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Impact of Supply of Money on Food Prices in India: A Causality Analysis

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Abstract

This study attempts to investigate the direction of casualty between food prices and money supply in the static and dynamic framework. We found that narrow measure of money supply (M_1) Granger causes food inflation while broad measure of money supply (M_3) does not in the static framework. This implies that money supply (M_1) is not neutral in determining food prices in the long run in the Indian context. From the dynamic framework of analysis we found that any one innovation in the broad measure of money supply (M_3) will have positive impact on the food inflation for next three years.

KEYWORDS: Food Prices. Money Supply. Granger-causality.

JEL CLASSIFIATION: C310, Q110, E510.

1. INTRODUCTION

Food prices play a major role in determining the inflationary situation of a country. By excluding food and energy prices, in general, and eliminating the products that have temporary price shocks, in particular, from the set of inflation we get what is commonly known as "core inflation". Since food prices are so volatile, they have a greater impact on the consumers' standard of living. In conventional framework of agricultural economics, food prices are also determined by the interaction of demand and supply of food products. For agricultural commodities, in the short run, supply is relatively inelastic or fixed. Hence, movement in prices occurs to clear the market. When supply exceeds demand, movement in the agricultural prices moved downwards and consumers purchase more. Conversely, when demand exceeds supply, movements in the agricultural prices are upwards and thereby, consumers purchase less. In the long run, farmers adjust production in response to market prices - they produce more at the time of hike in the food prices and vice-versa. Significantly, in aggregate terms demand of food items is not sensitive to the food prices as there is less scope of substitution. However, demand of individual food items is very sensitive to the food prices as there is more scope of substitution. Also, demand of food items is also determined by the supply of money in the economy. However, the impact of macro-economic factors, particularly monetary factors, on agricultural or food prices is very scantly researched. Tweeten [1] found that the monetary shocks have little impact on the food prices. Blessler and David [2] found that causality runs from money supply to agricultural prices. While Devadoss and Meyers [3] found that in the U.S.A agricultural prices are faster responsive vis-à-vis manufacturing prices to a change in the money supply. Hey and Anwar [4] found that there is unidirectional causality running from money supply to food/agricultural prices. In order to extend the existing literature, this study has made an attempt to investigate the causality between the supply of money (by incorporating broad and narrow measure of money supply) and food inflation in the Indian context.

Rest of the paper is organized as follows. Section 2 presents data source, variables definition and methodology adopted for empirical analysis followed by presentation of the data analysis and findings in section 3. In section 4, the conclusions based on the empirical analysis are presented.

2. OBJECTIVE, DATA SOURCE, VARIABLES DESCRIPTION AND METHODOLOGY

This study attempts to examine the direction of causality between money supply and food inflation in the context of India. For the analysis, we have adopted data from the Hand Book of Statistics of Indian Economy and assessed from the official website of Reserve Bank of India on 17 July 2009. The period of the study is 1970 to 2006. To measure money supply we have used two measures namely broad (M3) and narrow (M1) measure of money supply. Food inflation has been measured by Consumer Price Index of Industrial workers of Food items (CPI-IW-Food). To know the causality among these test variables in the Vector Error Correction Modeling (VECM) framework, certain pre-estimations (like testing the stationarity of the variables included in the VECM analysis and seeking the cointegration of the series) should be carried out without which conclusions drawn from the estimation will not be valid. Therefore, in the first step we have carried out unit root analysis by applying two different tests namely, (Augmented) Dickey Fuller (hereafter, DF/ADF) test, and Phillips and Perron [5] (hereafter, PP) test. In all cases, we will test the unit root property of the variables by employing the model suggested by the graphical plot of the variables in question. Augmented form of the DF test is used when there is problem of serial correlation and to choose appropriate lag length Schwarz Information Criteria (hereafter, SIC) has been preferred. Since PP test has advancements over DF/ADF test in the sense that whereas DF/ADF test use a parametric auto-regression to approximate the ARMA structure of the errors in the test regression, it corrects any serial correlation and heteroskedasticity in the errors. Therefore, PP test is also used for analysis. To select appropriate lag length in PP test we have adopted Newey-West using Bartlet kernel method. In both tests, null hypothesis is that series is non-stationary i.e., series has a unit root. For all cases, if critical value (which is based on Mackinnon [6]) exceeds the calculated value in absolute terms (less in negative terms) null hypothesis will not be rejected implying that that series is nonstationary. In both these tests, test involves the testing of coefficient associated with one year past value of dependent variable.

When it is found that variables used in this study are nonstationary and having same order of integration we have to proceed for cointegration analysis. In this study we have preferred Johansen and Juselius [7] (hereafter JJ) method (as Gonzalo, [8] has suggested that JJ test is superior to other tests of cointegration). JJ test provides two Likelihood Ratio (LR) test statistics for cointegration analysis. First test is trace (λ_{trace}) statistics and the second one is maximum eigenvalue (λ_{max}) statistics. The trace statistics tests the null hypothesis as such that the number of cointegrating relations is r against of k cointegration relations, where k is the number of endogenous variables. The maximum eigenvalue test tests the null hypothesis as such that there are r cointegrating vectors against an alternative of r+1 cointegrating vectors. Critical value for estimation has been obtained from Mackinnon-Haug-Michelis [9] which differs slightly from those provided by JJ. For both tests, if the test statistic value is greater than the critical value, the null hypothesis of r cointegrating vectors is rejected in favor of the corresponding alternative hypothesis.

Once the cointegrating vectors have been estimated among a set of variables one can proceed to carry out VECM analysis. If variables in the system are nonstationary and cointegrated, the Granger-causality test in VCM framework will be based on the following equations:

$$\Delta \mathrm{X}_t = \alpha_x + \sum_{i=1}^{k} \beta_{x,i} \Delta \mathrm{X}_{t-i} + \sum_{i=1}^{k} \gamma_{x,i} \Delta \mathrm{Y}_{t-i} + \varphi_x ECT_{x,t-i} + \varepsilon_{x,t} \ldots\ldots\ldots(1)$$

$$\Delta \mathrm{Y}_t = \alpha_y + \sum_{i=1}^{k} \beta_{y,i} \Delta \mathrm{Y}_{t-i} + \sum_{i=1}^{k} \gamma_{x,i} \Delta \mathrm{X}_{t-i} + \varphi_y ECT_{y,t-i} + \varepsilon_{y,t} \ldots\ldots\ldots(2)$$

Where, φ_x and φ_y are the parameters of the ECT term, measuring the error correction mechanism that drives the X_t and $Y_{t\ \mathrm{are}}$ back to their long run equilibrium relationship. However, if variables in the system are nonstationary and non-cointegrated, the Granger causality test will be based on the following equations:

$$\Delta \mathrm{X}_t = \alpha_x + \sum_{i=1}^{k} \beta_{x,i} \Delta \mathrm{X}_{t-i} + \sum_{i=1}^{k} \gamma_{x,i} \Delta \mathrm{Y}_{t-i} + \varepsilon_{x,t} \ldots\ldots\ldots(3)$$

$$\Delta \mathrm{Y}_t = \alpha_y + \sum_{i=1}^{k} \beta_{y,i} \Delta \mathrm{Y}_{t-i} + \sum_{i=1}^{k} \gamma_{x,i} \Delta \mathrm{X}_{t-i} + \varepsilon_{y,t} \ldots\ldots\ldots(4)$$

The null hypothesis (H_0) for the equations (1) and (3) is $H_0 : \sum_{i}^{k} \gamma_{x,i} = 0$ suggests that the lagged term ΔY does not belong to the regression i.e., it does not Granger cause ΔX. Conversely, the null hypothesis (H_0) for the equations (2) and (4) is $H_0 : \sum_{i}^{k} \gamma_{y,i} = 0$, suggesting that the lagged term ΔX does not belong to regression i.e., it does not Granger cause ΔY. The joint test of these null hypotheses can be tested either by F-test or Wald Chi-square (χ^2) test. In the present study, Wald Chi-square (χ^2) test has been preferred. This Wald Chi-square (χ^2) test gives us an indication of the 'short-term' causal effects or strict exogenity of the variables. If the coefficients of $\gamma_{x,i}$ are statistically significant, but $\gamma_{y,i}$ are not statistically significant, then X is said to have been caused by Y (unidirectional). The reverse causality holds if coefficients of $\gamma_{y,i}$ are statistically significant while $\gamma_{x,i}$ are not. But if both $\gamma_{y,i}$ and $\gamma_{x,i}$ are statistically significant, then causality runs both ways (bidirectional). Independence is identified when the $\gamma_{x,i}$ and $\gamma_{y,i}$ coefficients are not statistically significant in both the regressions. On the other hand, the significance of the lagged error-correction term(s) in the equations (1) and (2) (measured through t-test) will indicate the Granger causality (or endogenity) of the dependent variable. The coefficient of the lagged error-correction term, however, is a short-term adjustment coefficient and represents the proportion by which the long-term disequilibrium (or imbalance) in the dependent variable is being corrected in each short period. The non-significance or elimination of any of the lagged error-correction terms affects the implied long-term relationship and may be a violation of theory. The non-significance of any of the 'differenced' variables which reflects only the short-term relationship, does not involve such a violation because the theory typically has nothing to say about short-term relationships. The non-significance of both the t-test(s) as well as the F-tests in the VECM will imply econometric exogenity of the dependent variable.[1]

Diagnostic checks analysis has been performed to the models used for VECM to test the stochastic properties of the model such as residuals autocorrelation, heteroskedasticity, normality, and Wald-test of lag exclusion[2]. This was done so because if the model is stochastic then only further analysis based on the model is possible and inference drawn from the results of VEC modelling will not be biased.

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[1] The lagged error-correction term contains the log-run information, since it is derived from the long-term cointegration relationship(s). Weak exogenity of the variable refers to ECM-dependence, i.e. dependence upon stochastic trend.

[2] Presence of autocorrelation/serial correlation has been tested by using Lagrange Multiplier (LM) test by adopting same lag order as that of corresponding lag order in VECM by following Harris [10]. Presence of heteroskedasticity has been tested by using White heteroskedasticity test with inclusion of cross products as it checks the correctness of the specification of the model. Normality of residuals has been tested through Jarque-Bera (JB) normality test following Urzua's [11] method of residual factorization (orthogonalization) as it makes a small sample correction to the transformed residuals before computing JB test as sample elicit size of the present study is small.

3. DATA ANALYSIS AND RESULTS INTERPRETATION

First of all unit root test has been carried out for all variables using Dickey-Fuller (DF) or Augmented Dickey-Fuller test (ADF) and Pillips-Perron (PP) test. Results of unit roots are reported in table 1.

Table 1: Results of unit root

Variables	Unit root test statistics			
	Constant	Constant and Trend	DF/ADF (k)†	PP (k)ψ
Ln(M_3)	-----	Yes	-1.443787 (0)	-1.443787 (0)
D(Ln(M_3))	Yes	------	-4.644701* (0)	-4.471252* (6)
Ln(M_1)	-----	Yes	-1.665729 (1)	-1.669788 (2)
D(Ln(M_1))	Yes	------	-5.583639* (0)	-5.612390* (3)
Ln(CPIIWFOOD)	-----	Yes	-3.395746** (4)	-2.545013 (3)
D(Ln(CPIIWFOOD))	Yes	------	-4.971924* (1)	-5.157301* (3)
Note: (1)*and ** denotes significant at 1% level and 5% respectively. (2) “k” denotes lag length used to avoid problem of serial correlation. (3) “D” denotes first difference of the variable. (4) “†” denotes maximum lag selection is based on SIC. (5) “ψ” denotes Newey-West using Bartlett kernel method has been used to select appropriate lag length.				
Source: Author’s calculation				

It is evident from the Table 1 that all variables are nonstationary in their level form and they are turning to be stationary after first difference i.e., (I). Since all variable are (I) therefore, we can proceed for cointegration analysis. To proceed for cointegration first step is selection of appropriate lag length. Therefore, we have carried out a joint test of lag length selection (between M1 and CPI-IW-Food) which suggests (basing upon SBIC) we should take one lag of each variable.[3] So, we have chosen lag intervals (1, 1) and then joint test for cointegrating vector

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[3] Results of lag length selection can be obtained from the Author.

and model selection has been performed, that is what we call Pantula Principle.[4] We found from the results of Pantula Principle that SBIC has preferred model 4. Therefore, by choosing model 4, and lag interval (1, 1) we have carried out JJ cointegration test. Results of cointegration test are reported in the following table 2.

Table 2: Cointegration test

Cointegration test [Trend assumption: Linear deterministic trend (restricted) Lags interval (in first differences): 1 to 1]					
Unrestricted Cointegration Rank Test (Trace)					
H_0	H_a	Eigenvalue	Trace Statistic	5% Critical Value	Prob.**
None*	At most 1	0.583170	36.79012	25.87211	0.0015
At most 1	At most 2	0.161440	6.162410	12.51798	0.4399
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)					
H_o	H_a	Eigenvalue	Max-Eigen Statistic	5% Critical Value	Prob.**
None *	At most 1	0.583170	30.62771	19.38704	0.0008
At most 1	At most 2	0.161440	6.162410	12.51798	0.4399
Note: (1) * denotes rejection of the hypothesis at the 0.05 level. (2) **MacKinnon-Haug-Michelis [9] p-values					
Source: Author's calculation					

It is evident from the table 2 that both Trace and Eigenvalue criteria rejects the null hypothesis of none cointegrating vector against the alternative of at most one cointegrating vectors. Therefore, in the next step we have carried out Engle-Granger causality analysis in VECM framework. Result of Engle-Granger causality analysis has been reported in the following table 3.

Table 3: Engle-Granger causality analysis

Granger Causality Short Run (Wald test/χ^2)			Granger Causality Long Run
Dependent variables	Independent variables		
	D(M_1)	D(NCPIIWFOOD)	CointEq1
D(M_1)	------	0.381441	0.059913
D(NCPIIWFOOD)	4.895396*	------	1.835478*
Note: (1)* denotes significant at 1% level. (2) 'D" denotes first difference.			
Source: Author's calculation			

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[4] Results of model selection test can be obtained from the Author.

It is evident from Table 3 that money supply (measured by M_1) Granger cause food inflation and food inflation does not Granger cause money supply which implies that unidirectional causality exists from money supply to food inflation.

Cointegrating vectors i.e., error terms is significant when food inflation is the dependent variable and insignificant when money supply is dependent variable implying the weak exogenity of money supply.

To check the validity of VECM and Granger causality, we have carried out diagnostic checks analysis employing Wald test for lag exclusion, LM test for serial correlation, White test with cross products for heteroskedasticity and to check the specification of VECM, and J-B test for normality. Results of diagnostic checks are reported in the following table 4.

Table 4: Diagnostic checks analysis

<table>
<tr><td colspan="2">VEC Lag Exclusion Wald Tests (Chi-squared test statistics for lag exclusion) for Dlag 1. (Joint test)</td><td>P-Value</td></tr>
<tr><td colspan="2">6.797094</td><td>[0.147007]</td></tr>
<tr><td colspan="3">VEC Residual Serial Correlation LM Tests</td></tr>
<tr><td>1lag</td><td>7.342482</td><td>0.1189</td></tr>
<tr><td colspan="3">VEC Residual Normality Tests-Joint J-B test (Orthogonalization: Residual Covariance (Urzua)</td></tr>
<tr><td colspan="2">125.4434</td><td>0.0000</td></tr>
<tr><td colspan="3">VEC Residual Heteroskedasticity Tests with inclusion of cross products (Joint test of Chi-square)</td></tr>
<tr><td colspan="2">28.20846</td><td>0.4003</td></tr>
<tr><td colspan="3">Source: Author’s calculation</td></tr>
</table>

It is evident from the Table 4 that the specification of VECM is incorrect as J-B test rejects the null hypothesis of normality property of residuals. Therefore, we cannot proceed further for the analysis.

In the next step, we have carried out a joint test of lag length selection (between M_3 and CPI-IW-Food) which suggests that basing upon SBIC, AIC, HQIC and FPE we should take one lag of each variable.[5] So, we have chosen lag intervals (1, 1) and then joint test for cointegrating vector and model selection has been performed.[6] We found from the results of Pantula Principle that SBIC and AIC both have preferred model 3 and model 4 equally. Therefore, by choosing model 3 and model 4, and lag interval (1, 1) we have carried out JJ cointegration test. Results of cointegration test are reported in the following table 5.

Table 5: Cointegration test

Cointegration test [Trend assumption: Linear deterministic trend Lags interval (in first differences): 1 to 1]					
Unrestricted Cointegration Rank Test (Trace)					
H_0	H_a	Eigenvalue	Trace Statistic	5% Critical Value	Prob.**
None	At most 1	0.174265	7.010592	15.49471	0.5764
At most 1	At most 2	0.008782	0.308727	3.841466	0.5785
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)					
H_o	H_a	Eigenvalue	Max-Eigen Statistic	5% Critical Value	Prob.**
None	At most 1	0.174265	6.701865	14.26460	0.5250
At most 1	At most 2	0.008782	0.308727	3.841466	0.5785
Cointegration test [Trend assumption: Linear deterministic trend (restricted) Lags interval (in first differences): 1 to 1]					
Unrestricted Cointegration Rank Test (Trace)					
H_0	H_a	Eigenvalue	Trace Statistic	5% Critical Value	Prob.**
None	At most 1	0.175561	11.35558	25.87211	0.8542
At most 1	At most 2	0.123127	4.598772	12.51798	0.6546
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)					
H_o	H_a	Eigenvalue	Max-Eigen Statistic	5% Critical Value	Prob.**
None	At most 1	0.175561	6.756811	19.38704	0.9165
At most 1	At most 2	0.123127	4.598772	12.51798	0.6546
**MacKinnon-Haug-Michelis [9] p-values					
Source: Author's calculation					

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[5] Results of lag length selection can be obtained by from the Author.

[6] Results of model selection test can be obtained from the Author.

It is evident from the Table 5 that in none of the case the null hypothesis has been rejected by any of the criteria of JJ test. This implies that in this case cointegration does not exist. Therefore, in the next step by excluding the error correction term Engle-Granger causality analysis has been performed in VAR framework and results has been reported in the following table 6.

Table 6: Engle-Granger causality analysis

VAR Granger Causality (Wald test/χ^2)		
Dependent variables	Independent variables	
	D(M_3)	D(NCPIIWFOOD)
D(M_3)	------	2.618808
D(NCPIIWFOOD)	2.251988	------
Note: (1)*, denotes significant at 1% (2) 'D" denotes first difference.		
Source: Author's calculation		

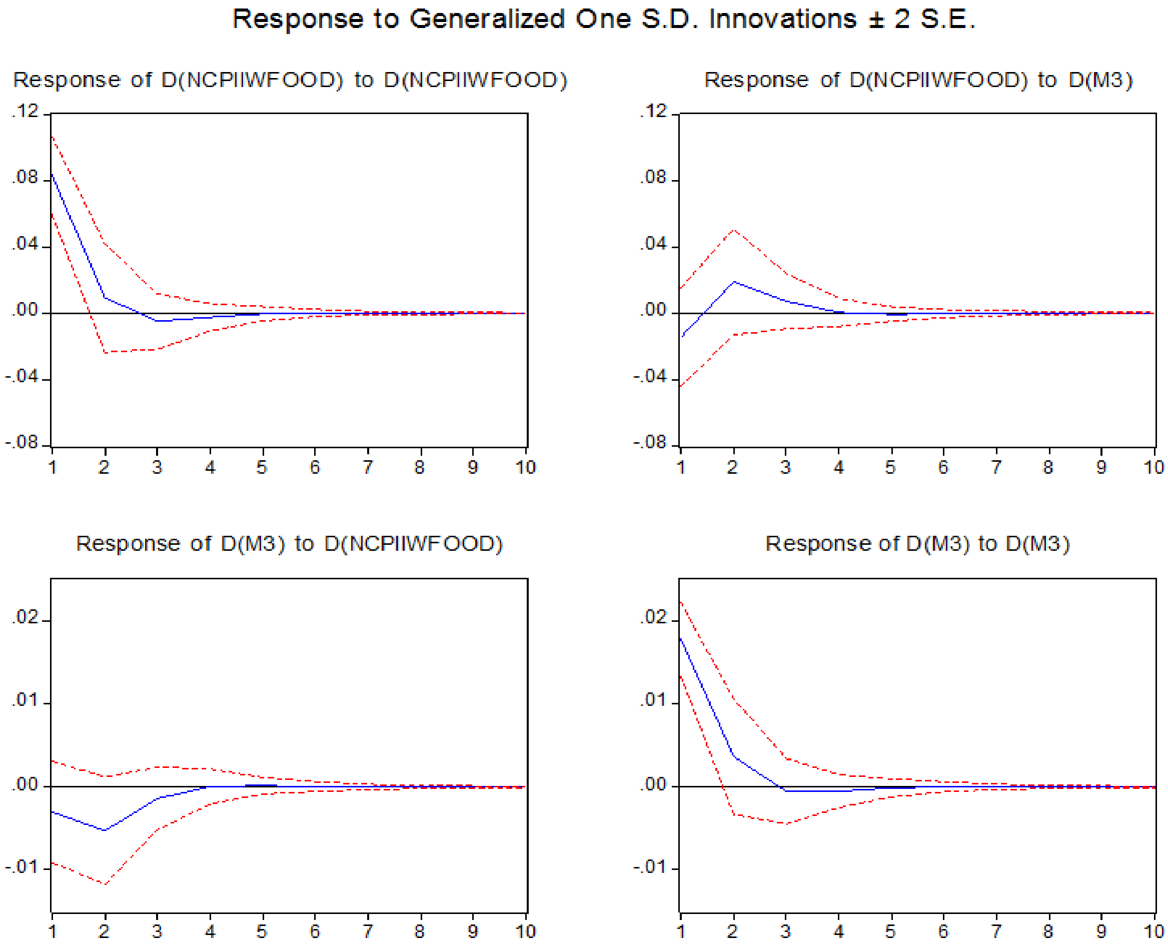
From Table 6 it is evident that both variables are independent to each other i.e., causality does not exists in either of the direction. Again, diagnostic checks analysis has been performed. Results of the analysis are presented in table 7.

Table 7: Diagnostic checks analysis

VEC Lag Exclusion Wald Tests (Chi-squared test statistics for lag exclusion) for Dlag 1. (Joint test)		P-Value
6.974192		[0.137258]
VEC Residual Serial Correlation LM Tests		
1lag	3.061796	0.5475
VEC Residual Normality Tests-Joint J-B test (Orthogonalization: Residual Covariance (Urzua)		
10.06992		0.3449
VEC Residual Heteroskedasticity Tests with inclusion of cross products (Joint test of Chi-square)		
18.18239		0.2532
Source: Author's calculation		

It is evident from table 7 that in none of the case null hypothesis has been rejected. This implies that specification of the VAR is correct and we can carry out analysis of IRFs. IRFs have been shown in the figure 1. From the figure 1 it is evident that response of food inflation in one standard deviation shock/innovation in money supply (M_3) is positive for just next year thereafter it effect is getting neutralized. And response of money supply (M_3) in one SD shock/innovation in food inflation is negative for the next year i.e., second year and thereafter, its impact starts to move towards positive direction but it dies off in the fourth year itself.

Figure 1: IRFs analysis



4. Conclusions

This study has made an attempt to analyze the dynamics of money supply (measured by M_1 and M_3) and food inflation (measured by CPI-IW-Food) in static and dynamic framework in Indian context. The period of the analysis is 1970 to 2006. We found that narrow measure of money supply Granger causes food inflation while broad measure of money supply does not. Further, in none of the case we found that food inflation Granger causes money supply. From the dynamic framework of analysis we found that any one innovation in the broad measure of money supply will have positive impact on the food inflation for next three years.

Therefore, on the basis of our study we conclude that money supply is not neutral in determining food prices in the long run in the Indian context. So, we recommend that Indian policy makers should control the money supply in order to control inflation in general and food inflation in particular. But it should be done with the mutual understanding of the monetary authority and food price regulatory authority of the government in order to reap the true benefits of it.

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