



EUROPEAN CENTRAL BANK

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**COMMODITY PRICES,
MONEY AND INFLATION**

by Frank Browne
and David Cronin



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CONTENTS

Abstract	4
Non-technical summary	5
1. Introduction	7
2. A model of the relationship between consumer prices, commodity prices and money	9
2.1 Basic propositions and hypotheses	9
2.2 The price adjustment process	11
2.3 A simple model of price adjustment	11
3. Econometric evaluation of the model	13
3.1 Econometric approach	13
3.2 Data	15
3.3 Unit root properties of individual series	16
3.4 Econometric evaluation using the Johansen procedure	17
4. Conclusion	22
References	24
Appendix: Description and sources of data	25
Tables and figures	26
European Central Bank Working Paper Series	32

Abstract

The influence of commodity prices on consumer prices is usually seen as originating in commodity markets. We argue, however, that long run and short run relationships should exist between commodity prices, consumer prices and money and that the influence of commodity prices on consumer prices occurs through a money-driven overshooting of commodity prices being corrected over time. Using a cointegrating VAR framework and US data, our empirical findings are supportive of these relationships, with both commodity and consumer prices proportional to the money supply in the long run, commodity prices initially overshooting their new equilibrium values in response to a money supply shock, and the deviation of commodity prices from their equilibrium values having explanatory power for subsequent consumer price inflation.

JEL codes: E310; E510; E520

Key words: overshooting; VECM; impulse response analysis

Non-technical summary

Commodity prices have recently re-surfaced in discussions of the inflationary outlook for western economies. The popular view seems to be that changes in commodity prices are a consequence of developments occurring solely in commodity markets. There has, however, been a resurgent interest in recent years in the argument that monetary conditions account for changes in commodity prices. The implication for empirical work is that commodity prices' influence on consumer prices may not be captured adequately by mechanical pass-through effects from the commodity market to the final goods market and a richer, monetary-based characterisation and modelling of their relationship is required.

Our view is that the influence of commodity prices on consumer prices occurs through a money-driven overshooting of commodity prices being corrected over time. On the basis of an initial discussion and a simple illustrative model, we formulate the qualitative relationships that we would expect to emerge in empirical work. We distinguish between commodities, whose prices are flexible, on the one hand, and consumer goods, whose prices are sticky, on the other. With this characterisation, a simple model is used to show that a flexible commodity price overshoots its new long run equilibrium value immediately following an exogenous change in the money supply, doing so to ensure equilibrium in the overall system of money and prices. The extent of this overshooting acts to predict subsequent changes in the price of the other good, namely the consumer good, whose price is initially unchanged.

Our empirical findings, for the United States, are supportive of the relationships that we posit exist between commodity prices, consumer prices and money, namely that both commodity and consumer prices are determined by the money supply in the long run, that commodity prices initially overshoot their new equilibrium values in response to a money supply shock, and that the deviation of commodity prices from their equilibrium value has explanatory power for subsequent consumer price inflation. As such, we find support for the view that the influence of commodity prices on consumer prices is a monetary phenomenon.

In conclusion, these results indicate that monetary aggregates have to be brought into studies of the commodity price-consumer price relationship. They also

indicate that a commodity price gap, estimated in the manner undertaken in this paper, could have a practical benefit in enhancing monetary analysis in trying to understand and predict inflation.

COMMODITY PRICES, MONEY AND INFLATION³

1. Introduction

Commodity prices have recently re-surfaced in discussions of the inflationary outlook for western economies, with oil price developments, in particular, being seen as a source of current inflationary pressures. The popular view seems to be that changes in commodity prices are a consequence of developments occurring solely in the relevant commodity market. Prompted perhaps by the recognition that recent experiences of steep commodity price increases have occurred alongside, or in the wake of, a relatively “easy” stance of monetary policy in advanced industrial economies, there has, however, been a resurgent interest in the argument that monetary conditions account for changes in commodity prices.⁴ The implication for empirical work is that commodity prices’ influence on consumer prices may not be captured adequately by mechanical pass-through effects and a richer, monetary-based characterisation and modelling of their relationship is required.

Our view is that the influence of commodity prices on consumer prices occurs through a money-driven overshooting of commodity prices being corrected over time. In this paper, we investigate empirically whether both the long run behaviour of consumer goods prices and commodity prices are money-driven by using a cointegrating VAR framework and, as a natural progression of the empirical findings, examine also whether the deviation (overshooting) of commodity prices from their long run values explains future consumer price inflation. On the basis of an initial discussion and a simple, illustrative model, we formulate the qualitative relationships that we would expect to emerge in the empirics. Our empirical findings are supportive of the long run and short run

³ The authors would like to thank Kieran McQuinn, Edward O’Brien, and Karl Whelan for their helpful comments on earlier drafts of this paper and Bernard Kennedy for research assistance.

⁴ The relevance of monetary conditions to commodity price changes has been highlighted in the financial press; for example, in three *Financial Times* articles: “More to oil shocks than Middle East” (C. Clover and A. Fifield, 29 July 2004), “Too much money to blame for rising price of oil, economists claim” (A. Fifield, 18 August 2004), and “How real interest rates cast a shadow over oil” (15 April 2005 and written by Jeffrey Frankel, a leading academic contributor in the area). In the academic literature, Barsky and Kilian (2002) have looked at the role of monetary fluctuations in explaining oil, and consumer, prices in the 1970s.

relationships that we posit exist between commodity prices, consumer prices and money, namely that both commodity and consumer prices are determined by the money supply in the long run, that commodity prices initially overshoot their new equilibrium values in response to a money supply shock, and that the deviation of commodity prices from their equilibrium value has explanatory power for subsequent consumer price inflation.

Frankel (1986) has already provided an overshooting theory of commodity prices, drawing on Dornbusch's (1976) theory of exchange rate overshooting.

Commodities are exchanged on fast-moving auction markets and, accordingly, are able to respond instantaneously to any pressure impacting on these markets.

Following a change in monetary policy, their price reacts more than proportionately (i.e., they overshoot their new long-run equilibrium) because the prices of other goods are sticky.

While Frankel uses arbitrage conditions to develop his model, we examine the relationship between commodity prices, consumer goods prices and the money supply in a pure-exchange economy framework. Our reading of Frankel also suggests that his emphasis is on the implications of monetary policy for commodity prices. We want to examine whether an exogenous change in money supply causes price disequilibrium in both commodity and consumer goods markets and how measures of both of these disequilibria can predict future changes in CPI inflation.⁵

The paper is organised as follows. In section 2, we distinguish between commodities, whose prices are flexible, on the one hand, and consumer goods, whose prices are sticky, on the other. With this characterisation, a simple two-good, two-period model is used to show that a flexible commodity price overshoots its new long run equilibrium value in the first period following an exogenous change in the money supply, doing so to ensure equilibrium in the

⁵ Surrey (1989), Boughton and Branson (1990, 1991), and Fuhrer and Moore (1992) are four other papers that have acknowledged the potential importance of monetary conditions to the relationship between commodity prices and consumer goods prices. Our paper, however, differs also from those contributions in the form of model and empirical methodology used.

Other, US studies on the commodity price-consumer price relationship (Webb 1988, Marquis and Cunningham 1990, Cody and Mills 1991, Pecchenino 1992, Blomberg and Harris 1995, and Furlong and Ingenito 1996) focus less on the role of monetary policy in the relationship and more on the signalling or predictive power of commodity prices for consumer price inflation.

overall system of money and prices. The extent of this overshooting acts to predict subsequent changes in the price of the other good, namely the consumer good, whose price is unchanged in the first period. In section 3, using US data, we employ the Johansen procedure to examine empirically the relationship between commodity prices, consumer good prices and money. Our model receives support from the data. First, commodity and consumer prices are each shown to be cointegrated with the money stock and to move proportionally to it in the long run. Secondly, commodity prices overshoot their new equilibrium level in response to a money shock, while consumer prices adjust more slowly and do not overshoot. Thirdly, the deviation of commodity prices from their long-run values has explanatory power for subsequent CPI inflation. A number of commodity price indices are used in the exercise to check the robustness of the results. Section 4 concludes by highlighting policy implications of these findings.

2. A Model of the Relationship between Consumer Prices, Commodity Prices and Money

2.1 Basic Propositions and Hypotheses

We combine two well-known monetarist propositions and an acknowledgement of the varying speeds of adjustment of prices across goods markets to put forward a view of the interrelationship between commodity prices, consumer prices and money. The first standard monetarist proposition is that exogenous changes in the money stock lead to equivalent percentage changes in the overall price level under conditions of stable money demand. The second proposition is the related, and equally conventional, monetarist argument that exogenous changes in the money stock are neutral in the long-run steady state, implying that all individual prices, whether they be consumer goods or commodities, adjust in the same proportion as the money stock, thus leaving all relative prices unchanged in the new steady state relative to their pre-money stock change configuration.

Intuitively, the one-for-one long run relationship between money and prices must ultimately hold for commodities as much as for consumer goods. This point is perhaps best made as follows: if cash (money) forms one-half of all transactions in the economy then a doubling of the amount of cash in the economy must result

eventually, *ceteris paribus*, in the prices of all goods traded within the economy – be they commodities or consumer goods – increasing twofold.

The third proposition stems from prices in commodity markets being able to respond much more rapidly than prices in consumer goods markets to changes in economic conditions, including monetary conditions, so that they can be characterised as flexible price goods. Being auction-based, there are fewer frictions in the price-adjustment process in commodity markets because participants are more equally empowered with more balanced information and resources than their consumer goods market counterparts. This clearly enables them to react quickly to changes in monetary conditions. The subset of sluggish-adjusting, or sticky, goods prices can be identified as consumer goods whose prices usually respond only with long and variable lags to changes in monetary conditions (to use Milton Friedman's characterisation). Such goods' prices respond slowly and gradually to monetary conditions but eventually adjust fully to changes in the nominal money stock. This price stickiness tends to be attributed to frictions in labour and goods markets that slow down price adjustment. The CPI, in large part, comprises such goods. The third proposition then is that, in response to a change in the (exogenous) money supply, commodity prices will compensate in the short run for CPI price stickiness by overshooting their new long run equilibrium values.⁶

These three building blocks concerning the behaviour of prices then suggest a number of testable hypotheses about inflation. First, commodity prices, as well as consumer prices, move in proportion to the money stock in the long run. Secondly, commodity prices initially overshoot their long-run equilibrium in response to a change in monetary conditions to compensate for the sluggishness in consumer good prices. Thirdly, an important variable in explaining inflation in the composite price of sluggishly-adjusting consumer goods (the CPI) is the correction of the prior overshooting in commodity prices. In other words, the mean-correction of commodity prices to equilibrium levels explains the subsequent adjustment in the price of the sluggish-price goods.

⁶ This is the well-known Le Chatelier's principle as applied to price theory: if not all goods prices in the economy are free to adjust fully to a change in economic conditions then other goods prices must initially overshoot their new equilibrium values to compensate, a dynamic feature that holds until all prices are able to adjust to their new equilibrium values.

2.2 The Price Adjustment Process

We now elucidate how consumer good and commodity markets interact in response to a change in the money supply. We assume, in the spirit of the quantity theory, that all money holdings are exogenously supplied and that there is a fixed endowment of goods in the economy in each period. There are two types of goods in the economy which are distinguished by their degree of price flexibility: a sticky-price (S) good (to represent consumer goods), whose price cannot adjust to a change in the money supply until the following period, and a flexible-price (F) good (to represent commodities), whose price is fully flexible in each period. Finally, we assume that the velocity of money is unchanging and, for convenience, assume it has a value of one.

Let's consider an exogenous increase in the money stock at the start of a period. Initially, there is no increase in the demand for money required for purchasing the S good (given its fixed endowment and unchanged price in the current period). To maintain overall equilibrium among goods prices, all of the additional money created must flow into the F good's own market driving up its fully flexible and instantaneously responsive price. Given that it only accounts for a fraction of the goods in the economy, its price, p^F , must rise further than will be required in the long run, in order to clear the money market. The price of the F good then overshoots its new long run value to equilibrate the money market.

The sticky price, p^S , rises in the second period. With the level of the nominal money stock fixed from the previous period, some of the excess money that flowed into the F sector in the first period is drained away causing p^F to fall. Invoking the second building block of the model concerning relative price neutrality, p^S rises in the same proportion as the money stock by the end of the second period. The first-round overshooting of p^F is corrected and it, accordingly, falls until its net increase over the two periods is also in proportion to the increase in the money stock.

2.3 A Simple Model of Price Adjustment

We now illustrate the relationship between money, sticky price goods and flexible price goods more formally. There are only two non-storable goods exchanged in the economy, whose volumes are unchanging and which together add up to total



output in the economy, y . The general price level, p , is a weighted combination of the price of both goods, p^F and p^S (as defined earlier), where the weights are given by their respective shares of trade, λ and $(1-\lambda)$:

$$p = \lambda p^F + (1-\lambda) p^S$$

where $0 < \lambda < 1$.

The relationship between money and the general price level is as follows:

$$m = p y$$

It is assumed that this holds in each period. Given that y does not change, this means that the overall price level always adjusts fully in the current period to changes in the nominal money stock.⁷

We can now consider the effects of a once-off increase (of μ percent) in the money supply in period t . The money-general price level identity then implies that the general price level in period t , p_t , equals $(1+\mu_t) p_{t-1}$. The price of the sticky-price good, p^S , does not adjust to the change in the money stock until the following period (in this case, period $t+1$, and, by implication, it remains at its $t-1$ price in period t) while the price of F , p^F , can change freely in each period. In period t then:

$$p_t \{= (1+\mu_t) p_{t-1}\} = \lambda p_{t-1}^F + (1-\lambda) p_{t-1}^S \quad (1)$$

In the following period, $t+1$, the price of S adjusts to its new equilibrium value [$p_{t+1}^S = (1+\mu_t) p_{t-1}^S$] and so:

$$p_{t+1} = \lambda p_{t+1}^F + (1-\lambda) p_{t+1}^S \quad (2)$$

Now since p_{t+1} is equal to p_t (as we are assuming no further change in the nominal stock of money in period $t+1$), we can then set the right-hand-sides of (1) and (2) equal to one another:

⁷ By implication, the real money supply does not change. There is consequently no need for an adjustment in the interest rate to equilibrate money demand to money supply and hence the interest rate does not need to be included in the money market equilibrium equation.

$$\lambda p_t^F + (1-\lambda) p_{t-1}^S = \lambda p_{t+1}^F + (1-\lambda) p_{t+1}^S \quad (3)$$

Since p_{t-1}^S equals p_t^S and p_{t+1}^F equals $(1+\mu_t) p_{t-1}^F$, this can be restated as:

$$\begin{aligned} \lambda p_t^F + (1-\lambda) p_t^S &= \lambda(1+\mu_t) p_{t-1}^F + (1-\lambda) p_{t+1}^S \\ \Rightarrow (1-\lambda)\{p_{t+1}^S - p_t^S\} &= \lambda \{p_t^F - (1+\mu_t) p_{t-1}^F\} \\ \Rightarrow p_{t+1}^S - p_t^S &= \{\lambda/(1-\lambda)\} \{p_t^F - (1+\mu_t) p_{t-1}^F\} \end{aligned} \quad (4)$$

The difference in the price-flexibility properties of both goods means that the size of the change in the price of the sticky price good (S) in period $t+1$ can be predicted in period t with knowledge of the difference between the current period known value of F (p_t^F) and the known equilibrium value to which it must adjust in period $t+1$ (i.e., $(1+\mu_t) p_{t-1}^F$), which, in turn, is dependent on the change in the money stock in the current period (μ_t). It should be obvious also that for positive values of μ , the left-hand-side of (4) is a positive value and so we can conclude from the other side of the equation that p_t^F must be greater than p_{t+1}^F (the new and final equilibrium value of F , which is $(1+\mu_t) p_{t-1}^F$). This means that following an increase in the money stock the price of F must initially overshoot its new equilibrium value in period t before declining to that equilibrium value in period $t+1$. The extent to which p^F must overshoot its new long run value is also affected by the relative weights in trade of the two goods, $\lambda/(1-\lambda)$. At the end of period $t+1$, both S and F 's respective prices have adjusted fully, in proportion to the rise in the nominal money stock.

3. Econometric Evaluation of the Model

3.1 Econometric Approach

The monetarist propositions embedded in the model above indicate that in empirical work we would expect to find two cointegrating relationships among the following four variables: a commodity price index (representing the flexible goods price, p^F), a consumer price index (for the sticky price good, p^S), the money stock, and a measure of national output. These should show long-run proportionality between the money stock and the commodity price index and between the money stock and the consumer price index (CPI). Furthermore, we

should be able to use deviations (specifically, overshooting) of the commodity price index from its long run equilibrium value (which is dependent on the size of the nominal money stock) to explain changes in the CPI in the following period. From section 2, this error-correction term would be expected to have a positive coefficient in a short-run dynamics equation explaining CPI inflation.

There are obvious similarities here to the familiar P-star/real-money-gap model of CPI inflation. In both cases, the deviation of a goods price from its equilibrium value is used to explain future CPI inflation. A key difference, however, is that in the P-star model, the deviation of the CPI from its own long run, monetarily-driven value is being used to explain changes in the same price index. We are indicating, however, that price disequilibrium in another goods market also helps to explain future CPI inflation.

Nevertheless, efficient estimation and use of our cointegration results can also provide us with a P-star gap, alongside the commodity price gap, to explain CPI inflation. We use the Johansen maximum likelihood approach to test for the existence of two cointegrating relationships among these variables and to estimate them in an efficient manner. If found, the two cointegrating relationships make two error correction terms available for explaining the short-term dynamics of the CPI, i.e. the rate of CPI inflation. The first term is the aforementioned deviation of the commodity price index from its long-run equilibrium value – the extent of overshooting in the commodity markets emphasised above. The second term is the deviation of the CPI from its own long-run equilibrium value. In using last-period values of both deviation terms to explain current changes in the CPI, the latter error-correction term is the familiar gap variable from the P-star model.

According to monetarist theory, the coefficient in P-star models is expected to be, and is usually reported, as a negative value. This is the value we would expect also from our model above. If we look again at equations (1) to (4) and revert to the period notation used there, we can see that in period t , while the flexible good's price, p^F_t , is greater than its contemporaneous equilibrium value, $(1+\mu_t)p^F_{t-1}$, the sticky good's price, p^S_t , is below its new equilibrium value, $(1+\mu_t)p^S_{t-1}$. The positive change in p^S in period $t+1$ is then preceded in period t by p^S being below its equilibrium value, the negative intertemporal relationship postulated in the P-star model. There is then a consistency and complementarity between the

P-star model and our modelling of the rate of change in p^S . From an econometric point of view, we feel it appropriate to include both error-correction terms in our short-run dynamics equation explaining changes in CPI inflation since both are expected, a priori, to have explanatory power and using both makes full use of the information made available from the Johansen procedure.

After outlining in the next sub-section the data used in this study, we proceed to report our main results in two stages, first by describing the unit root properties of individual series and then by reporting the cointegrating vector, impulse response and error-correction model results.

3.2 Data

We assess our model using quarterly US data. This covers the period 1959Q1 to 2005Q3 for all series with the exception of the Sensitive Materials Index, which is available up to 2004Q2.⁸ The “sticky” good price index series that we use in our study is the Consumer Price Index (CPI). We use a number of commodity price indices with the basic rationale being to see if there are similar results across these various indices. The selected series overlap with previous studies examining the relationship between commodity and consumer prices (Webb 1988, Marquis and Cunningham 1990, Furlong and Ingenito 1996).

The first commodity price index is the Commodity Research Bureau Spot Index (CRBSI). It is a measure of the collective movement in the prices of 22 basic commodities whose markets are presumed to be amongst the first to be influenced by changes in economic conditions and would, therefore, be expected to be sensitive to developments in the monetary environment. Along with this most broadly defined CRB spot index, one of the two major divisions of the index, the Raw Industrials (CRBRI) index, is also used. The Conference Board’s Sensitive Materials Index (SENSI) is a third commodity price index examined. It comprises raw materials and metals but excludes food and energy. A benefit of using indices of commodity groups rather than individual commodity prices is

⁸ The data series and sources are documented in the appendix.

that idiosyncratic factors impacting on individual commodity markets should have far less influence at the level of a multi-commodity, broadly-based index.⁹

Given the number of price relationships being examined, we use only one nominal money stock variable, the M2 money stock (M2), and one scale variable, real Gross Domestic Product (GDP), to keep the analysis focussed on the relationship between the price indices.

3.3 Unit Root Properties of Individual Series

The first step of our analysis is to investigate the unit root properties of all the aforementioned series over the full sample period. Natural logs of these variables are used in all empirical work. We use Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) statistics to test the order of integration of the level and first-difference of each variable. The appropriate lags for the ADF test are selected using the Akaike Information Criterion (AIC) and Schwartz Bayesian Criterion (SBC), while we follow Greene (2003, p.267) in using the smallest integer greater than or equal to T to the power of $\frac{1}{4}$ (where T is the sample size) in choosing the truncation point for the Newey-West adjustment required for calculating the PP statistic.

The test results in Table 1 support most level series being integrated of order one. The only exception is the CPI series where the evidence is mixed. For the first difference of this series, the null hypothesis of a unit root is not rejected by the ADF statistics. The hypothesis, however, is rejected by the non-parametric PP test. It is noted that the ADF test can fail to distinguish between a unit root and a near unit root process and will too often indicate that a series contains a unit root. The ADF statistics are only marginally greater than the 90 per cent critical value of -2.57. Given these arguments and evidence, we proceed on the basis that CPI, and all other series, are each integrated of order one [I(1)].

⁹ The other major tranche of the CRBSI, its food component, was also examined. However, the Johansen methodology gave very mixed results on the number of cointegrating vectors present when that commodity index was used, with one vector being indicated at the 95 significance level and three at the 90 percent level. Subsequent aspects of the econometric analysis also proved unfruitful for this index. The poor results for the food index may reflect the fact that it is not a broadly-based commodity basket. Idiosyncratic, market-specific factors could then be dominating the monetary impulse.

3.4 Econometric Evaluation using the Johansen Procedure

(i) Cointegration Analysis

Johansen's maximum likelihood procedure provides a unified framework for the estimation and testing of cointegrating relations in the context of vector autoregressions (VARs). In estimating each cointegrating VAR, we are using four I(1) variables. The consumer price index, CPI, the nominal money variable, M2, and the scale variable, GDP, are common to all sets of estimations while a different commodity price index is used in each VAR. In Table 2 then, the sticky price variable in each row is CPI while the commodity price indices used in each row are, respectively, CRBSI, CRBRI, and SENSI.

Our theory suggests we should find two cointegrating relationships for each VAR, with CPI being cointegrated with M2 and GDP and, likewise, cointegration occurring between the commodity price index and the same money and scale variables. Furthermore, we would expect the restriction that the coefficient on M2 is -1 to be upheld for both cointegrating vectors as our theory is premised on a one-for-one long run relationship between money and prices. If these specific cointegration relationships are established under the Johansen procedure, we can then undertake impulse response analysis and also use the two error-correction terms (that is the deviation of actual prices from their equilibrium values) generated to explain the dynamics of CPI, with the expectation that the two error correction terms' respective signs will be consistent with our model. For each row of Table 2, we are applying the Johansen procedure over the full sample period bar the last six quarters, which are kept over to test the predictive power of the short-term dynamic equations.

The results for the three commodity indices are shown in turn in rows (a) to (c) of Table 2. The first step in the Johansen procedure is to select the order of the VAR. We find that a sixth-order VAR is required to reduce serial correlation to acceptable levels across the equations in each VAR system and, accordingly, we choose that order in all estimations. We also estimate with no intercepts and no trends in the cointegrating vectors. With these choices made, the next step is to test for cointegration among the four variables (CPI, M2, GDP, and each alternative commodity price index) using Johansen's (1988) trace statistic. The results are reported in column (i) of Table 2. The trace statistic supports the

number of cointegrating vectors being two among the variables at the 90 percent significance level in the case of rows (a) and (c) and at the 95 percent level for row (b). Given these results and our *a priori* expectations, we proceed on the basis that there are exactly two cointegrating vectors for each of these three sets of variables.

To ascertain whether the two cointegrating vectors identified in the rows reflect long run monetary determination of both commodity and consumer prices, exactly-identifying restrictions are initially imposed in each of these rows. For each set of variables, CPI is set equal to one and the commodity price index equal to zero in the first vector while the numerical ordering is reversed for the second vector, i.e. CPI is set equal to zero and the commodity price index to one. The maximum-likelihood estimates of these exactly-identified cointegrating relations are shown in column (ii) of Table 2. The M2 coefficient has the correct, negative sign and is statistically significant across all six vectors reported. The GDP coefficients have the correct, in this case positive, sign and are statistically significant in all of the CPI vectors but are insignificant in the case of the commodity price index vectors.

Since we would expect M2 to have a unitary elasticity (indicating long-run proportionality between it and the relevant price index) and all the GDP coefficients to be positive and statistically significant in an economically-meaningful outcome, we next test the over-identifying restrictions of setting the M2 coefficient equal to -1 for both cointegrating relations in each of the three sets of regressions. The log-likelihood ratio (LR) tests of these restrictions are reported in column (iii) of Table 2. The restrictions receive general support across all rows with the LR statistic being less than the 95 percent critical value in all cases. We also see in all rows under column (iv) of Table 2 that with the hypothesised economic relationship of long run proportionality between prices and money holding, all the coefficients on GDP are now highly significant, of a correct sign and of an acceptable size. We have, therefore, support for long-run monetary determination of both consumer and commodity prices.

(ii) Impulse Response Analysis

Figures 1 to 4 plot the outcomes of impulse response analyses conducted on the three sets of cointegrating vectors reported in column (iv) of Table 2. In Figure 1, the time profiles of the effects of system-wide shocks on the cointegrating vectors are reported. These indicate stability in the cointegrating vectors with each relation converging, albeit slowly, towards their respective equilibria. With support for systemic stability across each set of cointegrating vectors, we next focus on the generalised impulse response of the price variables to a M2-specific shock, given that we have posited money as the system's exogenous variable. We plot first in Figure 2 the impact of the money shock on the cointegrating vectors and then on the individual variables in Figure 3. In the individual panels of Figure 2, it can be seen that convergence toward their respective equilibria is evident over time for the CPI and the relevant commodity price index cointegrating vectors following the money shock. Convergence to equilibrium is quite slow, a process that would seem consistent with the "long and variable" transmission of money to prices.

The patterns of convergence for the cointegrating vectors in the three panels of Figure 2 can be understood better by looking at the impact of the M2 shock on the consumer and commodity price variables in Figure 3. The CPI and commodity price series plotted in each panel seem to converge toward the same, higher and money-dictated level over time. In other words, long run proportionality between prices – both of consumer and commodity goods – and money is re-established after the shock to the monetary variable, albeit with a considerable lag. The pattern of adjustment of the two price indices is also similar across the three panels with the commodity price index rising quickly over the first 12 quarters or so to a peak while the CPI adjusts only slowly and steadily upwards over time. In panels (a) and (b), there is an evident initial overshooting of its equilibrium value by the commodity price index followed by a subsequent decline toward that equilibrium value. In short, those panels, where CRBSI and CRBRI are the respective commodity price indices, mimic closely the patterns hypothesised earlier. For panel (c), where SENSI is the commodity price index, there is a sharp initial rise in the commodity price index but it does not overshoot its new long-run equilibrium. It would also seem from the corresponding panel in Figure

2 that long run equilibrium is re-established later than in panels (a) and (b). The CPI can be seen to adjust little in the initial quarters after the money shock and then to rise steadily toward its new equilibrium. The impulse response of the GDP variable is also shown in Figure 3. It receives a positive but short-lived boost from the money supply shock before reverting to its initial value.

We plot the rates of change of these impulse responses of CPI, GDP and the respective commodity price indices to the money shock in Figure 4. The rate of change (or inflation) of each of the commodity price indices peaks after five quarters and then starts to decline. The rate of change moves into negative territory after 12-14 quarters, a development consistent with the correction of the overshooting. CPI inflation only picks up after about five quarters, i.e. after commodity price inflation has peaked. It then rises steadily to a peak at quarter 12, a result in line with the recent findings of Batini and Nelson (2001) on the peak response of CPI inflation to money growth, and broadly coinciding with commodity price inflation turning negative in value. CPI inflation only declines slowly and steadily after this peak. The positive boost to GDP growth only lasts two or three quarters.

(iii) Short-Run Dynamic Analysis

We proceed to the final stage of our econometric analysis, which is to examine the short-run dynamic equations following the identification of the cointegrating vectors. The two cointegrating relationships identified in column (iv) of Table 2, with, in turn, long-run proportionality between M2 and CPI and between M2 and the commodity price index under consideration, produce two error correction (EC) terms. This means that we have two EC terms available among each set of results to explain subsequent changes in sticky prices, as represented by CPI.

The first EC term (EC1) is the “own” EC term, being the residual from the cointegrating vector involving the dependent variable in the short-run model, CPI, M2 and GDP (for example, the residual from the “CPI – M2 + 0.41 GDP” vector in column (iv), row (a) of Table 2 is the subsequent EC1 term used in the final column for that row). This error term measures how much CPI deviates from its own long-run, monetarily-driven value and is akin to the deviation of P from P* in the P-star model in explaining subsequent changes in CPI. In line with section 2,

and also with P-star theory and empirics, we expect the first lag of this EC term to have a negative coefficient in a model where the change in CPI is the dependent variable.

The second EC term (EC2) is the deviation of the particular commodity price index from its long-run value (so, to continue the previous example, in column (iv), row (a) of Table 2 it is the residual from the “CRBSI – M2 + 0.49 GDP” vector). By reference to our theoretical model and earlier discussion, we expect the first lag of this EC term to have a positive coefficient in explaining changes in CPI. The pair of cointegrating vectors in each row then provide the two error correction terms reported in the final column, (v), of Table 2 for each of these respective rows.

In modelling the short-run behaviour of CPI, we follow convention by regressing its first difference (Δ CPI) on the two EC terms, each lagged one quarter, and the first five lags of the changes of the four variables included in the cointegrating VAR system. With the large number of right-side variables involved and the focus of this study, we report only the coefficients on the two error terms among all the coefficients in column (v) of Table 2.¹⁰ Both EC terms have the expected signs and are statistically significant in all rows. The predictive failure (PF) statistics reported in column (v) indicate that all short-term dynamic equations have forecasting power for CPI inflation at conventional significance levels. CUSUM and CUSUMQ tests of structural stability, not shown, do not detect any systematic changes in the regression coefficients at the 5 percent level.

The short-run dynamic equations explaining CPI inflation include the first five lags of changes in the relevant commodity price index, which for space reasons are not reported in Table 2. Those five lags capture the short-term impact of the respective commodity baskets on CPI inflation. Across the three sets of results reported in Table 2, the coefficient on the first lag of the commodity price change is positive and statistically significant, while all subsequent lags are insignificant. These first-lag coefficients range between 0.02 and 0.03.

¹⁰ Along with predictive failure (PF) statistics discussed below, we also report R-square values and serial correlation (SC) statistics.

(iv) Assessment

We conclude that this empirical analysis is, on the whole, broadly supportive of our model and underlying hypotheses. Long-run proportional relationships between money and, in turn, consumer prices and commodity prices are not rejected by the Johansen procedure. The impulse response analysis illustrates the comparatively quick reaction of commodity prices to a monetary shock and the slow rise in the CPI to the same shock. The graphical output also supports long run proportionality between money and both sets of prices in all three cases considered and an overshooting of commodity price indices of their new equilibrium values following the money shock was visible for CRBSI and CRBRI. For those indices and SENSI, we also find both consumer and commodity price error-correction-terms to have explanatory power for subsequent CPI inflation.

It can be concluded then that the deviation of commodity price indices from their long run, money-driven values, as established by cointegration analysis, contributes to explaining subsequent consumer goods inflation. As such, we find support for the view that the influence of commodity prices on consumer goods prices is a monetary phenomenon.

4. Conclusion

This paper is inspired largely by recent experience of rapid commodity price increases, following closely on a fairly prolonged accommodating stance of US Federal Reserve monetary policy that was accompanied by strong money growth. When combined with similar policy stances and rapid money growth in the euro area and Japan, it suggests a causal role for monetary developments in driving commodity prices and the likelihood of this spilling over to consumer good prices in time. The paper was also motivated by the recent revival of interest in such a link between monetary developments and commodity prices.

The account of the relationship between commodity prices and consumer good prices is typically couched in terms of commodity prices inflating consumer good prices via cost-push mechanisms. The core message of this paper, however, is that the price relationship between both types of goods is probably being misinterpreted as originating in the commodity market and would be more

appropriately described as money-driven. Generalised commodity price rises do lead consumer price inflation but we would argue that this is a manifestation of the differing speeds of adjustment of the prices of both types of goods to monetary developments and not necessarily the result of exogenous, commodity market-specific events. As detailed in section 3, our model receives support from data for the US economy from 1959Q1 up to the present.

In conclusion, these results indicate that monetary aggregates have to be brought into studies of the commodity price-consumer price relationship. They also indicate that a commodity price gap, estimated in the manner undertaken in this paper, could have a practical benefit in enhancing monetary analysis in trying to understand and predict inflation. The results also suggest, by way of corollary, that the popular trend towards downplaying monetary aggregates in the broad formulation of monetary policy could usefully be re-examined.

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Appendix: Description and Sources of Data

Consumer Price Index for All Urban Consumers: All Items	Index: 1982-84 = 100	SA	US Department of Labor: Bureau of Labor Statistics
CRB Spot Index	Index: 1967 = 100	NSA	Commodity Research Bureau
CRB Raw Industrials Sub-Index	Index: 1967 = 100	NSA	Commodity Research Bureau
Index of Sensitive Materials Prices	Index: 1992=100	SA	The Conference Board
M2	\$ billion	SA	Board of Governors of the Federal Reserve System
Gross Domestic Product	Billions of Chained 2000 Dollars	SAAR	US Department of Commerce: Bureau of Economic Analysis

SA: Seasonally-Adjusted; NSA: Not Seasonally-Adjusted; SAAR: Seasonally Adjusted Annual Rate.

Table 1: Unit Root Test Results

	CPI	CRBSI	CRBRI	SENSI	M2	GDP
Levels						
ADF (AIC)	-1.72	-2.45	-2.22	-1.91	-0.69	-2.99
ADF (SBC)	-1.72	-1.94	-2.22	-2.12	-0.34	-2.99
Phillips-Perron	0.58	-1.07	-1.20	-0.81	0.40	-1.59
Critical 95 per cent value = -3.44						
First Difference						
ADF (AIC)	-2.48	-5.65	-6.50	-6.27	-3.15	-6.79
ADF (SBC)	-2.48	-5.65	-6.96	-6.27	-6.68	-9.97
Phillips-Perron	-3.55	-6.54	-7.97	-5.72	-6.19	-8.91
Critical 95 per cent value = -2.88						

Table 2: Johansen Cointegration Analysis and Short Run Dynamic Equation Results

	(i)			(ii)	(iii)	(iv)	(v)
p^F	Trace Statistic*			Exactly Identified Restrictions	LR** statistic	Over Identifying Restrictions	Short Run Dynamic Equations
	1	2	3				
(a) CRBSI	50.45	21.91	8.52	CPI - 0.85 M2 + 0.24 GDP (0.08) (0.09) CRBSI - 0.54 M2 - 0.02 GDP (0.17) (0.19)	1.70	CPI - M2 + 0.41 GDP (0.02) CRBSI - M2 + 0.49 GDP (0.06)	Δ CPI = -0.0185 EC[-1] + 0.0054 EC2[-1] ... (0.0073) (0.0024) R-SQUARE = 0.73; SC: CHSQ (4) = 4.25; PF: CHSQ (6) = 6.78
(b) CRBRI	51.50	24.24	8.63	CPI - 0.85 M2 + 0.24 GDP (0.08) (0.09) CRBRI - 0.59 M2 + 0.02 GDP (0.19) (0.21)	1.22	CPI - M2 + 0.41 GDP (0.02) CRBRI - M2 + 0.47 GDP (0.06)	Δ CPI = -0.0203 EC[-1] + 0.0065 EC2[-1] ... (0.0075) (0.0026) R-SQUARE = 0.73; SC: CHSQ (4) = 4.91; PF: CHSQ (6) = 6.80
(c) SENSI	49.37	21.74	7.58	CPI - 0.83 M2 + 0.22 GDP (0.07) (0.07) SENSI - 0.72 M2 + 0.21 GDP (0.12) (0.13)	1.61	CPI - M2 + 0.41 GDP (0.03) SENSI - M2 + 0.52 GDP (0.05)	Δ CPI = -0.0243 EC[-1] + 0.0116 EC2[-1] ... (0.0085) (0.0044) R-SQUARE = 0.73; SC: CHSQ (4) = 5.85; PF: CHSQ (6) = 2.49

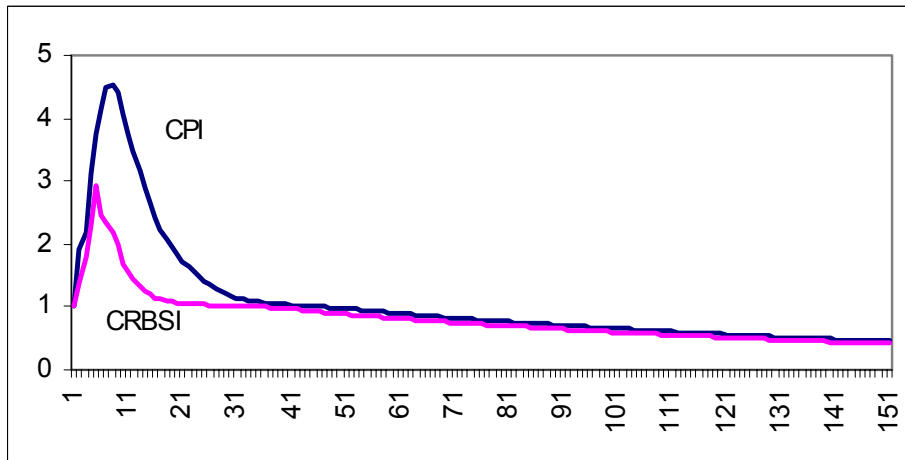
* The 95 per cent critical values for the trace statistic are, for each respective r, 39.81, 24.05 and 12.36. The 90 per cent critical values are, respectively, 36.69, 21.46 and 10.25.

** The LR statistic has a chi-square distribution with two degrees of freedom. The 95 percent critical value is 5.99 and the 99 percent critical value is 9.21.

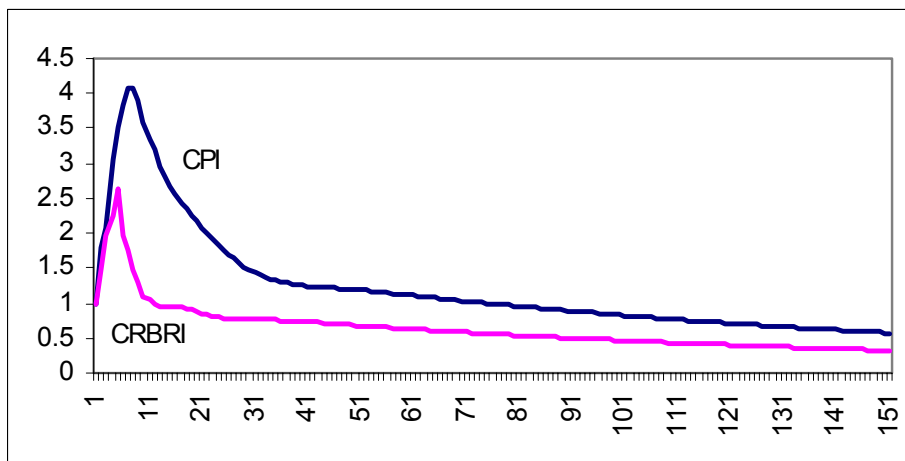
Note: Standard error in round brackets (), Lags in square brackets [].

Figure 1: Persistence Profiles of Cointegrating Vectors to System-wide Shocks

(a) CRBSI



(b) CRBRI



(c) SENSI

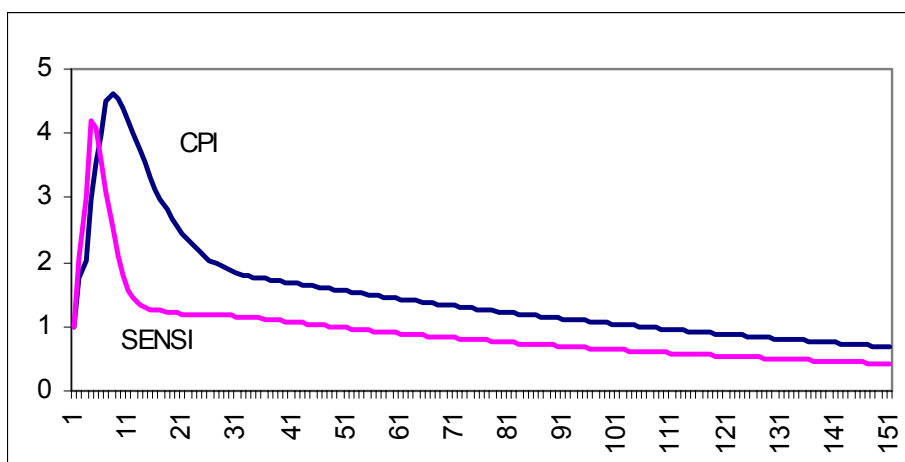
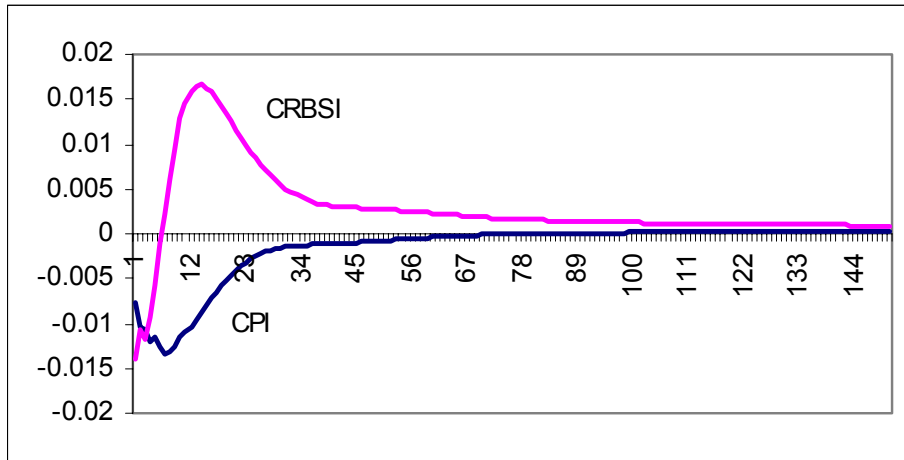
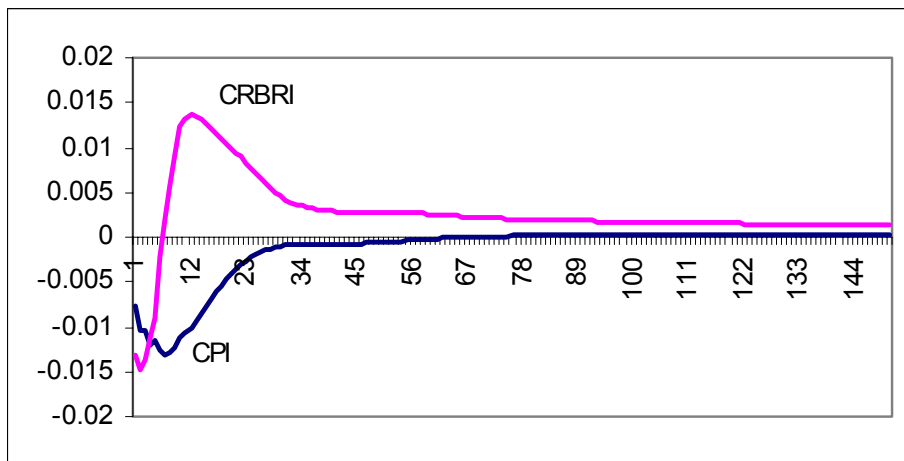


Figure 2: Impulse Response of Cointegrating Vectors to a Shock in the M2 Equation

(a) CRBSI



(b) CRBRI



(c) SENSI

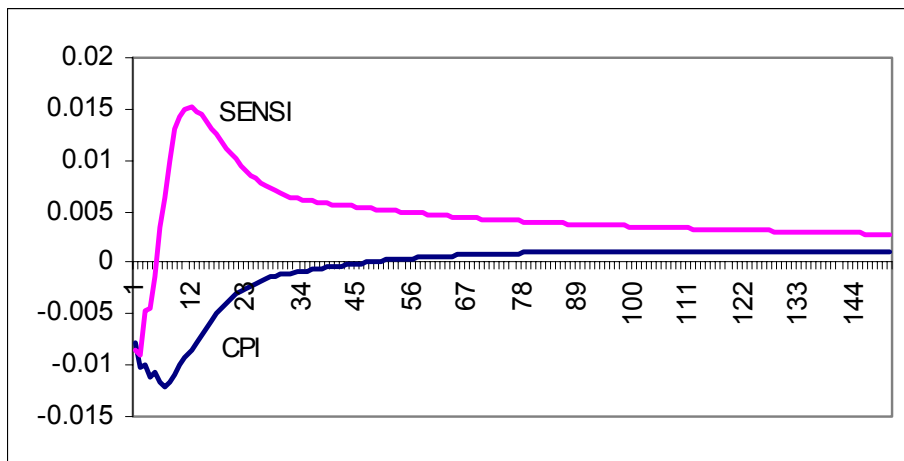
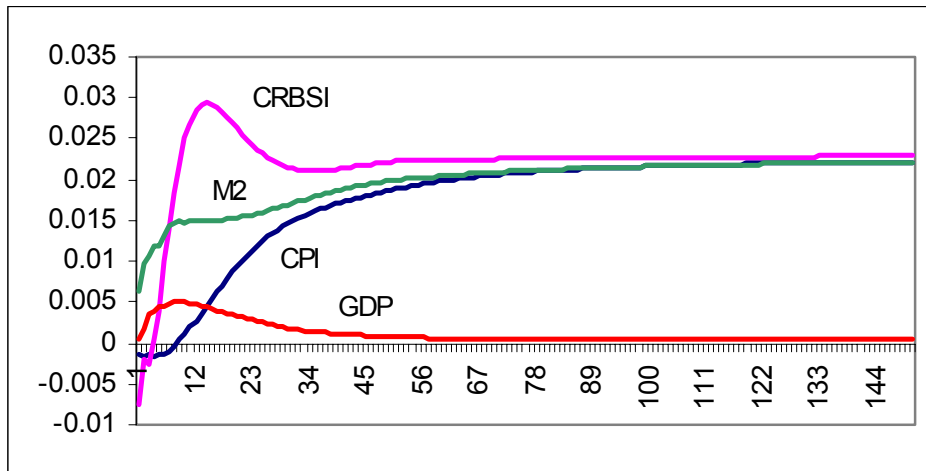
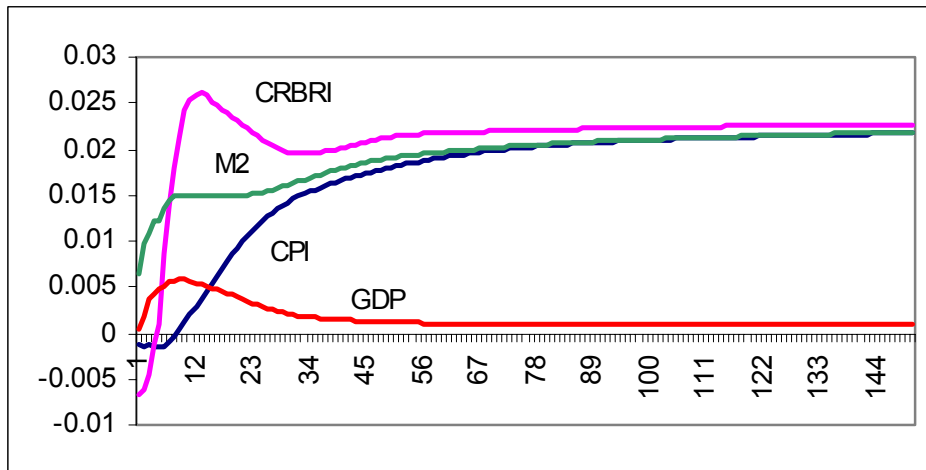


Figure 3: Impulse Response of Variables to a Shock in the M2 Equation

(a) CRBSI



(b) CRBRI



(c) SENSI

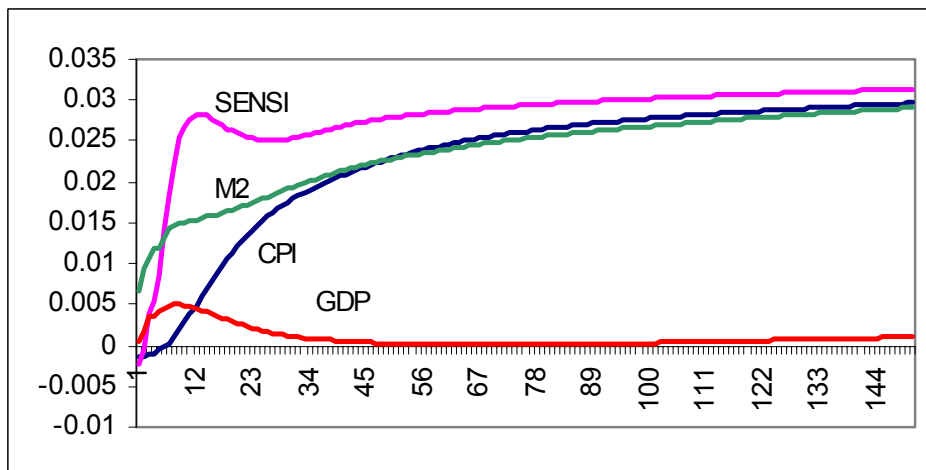
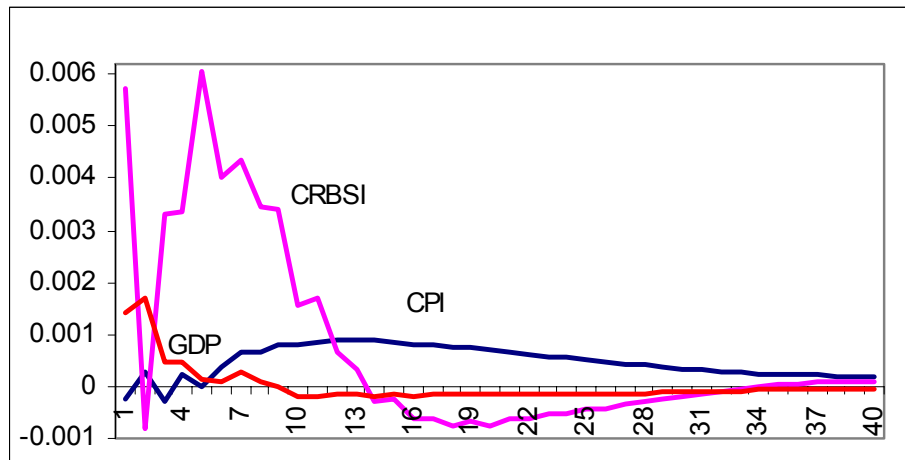
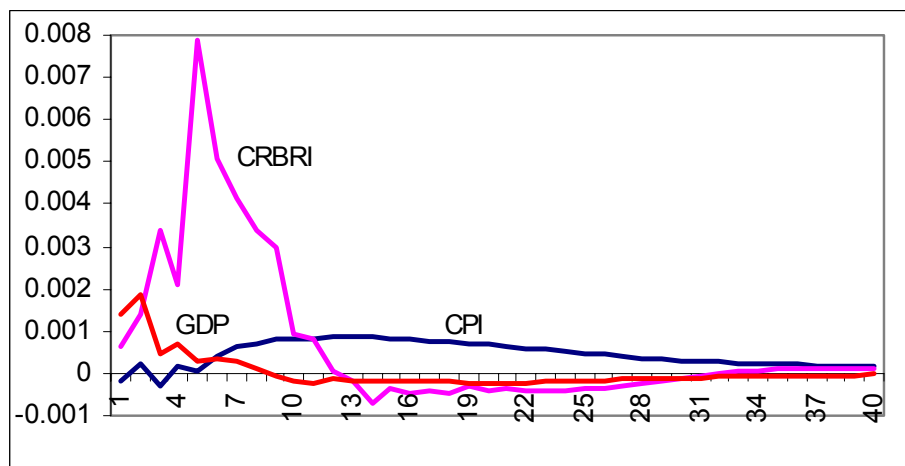


Figure 4: Impulse Response of Variables to a Shock in the M2 Equation – Rates of Change

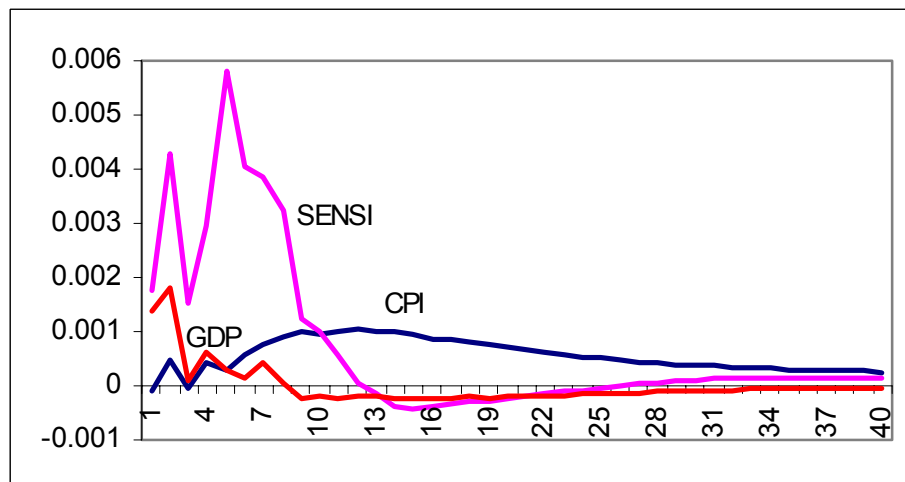
(a) CRBSI



(b) CRBRI



(c) SENSI



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