutrality only, under the maintained hypothesis of rationality, are analyzed by computing the likelihood ratio statistic where the constrained system is (1) and (2) and the unconstrained system is (1) and (3) with $\gamma = \gamma^*$ imposed. Finally, the rationality proposition, without maintaining the neutrality, is tested by examining the likelihood ratio statistic where the constrained system is (1) and (3) with $\gamma = \gamma^*$ imposed and the unconstrained system is (1) and (3) with $\gamma = \gamma^*$ not imposed. The joint hypothesis, neutrality and rationality propositions are tested by estimating the appropriate constrained and unconstrained systems. From the estimated results of the corresponding constrained and unconstrained systems, the likelihood ratio statistic is constructed as:

$$2T\,[\log(SSR^c) - \log(SSR^u)], \tag{4}$$

where SSR^c is the sum of squared residuals from the constrained system, SSR^u is the sum of squared residuals from the unconstrained system, and T is the number of observations in each equation. The test statistic is asymptotically distributed as $\chi^2(q)$ under the null hypothesis, where q is the total number of restrictions imposed.

III. Empirical Results

This section discusses the money forecasting equation and the empirical results of the MRE hypothesis tests on the beef, pork, and chicken markets.

Money Forecasting Equation

The specification of the money growth equation is based on the notion that agents use all the available information in predicating the money supply growth. Thus, money supply growth is estimated as a function of its own lagged values and a host of other relevant macrovariables. These variables are real gross national product (GNP), nominal GNP, inflation rate, three-month treasury bill rate, unemployment rate, exchange rate, government deficit, real government expenditure, and the balance of payments on the current account. Following Mishkin (1982a), four lags were selected for each of these variables, and each variable was chosen by using the Granger F-tests under the null hypothesis that the coefficients of four lag sets of each variable are jointly zero. Based on this criterion, the lagged money supply growth, the three-month treasury bill rate, and the unemployment rate were included in the money forecasting equation.

In estimating the money forecasting equation, it is important to take into account the changes that occurred in the monetary policy procedures; failure to incorporate the changes would lead to misspecification of the money forecasting equation and may distort the test results. In view of this, the money supply growth equation was estimated by allowing for the well-known change in the Federal Reserve Operation Procedures in 1979:4 and the important change in the weight placed on the interest rate in 1975:1.[7] Specifically, the slope coefficients of the interest rate at 1975:1 and 1979:4 were allowed to change.

Quarterly data covering the period from 1965:1 to 1987.4 were used for the analysis. The data for the M1 money supply and the treasury bill rate were obtained from the St. Louis Federal Reserve Bank. The unemployment rate was collected from the International Financial Statistics of the International Monetary Fund. The data for the chicken, pork, and beef productions were obtained from <u>Livestock and Poultry Situation Outlook</u>, the U.S. Department of Agriculture. The price data for beef, pork, and chicken were collected from <u>Livestock and Poultry</u>, the U.S. Department of Agriculture.

The money forecasting equation estimated using OLS, with standard errors in parentheses, is

$$M_t = \underset{(.009)}{.0108}$$

$$+ \underset{(.111)}{.5901M_{t-1}} - \underset{(.1166)}{.081M_{t-2}} + \underset{(.0985)}{.0157M_{t-3}} - \underset{(.0858)}{.0021M_{t-4}}$$

$$F(4,72) = 8.56$$

$$- \underset{(.0012)}{.0048TB_{t-1}} + \underset{(.0018)}{.0084TB_{t-2}} - \underset{(.0019)}{.0057TB_{t-3}} + \underset{(.0017)}{.0013TB_{t-4}}$$

$$F(4,72) = 6.59$$

$$+ \underset{(.0007)}{.0002TB_{t-1}{*}D1} - \underset{(.0009)}{.0027TB_{t-2}{*}D1} + \underset{(.0011)}{.0056TB_{t-3}{*}D1} - \underset{(.0010)}{.0031TB_{t-4}{*}D1}$$

$$F(4,72) = 7.07$$

$$+ \underset{(.001)}{.0001TB_{t-1}{*}D2} + \underset{(.001)}{.001TB_{t-2}{*}D2} - \underset{(.001)}{.003TB_{t-3}{*}D2} - \underset{(.001)}{.0027TB_{t-4}{*}D2}$$

$$F(4,72) = 2.38$$

$$- \underset{(.0215)}{.0387UN_{t-1}} + \underset{(.0323)}{.0847UN_{t-2}} - \underset{(.0318)}{.0444UN_{t-3}} - \underset{(.0190)}{.0012UN_{t-4}}$$

$$F(4,72) = 1.85$$

$$R^2 = .70, \quad \hat{\sigma} = .00004 \quad DW = 1.94,$$

where M_t = growth rate of M1 money supply, TB = three-month treasury bill rate, UN = log of unemployment rate, D1 = zero from 1965:1 to 1979:3 and one otherwise, D2 = zero from 1965:1 to 1974:4 and one otherwise, $\hat{\sigma}$ = standard error of estimate, and DW = Durbin Watson statistic.

The F-statistics reported in the money forecasting equation test the explanatory power of the four lagged values of each variable in predicting the money supply growth. The approximate critical value of F-statistics at the 5 percent level is 2.50 and at the 1 percent level is 3.60. Four lagged values of money supply growth, the treasury bill rate, and the 1979 change in the expectation process (as reflected by TB*D1) are significant at the 1 percent level. Four lagged values of money growth capture the persistence effects not explained by other independent variables. The treasury bill rate captures the policy changes in the money supply pursued by the Fed in response to interest rate changes. The change in expectations in 1975 is marginally significant. The coefficients of the lagged unemployment rate reflect the counter cyclical response of money growth. The unemployment rate is included to maintain a tie to the money forecasting specification in the original Barro study and numerous other neutrality studies.[8] The specification employed for the money forecasting equation is used in the joint estimation procedure.

Test Results of the MRE Hypothesis

The likelihood ratio tests of the MRE hypothesis on the beef, pork, and chicken markets are summarized in Table 1. Earlier studies, particularly Mishkin (1982a and 1983), noted that the test results are affected by the lag length (the value of n in equations (2) and (3)) of the unanticipated and anticipated money supply growths. Thus, to provide more information on the robustness of the results, the tests were carried out with eight and twelve quarters of the anticipated and unanticipated money supply growths.[9]

The likelihood ratio test results in Table 1 show that, for both lag lengths and in all three markets, the MRE hypothesis is strongly rejected. The joint hypothesis is rejected at the 1% level in all cases. Further tests were conducted to ascertain whether the rejection of the joint hypothesis is due to neutrality or rationality constraints. Separate tests of neutrality and rationality indicate that both are not supported in all three markets. These results hold true for both short-lag and long-lag length models. The neutrality hypothesis is rejected far more strongly than the rationality hypothesis in

Table 1. Likelihood Ratio Tests of Macro Rational Expectation Hypothesis in the Livestock Markets[1,2]

$$LG_{jt} = \delta_j + \sum_{i=0}^{n} \beta_{ji} (M_{t-i} - X_{t-1-i}\gamma_j) + \sum_{i=0}^{n} \alpha_{ji} (X_{t-1-i}\gamma_j) + \sum_{k=0}^{m} \theta_{jk} Z_{jkt} + \sum_{\ell=1}^{4} \rho_{j\ell} v_{jt-\ell} + e_t$$

Model	7 Lags of Anticipated and Unanticipated Monetary growth	11 Lags of Anticipated and Unanticipated Monetary growth
Beef Market		
Joint Hypothesis	$\chi^2(19) = 47.37^{**}$	$\chi^2(23) = 83.10^{**}$
Neutrality	$\chi^2(8) = 28.16^{**}$	$\chi^2(12) = 60.18^{**}$
Rationality	$\chi^2(11) = 19.71^{*}$	$\chi^2(11) = 22.92^{*}$
Pork Market		
Joint Hypothesis	$\chi^2(19) = 101.29^{**}$	$\chi^2(23) = 120.01^{**}$
Neutrality	$\chi^2(8) = 61.23^{**}$	$\chi^2(12) = 59.28^{**}$
Rationality	$\chi^2(11) = 40.07^{**}$	$\chi^2(11) = 60.73^{**}$
Chicken Market		
Joint Hypothesis	$\chi^2(19) = 58.19^{**}$	$\chi^2(23) = 67.07^{**}$
Neutrality	$\chi^2(8) = 37.33^{**}$	$\chi^2(12) = 28.14^{**}$
Rationality	$\chi^2(11) = 20.86^{*}$	$\chi^2(11) = 38.93^{**}$

The likelihood ratio statistic is computed as $2T [\log(SSR^c) - \log(SSR^u)]$ where SSR^c and SSR^u are the sum of squared residuals from the constrained and unconstrained systems, respectively.

*Significant at the 5 percent level
**Significant at the 1 percent level

[1]The subscript j in the model refers to the beef, pork, or chicken market.

[2]The output equations are corrected for fourth-order serial correlation.

the short-lag length models. The neutrality hypothesis is rejected at the 1% percent level in all three markets but the rationality hypothesis is rejected only at the 5% level in beef and chicken markets. In the long-lag length model neutrality hypothesis is rejected at the 1% level in all three markets, and rationality hypothesis is rejected at 1% in the pork and chicken markets and at 5% level in the beef market. What follows next is the discussion of the cause for the rejection of the neutrality proposition.

The reasons for why neutrality is not supported can be understood by closely examining the movements of output and input prices in these three markets. Conventional wisdom would suggest that agricultural commodity prices are perfectly flexible (see Bordo, 1980). However, many farm programs in the United States are designed to stabilize prices of primary agricultural commodities such as feed grains and wheat through buffer stock programs. For example, the price stabilization programs such as the loan rates and farmer owned reserve programs stabilize the nominal prices of feed grains and wheat within the lower and upper price bounds. Specifically, the loan rates program provides downside price protection, whereas the Farmer Owned Reserve (FOR) program limits the upward movements of prices (Wright, 1985). Thus, these programs restrict the movements of feed grains and wheat prices between a minimum price (loan rate) and a maximum price (release price). Consequently, these programs impart some rigidity to the prices of feed grains and wheat which are used as inputs (feed) in the livestock sector. While the U.S. government administers price stabilization programs in the input markets, it does not intervene in the livestock output markets. Therefore, the output markets in the livestock sector are primarily auction markets with perfectly flexible output prices. Consequently, movements in crop prices are sluggish relative to auctioneer-type livestock product prices.

In addition, because of the minimun and maximum bounds set on feed grains and wheat prices by the U.S. farm programs, the movements of these input prices to any aggregate demand shocks such as money supply shocks are also restricted. Furthermore, as theoretically illustrated by Fischer (1977), the anticipated monetary policy will have real impacts since input prices are relatively less flexible than the output prices. The test results in Table 1, which indicate a strong rejection of neutrality proposition, provide the empirical evidence to substantiate that the systematic monetary policy does affect the outputs of livestock markets. A deeper understanding of the test results in Table 1 can be accomplished by studying the estimated output equations, which are discussed next.

For each market, two output equations representing eight and twelve quarters of both anticipated and unanticipated money supply growth were estimated. Since the estimated results are similar across lag specifications and because of the space limitation, only the results of the output equations with twelve quarters of the anticipated and unanticipated money growths are reported in Tables 2, 3, and 4.[10] Each output equation was estimated nonlinearily with the growth rate of the beef, pork, or chicken production as a dependent variable and current and eleven lags of the anticipated and unanticipated money growths as regressors; in addition to the money growth variables, a constant term and three seasonal dummy variables were also included as regressors. The seasonal dummy variable Z_{j1t} in equation (3) is defined as one in the first quarter and zero in the other three quarters. Z_{j2t} and Z_{j3t} are defined similarly. These three quarterly dummy variables account for seasonality and biological restrictions in the production process of beef, pork, and chicken. The significance of the estimated coefficients of these dummy variables (Table 2 - 4) demonstrate the appropriateness of including these variables in the estimation.

It is important to correct for the serial correlation of error terms in the output equations in order to obtain valid test statistics. Consequently, very careful attention was given in correcting the serial correlation of the residuals to ensure that residuals are white noise. The output equations were corrected for fourth-order serial correlation, which is generally sufficient in reducing the residuals to white noise when quarterly data is used. Tables 2 - 4 also present the estimated coefficients ($\hat{\rho}_{j\ell}$, $\ell = 1, 2, 3,$ and 4) for the fourth-order autocorrelation correction. The significance of one or more $\hat{\rho}_{j\ell}$ estimates in all three markets underscores the importance of the higher order autocorrelation correction.

Table 2. Nonlinear Joint Estimates of Beef Output Model with Twelve Quarters of Monetary Variables[1,2]

$$LG_{bt} = \delta_b + \sum_{i=0}^{n} \beta_{bi} (M_{t-i} - X_{t-1-i}\gamma_b) + \sum_{i=0}^{n} \alpha_{bi} (X_{t-1-i}\gamma_b) + \sum_{k=0}^{m} \theta_{bk} Z_{bkt} + \sum_{\ell=1}^{4} \rho_{b\ell} v_{bt-\ell} + e_t$$

$\hat{\beta}_{b0}$ = .528(0.68)	$\hat{\alpha}_{b0}$ = -.706(-1.03)	$\hat{\delta}_b$ = .216(2.37)
$\hat{\beta}_{b1}$ = 1.252(1.26)	$\hat{\alpha}_{b1}$ = .249(0.31)	$\hat{\theta}_{b0}$ = -.043(-3.12)
$\hat{\beta}_{b2}$ = -.007(-.01)	$\hat{\alpha}_{b2}$ = -.111(-.1)	$\hat{\theta}_{b1}$ = -.009(-.57)
$\hat{\beta}_{b3}$ = 2.57(1.5)	$\hat{\alpha}_{b3}$ = -.927(-.76)	$\hat{\theta}_{b2}$ = -.014(-1.06)
$\hat{\beta}_{b4}$ = 5.454(2.78)	$\hat{\alpha}_{b4}$ = 1.113(.74)	$\hat{\rho}_{b1}$ = -.224(-1.71)
$\hat{\beta}_{b5}$ = 6.676(2.81)	$\hat{\alpha}_{b5}$ = 1.105(0.65)	$\hat{\rho}_{b2}$ = -.588(-4.31)
$\hat{\beta}_{b6}$ = 5.391(2.02)	$\hat{\alpha}_{b6}$ = 4.167(2.09)	$\hat{\rho}_{b3}$ = -.227(-1.73)
$\hat{\beta}_{b7}$ = 7.258(2.67)	$\hat{\alpha}_{b7}$ = 2.578(1.18)	$\hat{\rho}_{b4}$ = -.324(-2.5)
$\hat{\beta}_{b8}$ = 6.621(2.62)	$\hat{\alpha}_{b8}$ = 5.763(2.62)	$\hat{\sigma}_b^2$ = .0007
$\hat{\beta}_{b9}$ = 5.874(2.54)	$\hat{\alpha}_{b9}$ = 2.654(1.25)	
$\hat{\beta}_{b10}$ = 1.62(0.97)	$\hat{\alpha}_{b10}$ = 3.245(1.81)	
$\hat{\beta}_{b11}$ = 3.019(2.11)	$\hat{\alpha}_{b11}$ = 2.579(1.67)	
$\sum_{i=0}^{11} \hat{\beta}_{bi}$ = 46.256	$\sum_{i=0}^{11} \hat{\alpha}_{bi}$ = 21.709	

[1]The values in parentheses are asymptotic t-statistics. Critical values of the approximate t-statistics are as follows: $t_{0.05,120} \approx 1.98$ and $t_{0.01,120} \approx 2.617$.

[2]The subscript b in the model refers to the beef market.

Table 3. Nonlinear Joint Estimates of Pork Output Model with Twelve Quarters of Monetary Variables[1,2]

$$LG_{pt} = \delta_p + \sum_{i=0}^{n} \beta_{pi} (M_{t-i} - X_{t-1-i}\gamma_p) + \sum_{i=0}^{n} \alpha_{pi} (X_{t-1-i}\gamma_p) + \sum_{k=0}^{m} \theta_{pk} Z_{pkt} + \sum_{\ell=1}^{4} \rho_{b\ell} v_{bt-\ell} + e_t$$

$\hat{\beta}_{p0}$ = -1.178(-1.10)	$\hat{\alpha}_{p0}$ = -.427(-.37)	$\hat{\delta}_p$ = -.05(-0.41)
$\hat{\beta}_{p1}$ = -2.593(-2.17)	$\hat{\alpha}_{p1}$ = 3.258(2.26)	$\hat{\theta}_{p0}$ = -.221(-14.24)
$\hat{\beta}_{p2}$ = -3.223(-1.87)	$\hat{\alpha}_{p2}$ = 2.937(1.95)	$\hat{\theta}_{p1}$ = -.153(-8.93)
$\hat{\beta}_{p3}$ = -2.355(-1.22)	$\hat{\alpha}_{p3}$ = 1.46(1.01)	$\hat{\theta}_{p2}$ = -.215(-14.42)
$\hat{\beta}_{p4}$ = -2.104(-1.31)	$\hat{\alpha}_{p4}$ = 1.937(1.54)	$\hat{\rho}_{p1}$ = .13(.96)
$\hat{\beta}_{p5}$ = 1.047(.67)	$\hat{\alpha}_{p5}$ = -1.249(-1.0)	$\hat{\rho}_{p2}$ = -.087(-.67)
$\hat{\beta}_{p6}$ = 0.496(.33)	$\hat{\alpha}_{p6}$ = -3.581(-2.68)	$\hat{\rho}_{p3}$ = .119(1.03)
$\hat{\beta}_{p7}$ = 2.016(1.29)	$\hat{\alpha}_{p7}$ = -1.218(-0.89)	$\hat{\rho}_{p4}$ = -.123(-1.13)
$\hat{\beta}_{p8}$ = -1.267(-.81)	$\hat{\alpha}_{p8}$ = 1.353(.99)	$\hat{\sigma}_p^2$ = .001
$\hat{\beta}_{p9}$ = -3.247(-2.11)	$\hat{\alpha}_{p9}$ = 1.802(1.22)	
$\hat{\beta}_{p10}$ = -2.353(-1.4)	$\hat{\alpha}_{p10}$ = 2.907(1.83)	
$\hat{\beta}_{p11}$ = -.49(-.33)	$\hat{\alpha}_{p11}$ = 3.424(2.52)	
$\sum_{i=0}^{11} \hat{\beta}_{pi}$ = -15.251	$\sum_{i=0}^{11} \hat{\alpha}_{pi}$ = 12.603	

[1]The values in parentheses are t-statistics. Critical values of the approximate t-statistics are as follows: $t_{0.05,120} \approx 1.98$ and $t_{0.01,120} \approx 2.617$.

[2]The subscript p in the model refers to the pork market.

Table 4. Nonlinear Joint Estimates of Chicken Output Model with Twelve Quarters of Monetary Variables[1,2]

$$LG_{ct} = \delta_c + \sum_{i=0}^{n} \beta_{ci} (M_{t-i} - X_{t-1-i}\gamma_c) + \sum_{i=0}^{n} \alpha_{ci} (X_{t-1-i}\gamma_c) + \sum_{k=0}^{m} \theta_{ck} Z_{ckt} + \sum_{\ell=1}^{4} \rho_{c\ell} v_{ct-\ell} + e_t$$

$\hat{\beta}_{c0}$ = -2.204(-5.01)	$\hat{\alpha}_{c0}$ = .186(.41)	$\hat{\delta}_c$ = -.108(-3.45)
$\hat{\beta}_{c1}$ = .253(0.48)	$\hat{\alpha}_{c1}$ = .887(1.51)	$\hat{\theta}_{c0}$ = .071(10.79)
$\hat{\beta}_{c2}$ = -1.357(-2.43)	$\hat{\alpha}_{c2}$ = -.167(-.29)	$\hat{\theta}_{c1}$ = .157(20.28)
$\hat{\beta}_{c3}$ = .943(1.39)	$\hat{\alpha}_{c3}$ = 1.425(1.85)	$\hat{\theta}_{c2}$ = .078(12.26)
$\hat{\beta}_{c4}$ = -2.119(-3.65)	$\hat{\alpha}_{c4}$ = -.308(-.49)	$\hat{\rho}_{c1}$ = .242(2.02)
$\hat{\beta}_{c5}$ = 1.884(3.01)	$\hat{\alpha}_{c5}$ = -.015(-.02)	$\hat{\rho}_{c2}$ = -.227(-2.01)
$\hat{\beta}_{c6}$ = .943(1.36)	$\hat{\alpha}_{c6}$ = -.13(-0.19)	$\hat{\rho}_{c3}$ = .527(4.41)
$\hat{\beta}_{c7}$ = .673(.99)	$\hat{\alpha}_{c7}$ = .702(.96)	$\hat{\rho}_{c4}$ = -.293(-3.04)
$\hat{\beta}_{c8}$ = -3.519(-4.85)	$\hat{\alpha}_{c8}$ = .315(.43)	$\hat{\sigma}_c^2$ = .017
$\hat{\beta}_{c9}$ = -.668(-.85)	$\hat{\alpha}_{c9}$ = .178(.21)	
$\hat{\beta}_{c10}$ = .115(.15)	$\hat{\alpha}_{c10}$ = .092(.12)	
$\hat{\beta}_{c11}$ = 2.056(2.59)	$\hat{\alpha}_{c11}$ = 1.226(1.54)	
$\sum_{i=0}^{11} \hat{\beta}_{ci}$ = -3.0	$\sum_{i=0}^{11} \hat{\alpha}_{ci}$ = 4.391	

[1]The values in parentheses are t-statistics. Critical values of the approximate t-statistics are as follows: $t_{0.05,120} \approx 1.98$ and $t_{0.01,120} \approx 2.617$.

[2]The subscript c in the model refers to the chicken market.

A closer examination of the estimates of the output equations provides further insights into the neutrality test results. In determining the real output responses, one needs to study whether the output prices are relatively more or less flexible than the input prices. Specifically, if the output prices are relatively more flexible than the input prices, the impacts of the anticipated monetary policy on real output will be positive. Thus in the livestock sector, because of the relative rigidity of input prices we would expect positive impacts of the perceived money growth on beef, pork, and chicken outputs.

In Table 2 estimated results of the beef output model are presented. The results indicate that the model fits the data well. Our primary focus is on the estimates of β_{bi} and α_{bi} coefficients, which capture the effects of the unanticipated and anticipated money supply growths, respectively. The coefficients of the anticipated money growth variables indicate why the neutrality proposition is rejected as illustrated in Table 1. Out of the twelve α_{bi} estimates, nine are positive and only three are negative, and these three negative coefficients are small in magnitude and also insignificant. Furthermore, the impacts of the anticipated monetary policy persist over a three-year period. The sum of the α_{bi} estimates is 21.709. Thus, contrary to the MRE, the anticipated monetary policy does seem to be important in effecting the real output. The unanticipated money growth variables also have significant impacts. Many of the β_{bi} coefficients' asymptotic t-statistics are greater than two. The unanticipated money growth impacts also persist over a three-year period.

In Table 3 the coefficient estimates of the pork output model are reported. As in the beef output equation, the anticipated money growth variables have significant impacts. Many of the asymptotic t-statistics are greater than two. Also the impacts persist over a three-year period. Out of the twelve α_{bi} estimates, eight are positive and only four are negative, and of these four negative coefficients only one is significant. The sum of the impacts of the anticipated money growth variables is 12.603. Therefore, as implied by the neutrality tests in Table 1, the anticipated monetary policy does have a significant impact on pork production. Unlike the beef output model, the coefficients of the unanticipated money growth have no definite pattern, and their signs are also mixed. Moreover, the coefficients of the anticipated money growth is generally higher than those of the unanticipated money growth and also tend to have higher asymptotic t-statistics. Nearly four of the α_{pi} estimates are statistically significant compared to only two of the β_{pi} coefficients. Thus in the pork market, contrary to the implications of the MRE, anticipated movements in the monetary policy do not seem to be less important than the unanticipated movements.

The estimated results of the chicken output equation are presented in Table 4. These results follow a similar pattern as in the beef and pork output results. Out of the twelve α_{hi} estimates, eight are positive and only four are negative, and these four negative coefficients are small in magnitude and also insignificant. The sum of the impacts of the anticipated monetary policy is positive, and also the positive impacts persist over a three-year period. This is evident from the positive coefficients in the last five quarters. The signs of unanticipated coefficients are mixed, and these coefficients have no distinct pattern.

The other proposition contained in the MRE hypothesis, i.e., rational expectations, is also rejected but not as strongly as the neutrality proposition. Rejection of the rationality proposition in the livestock market is not surprising because previous studies have shown that livestock producers do not use rational expectations in making their production decisions (Brandt and Roth, 1980; Roy, Foote, and Sadler, 1974). Producers in these markets generally tend to follow static or adaptive expectations.

IV. Concluding Remarks

The test of the macro rational expectation hypothesis at the industry or market level is needed because, as Blinder and Mankiw (1984) illustrated, evaluation of monetary impacts at the aggregate level may provide a misleading picture of the disaggregate level impacts. This is because the aggregate analysis of the MRE can mask the true impacts of the monetary policy in a specific market since the underlying structure of the individual markets may differ, and also each market may experience a differing degree of input and output price flexibilities. Also, examination of specific markets would allows us to study the nature of the industry and ascertain the reasons for the cause of the nonneutrality.

In this study empirical tests of the MRE on three livestock markets-- beef, pork, and chicken--are conducted. The test procedure uses a joint nonlinear estimation of real output and money forecasting equations. The results reveal that the MRE hypothesis is strongly rejected. Separate tests of neutrality and rationality hypotheses are also unfavorable in supporting these hypotheses. The neutrality hypothesis is the major contributor to these rejections, whereas the rationality hypothesis contributes to a lesser degree. Thus, the chief conclusion of this study is that the anticipated monetary policy does matter in effecting the output in these three markets. The empirical results corroborate the theoretical findings of the nonneutrality models of Fischer (1977), Phelps and Taylor (1977), and Gauger (1984), which incorporate nominal price rigidities.

The reason for the nonneutrality of the anticipated monetary policy in the livestock markets is that the output prices are freely flexible, whereas the input prices are not freely flexible. This is because the U.S. government does not intervene in the livestock markets, but it does intervene in the input (feed grains and wheat) markets to stabilize the prices, which limit the movements of these input prices.

The implications of the results are that the individual agricultural commodity markets, such as the livestock markets, grains markets, and vegetable markets, are subject to differential impacts of the systematic and unsystematic monetary policies because of the varying degree of price flexibilities in these markets. As a result, money supply shocks are likely to have favorable impacts on some commodity markets and unfavorable impacts on other commodity markets. The policy makers should be aware of these differential impacts and should study the developments taking place in the monetary policies in formulating the commodity price support polices. This is particularly important in view of the increased integration between the agricultural and non-agricultural sectors.

Endnotes

1. Other assumptions used in these models are marketing clearing and information asymmetrics.

2. Other studies which tested the neutrality proposition are Small (1979) and Leiderman (1980).

3. Also see Kretzmer (1989) for disaggregate testing of the monetary neutrality proposition.

4. In addition to these special characteristics, livestock markets are the only markets in the agricultural sector where quarterly data is available. For other markets in the agricultural sector, quarterly data is not available because of the annual nature of the production process. In the macroeconomics literature there has been a considerable amount of work which criticizes studies that use annual data to test the MRE hypothesis. The major criticism, among others, is that it is not appropriate to use annual data to forecast the anticipated money supply growth because the annual time interval is too long. Agents are concerned with short-term (monthly or quarterly) money supply growth, and they use information that are readily available on a daily basis to predict the short-term money supply growth. Also, annual data seems to preclude the possibility of estimating the impacts of money supply shocks on the size and duration of the adjustment path of a real variable. These criticisms rule out the possibilities of testing the MRE hypothesis on crop markets such as corn, wheat, and soybeans because of the annual nature of production. Thus, it is important to consider quarterly data to test the MRE hypothesis. As already noted, livestock markets, in addition to having the special characteristics of differing price flexibilities, are the only markets in the agricultural sector where quarterly production data is available, and thus these markets are chosen for this study.

5. Bordo (1980) and Bessler (1984) analyzed the impacts of money supply changes on sectoral prices with differing degrees of flexibility.

6. The problem of the nonstationarity in the levels of output variables is overcome by using the growth rates of output (see Nelson and Plosser, 1982).

7. Slope coefficients of lagged money growth terms at 1975:1 and 1979:4 were not significant.

8. The unemployment rate is significant in the money forecast equation estimated by Barro (1978); and Barro and Rush. However, their money forecast equation does not include interest rates. In the money forecast estimation in this study, the unemployment rate is no longer significant at the 5% level when the interest rate is included as an information source.

9. Models with 16 and 20 quarters of the anticipated and unanticipated money supply growths were also estimated. However, the estimated coefficients after twelve quarters were not significant, and thus the results of these models are not reported.

10. Estimated output equations with eight quarters of the anticipated and the unanticipated money supply growths, and estimated models for each market with only the unanticipated money supply growth as regressors are available from the author upon request.

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