Price Inertia: Money Supply and Price Changes

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I. INTRODUCTION

A modern economy is comprised of markets with different degree of price flexibilities. For instance, Phelps and Taylor (1977) identify long-term contracts as a cause of nominal price rigidities (also see Fischer, 1977 for wage rigidities). Gordon (1982) elaborates that adjustment costs and decentralisation of decision making can cause prices to be sticky. Devadoss and Choi (1991) and Wright (1985) documents that the U.S. agricultural programs' price-fixing policies such as price support and storage schemes impart sluggishness to commodity prices. Furthermore, regulated and administered prices for such items as postal charges, public transportation, and telephone charges can cause the prices in these markets to be relatively rigid (Dexter et al. 1993). In contrast, in markets where prices are freely determined (e.g. precious metal and food markets), the prices tend to be very flexible. Thus, in a modern economy, prices in some markets are more flexible than the aggregate price, while prices in other markets are less flexible than the aggregate price. This fact is highlighted by Figures 1 and 2.

Figure 1 plots the percentage changes of aggregate CPI and fruits and vegetable prices from 1969.II to 1991.III. It is clear from this plot, fruits and vegetable prices are not only more flexible than the aggregate price but also show frequent declines reflecting the effects of market forces and economic conditions. Figure 2 presents a plot of the percentage changes of aggregate CPI and postal prices. At a first glance, this figure may imply that postal prices are more flexible than the CPI. However, a closer examination of this figure reveals that during a period of about twenty three years from 1969.II to 1991.III, postal prices changed only about eight times. This is because the U.S. postal service is

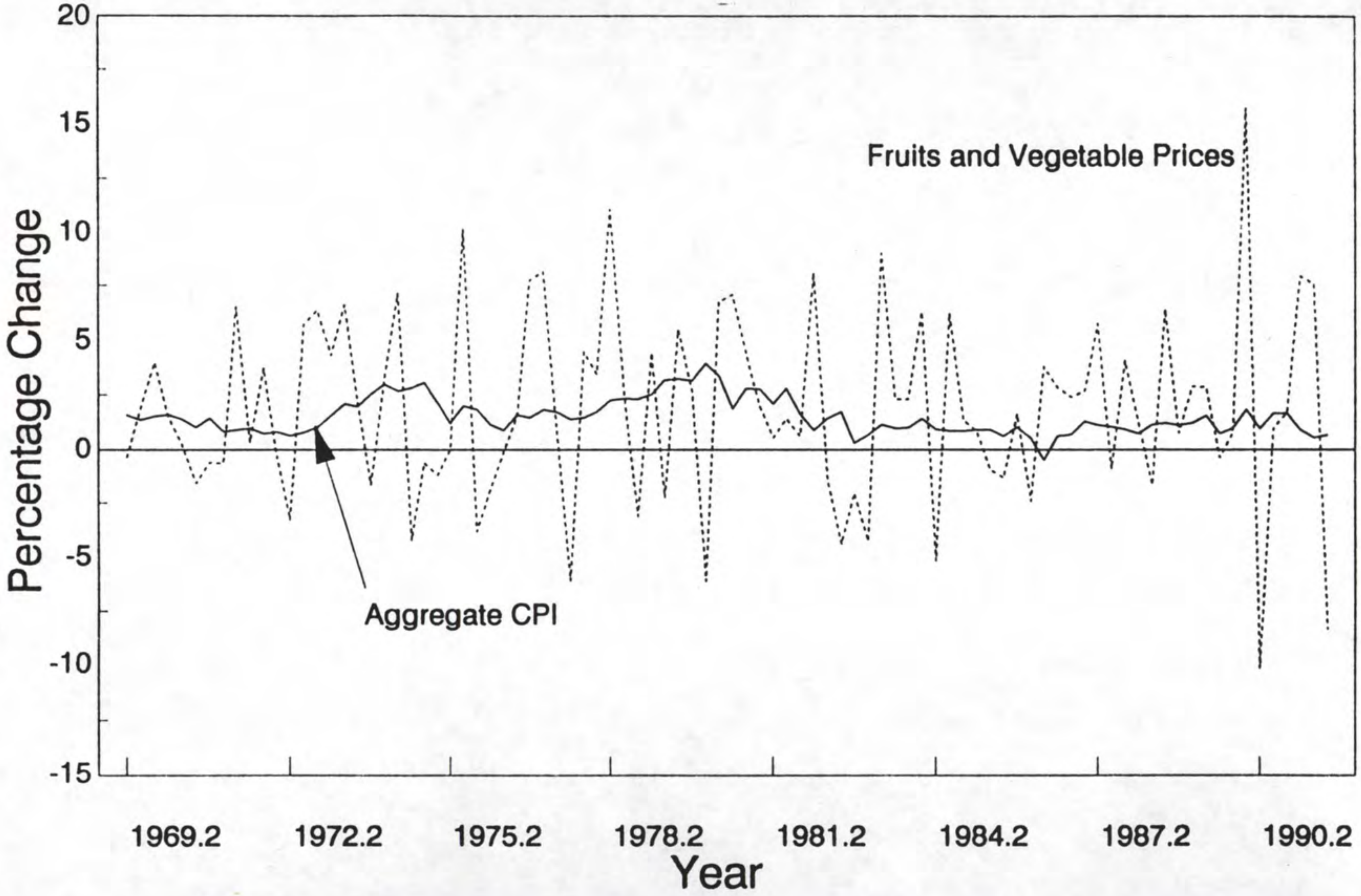

Figure 1. Plots of Aggregate CPI and Fruits and Vegetable Prices

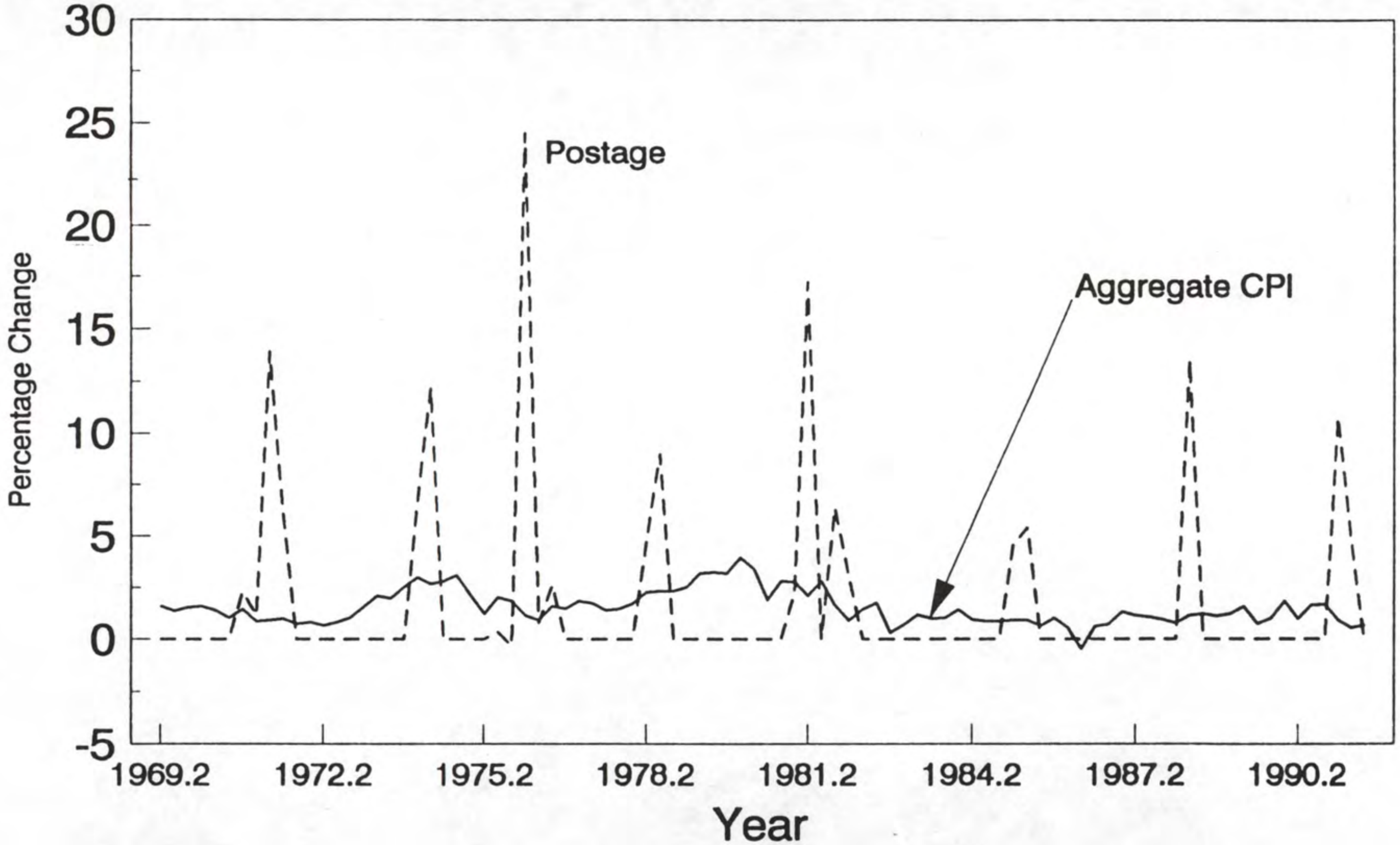

Figure 2. Plots of Aggregate CPI and Postage Prices

administered by the government and prices are regulated, and thus prevent the postal prices from adjusting to economic forces. Thus each spike in Figure 2 corresponds to a new administered price settings by the government. Furthermore, since they are administratively set, postal prices, unlike the fruits and vegetable prices, do not show any downward flexibility in response to market forces and economic conditions.

The key element of the study is the realisation that the economy is comprised of markets with differing degrees of price adjustments. Price stickiness is often cited for the real effects of monetary policy and for slow recovery of the economy from a recession. Because price inertia has such important implications for the new-Keynesian economics, it is important to study the speed of the response of the price levels to money supply.

The simple quantity theory of money asserts that, because the velocity of money and full-employment output are constants, if the money supply doubles, the price level must also double (Mishkin, p. 415, 1989). This view of the quantity theory of money is also supported by the policy ineffectiveness proposition pioneered by Lucas (1972) and Barro (1976). According to the policy ineffectiveness proposition, only the unanticipated money supply growths have impacts on real economic variables, and the anticipated money supply growths have no real impacts. One of the key assumptions essential to the validity of this proposition is the *perfect flexibility of prices.*[1] The corollary of the policy ineffectiveness proposition, as expounded by Gordon (1982) in invalidating this proposition, is that because output does not respond to anticipated money supply changes and remains at the natural level, the price level responds contemporaneously and proportionately to the anticipated changes in the money supply. This conclusion is also consistent with Barro's hypothesis that "perceived movements in the money stock ... imply equiproportionate, contemporaneous movements in the price level" (1978, pp. 565-66). This one-to-one relationship between the anticipated money supply and the price level has also been shown theoretically by Barro (1976) and Hercowitz (1981). It is this conclusion that needs to be tested by accounting for the *differing speed of adjustments of prices in various sectors.*

The purpose of this study is to explore theoretically and empirically the link between money supply and prices levels by examining the gradual price adjustment mechanism. More specifically, this study tests Barro's hypothesis of the one-to-one relationship between the log of current money stock and the log of price levels and analyses the effects of unanticipated money growths on prices. Five prices considered for the study are: fruits and vegetable prices, medical care prices, newspaper prices, postal prices, and the aggregate CPI. Fruits and vegetable and medical care prices are chosen because they are freely determined and thus are highly flexible. The study of medical care prices has added interest because of the U.S. government's proposal to curb the escalating health care costs. Newspaper and postal prices are chosen because they are administratively set on regular intervals and relatively rigid. The aggregate CPI is chosen because examination of the response of CPI to monetary policy will provide a basis for comparing responses of four market level prices.

In section II, a theoretical model is developed by incorporating price stickiness within a basic equilibrium model of the variety put forward by Barro (1976), and Hercowitz (1981) to show that the money stock has less than an equiproportionate effect on the price levels. This result is particularly appealing because the localised-market framework of the rational expectation model, which showed a one-to-one relationship between the anticipated money and the price levels, is used to invalidate this equiproportional link.

Section III presents the empirical model and reviews the various estimation approaches found in the literature in analysing the policy ineffectiveness proposition. The approach used in this study is the computationally intensive parametric bootstrap method developed most recently by Smith and McAleer's (1993). A brief description of the estimation procedure of this bootstrap method is also provided in this section. Section IV presents the estimated results of money forecasting equation and price equations. The money forecasting equation is estimated to decompose the actual money supply growths into systematic and unsystematic components. Then the five price equations are estimated. The empirical results are unfavorable to the hypothesis of a one-to-one relationship between current money stock and prices, rather they lend distinct support to conclusions of a sluggish price adjustment model that money stock has less than equiproportionate effect on prices. Empirical results also show that the effects of unanticipated money growths on prices vary across markets. The final section ends with brief concluding remarks.

II. THEORETICAL MODEL

The purpose of this section is to develop a theoretical model by incorporating price stickiness within a basic equilibrium model of the partial information-localised market framework of a rational expectation model to show that the perceived money supply has less than an equiproportionate effect on the aggregate price.

According to the partial-information rational expectations model of Hercowitz (1981), which is a modified version of the model developed by Barro (1976), the economy is comprised of numerous markets indexed by z. Agents in each market have full information about the relevant aggregate variables with a one-period lag, and current information on the local market price, $P_t(z)$. Market participants do not know the current prices in other markets. The key elements of this model are that individuals possess incomplete current information and make supply and demand decisions by responding to relative prices as they are locally perceived. Because of the lack of information, participants are not able to differentiate between the aggregate and market-specific shocks. As a result, individuals misinterpret unanticipated aggregate shocks that cause changes in relative prices as market-specific shocks and, in turn, respond by changing their demand and supply behavior to these shocks, which leads to real effects of unperceived aggregate shocks. However, anticipated money growth is perceived by agents in all markets as an economy-wide effect and results in a proportional change in prices. Consequently, anticipated money growth does not affect the relative prices and real economic variables.

The point of departure of this study is to incorporate sluggish price adjustments in this imperfect information model and demonstrate that the anticipated money growth has less than an equiproportionate effect on the aggregate price. Sluggish price adjustments in the model capture the various degree of price stickiness across markets.

Following Hercowitz (1981), the log-linear forms of supply and demand functions for commodity z are represented as:

$$y_t^s(z) = \alpha^s(z)[P_t(z) - EP_t] + \varepsilon_t^s(z), \qquad \alpha^s(z) > 0, \qquad (1)$$

$$y_t^d(z) = -\alpha^d(z)[P_t(z) - EP_t] + [M_t - EP_t] + \varepsilon_t^d(z), \qquad \alpha^d(z) > 0, \qquad (2)$$

The operator E denotes expectation conditional on all the available information in market z. P_t is the log of the economy-wide aggregate price and M_t is the log of money stock. The supply of commodity z, $y_t^s(z)$, depends on the perceived relative price in that market. The demand for commodity z, $y_t^d(z)$, depends on the perceived relative price and the aggregate shock, $M - EP_t$. The stochastic terms $\varepsilon_t^s(z)$ and $\varepsilon_t^d(z)$ capture relative supply and demand shifts, respectively. It is assumed that the excess demand shifter, $\varepsilon_t(z) \equiv \varepsilon_t^d(z) - \varepsilon_t^s(z)$, is independent and normally distributed with mean zero and variance σ_ε^2.

Prices in a market may move sluggishly because factors such as adjustment costs, sales contracts, price regulation, government price support policies, and decentralised planning can prevent prices from adjusting instantaneously. Various degrees of price flexibility or rigidity can be captured by the formula:

$$P_t(z) - P_{t-1}(z) = \gamma(z)[P_t^*(z) - P_{t-1}(z)], \qquad 0 < \gamma(z) \leq 1 \qquad (3)$$

where $P_t^*(z)$ is the market clearing price at which supply equals demand. The range of $\gamma(z)$ from zero to one implies that the degree of price flexibility varies across markets. Markets with $\gamma(z)$ values closer to zero have more rigid prices. On the other hand, markets with $\gamma(z)$ values closer to one have fairly flexible prices. Values of $\gamma(z)$ equal to one, of course, imply perfectly flexible prices. It should be pointed out that sluggish price adjustments are not incompatible with the rational expectation approach. As elucidated by Gordon (1982), economic agents realise the price inertia, and thus, take this into account, along with other relevant past information, in forming the expectations rationally.

To complete the model, the growth rate of money supply, comprising systematic and random components, is specified as:

$$M_t - M_{t-1} \equiv \Delta M_t \equiv m_t = g_t + u_t \tag{4}$$

where g_t and u_t are anticipated and unanticipated money growth at time t, respectively. Thus, g_t is the expected money supply growth based on all economy-wide information shared by agents in all markets. Consequently, g_t is the same in all markets. The random component, u_t, is taken to be generated by a temporally independent white noise process with mean zero and variance σ_u^2. However, the posterior expectation of unanticipated money supply depends on local market price, $P_t(z)$, and thus, it varies across markets.

Since $P_t^*(z)$ is defined as the market clearing price at which supply in (1) is equal to demand in (2), the solution for price $P_t^*(z)$, after substituting for M_t from equation (4), can be written as:

$$P_t^*(z) = [1 - \lambda(z)]EP_t + \lambda(z)[M_{t-1} + g_t + u_t + \varepsilon_t(z)] \tag{5}$$

where $\lambda(z) = \dfrac{1}{\alpha^s(z) + \alpha^d(z)}$. Inserting $P_t^*(z)$ into the price adjustment equation (3), we get

$$P_t(z) = (1 - \gamma(z))P_{t-1}(z) + \gamma(z)[1 - \lambda(z)]EP_t + \gamma(z)\lambda(z)[M_{t-1}+ g_t+ u_t+ \varepsilon_t(z)]. \tag{6}$$

This price equation is not a reduced-form equation since EP_t appears in it. Equation (6) is readily interpreted as follows: $P_t(z)$ is determined by a set of "demand-pull" variables that include the money supply and the excess demand shifter and a "cost-push" term, EP_t. The lagged price captures the effect of gradual price adjustment. Since participants know the prices of their commodities but not the prices in other markets, they form expectations about the economy-wide aggregate price based on $P_t(z)$ and other available information.

Next, price is determined as a function of exogenous variables by using the method of undetermined coefficients. By utilising the model's log linearity, a reduced-form solution for the aggregate price is conjectured as:

$$P_t = \Pi_1 P_{t-1} + \Pi_2 M_{t-1} + \Pi_3 g_t + \Pi_4 u_t \tag{7}$$

where the Πs are unknown parameters. The aggregate price is determined by its own lag and the current money supply, which, as in (4), consists of M_{t-1}, g_t, and u_t. The lagged aggregate price enters the P_t equation because the partial adjustment assumption entails that individual market price depends on its lag price (see equation (6)). Recognising that M_{t-1} and g_t are fully perceived at time t, whereas the posterior expectation of u_t is conditional on market-specific information, the expected aggregate price can be written as:

$$EP_t = \Pi_1 P_{t-1} + \Pi_2 M_{t-1} + \Pi_3 g_t + \Pi_4 Eu_t. \tag{8}$$

The key to the formation of the aggregate price expectations is the computation of Eu_t conditional on the market-specific information, $P_t(z)$. The conditional expectations of u_t are calculated, in effect, by linearly projecting u_t on $P_t(z)$. That is,

$$Eu_t|P_t(z) = [\frac{\sigma_u^2}{\sigma_u^2 + \sigma_\varepsilon^2}][u_t + \varepsilon_t(z)]. \tag{9}$$

Substituting (9) into (8), we find that

$$EP_t = \Pi_1 P_{t-1} + \Pi_2 M_{t-1} + \Pi_3 g_t + \Pi_4[\frac{\sigma_u^2}{\sigma_u^2 + \sigma_\varepsilon^2}][u_t + \varepsilon_t(z)]. \tag{10}$$

The expected aggregate price from (10) is plugged into the market-specific price in (6) to obtain

$$P_t(z) = [1-\gamma(z)]P_{t-1}(z) + \gamma(z)[1-\lambda(z)]\{\Pi_1 P_{t-1} + \Pi_2 M_{t-1} + \Pi_3 g_t + \Pi_4[\frac{\sigma_u^2}{\sigma_u^2 + \sigma_\varepsilon^2}][u_t + \varepsilon_t(z)]\} + \gamma(z)\lambda(z)[M_{t-1} + g_t + u_t + \varepsilon_t(z)]. \tag{11}$$

The general price is obtained by averaging $P_t(z)$ across all markets[2]:

$$P_t = [(1-\gamma)+\gamma(1-\lambda)\Pi_1]P_{t-1} + [\gamma(1-\lambda)\Pi_2 + \gamma\lambda]M_{t-1} + [\gamma(1-\lambda)\Pi_3 + \gamma\lambda]g_t + [\gamma(1-\lambda)\Pi_4 \frac{\sigma_u^2}{\sigma_u^2 + \sigma_\varepsilon^2} + \gamma\lambda]u_t. \tag{12}$$

Noting that equations (12) and (7) are equal, the four Π coefficients are determined by matching corresponding terms in the two equations. The resulting solution is

$$\Pi_1 = \frac{1-\gamma}{1+\lambda\gamma-\gamma}, \quad \Pi_2 = \frac{\lambda}{\lambda+\frac{1}{\gamma}-1}, \quad \Pi_3 = \frac{\lambda}{\lambda+\frac{1}{\gamma}-1}, \text{ and } \Pi_4 = \frac{\gamma(\sigma_u^2+\sigma_\varepsilon^2)}{[\gamma+\frac{1}{\lambda}(1-\gamma)]\sigma_u^2 + \frac{\sigma_\varepsilon^2}{\lambda}}. \tag{13}$$

These Π coefficients and M_{t-1} from equation (4) are substituted into (11) to obtain the market price $P_t(z)$ and into (7) or (12) to obtain the aggregate price P_t:

$$P_t(z) = [1-\gamma(z)]P_{t-1}(z) + \gamma(z)\frac{(1-\lambda(z))(1-\gamma)}{1+\lambda\gamma-\gamma}P_{t-1} + \gamma(z)\frac{[\lambda+\lambda(z)(\frac{1}{\gamma}-1)]}{\lambda+\frac{1}{\gamma}-1}M_t + \gamma(z)\frac{(\lambda(z)-1)\sigma_\varepsilon^2}{(\lambda+\frac{1}{\gamma}-1)\{[\gamma+\frac{1}{\lambda}(1-\gamma)]\sigma_u^2+\frac{\sigma_\varepsilon^2}{\lambda}\}}u_t + \gamma(z)\frac{[\gamma+\lambda(z)\frac{(1-\gamma)}{\lambda}]\sigma_u^2 + \frac{\lambda(z)}{\lambda}\sigma_\varepsilon^2}{[\gamma+\frac{1}{\lambda}(1-\gamma)]\sigma_u^2 + \frac{\sigma_\varepsilon^2}{\lambda}}\varepsilon_t(z). \tag{14}$$

$$P_t = \frac{1-\gamma}{1+\lambda\gamma-\gamma}P_{t-1} + \frac{\lambda}{\lambda+\frac{1}{\gamma}-1}M_t + \frac{\gamma(\lambda - 1)\sigma_\varepsilon^2)}{(\lambda+\frac{1}{\gamma}-1)\{[\gamma+\frac{1}{\lambda}(1-\gamma)]\sigma_u^2 + \frac{\sigma_\varepsilon^2}{\lambda}\}}u_t. \tag{15}$$

Important results in equation (14) and (15) can be readily interpreted. First, the coefficients of M_t are less than one. That is, when prices move sluggishly (i.e., $0 < \gamma(z) < 1$ and thus $0 < \gamma < 1$), they do not adjust instantaneously to the changes in M_t. Consequently, movements in M_t are not fully captured by $P_t(z)$ and P_t, and thus, the coefficients of M_t are less than one in both $P_t(z)$ and P_t equations.[3] This finding does not corroborate Barro's interpretation that "perceived movements in money ... have equiproportionate, contemporaneous effects on the price level" (1978, p. 559), and thus, the policy ineffectiveness proposition is invalidated.

Second, if prices are perfectly flexible, i.e., $\gamma(z)$ and γ are set to one, the coefficients in equations (14) and (15) will simplify. Particularly, the coefficients of M_t will become one; the lagged prices will drop out; and the ensuing result is

$$P_t(z) = M_t + \frac{(\lambda(z)-1)\sigma_\varepsilon^2}{\lambda\sigma_u^2 + \frac{\sigma_\varepsilon^2}{\lambda}}u_t + \frac{\sigma_u^2 + \frac{\lambda(z)}{\lambda}\sigma_\varepsilon^2}{\sigma_u^2 + \frac{\sigma_\varepsilon^2}{\lambda}}\varepsilon_t(z). \tag{16}$$

$$P_t = M_t + \frac{(\lambda-1)\sigma_\varepsilon^2}{\lambda\sigma_u^2 + \frac{\sigma_\varepsilon^2}{\lambda}}u_t. \tag{17}$$

In this case, market prices and the aggregate price will change equiproportionately in response to the current money stock changes. However, if prices are imperfectly flexible, they will not respond proportionately to money stock changes as captured in equations (14) and (15).

Third, the response of individual market price to changes in current money stock and unperceived money growths depends on, in addition to $\gamma(z)$, the elasticity of supply and demand (i.e., $\lambda(z)$) in that market. Specifically, the unanticipated money growth can have negative (positive) effects on market prices if $\lambda(z) < (>) 1$, i.e., elastic (inelastic) supply and demand. This can be seen by examining the numerator of the coefficient of u_t in equation (14), which is negative for $\lambda(z) < 1$ and the denominator is always positive. Similarly, the response of aggregate price to changes in current money stock and unperceived money growth depends on, in addition to γ, the average elasticity of supply and demand across markets (i.e., λ).

Fourth, since the market price adjustment assumption in equation (3) implies that $P_t(z)$ is a weighted average of lag price $P_{t-1}(z)$ and market clearing price $P_t^*(z)$ with weights equal to $(1-\gamma(z))$ and $\gamma(z)$, respectively, $P_{t-1}(z)$ enters the $P_t(z)$ equation (14) with the coefficient of $(1-\gamma(z))$, and the rest of the arguments have the weight $\gamma(z)$. Thus, $(1-\gamma(z))$ captures the effect of the price inertia in the market z, and $\gamma(z)$ reflects the contribution of market forces in determining the price in z. $P_t(z)$ also depends on aggregate lag price that reflects the effects of price sluggishness in other markets. Since the individual market price depends on its lag price, so does the aggregate price (equation (15)).

III. EMPIRICAL ANALYSIS

The framework used in the empirical analysis involves estimation of a policy forecasting or expectation equation (also known as feedback rules) and reduced-form equations. In this study, the forecasting equation is the money growth equation, and the reduced-form equations are the price equations. The specification used to forecast the money growth is represented by the following equation:

$$MG_t = Z_{t-1}\phi + u_t \tag{18}$$

where MG_t is the actual money growth in t, Z_{t-1} is the vector of observable economic variables relevant to forecasting MG_t, ϕ is the corresponding coefficient vector, and u_t is the disturbance term assumed to be generated by a temporally independent white noise and thus uncorrelated with independent variables. The policy forecasting equation is used to identify the predictable and random portions of the actual money growth. The predicted values represent the anticipated policy measures and the residuals, the unanticipated measures. Thus, the anticipated money growth denoted as MG_t^a is equal to $Z_{t-1}\phi$, and the unanticipated money growth, MG_t^u,is equal to $MG_t - Z_{t-1}\phi = u_t$.

The price equations are estimated as a function of unanticipated money growths, and other pertinent variables that influence prices:

$$P_t(z) = b + \sum_{i=0}^{n} \beta_i MG_{t-i}^u + \psi_1 MS_t + \psi_2 P_{t-1}(z) + \psi_3 P_{t-1} + \epsilon_t(z) \tag{19}$$

where $P_t(z)$ is the log of prices in market z (fruits and vegetable, medical care, newspaper, and postal prices), MS_t is the log of the money stock, P_t is the aggregate price, $\epsilon(z)$ is the error term, and n is the number of lags. This empirical equation corresponds to market-level price equation (14) in section II. The empirical equation corresponding to the aggregate price equation (15) is

$$P_t = c + \sum_{i=0}^{n} \delta_i MG_{t-i}^u + \theta_1 MS_t + \theta_2 P_{t-1} + \xi_t \tag{20}$$

The estimation approach used in the pioneer work of Barro (1978) is a two-step ordinary least squares (2SOLS). In the first step of the 2SOLS, the expectation equation is estimated. In the second step, the predicted and residual values from the expectation equation are used, respectively, as the perceived and unperceived policy variable in the estimation of price equations. Therefore, in the second step, the price equation is estimated using the "generated regressors" from the expectation equation. Since its introduction by Barro, the 2SOLS approach has been criticised on a number of grounds by various researchers. Smith and McAleer (1993) provide a thorough and extensive coverage of past studies which dealt with the estimation problems of the generated regressor models. In particular, Figure 1 on page 351 of their study gives an excellent summary of all the relevant work. In the interest of brevity, however, only a few of these studies are reviewed here.

Mishkin (1982) noted that the 2SOLS ignores possible covariances between the parameters across the policy forecasting and price equations. Thus, if covariances between the parameters across equations are nonzero, the 2SOLS estimates are not efficient and also the test statistics are invalid. To remedy this problem, he developed a full information maximum likelihood (FIML) procedure in which the forecasting and price equations are simultaneously estimated using a joint nonlinear estimation. However, the problems with the 2SOLS approach in the presence of generated regressor variables go beyond the efficiency loss addressed by Mishkin. The 2SOLS does not correct for the nonspherical nature of the disturbance and as a result, the estimates of the covariance matrix of the coefficients ignore the approximation infused by the presence of generated errors.

Pagan (1984) examined the econometric problems with the Barro's 2SOLS and concluded that 2SOLS estimates of standard errors are incorrect and it is biased against acceptance of the policy ineffectiveness proposition. Thus, a correct computation of standard errors will not reverse Barro's conclusions. However, Pagan (1984) expounds that the presence of lagged dependent variable in the forecasting equation will make the coefficient estimates of the lagged unanticipated variables and other variables in the price equation inefficient. The procedure developed by Pagan is identified in the literature as 2SOLS with correct standard errors.

Hoffman et al. (1984) experimented with Monte Carlo simulations to test the performance of three procedures: a) 2SOLS, b) 2SOLS with correct standard errors, and c) FIML. In these experiments, the 2SOLS with correct standard errors and FIML procedures performed well, although the FIML procedure favored overrejection of the true null hypothesis. Hoffman (1987) proposed a generalised least square (GLS) method which incorporates the appropriate covariance matrix of the errors and accounts for the nonspherical nature of the disturbance in estimating the reduced-form equation.

The most recent development in solving the econometric problems of the generated regressor models is an excellent work by Smith and McAleer (1993) published in this journal (also see Smith and McAleer, 1990). By addressing the problems with the previous empirical procedures, they developed a parametric bootstrap method to compute correct standard error estimates. Smith and McAleer (1993, p. 350) note that the bootstrap method "is a very useful computer-intensive method for obtaining estimates of standard errors in situations where it is computationally difficult to calculate the correct standard errors, or when the analytical expressions are intractable." They developed two novel variants of parametric bootstrap method, namely, two-step bootstrap and system bootstrap. The system bootstrap is preferred over the two-step bootstrap because the former requires fewer number of replications and allows contemporaneous covariance between the residuals from the forecasting and reduced-form equations. The presence of lagged money growths in the expectation equation necessitates bootstrapping of these lagged variables along with current money growths, which calls for a dynamic bootstrap. In what follows, a brief description of the various steps involved in the dynamic system bootstrap method is provided.

In the bootstrap method, as in 2SOLS, the expectation equation is estimated and the residual (predicted) series from this equation is used as the unanticipated (anticipated) money supply growths in the estimation of price equations. Then, the estimated residuals from the money growth and price equations are used to generate an empirical distribution of residuals by random sampling with replacement. Using the money growth residuals from this random sampling and the parameter estimates in the first step of the 2SOLS, new current and lagged values of money growths are generated. Similarly, using the money growth and price residuals from the random sampling and the parameter estimates in the second step of the 2SOLS a new price series is generated. With the new values for the current and lagged money growths, the expectation equation is reestimated, and a new series of residuals (unanticipated money growths) is generated. With these unanticipated money growths and the new price series, the price equation is reestimated to obtain the parameter and standard error estimates. This bootstrapping is replicated 1000 times to obtain more accurate estimates.

IV. EMPIRICAL RESULTS

This section presents the estimated results of feedback rules for the money growth equation and price equations which are estimated using the dynamic system bootstrap method.

Monetary Policy Forecasting Equation

The approach used to specify the feedback rules employs the Granger causality tests in conjunction with Theil's (minimum standard error) criterion to choose the appropriate explanatory variables and correct lag length for these variables. Since an appropriate feedback rule should be based on all the available information, the money supply growth was regressed on its own past values and other pertinent monetary policy response macro variables which are readily available to the public for predicting future policy actions. These macro variables include: the real gross national product (GNP), nominal GNP, three-month treasury bill rate, inflation rate, unemployment rate, fiscal policy measure, exchange rate, and the balance of payments on current accounts.

The first step in the estimation of the feedback equation is to specify an appropriate lag length. Because monetary policies are formulated based on the performance of the macroeconomic variables in the immediate preceding quarters, four to eight lags were considered for each of these variables. Furthermore, we considered a common lag length for all the explanatory variables. Based on Theil's $\bar{R}^2$ criterion, a lag length of seven yielded the highest $\bar{R}^2$. The choice of a common lag length prevents the researchers from searching for alternative specifications that would produce results confirming any a priori belief. Following Mishkin (1982), we used multivariate Granger tests to determine the significance of these variables in the money supply forecast equation. An F-test, under the null hypothesis that seven coefficients of the individual policy response variables are jointly zero, was carried out. On the basis of this criterion, the money growth (MG) equation is specified as a function of the lagged money growths, fiscal policy measure (FP), real GNP, unemployment rate (UN), and the change in the three-month treasury bill rate (TBR). The fiscal policy measure is generated by deflating the change in the real middle-expansion trend *budget surplus* with potential GNP.[4,5] This measure of fiscal policy is independent of the particular position of the business cycle, and thus, is abstracted from the automatic stabilising feature of the fiscal policy (Laumas and McMillin, 1984).

Quarterly data covering the period 1948:4 to 1991:3 are used for estimating the forecasting equation. Data for government expenditure, revenues, and real GNP are collected from the National Income and Product Accounts of the United States and various issues of the Survey of the Current Business published by the U.S. Department of Commerce. The data for money supply and the three-month treasury bill rate are obtained from the St. Louis Federal Reserve Bank. The unemployment rate is collected from the International Financial Statistics. The CPI prices for fruits and vegetables, medical care, newspaper, and postage were obtained from the U.S. Department of Labour, Bureau of Labour Statistics' electronic data base.

Table 1 reports the OLS estimates of the money supply growth equation with t-statistics and F-statistics with the significance levels. The F-statistics test the explanatory power of the seven lagged values of each variable in predicting the money supply growth. The computed F-statistics indicate that lagged money growths, fiscal policy, unemployment rate, and interest rates are highly significant and real GNP is marginally significant. Thus, these variables play important roles in predicting the money supply growth. The Durbin-Watson statistic of 1.998 indicates no evidence of serial correlation. The lagged values of the money supply growth capture the persistence effects not explained by other independent

Regressors	Estimates	t-statistics	F-statistics	Significant Level
Constant	-0.063	-0.31		
MG_{t-1}	0.517	5.93		
MG_{t-2}	0.260	2.69		
MG_{t-3}	-0.112	-1.17		
MG_{t-4}	0.215	2.23	20.886	0.00
MG_{t-5}	-0.074	-0.73		
MG_{t-6}	0.024	0.25		
MG_{t-7}	-0.070	-0.83		
FP_{t-1}	-0.129	-2.84		
FP_{t-2}	0.089	1.89		
FP_{t-3}	0.084	1.81		
FP_{t-4}	-0.051	-1.16	2.650	0.01
FP_{t-5}	0.043	1.00		
FP_{t-6}	0.042	1.00		
FP_{t-7}	-0.021	-0.53		
$RGNP_{t-1}$	-0.019	-1.91		
$RGNP_{t-2}$	-0.008	-0.61		
$RGNP_{t-3}$	-0.008	-0.53		
$RGNP_{t-4}$	0.013	0.87	1.881	0.07
$RGNP_{t-5}$	0.028	1.88		
$RGNP_{t-6}$	0.017	1.34		
$RGNP_{t-7}$	0.017	1.78		
UN_{t-1}	-0.485	-2.81		
UN_{t-2}	0.946	3.04		
UN_{t-3}	-0.277	-0.80		
UN_{t-4}	0.039	0.12	3.049	0.00
UN_{t-5}	-0.346	-1.13		
UN_{t-6}	0.156	0.65		
UN_{t-7}	0.029	0.26		
TBR_{t-1}	-0.643	-8.25		
TBR_{t-2}	0.078	0.76		
TBR_{t-3}	0.174	1.62		
TBR_{t-4}	-0.188	-1.70	13.089	0.00
TBR_{t-5}	0.244	2.16		
TBR_{t-6}	-0.043	-0.39		
TBR_{t-7}	-0.063	-0.69		
$R/\bar{R}^2$	0.736/0.668			
DW	1.998			
S.E.	0.566			

Notes: MG_t = M1 money supply growth, FP_t = change in the real middle-expansion trend budget deficit relative to potential GNP, $RGNP_t$ = real gross national product, UN_t = unemployment rate, and TBR_t = change in three-month Treasury bill rate. The approximate critical values of t-statistics are 1.645 at the 10%, 1.960 at the 5%, and 2.576 at the 1% levels. The F-statistics test the null hypothesis that the coefficients on the seven lagged values of each of the explanatory variables are equal to zero. The degrees of freedom of F-statistics are 7 and 136, and variables. The interactions between government expenditures and money supply growth are evident from the fact that the lagged values of the fiscal policy are significant in predicting the money supply growth. The Federal Reserve Bank's contractionary/expansionary monetary policies in response to economic booms/slumps are captured by the lagged values of real GNP growths. The coefficients of the lagged unemployment rate reflect the counter cyclical response of monetary policy to the unemployment rate. The treasury bill rate captures the policy changes pursued by the government in response to interest rate changes.

Price Equations

This subsection analyses the effects of money stock and unanticipated money growths on fruits and vegetables, public transportation, medical care, newspaper, and postage prices and the aggregate CPI. These prices are selected because they cover the wide spectrum of price flexibilities -- from highly flexible fruits and vegetable and medical care prices to very rigid newspaper and postal prices. Dexter et al. (1993) also note that food prices are flexible because they are freely determined, and on the other hand, postal prices are sticky because they are regulated. The aggregate CPI is selected for a benchmark comparison of monetary effects on other prices vis-a-vis on CPI.

The residuals from the estimated feedback rule equation are used as the unanticipated money growths in the price equations. Firstly, price equations are estimated with unanticipated money growths as only explanatory variables. Secondly, price equations are estimated with unanticipated money growths plus current money stocks, lagged own market price and lagged aggregate price as explanatory variables as shown in equation (19). The aggregate price equation (20), in accordance with the theoretical specification of equation

(15) does not include lagged market prices. An issue of disagreement in policy ineffectiveness studies is the appropriate number of lags of unanticipated money growths, i.e., the values of n in equations (19) and (20). Mishkin (1982) examined short and long lag models and concluded policy ineffectiveness results differ across lag specifications. For instance, Mishkin opts (1982) for a longer lag by noting that exclusion of relevant variables will result in invalid test statistics; in contrast, inclusion of irrelevant variables will at worst only decrease the power of tests and expound rejections even more telling, but will not yield incorrect test statistics. In light of this suggestion, we estimate the model with a lag length of 12.

Table 2 presents the dynamic system bootstrap estimates of price equations with unanticipated money growths as the only explanatory variables.[6] Barro (1978, pp.559-560 and p.564) concluded that the current and lagged values of the unanticipated money growth have negative effects on the price level. Barro included only five lags of unanticipated money growth in the estimation of the price equation in obtaining this result. However, we use a longer lag length of 12 as suggested by Mishkin (1982).

The estimated coefficients of unanticipated money growths are positive for fruits and vegetable prices, medical care prices, and aggregate prices. The sum of unanticipated money coefficients are also positive and significant in these equations. On the other hand, in the newspapers and postage price equations some of the estimates of the unanticipated money growth coefficients are negative and the sums of these estimates are negative and insignificant. Thus, empirical results show that the unanticipated money growths have short-run positive impacts on fairly flexible prices (fruits and vegetable and medical care prices)

Table 2. Estimates of Price Equations with Unanticipated Money Growths as Regressors.

Regressors	Fruits & Vegetable Prices	Medical Care Prices	Newspaper Prices	Postage Prices	Aggregate CPI
Intercept	3.905(0.062)	3.770(0.070)	4.494(0.041)	4.487(0.040)	3.908(0.056)
MG^u_t	0.062(0.102)	0.076(0.122)	-0.033(0.120)	-0.021(0.112)	0.055(0.092)
MG^u_{t-1}	0.076(0.119)	0.090(0.140)	-0.009(0.133)	-0.002(0.122)	0.055(0.107)
MG^u_{t-2}	0.080(0.114)	0.080(0.138)	0.003(0.128)	0.017(0.126)	0.058(0.104)
MG^u_{t-3}	0.081(0.113)	0.084(0.142)	0.005(0.123)	0.026(0.122)	0.060(0.102)
MG^u_{t-4}	0.079(0.116)	0.083(0.137)	-0.014(0.134)	-0.024(0.130)	0.066(0.104)
MG^u_{t-5}	0.083(0.114)	0.088(0.146)	-0.015(0.127)	-0.026(0.130)	0.065(0.107)
MG^u_{t-6}	0.071(0.117)	0.072(0.140)	0.001(0.129)	-0.002(0.125)	0.062(0.104)
MG^u_{t-7}	0.060(0.118)	0.062(0.134)	0.013(0.134)	0.012(0.124)	0.048(0.110)
MG^u_{t-8}	0.040(0.113)	0.045(0.146)	0.009(0.133)	-0.009(0.126)	0.045(0.111)
MG^u_{t-9}	0.037(0.120)	0.046(0.139)	-0.028(0.130)	-0.037(0.124)	0.042(0.104)
MG^u_{t-10}	0.057(0.117)	0.055(0.135)	-0.008(0.126)	-0.007(0.124)	0.054(0.103)
MG^u_{t-11}	0.062(0.119)	0.058(0.137)	0.022(0.131)	0.016(0.120)	0.052(0.107)
MG^u_{t-12}	0.054(0.115)	0.073(0.137)	0.012(0.124)	-0.008(0.124)	0.062(0.108)
Coef. Sum	0.841(0.426)	0.912(0.495)	-0.043(0.531)	-0.063(0.504)	0.723(0.377)

Notes: Price equations are estimated using the dynamic system bootstrap method.

and negative effects on relatively rigid prices (newspaper and postage prices). The positive effects of unanticipated money growth on flexible-price markets, which are characterised by inelastic supply and demand, are consistent with the theoretical results of partial-information rational expectation model. According to this model, the unanticipated money supply growth is misinterpreted as a market-specific shock because market participants with imperfect information cannot distinguish between aggregate and market-specific shocks. As a result, the unanticipated money growth interferes with market signals, and participants in these markets perceive changes in prices in the short run.

On the other hand, if market prices are sticky, the unanticipated money growth may not have significant effects. As elaborated previously, newspaper and postage prices are rigid. Newspaper prices are changed only infrequently because frequent changes of prices will cause dissatisfaction among customers and may result in loss of customers. Also for easy transactions, newspaper prices are set at a round figure such as 50 cents. Thus, newspaper publishers are cautious of frequent price changes and adhere to a set price for a period of time.

The postage prices are adjusted even more infrequently because of government regulation. For instance, to increase the postage the postal department has to obtain the approval of the U.S. Congress. The U.S. postal service is also subsidised by the government and it can withstand modest cost increases resulting from inflation. Furthermore, frequent price changes may lead to revenue loss because of the unsold stamps left over from the previous printings. Also, frequent price changes may bring grumbling from consumers. Because of these factors, postal prices are changed approximately once every three years or so as illustrated in Figure 2. Since the newspaper and postage prices are fairly rigid, they do not respond to unanticipated money growths. Another feature of these prices is that they are almost always changed only upwards. Thus, during a period of money supply decrease, for example to curb inflation, these prices are not adjusted downwards. Thus, the unanticipated money growths have insignificant and negative effects on these prices.

Table 3 presents the estimated results of the price equations with the inclusion of current money stock, lagged market prices, and lagged aggregate price, in addition to the unanticipated money growths, as regressors. The policy ineffectiveness proposition predicts a coefficient of one for the log of the money stock in the price equations as elucidated in Barro (1978, p.559 and p.562). In contrast, the sluggish price adjustment model predicts that the effect of the log of the money stock will be less than one (refer to equations (14) and (15)). The estimated coefficient of the log of the money stock ranges from a low of 0.145 for postal prices to a high of 0.563 for medical care prices. The estimated coefficient of the log of money stock of 0.836 in the aggregated price equation, though close to one, is statistically less than one as evident from the standard error of 0.012. This result does not lend support to Barro's conclusion that there is a one-to-one effect of the log of the money stock on the log of the price. Thus, these empirical results do not confirm the conclusions of the policy ineffectiveness proposition, rather they provide strong evidence to the theoretical results of the sluggish price adjustment model. The relatively longer magnitude for the coefficient of log of money stock in the aggregate price equation compared to those for the market price equations corroborate the conclusions of Blinder and Mankiw (1984). They note that varying degrees of price rigidities can cause the effect of monetary policy at the

Table 3. Estimtes of Price Equations with Unanticipated Money Growths, Current Money Stock, and Lagged Prices as Regressors.

Regressors	Fruits & Vegetable Prices	Medical Care Prices	Newspaper Prices	Postage Prices	Aggregate CPI
Intercept	-1.055(0.066)	-1.871(0.044)	-0.093(0.078)	0.579(0.172)	-1.007(0.045)
MS_t	0.481(0.045)	0.563(0.028)	0.259(0.029)	0.145(0.081)	0.836(0.012)
$P_{t-1}(z)$	0.020(0.013)	0.046(0.005)	-0.005(0.003)	-0.007(0.012)	--
P_{t-1}	0.565(0.050)	0.602(0.032)	0.676(0.048)	0.687(0.126)	0.067(0.007)
MG^u_t	-0.000(0.009)	0.000(0.007)	-0.006(0.008)	-0.008(0.019)	0.000(0.012)
MG^u_{t-1}	0.009(0.009)	0.000(0.007)	-0 005(0.008)	-0.005(0.022)	0.002(0.012)
MG^u_{t-2}	0.007(0.009)	0.002(0.007)	-0.001(0.008)	0.010(0.023)	0.002(0.012)
MG^u_{t-3}	0.000(0.010)	0.002(0.007)	0.001(0.009)	0.009(0.022)	0.003(0.012)
MG^u_{t-4}	0.003(0.010)	0.001(0.007)	-0.005(0.009)	-0.028(0.025)	0.002(0.012)
MG^u_{t-5}	0.006(0.010)	0.001(0.007)	-0.002(0.009)	-0.001(0.026)	0.001(0.013)
MG^u_{t-6}	0.003(0.011)	0.001(0.007)	0.002(0.009)	-0.003(0.026)	0.002(0.013)
MG^u_{t-7}	-0.003(0.010)	0.002(0.007)	0.005(0.009)	0.023(0.026)	0.001(0.013)
MG^u_{t-8}	-0.003(0.010)	0.002(0.007)	0.001(0.009)	-0.007(0.025)	0.002(0.013)
MG^u_{t-9}	-0.006(0.010)	0.001(0.007)	-0.002(0.008)	-0.004(0.025)	0.001(0.013)
MG^u_{t-10}	-0.000(0.011)	0.000(0.007)	0.000(0.008)	-0.002(0.023)	0.001(0.013)
MG^u_{t-11}	0.008(0.010)	0.001(0.007)	0.002(0.008)	-0.003(0.021)	0.000(0.014)
MG^u_{t-12}	-0.004(0.010)	0.001(0.006)	0.000(0.007)	-0.007(0.021)	0.000(0.014)
Coef. Sum	0.020(0.345)	0.0153(0.023)	-0.011(0.035)	-0.047(0.107)	0.017(0.050)

Notes: Price equations are estimated using the specifications in equations (19) and (20) and the dynamic system bootstrap method.

aggregate level to net out the differing impacts at the market level.

The coefficients of unanticipated money growths are all positive in the medical care price equation and mostly positive in the fruits and vegetable price equation. Thus, the sums of the coefficients are also positive in these equations. However, similar to the results in Table 2, most of the unanticipated money growth coefficient estimates in the newspaper and postal price equations are negative and thus the sums are also negative. It should be noted that these estimates are not as significant as those in Table 2 because of the presence of lagged market prices and the aggregate price. The aggregate price equation is significant in all the equations, which capture the effects of price flexibility/sluggishness in other markets.

The price equations were also estimated by including *anticipated* money growths, in addition to unanticipated money growths, as explanatory variables. The results of these estimations, which are not presented here in the interest of brevity, indicate that the estimated coefficients of anticipated money growths are significant in the flexible price equations, implying that these prices do respond to changes in perceived money growths. Furthermore, this result reject Barro's hypothesis (p. 565) that the anticipated money growths are irrelevant to the determination of prices, and lead to a conclusion that the anticipated monetary policy do matter in effecting prices if prices are flexible. Only in sticky-price markets, do anticipated money growths have insignificant effects on the prices.

IV. CONCLUSIONS

Differing assumptions regarding price level adjustments to macroeconomic policy changes contribute to some of the long standing disputes between monetarists and Keynesians. Monetarists believe that the economy is comprised of markets with perfectly flexible prices. On the contrary, the Keynesian economy is characterised by nominal rigidities. Perfect flexibility or stickiness of prices has important implications for the conduct of monetary policy. Numerous theoretical studies (Fischer, 1977; Phelps and Taylor, 1977; Blinder and Mankiw, 1984; and Gordon, 1982) have shown that nominal rigidities provide a role for the aggregate demand policies to influence the real economic variables. Many empirical studies (Gordon, 1982; Mishkin, 1982; and Laumas and McMillin, 1984) have also provided evidence that the anticipated aggregate demand policies have real effects.

The current study highlights the less than perfect link between the money supply and prices when prices are sticky or adjust sluggishly. More specifically, this paper develops a theoretical model using the partial information-localised market framework of rational expectation models to show that if nominal prices adjust sluggishly, the money stock will have a less than equiproportionate effect on aggregate price and the effects of unanticipated monetary policy on prices vary depending on the degree of price flexibility in these markets. The empirical analysis uses the parametric bootstrap method recently developed by Smith and McAleer (1993). The bootstrap method is computationally intensive and very useful for obtaining correct standard error estimates. The empirical evidence provides distinct support to the theoretical findings of the sluggish price adjustment model and rejects the conclusions of the policy ineffectiveness proposition. In particular, the coefficient of the log of the money stock is significantly less than one, ranging from a low of 0.145 for postal prices to a high of 0.563 for medical care prices. The unanticipated monetary policy has significant short-run positive impacts on flexible prices and on the aggregate price and insignificant and negative effects on sticky prices.

The policy implications are that the monetary policies can and do affect the price level. However, the extent to which the monetary policies can influence the price depends on the price inertia in various markets. For the monetary authority to effectively control inflation, they need to have a good understanding of price adjustment mechanisms in various markets. This understanding is also crucial if the monetary authority wants to stabilise real economic variables such as real GNP and unemployment. Price sluggishness in various markets and the lack of understanding of the price adjustments by policy makers can explain why the economy recovers slowly from recession, and why counter-active policies are often ineffective in curing recession.

ENDNOTES

1. Other assumptions crucial to the policy ineffectiveness proposition are rational expectations, market clearing, and information asymmetries.

2. The averages of $\gamma(z)$ and $\lambda(z)$ are denoted by γ and λ, respectively. The average of $\varepsilon_t(z)$ is zero.

3. To show that the coefficient of M_t is less than one in the $P_t(z)$ equation, we need to assume $\gamma(z) = \gamma$ and $\lambda(z) = \lambda$.

4. Data for the real middle-expansion budget surplus was calculated by deflating the difference between the nominal receipts and expenditures by the GNP deflator. The potential GNP was generated from the predicted values from the regression of the log of real GNP on a constant and a time trend with first-order autocorrelation correction.

5. This definition of fiscal policy measure was introduced by Dornbusch and Fischer (1981) in their popular macroeconomic text and also employed by Laumas and McMillin (1984).

6. Fruits and vegetable, medical care, and the aggregate price equations are estimated over the period 1951.1 to 1991.3. Since the data for the newspaper and postal price equations start only from 1969.1, these two price equations are estimated over the period 19569.1 to 1991.3.

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