A cointegration and error correction approach to the determinants of inflation in India

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Determinants of Inflation in India

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Abstract

No doubt that the persistent rise in the price levels of commodities and services adversely affects the economic performance. The goal of each and every Government is to maintain low and relatively stable levels of inflation. Creeping or mild inflation can be viewed as having favorable impacts on the economy; on the other hand zero inflation is harmful to other sectors in the economy. The right level of inflation, is somewhere in the middle. The study analyzed the major determinants of inflation in India extracting 54 time series quarterly observations. The study employed Johansen-juselius cointegration methodology to test for the existence of a long run relationship between the variables. The cointegrating regression so far considers only the long-run property of the model, and does not deal with the short-run dynamics explicitly. For this, the error correction from the long run determinants of inflation is then used as a dynamic model to estimate the short run determinants of inflation. The study concluded that the GDP and broad money have a positive effect on the inflation in long run. On the other hand, interest rate and exchange rate has a negative effect. The income coefficient is 0.37 and showing significant, implying that in India, a one percent increase in income while others keep constant contributes 0.37% increase in inflation. Similarly the money coefficient is 0.047 and showing significant, implying that in India, one percent increase in money supply leads to a 5% increase in price level.

Keywords: Wholesale price index, GDP, India, unit root, cointegration, Error correction

Introduction

Inflation is an important concept in the history of economic thought and can be defined as a sustained rise in the general level of prices i.e. a persistent rise in the price levels of commodities and services, leading to a fall in the currency's purchasing power. High inflation is bad for the economy and it adversely affects economic performance. Even moderate levels of inflation can distort investment and consumption decisions. Reducing inflation also has costs associated with the including lost output and higher rates of unemployment. The problem of inflation used to be confined to national boundaries, and was caused by domestic money supply and price rises. In this era of globalization, the effect of economic inflation crosses borders and percolates to both developing and developed nations. Too much money in circulation, increases production costs, declines in exchange rates, decreases in the availability of limited resources such as food or oil etc are the basic causes of inflation. Inflation is a sign that an economy is growing, but excessive economic growth can be detrimental as it can lead to hyperinflation as experienced, at the other extreme, an economy with no inflation has essentially stagnated. The right level of economic growth, and thus the right level of inflation, is somewhere in the middle. Creeping or mild inflation can be viewed as having favorable impacts on the economy; on the other hand zero inflation is harmful to other sectors in the economy with falling prices, profits, and employment. In general, unpredicted running and galloping inflation are regarded has unprecedented effects on an economy because it distort and disrupt the price mechanism, discourage investment and saving, adversely effects fixed income group, creditors and ultimately leads to the breakdown of morals.

Review of Literature

Gary G. Moser (1995) analyzed the dominant factors influencing inflation in Nigeria by employing the cointegration and Error correction methods for the data ranges from 1960 to 1993. They used real income, broad money, annual rain fall and Naira-US dollar bilateral exchange rate as their explanatory variables. They found that monetary expansion, driven mainly by expansionary fiscal policies, explains to a large degree the inflationary process in Nigeria. Other important factors were the devaluation of the naira and agro climatic conditions.

Lim and Papi (1997) examined the major determinants of inflation in Turkey for the ranging 1970 to 1995. The study employed Johansen Co integration technique and on the basis of the result they concluded that money, wages, prices of exports and prices of imports have positive influence on domestic price level where as exchange rate exerts inverse effect on the domestic price level in Turkey.

Ilker Domaç (1998) investigated both the behavior and determinants of inflation in Albania by applying co-integration and error-correction techniques to the inflation process. They used Inflation, budget deficit, exchange rate depreciation, money growth and real GDP as variables in his study. The results of the Granger Causality tests indicated that M1and the exchange rate has an important predictive content for almost the entire individual items of the CPI. The results of co-integration and error-correction techniques confirmed that, in the long run, inflation is positively related to both money supply and the exchange rate, while it is negatively related to real income.

Kuijs (1998) investigated the major determinants of price level, output and exchange rate in Nigeria using Vector Autoregressive (VAR) model. The study suggests that first lag of prices, 3rd lag of prices, 1st lag of excess money supply and 1st lag of output gap are directly related to price level where as 2nd lag of prices, 4th lag of exchange rate and output gap are indirectly linked with price level in Nigeria.

Liu and Adedeji (2000) studied the determinants of inflation in the Islamic Republic of Iran for data covering the period from 1989 to 1999. By applying Johansen co-integration test and vector error correction model, they concluded that lag value of money supply, monetary growth, four years previous expected rate of inflation are positively contributed towards inflation while two years previous value of exchange premium is negatively correlated with inflation.

Mosayed and Mohammad (2009) examined the determinants of inflation in Iran for the data from 1971 to 2006. The study adopted Autoregressive and distributed lag model (ARDL) and concluded that money supply, exchange rate, gross domestic product, change in domestic prices and foreign prices, a variable that capture the effect of Iran or Iraq war are the major determinants of inflation in Iran and all are positively contributing to the domestic prices in Iran.

Abidemi and Malik (2010) analyzed simultaneous inter relationship between inflation and its major determinants in Nigeria for the period from 1970 to 2007. The study adopted Johansen co-integration methodology and error correction model (ECM) and conclude their study revealing that growth rate of GDP, money supply, Imports, 1st lag of inflation and interest rate are positively associated with inflation rate, while fiscal deficit and exchange rate are indirectly associated to inflation.

Armstrong Dlamini and Tsidi Nxumalo (2011) used annual data from 1974 to 2000 and analyzed the determinants of inflation in Swaziland by employing the econometric technique of cointegration and error correction model (ECM).They used real income, nominal money supply, nominal interest rate, nominal exchange rates, nominal wages, and South African consumer prices as explanatory variables and Swaziland consumer price index as the dependent variable. They found that the impact of the money supply variable on inflation is insignificant; suggesting that money supply growth in Swaziland does not accord with normal behavioral expectations towards inflation. Interest rates seem to play no significant role in the inflation function for Swaziland. The study found that the exchange rate has a significant long-run influence on the level of prices in Swaziland and the foreign price as have a significant long run influence on the level of prices of Swaziland.

Data, Methodology and Empirical Results

In order to investigate the determinants of inflation in India, the following data are used. The data used in this study are cumulated from various secondary sources. The variable such as wholesale price index (WPI), broad money (M3), real gross domestic product (GDP_{FC}) and prime lending rate are collected from CMIE. The bilateral exchange rate between dollar and rupee are collected from www.exchangerate.com. The data collected over a period of 1996Q1 to 2009Q2. The WPI estimated 1993-94 constant prices, whereas GDP_{FC} is estimated on the basis of 1999-00 constant price and GDP and broad money are seasonally adjusted.

To investigate the above issue the study uses the 54 quarterly observations from 1996Q1 to 2009Q2. The choice of sample period is due to capture short term dynamics of inflation. In order to study the various determinants of inflation in India, we considered five variables, namely WPI, real GDP, prime lending rate, broad money and bilateral exchange rate. The statistical and time series properties of each and every variable are examined using the conventional unit root test.

The study employs the econometric technique of cointegration and error correction model (ECM) in order to estimate a more specific relationship between inflation and its determinants. The ECM, as a tool of analysis, overcomes the problems of spurious regression through the use of appropriate differenced variables in order to determine the short-term adjustments in the model. Cointegration analysis on the other hand provides the potential information about long term equilibrium relationship of the model.

The relationship between inflation and its key determinants is an important building block in macro-economic theories and is a crucial component in the conduct of monetary policy. The proper specification of the model is very important and constitutes primary step for robust results to obtain. In all the countries the determinants of inflation are almost same, only the difference is on their magnitude.

There are however, generally three functional forms dominating the literature: linear-additive, log-linear and linear-no additive. There is general consensus that the log linear version is the most appropriate functional form. We hypothesize that the fundamental variables that determine inflation in India are real GDP, prime lending rate, broad money and exchange rate. For estimation purposes, we use the logarithmic transformation of quarterly data for the period 1996:01–2009:02. we specify the following equation, where all variables except prime lending rate are expressed in logarithmic forms, ε is a random error term, and t is a quarterly time index.

$$Ln\ P_t = \alpha + \beta ln Y_t + \delta R_t + \phi ln\ M_t + \gamma ln X_t + \varepsilon_t$$

P= wholesale price index (1993-94 base year prices)

Y= Nominal gross domestic product (1999-00 base year prices)

M= Broad money, R= Prime lending rate, X= rupee- dollar bilateral exchange rate

ε= error term

The first step of the strategy of our empirical analysis involves determining the order of integration. Most time series are trended and therefore in most cases are nonstationary. The problem with non stationary or trended data is that the standard OLS regression procedure can easily lead to incorrect conclusion. A series of Augmented Dickey-Fuller unit root test is performed to determine the order of integration of the variables.

Table shows the ADF test results for both at the level and the first difference on intercept and intercept and trend.

Table (1)

	Intercept only		Intercept and trend	
Variables	Level	First difference	Level	First difference
	Prob: value	Prob: value	Prob: value	Prob: value
ln P	0.9984(5)	0.0000(0)	0.0602(1)	0.0001(0)
ln Y	1.0000(2)	0.0000(1)	0.3054(2)	0.0000(1)
R	0.0842(0)	0.0000(0)	0.06444(0)	0.0000(0)
Ln M	0.9970(2)	0.0033(1)	0.0771(7)	0.0105(1)
Ln x	0.1080(3)	0.0000(0)	0.3408(3)	0.0000(0)

(Numbers in parenthesis are the number of lags)

The reported result in table reveals that the hypothesis of a unit root can’t be rejected in all variables in levels. However, the hypothesis of a unit root is rejected in first differences at 0.05 level of significant which indicates that all variables are integrated of degree one, I(1). That means all the variables achieve stationarity only after first difference.

The estimation of the equation by direct OLS gives the following integration equation.

$$\hat{P} = 0.769524 + 0.031479y_t - 0.003224R_t + 0.307648M_t - 0.098304x_t$$

(2.937358) (0.662551) (-1.458706) (8.804150) (-2.390108)

(0.0050) (0.5107) (0.1510) (0.000) (0.0207)

Adj R^2= 0.994411 F= 2358.394 DW=1.165611

The estimated parameters of equation are in accordance with economic theory. Prime lending rate and exchange rate have negative parameters while income and broad money has positive coefficients. All coefficients are statistically significant at 0.05 % level except income and prime lending rate. Here we have high R^2 and t-values, but ε_t is not white noise. All the variables give the expected result, but the nonstationarity of variable biased the previous estimation, and the low value of DW can be interpreted as sign of spurious regression.

The criterion for selecting the lag length consist an important step. There are different tests that would indicate the optimal number of lags. The study utilizes the SC criterion to ensure sufficient power of the Johansen procedure.

The next step in our empirical analysis is to test for cointegration. Since the variables are considered to be I(1), the cointegration method is appropriate to estimate the long run demand for money. The concept of cointegration is that non-stationary time series are cointegrated if a linear combination of these variables is stationary. The cointegration requires the error term in the long-run relation to be stationary. Suppose there are two variable Y_t ad X_t and both Y_t and X_t follows I (1) process, Still the linear combination $U_t=Y_t - \alpha X_t$ is I (0). If so, both Y_t and X_t are said to be cointegrated and a is the cointegrating parameter. The maximum likelihood approach to test for cointegration is based on the following system of equations

$$\Delta x_t = \pi x_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta x_{t-i} + \varepsilon_t$$

The number of independent cointegrating vector is equal to the rank of matrix π, If rank of $\pi = 0$; then π is a null matrix and equation turns out to be a VAR model, whereas If rank of $\pi =1$, there is one cointegrating vector and $\pi\, x_{t-1}$ is an error correction term. Johansen suggests that it can be done by testing the significance of characterizes roots of π.

Johansen suggests two test statistics to test the null hypothesis that numbers of characteristics roots are insignificantly different from unity.

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i)$$

$$\lambda_{\max}(r, r+1) = -T \ln(1-\hat{\lambda}_{r+1})$$

λ_i = estimated characteristic roots or Eigen values

T = the number of usable observations

λ_{trace} test the null hypothesis

$r = 0$ against the alternative of $r > 0$

λ_{max} test the null hypothesis

$r = 0$ against the alternative of $r = 1$

The theory asserts that there exists a linear combination of this non-stationary that is stationary. Solving for the error term, we can rewrite the relation as

$$\varepsilon_{t=} \alpha\text{-}\beta lnY_t \text{-}\delta R_t \text{-}\phi ln\ M_t \text{-}\gamma lnX_t$$

Since $\{\varepsilon_t\}$ must be stationary, it follows that the linear combination of integrated variables given by the right hand side of must also be stationary.

Cointegration test result

Unrestricted cointegration Rank test (Trace)				
Null hypothesis	Eigen Value	Trace statistics	5 percent critical value	Porb.**
r=0*	0.576467	102.6474	69.81889	0.0000
r≤1*	0.467886	57.97292	47.85613	0.0042
r≤2	0.233837	25.16622	29.79707	0.1556
r≤3	0.148988	11.31545	15.49471	0.1928
r≤4	0.054722	2.926370	3.841466	0.0871
Unrestricted cointegration Rank test (Maximum Eigenvalue)				
Null hypothesis)	Eigen Value	Max-Eigenvalue	5 percent critical value	Porb.**
r=0*	0.576467	44.67449	33.87687	0.0018
r≤1*	0.467886	32.80671	27.58434	0.0097
r≤2	0.233837	13.85076	21.13162	0.3774
r≤3	0.148988	8.389084	14.26460	0.3405
r≤4	0.054722	2.926370	3.841466	0.0871

(denotes the rejection of the hypothesis at the 0.05 level. And ** are Mackinnon-Hauge-Michelis (1999) p-values.)*

The above table shows that the null hypothesis of no cointegration is rejected at the conventional level (0.05) and the study conclude that there exists a relationship among the proposed variables in the long run. Trace test and Eigen value test indicates that there are two cointegrationg vector.

Normalized cointegration coefficients				
lnP	lnY	R	lnM	lnx
1.0000	0.376811 (0.07187)	-0.009078 (0.00283)	0.047984 (0.05220)	-0.064723 (0.060)

The normalized cointegration equation is depicted in above table which reveals that the income and money has a positive effect on inflation. On the other hand, prime lending rate and exchange rate has a negative. The income coefficient is 0.37 and showing significant, implying that in India, a one percent increase in income while others keep constant contributes 0.37% increase in inflation. Similarly the money coefficient is 0.047 and showing significant, implying that in India, one percent increase in money supply leads to a 5% increase in price level. Interest rate and exchange rate carries expected negative and significant coefficient.

By specifying the long run determinants of inflation in an error correction model, the short run as well as the long run effects of all right hand side variables in equation are estimated in one step, which is a major advantage that error correction modeling has in comparison to other estimation.

The dynamic relationship includes the lagged value of the residual from the cointegrating regression (ε_{t-1}) in addition to the first difference of variables which appear in the right hand side of the long run relationship (Y, M, R and X). The inclusion of the variables from the long run relationship would capture short run dynamics.

The ECM simply defined as

$$\Delta P_t = \lambda p(P_{t-1} - \alpha - \beta Y_{t-1} - \delta R_{t-1} - \phi M_{t-1} - \gamma X_{t-1}) + \varepsilon_{pt}$$
$$\Delta Y_t = \lambda y(P_{t-1} - \alpha - \beta Y_{t-1} - \delta R_{t-1} - \phi M_{t-1} - \gamma X_{t-1}) + \varepsilon_{yt}$$
$$\Delta R_t = \lambda r(P_{t-1} - \alpha - \beta Y_{t-1} - \delta R_{t-1} - \phi M_{t-1} - \gamma X_{t-1}) + \varepsilon_{Rt}$$
$$\Delta M_t = \lambda m(P_{t-1} - \alpha - \beta Y_{t-1} - \delta R_{t-1} - \phi M_{t-1} - \gamma X_{t-1}) + \varepsilon_{mt}$$
$$\Delta X_t = \lambda x(P_{t-1} - \alpha - \beta Y_{t-1} - \delta R_{t-1} - \phi M_{t-1} - \gamma X_{t-1}) + \varepsilon_{xt}$$

Where, the elements of ε_t s are white noise errors and λ_s are speed of adjustment parameters and α ,β,δ ,ф and γ are short run parameters. All the variable in the ECM are stationary, and therefore, the ECM has no problem of spurious regression.

Error correction	D(P)	D(Y)	D(R)	D(M)	D(X)
Coint Eq1	0.310190	-1.327206	2.406123	-0.041910	-0.322688
Standard error	(0.09888)	(0.24730)	(3.76831)	(0.11202)	(0.31411)
t statistics	[-3.13701]	[5.36680]	[-0.63851]	[0.37413]	[1.02731]

The above table shows the speed of adjustment coefficients, which reveals that only two variables are adjusting. The adjustment coefficient on cointegration equation 1 for the GDP is negative. The adjustment coefficient for broad money and exchange rate are showing negative, as it should be, but both adjusting coefficient are showing insignificant. Similarly adjustment coefficient for prime lending rate is showing positive, as it should be. But the estimated error correction model enjoys a very low goodness of fit (R^2=0.248572, adj R^2 =0.0178382). The empirical study is performed by using PC version of Eviews 6.0.

Conclusion

The study used five variables extracting 54 quarterly observations from 1996Q1 to 2009Q2. Since all the variables have unit root at levels the study utilizes Johansen-juselius cointegration analysis to test for the existence of a long run relationship between the variables. The cointegrating regression so far considers only the long-run property of the model, and does not deal with the short-run dynamics explicitly. For this, the error correction from the long run determinants o0f inflation is then used as a dynamic model to estimate the short run determinants of inflation. Both the trace test and Eigen value test indicates that there are two cointegrationg vector. The study concluded that the GDP and broad money have a positive effect on the inflation in long run. On the other hand, interest rate and exchange rate has a negative effect. All variables carry expected result. The income coefficient is 0.37 and showing significant, implying that in India, a one percent increase in income while others keep constant contributes 0.37% increase in inflation. Similarly the money coefficient is 0.047 and showing significant, implying that in India, one percent increase in money supply leads to a 5% increase in price level.

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