

**Capital Inflows, Inflation and Exchange  
Rate Volatility: An Investigation for  
Linear and Nonlinear  
Causal Linkages**

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## ABSTRACT

Since the early 1990s, there is an upsurge in foreign capital flows to developing economies, particularly into emerging markets. One view argues that capital inflows do help to increase efficiency, a better allocation of capital and to fill up the investment-saving gap. Adherents to that view advise countries to launch capital account liberalisation. In this study, we investigate the effects of capital inflows on domestic price level, monetary expansion and exchange rate volatility. To proceed with this, linear and nonlinear cointegration and Granger causality tests are applied in a bi-variate as well as in multivariate framework. The key message of the analysis is that there is a significant inflationary impact of capital inflows, in particular during the last 7 years. The finding suggest that there is a need to manage the capital inflows in such a way that they should neither create an *inflationary pressure* in the economy nor fuel the *exchange rate volatility*.

*JEL classification:* C22; C32; F21; F31; F32

*Keywords:* Capital Inflows, Inflationary Pressures, Exchange Rate Volatility, Monetary Expansion, Nonlinear Dynamics

## 1. INTRODUCTION

Despite the access to foreign funds in general and to foreign direct investment (FDI) in particular have helped to finance economic development and encouraged positive growth externalities, the abrupt improvement of the process of integration of emerging market countries with international capital markets has brought problems for the host economies. Some researchers have analysed that capital inflows create some difficulties for the recipient countries in the form of *real appreciation* of their currencies. These difficulties include loss of competitiveness by exporters, spending boom, asset market bubbles, banking crises and the undermining of a strategy to achieve monetary stability by pegging the exchange rate.

Efforts to maintain a peg definitely imply that the central bank must intervene by absorbing the foreign exchange brought in by the capital inflows. However, such purchases not only increase the *monetary base* and generate *inflationary* dynamics but also lead to the expansion of bank deposits and loans. The expansion of bank balance sheets owing to capital inflows may deteriorate the fragility of the banking system if bank supervision is not fully effective.

The effects of capital inflows on domestic financial indicators depend on the ways in which they flow in to an economy. They also depend on whether the inflows are sustainable or temporary. Theoretically, the forces driving capital inflows differ country to country and can be classified into three clusters: first, an exogenous increase in the domestic productivity of capital, second, an autonomous increase in the domestic money demand function and, third, external factors, such as a reduction in international interest rates. The former two are known as “*pull*” factors and the latter one is called “*push*” factors.<sup>1</sup> Table 1 shows the effects of capital inflows on certain financial indicators under different sources of foreign capital flows.

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<sup>1</sup>Other things remain constant, capital inflows owing to “pull” factors will cause an upward pressure on domestic interest rates, whereas capital inflows caused by “push” factors, such as a fall in international interest rates, will have a tendency to put downward pressure on domestic interest rates on one hand. On other hand, it will initially drive up nominal and real balances, but then, as domestic price level increases, real balances may decline.

Table 1

*Causes of Capital Inflows and the Trend of Financial Indicators*

Financial Indicators	Pull Factors		Push Factors
	Upward Shift of Money Demand Function	An Exogenous Increase in Productivity of Domestic Capital (Sustained Inflows)	External Factors, Such as Declining International Interest Rates (Temporary Inflows)
1. Base Money	↑	↑	↑
2. Foreign Reserves	↑	↑	↑
3. Interest Rate	↑	↑	↓
4. Domestic Currency Value	↑	↑	↑
5. Inflation	↓	↑	↑
6. Equity Prices	↓	↑	↑
7. Real Money Balance	↑	↓	↑

The arrows signs in the table indicate the increasing (↑) and decreasing (↓) trends. The capital inflows caused by either “push” or “pull” factors positively impact on monetary base of the host country, foreign reserves and appreciation of the currency value. For remaining indicators, the impact of capital inflows, however, depends upon the channel of flows. For instance, capital inflows driven by pull factors—an upward shift of money demand curve and an exogenous increase in productivity of domestic capital—have an upward pressure on market rate of interest. In contrast, when foreign capital inflows fuelled owing to external factors—such as a decline in international interest rate etc.—will be associated with a decline in interest rates.

Regarding inflation and equity price, the capital inflows have positive impact on them if foreign capital surge caused by an exogenous growth in productivity of domestic capital or/and by declining interest rate in foreign money markets, while it will be apt to put downward pressure on domestic inflation and equity prices as well when flows due an upward move in demand curve. Capital inflows attracted by an enhancement in productivity of domestic capital will pull up the real money balance, while the capital inflows arrived through other sources will drive it down.

The objective of the study is to explore the impact of capital inflows on domestic prices and exchange rate volatility. The motivation for this study is based on the whispers which the data emit about Pakistan’s economy over the period from 1990 to 2007. We start by an inclusive look at the trends of some selected economic indicators (see Table 2). As percentage of GDP, the estimates on national savings do not show a significant upward trend and remain steady between a narrow-range of 16.5 to 20.8. On the contrary, inflation rate and weighted average lending rate both have an increasing trend and this upward trend got further heat during the last three fiscal years. Notably, the volume of credit to private sector has risen during the examined period. It was only 103.0 billion dollar in 1998-99, which rose to 356.3 in 2006-07. This enormous

Table 2

*Selected Economic Indicators (FY1999 to FY2007)*

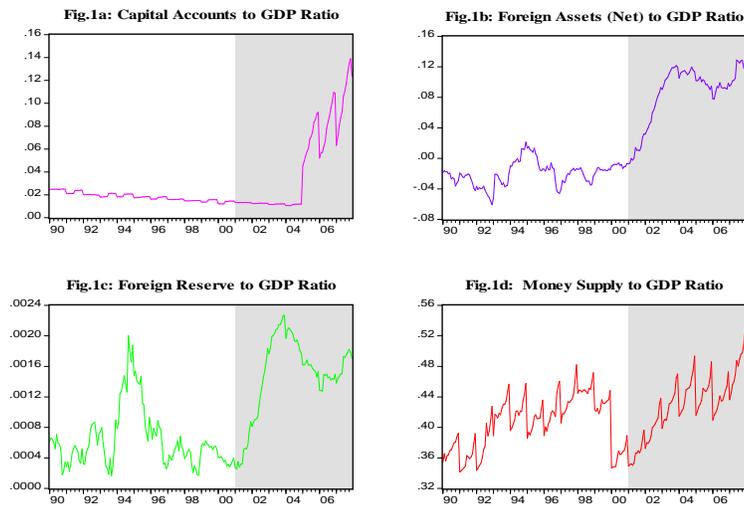
Economic Indicators	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
Real GDP Growth	4.2	3.9	1.8	3.1	4.7	7.5	9.0	6.6	7.0
National Saving (% of GDP)	11.7	15.8	16.5	18.6	20.8	17.9	17.5	17.7	18.1
Inflation	5.7	3.6	4.4	3.5	3.1	4.6	9.3	7.9	7.8
Fiscal Deficit (% of GDP)	6.1	5.4	4.3	4.3	3.7	2.4	3.3	4.2	4.2
Credit to Private Sector <sup>a</sup>	103.0	18.0	48.6	53.0	168.0	325.0	390.3	401.8	356.3
Public Debt (% of GDP)	100.4	94.8	82.8	79.7	75.1	67.1	62.2	57.2	55.2
Weighted Avg. Lending Rate	15.4	14.0	13.7	13.1	7.58	5.05	8.2	10.2	10.6
Current Balance (% of GDP)	-4.1	-1.6	-0.7	0.1	3.8	1.4	-1.6	-3.9	-4.9

<sup>a</sup> the estimates are in billion U.S dollars. *Source:* Ministry of Finance.

increase, to some extent, is the indication of an expansion of monetary base of the economy. Finally, the growth rate in real GDP have risen from 1.8 percent in 2000-01 to 7.5 percent in 2003-04, further increased to 9.0 percent in the next year, dropping to 6.6 percent in fiscal year 2005-06 and then again rising 7.0 in 2006-07.

As the visual inspection of the data is a critical first step in any econometric analysis, the time-series plots of four ratio variables (Given in Figure 1).<sup>2</sup> Since scales differ in case of each variable, the plots should be interpreted carefully. The breaks in series are usually associated with currency crises or other regime breaks.

**Fig. 1. Time-series for Ratio Variables over the Period from January 1990 to December 2007**



<sup>2</sup> The software EViews 5.0 has used for all computations and graphical output in this study.

All the four ratios apart from capital account to GDP ratio, which shows a gradual decline between the period 1990 to 2004 and a rapid consistent increase for subsequent period, have much dynamic behaviour over the examined sample period. Interestingly, however, the money supply to GDP ratio is more fluctuated as compared to both the ratio of foreign reserves to GDP and the ratio of net foreign assets to GDP. All the four ratios have shown a rapid increase during the period of 2001 to 2007. Now, clearly, the two questions come up in mind: First, is there any association between monetary base of the economy and capital inflows? And second, whether the significant increase in capital inflows during the period of 2001 to 2007 is the result of better macroeconomic performance or just capital arrived due to some push factors.

To proceed the story further, we estimate the correlation coefficients to assess the relationship among the variables. As Figure 1 provides significance evidence of the presence of a structure break in the data, we divide the full-sample period into two sub-sample periods. The first sub-sample period ranging from January 1990 to December 2000 and the second sub-sample spans from January 2001 to December 2007. Since the core objective of the analysis is to quantify the affect of capital inflows on monetary indicators such exchange rate, inflation level and interest rate this division seems rational because a large capital surge arrived during 2001 to 2007. The correlation matrixes for first and second sub-periods are presented in Table 3 and Table 4, respectively.<sup>3</sup>

Table 3

*Correlation Coefficients for the Period January 1990 to December 2000*

Variables	Ratio Series				Log Form First-Difference Series		
	CAR	FAR	FRR	MSR	LCCPI	LMMR	LCNER
FAR	-0.260						
FRR	0.130	0.648					
MSR	-0.322	0.047	0.125				
LCCPI	0.316	-0.023	0.130	-0.098			
LMMR	-0.203	0.095	0.040	0.246	-0.089		
LCNER	-0.037	-0.066	-0.129	0.022	-0.026	-0.040	
LDC	0.182	-0.249	-0.040	-0.003	0.011	0.229	0.239

\*Bold values indicate that the correlation is significant at the 0.05 level.

<sup>3</sup> See data Section 4 in the text for definition and notation used for the variables.

Table 4

*Correlation Coefficients for the Period January 2001 to December 2007*

Variables	Ratio Series				Log Form First-Difference Series		
	CAR	FAR	FRR	MSR	LCCPI	LMMR	LCNER
FAR	0.388						
FRR	0.126	0.949					
MSR	0.654	0.857	0.715				
LCCPI	0.229	0.297	0.238	0.241			
LMMR	0.567	-0.355	-0.574	-0.010	-0.037		
LCNER	0.053	-0.138	-0.176	-0.088	-0.084	-0.052	
LDC	0.263	0.350	0.323	0.511	-0.054	0.451	0.006

\* Bold values indicate that the correlation is significant at the 0.05 level.

The estimates on correlation coefficient provide some fascinating information about the association of the variables. The relationship has been changed dramatically during the *massive* capital surge episode in 2001-2007. For instance, the ratio of money supply to GDP is only significantly correlated, it is also interesting to note that the magnitude is negative, with capital account ratio to GDP during the period from 1990 to 2000 when the capital inflows were stumpy and inconsistence. Moreover, this ratio is not significantly influenced by the net foreign assets to GDP and foreign reserves to GDP ratios. During the period of large capital inflows from 2001 to 2007, however, not only the magnitude of correlation between the ratio of money supply to GDP and the net foreign assets to GDP and foreign reserves to GDP ratios have considerably been improved but also appeared statistically significant. It implies that after 2001, the foreign capital inflows have played a significant role in expanding the monetary base of the economy.

The estimates of the correlation between the rate of inflation and the net capital inflows to GDP, the balance of capital account to GDP and the foreign reserves to GDP ratios provide another interesting insight about the association of capital inflows and inflationary pressures. The inflation rate is significantly positively correlated with the four ratios during the period of 2001-2007, whereas it was only significantly related with the capital account ratio to GDP over the period from 1990 to 2000.

Table 4 provides another offensive piece of evidence that is, the change in domestic debt is approximately 50 percent correlated with the monetary base of the economy during the latter sub-period, though both were independent of each other in earlier periods. In sum, the coefficients of correlation are providing some preliminary evidence of the dynamic interactions between capital inflows and inflationary pressures: a theme that is explored in the next section. Moreover, the estimate clearly indicating that there was a *structure break* in 2001 and is a possibility that there may be *nonlinearities* exists in the salient economic relationships. This motivates us to apply the nonlinear cointegration

and Granger causality test to examine the long- and short-run linkages among the variables.

Another appealing indication of the findings presented in Tables 1 to 4 is the doubt about the effectiveness of the policy used by the State Bank of Pakistan (SBP) to manage the capital inflows, particularly, during the second sub-period. Theoretically, whether the monetary base is altered or not by capital inflows depends upon whether the central bank intervenes to maintain a fixed exchange rate or allows it to float freely with no intervention. If there is intervention, then an accumulation of international reserves presents an increase in the net foreign exchange assets of the central bank and directly affects the monetary base. And this distress gets worse further in case when the central bank does intervention in inefficient way.

For an effective *absorption* and *sterilisation* of foreign capital inflows, it is necessary to know that whether the relationship between capital inflows and monetary indicators which suggested by correlation coefficients is stable in the long run or just the short-term phenomenon. This is the question which our paper tries to address. If we would be able to find any significant causation running from capital inflows to monetary indicators then, definitely, the continuity of the existing foreign exchange management policy could spell *trouble* for the economy—especially domestic price level and exchange rate volatility. Our paper differs from the existing literature in two ways. This is, as we know the best, a first attempt to explore the impact of capital inflows on inflationary dynamics in Pakistan. Secondly, we consider the nonlinear model as well instead of just focusing on the linear model.

The rest of the study is structured as follows. Section 2 reviews the literature. Section 4 describes the econometric methodology and data. Section 5 presents the results from testing the linear and nonlinear causal linkages. Finally, Section 6 concludes the study.

## 2. LITERATURE REVIEW

Edwards (2000) investigates the dynamic association between exchange rate regimes, capital flows and currency crises in emerging economies. The study draws on lessons learned during the 1990s, and deals with some of the most important policy controversies that emerged after the Mexican, East Asian, Russian and Brazilian crises. He concludes that under the appropriate conditions and policies, floating exchange rates can be effective and efficient.

A study by Kohli (2001) discusses the pressures of a capital surge upon domestic monetary management in India over the period from 1970 to 1999. The author reports that during the capital surge episode in 1993-95, the central bank's monetary target, as M3 growth rate was 15 to 16 percent during this period, was overshoot and monetary base expended in both nominal and real terms. Empirical evidence shows that domestic private sector credit is the only variable that can be used effectively to control inflation in case of large capital inflows.

Taylor (2001) discusses the failure of liberalised policies in Argentina. He says that Argentina has failed in maintaining the liberalised policies about capital flows and a firm currency. Argentina had anti-inflation program based on freezing the exchange rate in the early 1990s. This means that the money supply within the country and the supply of credit to firms are tied directly to international reserves. So if the country gets capital inflows, the supply of money and credit increases, leading to a substantial increase in domestic prices.

Musinguzi and Benon (2002) discuss the management of inflows in Uganda. Using monthly data and an Autoregressive Distributed Lag (ARDL) Approach to Cointegration, they conclude that the import unit price, nominal exchange rate and base money significantly and positively drive the composite headline annual inflation in Uganda in the long run.

Glick and Michael (2002) investigate whether legal restrictions on international capital flows are associated with greater currency stability. They use a comprehensive panel data set of 69 developing countries over the period from 1975 to 1997, identifying 160 currency crises. They find evidence that restrictions on capital flows do not effectively protect economies from currency problems.

Chakraborty (2003) discussed the relationship between capital inflows, real effective exchange rate for India between 1993Q2 to 2001Q1. Using an unrestricted VAR framework, the study provides evidence that the real effective exchange rate is response to one standard deviation innovation to foreign capital inflows.

Cook and Michael (2005) develop a model of capital inflows that are linked to exchange rate regime. The key message of the analysis is that a hard peg is undesirable in the absence of commitment in fiscal policy. They made argue that if fiscal policy must be financed by money creation rather than direct taxation, then a fixed exchange rate rule may cause both over-borrowing and a subsequent exchange rate crisis.

Gupta (2005) analysed the effects of financial liberalisation on inflation. He develops a monetary and endogenous growth, dynamic general equilibrium model of a small open semi-industrialised economy, with financial intermediaries subjected to obligatory "high" reserve ratio, serving as the source of financial repression. He applied the model on data from four Southern European semi-industrialised countries, namely Greece, Italy, Spain and Portugal. The results indicate a positive and statistical significant association between inflation and financial repression.

Due and Sen (2006) examine the interactions between the real exchange rate, level of capital flows, volatility of flows, fiscal and monetary policy indicators and the current account surplus for Indian economy for the period 1993Q2 to 2004Q1. The estimations indicate that the variables are cointegrated and each Granger causes to the real exchange rate.

Robe, *et al.* (2007) in their study review the experiences of a number of European countries in coping with capital inflows. The findings of their study suggest that as countries become more integrated with international financial markets, there is little room to regulate capital flows effectively.

### 3. THE EMPIRICAL MODEL, METHODOLOGY AND DATA

To provide economic rationale, we articulate the impact of foreign capital inflows on domestic prices as follows. Suppose the private sector of an economy receives a gift of  $G$  dollars from abroad. Now government does not allow to private sector to use these dollars and buys the dollars from the private sector at the ongoing exchange rate  $e$ , with newly created money and adds  $G$  dollars to its reserves. Consequently, we obtain the aggregate expenditures as follows:

$$E = \bar{M} + eG \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (1)$$

where  $E$  denotes the nominal expenditures on goods and services,  $\bar{M}$  is the pre-gift nominal money stock, and  $e$  is the nominal exchange rate. As expression (1) also represents the demand for money, the money market equilibrium condition is

$$M^d = M^s = \bar{M} + eG \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (2)$$

Considering the quantity theory of demand for money, the nominal price ( $P_N$ ), in equilibrium is defined as

$$P_N = \frac{V \times M^s}{Y} = \frac{V \times \bar{M} + eG}{Y} \quad \dots \quad \dots \quad \dots \quad \dots \quad (3)$$

where  $V$  is the income velocity of money and  $Y$  denote the aggregate level of output. Equation (3) provides a positive relation between capital inflows and domestic price levels (i.e.,  $\frac{\partial P_N}{\partial G} > 0$ ) and a negative relationship between the

level of output and prices (i.e.,  $\frac{\partial P_N}{\partial Y} < 0$ ). Thus, as long as the government adds

the gift  $G$  to its reserves, and does not allow it to be absorbed in the economy, it would produce only an inflationary effect. When estimating Equation (3), different explanatory variables are used to ensure that empirical links between capital inflows and inflationary dynamics are not spurious. The choice of explanatory variables in our empirical work is based on availability of data, previous evidence found in the literature and aforesaid theoretical rationalisations.

Regarding the linear long- and short-run relationship, we use the standard Johansen's cointegration test and the Granger causality test, respectively. As these two tests are very common in literature, we do not present here. Below,

however, the nonlinear cointegration and causality tests are explained in details. We use the Lin and Granger (2004) to explore the nonlinear long-run relationships.

Let  $x_t$  be a linear integrated process and  $y_t$  and  $x_t$  are called nonlinearly cointegrated with function  $f$  provided  $u_t = y_t - f(x_t)$  has asymptotic order smaller than those of  $y$  and  $f(x)$ . Lin and Granger (2004) defined the following steps to test the null of non-linear cointegration against of alternative of no nonlinear cointegration.

- (1) Identify the possible nonlinear function for using Alternative Conditional Expectation (ACE) criterion (i.e., logarithm, exponential, square root, Box-Cox transformation, etc.).
- (2) Apply the Nonlinear Least Square (NLS) method the estimate the parameters of the specified function.
- (3) Obtain the residuals from the estimated model and store.
- (4) Apply KPSS test for estimated residual to test the null of nonlinear cointegration.

Lin and Granger (2004) said that if the null hypothesis is specified as cointegration, KPSS-test would give the right distribution under the null hypothesis and power approaching one as sample size grows under the alternative.

To examine the nonlinear short-run causality, we use the Hristu-Varsakkeis and Kyrtsov (2006) nonlinear Granger causality test—know as the bivariate noisy Mackey-Glass (hereafter M-G) model and is based on a special type of nonlinear structure developed by Kyrtsov and Labys (2006). The model is given below:

$$X_t = \alpha_{11} \frac{X_{t-\tau_1}}{1 + X_{t-\tau_1}^{c_1}} - \delta_{11} X_{t-1} + \alpha_{12} \frac{Y_{t-\tau_2}}{1 + Y_{t-\tau_2}^{c_2}} - \delta_{12} Y_{t-1} + \xi_{1t} \quad \xi_{1t} \approx N(0,1) \quad (4)$$

$$Y_t = \alpha_{21} \frac{X_{t-\tau_1}}{1 + X_{t-\tau_1}^{c_1}} - \delta_{21} X_{t-1} + \alpha_{22} \frac{Y_{t-\tau_2}}{1 + Y_{t-\tau_2}^{c_2}} - \delta_{22} Y_{t-1} + \xi_{2t} \quad \xi_{2t} \approx N(0,1) \quad \dots \quad (5)$$

where  $X$  and  $Y$  are a pair of related time series variables, the  $\alpha_{ij}$  and  $\delta_{ij}$  are parameters to be estimated,  $\tau_i$  are delays,  $c_i$  are constants. The best model (4) is that allowing the maximum Log Likelihood value and minimum Schwarz information criterion.

As mentioned in Kyrtsov and Labys (2006, 2007), and Kyrtsov and Vorlow (2007), the principle advantage of model (31) over simple VAR alternatives is that the nonlinear M-G terms are able to capture more complex dependent dynamics in a time series. The test aims to capture whether past samples of a variable  $Y$  have a significant nonlinear effect (of the

type  $\frac{Y_{t-\tau_2}}{1 + Y_{t-\tau_2}^{c_2}}$ ) on the current value of variable  $X$ . Test procedure begins by

estimating the parameters of a M-G model that best fits the given series, using ordinary least squares. To test reverse causality (i.e., from  $X$  to  $Y$ ), a second M-G model is estimated, under the constraint  $\alpha_{22} = 0$ .

The latter equation represents null hypothesis. Let  $\hat{\xi}_{1t}, \hat{\zeta}_{1t}$  be the residuals produced by the unconstrained and constrained best-fit M-G models, respectively. Next, compute the sums of squared residuals  $S_c = \sum_{t=1}^N \hat{\zeta}_{1t}^2$  and  $S_u = \sum_{t=1}^N \hat{\xi}_{1t}^2$ . Let  $m$  is the number of free parameters in the M-G model and  $k$  is number of parameters set to zero when estimating the constrained model, then the test statistic is defined as

$$S_F = \frac{(S_c - S_u)/k}{S_u/(N - m - 1)} \approx F_{k, N-m-1}$$

If the calculated statistics is greater than a specified critical value, then someone rejects the null hypothesis that  $Y$  does not nonlinearly causes  $X$ .

We use monthly data over the span from 1990 to 2007. The main source of data is the IMF's International Financial Statistics (CD-ROM). The variable are the log of market interest rate (line 60b and denoted by MMR), the log of nominal exchange rate (line ae and denoted by NER), the log of manufacturing Production Index (line 66ey and denoted by MPI), the log of consumer price index (line 64 and denoted by CPI), the ratio of foreign reserves to GDP ratio (line 1Id times line ae divided by line 90b and denoted by FRR), the ratio of net foreign assets to GDP (line 31n divided by line 90b and denoted by FAR), the ratio of abroad money supply to GDP (lines 34 plus 35 divided by line 90b and denoted by MSR), the ratio of capital account to GDP (line 37a divided by 90b and denoted by CAR) and the log value domestic credit growth (line 32 and denoted by LDC).<sup>4</sup>

#### 4. EMPIRICAL RESULTS

The first step involved in applying cointegration is to determine the order of integration of each variable/series. This was achieved by estimating the ADF and KPSS unit root tests. The estimated statistics of ADF and KPSS tests for level are presented in Table 5. To find an appropriate lag length for ADF tests, we use the criterion developed by Campbell and Perron (1991). Accordingly, it is started with a maximum lag length of  $k$ , and sequentially deleted insignificant

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<sup>4</sup>Here, the domestic debt includes claims on general government (net), claims on non-financial public enterprises, claims on private sector, and claims on nonblank financial institutions.

Table 5

*Unit Root Test Results for Level Series (January 1990 to December 2007)*

Variables	ADF		KPSS	
	$t_{ADF(c)}$	$t_{ADF(c+t)}$	$LM_{KPSS(c)}$	$LM_{KPSS(c+t)}$
<b>Ratio Form Variables</b>				
CAR	0.921	0.330	0.738	0.342
FAR	-0.844	-2.695	1.496	0.287
FRR	-1.982	-2.689	0.845	0.182
MSR	-2.109	-2.779	0.672	0.166
<b>Log Form Variables</b>				
LCPI	-2.903	-2.283	1.838	0.421
LMPI	1.005	-0.735	1.639	0.440
LMMR	-2.288	-2.364	0.440	0.161
LNER	-2.086	-0.389	1.792	0.413
LREER	-1.877	-3.948	1.697	0.213
LDC	-0.045	-2.511	1.828	0.239
<b>Log Form First Differenced Variables</b>				
LCCPI	-6.178	-6.725	0.946	0.284
LCMPI	-6.286	-6.465	0.088	0.036
LCNER	-14.417	-14.685	0.552	0.093

Notes:  $t_{ADF(c)}$  and  $t_{ADF(c+t)}$  are the standard ADF test statistics for the null of non-stationary of the variable in the study without and with a trend, respectively, in the model for testing.  $LM_{KPSS(c)}$  and  $LM_{KPSS(c+t)}$  are the KPSS test statistics for the null of stationary of the variable in the study without and with a trend, respectively in the model for testing. The 10 percent and 5 percent asymptotic critical values are -2.57 and -2.86 for  $t_{ADF(c)}$  respectively, and are -3.12 and -3.41 for  $t_{ADF(c+t)}$  respectively. The 10 percent and 5 percent asymptotic critical values are 0.347 and 0.463 for  $LM_{KPSS(c)}$  respectively, and 0.119 and 0.146 for  $LM_{KPSS(c+t)}$  respectively. \* and \*\* denote rejection of the null hypothesis at the 10 percent and 5 percent significant levels, respectively.

lags until the last lag was significant. The null hypothesis of non-stationary cannot be rejected at any common level of significance for all the said series at their levels. However, in some cases, the positive statistics are indicating positive autocorrelation.

The KSPP test statistics  $\eta_u$  and  $\hat{\eta}_\tau$  are estimated at the values of lag 3 to test the null hypothesis of stationarity with and without a time trend, respectively. The choice of three as the maximum value  $l$  is based on wisdom that the autocorrelations in monthly series has considerably died at  $l = 3$ . Since the estimated test statistic,  $\eta_u$ , is greater than the critical values (at all examined lag values) for all the said series expect for the log change in manufacturing output, therefore, we reject the null of stationarity in favour of the alternative of unit roots, that is, all the series have unit roots. However, if the deterministic trends are present in the series then the rejections of the hypothesis of level stationarity are not considered reliable.

We therefore test the null hypothesis of stationarity around a deterministic linear trend. The estimated  $\hat{\eta}_\tau$  statistics of lag 1 to 3 are reported

in last column of Table 5. The estimated statistics are significantly greater than critical values. Consequently, the null hypothesis of trend stationarity is rejected at any usual level of significance. Thus, it can be concluded that all the said series follow unit roots (non-stationary) both around a level and around a linear trend in their levels apart from the log value of consumer price index that is trend stationary in its level. Since the first-difference of the series appear stationary,<sup>5</sup> all the series are integrated of order one (i.e.,  $I(1)$ ).

The next step to carry on the cointegration testing procedure is to determine the autoregressive order ( $m$ ) of the models. The prime objective here is to select the optimal lag-length ( $m$ ) that eliminates any autocorrelation present in the residuals. We use the sequential modified likelihood ratio (LR) test to decide the number of lags to be included in the empirical models. The modified LR statistic is used to test for the exclusion of the maximum lag (say 12<sup>th</sup>). If the exclusion of the 8<sup>th</sup> lag is not rejected, the VAR order is reduced to 7, and the significance of the 7<sup>th</sup> lag is tested. The method continues until the reduction of the lag order by 1 at the 5 per cent significance level cannot be rejected.

The specification of the vector error correction (VEC) model is based on the presence of a cointegration relation. If such a relation exists, then it can be posited that at least one linear combination of the non-stationary series is stationary and that there is therefore a long-run equilibrium relationship among the variables. Since the data does exhibit any significant linear deterministic trend, we estimate the cointegration equation with intercept but without linear trend term. The results from multivariate Johansen Cointegration test for the first sub-period from January 1990 to December 2000 are given in Table 6.

Table 6

*Results from Multivariate Johansen Cointegration Analysis  
(January 1990 to December 2000)*

Null Hypothesis	Model I		Model II		Model III		Model IV	
	$\lambda_{\max}$	$\lambda_{Trace}$	$\lambda_{\max}$	$\lambda_{Trace}$	$\lambda_{\max}$	$\lambda_{Trace}$	$\lambda_{\max}$	$\lambda_{Trace}$
$r = 0$	31.36*	66.95*	39.63*	104.50*	41.50*	84.93*	51.94*	126.12*
$r \leq 1$	21.11	35.59*	27.31	64.87*	18.80	43.43*	31.52*	74.17*
$r \leq 2$	9.00	14.48	23.86	17.57	17.38	24.62	21.83	42.65*
$r \leq 3$	5.48	5.48	9.53	13.71	7.25	7.25	11.77	20.82
$r \leq 4$	–	–	4.17	4.17	–	–	9.05	9.05

*Note:* \*Denotes the rejection of the hypothesis at the 1 percent level of significance.

<sup>5</sup>The results for first-difference series are not given here to economize the space, however, are available upon request.

The trace ( $\lambda_{Trace(r)}$ ) and the maximum eigenvalue ( $\lambda_{max}$ ) statistics are used to identify the number of existing cointegrating vectors. We use three different measures namely net foreign assets to GDP ratio, foreign reserves to GDP ratio and capital account surplus to GDP ratio as proxies for foreign capital inflows. Accordingly, the four models are estimated using a set of other control variables—varies model to model, to explore the net impact of capital inflows on domestic price level.

The estimates provide strong evidence of existing at least one cointegrating vector and this finding is robust across the four models. For instance, the trace test statistics indicate two cointegration equations at the one percent level of significance whereas the maximum eigenvalue statistics provide evidence of a single vector at the same level of significant for Model I, II and III. However, for Model IV, there are two statistically significant cointegrating vectors based on maximum eigenvalue test, while we found three vectors by trace test. Since the maximum eigenvalue test has a sharper alternative hypothesis as compared to trace test, we use it to select the number of cointegrating vectors.

The estimates for the second sub-period from January 2001 to December 2007 are presented in Table 7. For model I and IV, we find that the maximum eigenvalue test statistics indicate a single cointegrating vector, whereas, the trace test statistics identify 2 for Model I and 3 for Model IV. In case of Model II, both tests provide the evidence of the existing of 2 significant cointegrating vectors. As for Model III, the maximum eigenvalue test has been failed to explore any statistically significant cointegrating vector, however, the trace test indicate two significant cointegration equations.

Table 7

*Multivariate Johansen Cointegration Tests (January 2001 to December 2007)*

Null Hypothesis	Model I		Model II		Model III		Model IV	
	$\lambda_{max}$	$\lambda_{Trace}$	$\lambda_{max}$	$\lambda_{Trace}$	$\lambda_{max}$	$\lambda_{Trace}$	$\lambda_{max}$	$\lambda_{Trace}$
$r = 0$	27.98*	57.97*	39.60*	97.72*	25.97	61.45*	36.23*	92.5*
$r \leq 1$	16.73	29.99*	32.74*	58.12*	18.63	35.48*	24.66	56.3*
$r \leq 2$	13.23	13.26	14.15	25.38	15.94	16.85	18.93	31.6*
$r \leq 3$	0.03	0.03	11.22	11.23	0.91	0.91	12.63	12.7
$r \leq 4$	–	–	0.01	0.01	–	–	0.08	0.1

Note: \*Denotes the significant tests at the 1 percent level of significance.

### Impulse Response Function (IRF)

The study uses impulse response function as *an additional* check of the Cointegration test's findings. Followed by Order and Fisher (1993), Cholesky-type of contemporaneous identifying restrictions are employed to draw a meaningful interpretation. The recursive structure assumes that variables appearing first contemporaneously influence the latter variables but not vice

versa. It is important to list the most exogenous looking variables earlier than the most endogenous looking variables.

Impulse response functions for the first and second sub-periods are shown in Figures 3 and 4, respectively. This function accounts the dynamic response of domestic price level to a one standard deviation shock of net foreign assets to GDP ratio, foreign reserves to GDP ratio, money supply to GDP ratio, market interest rate, government public debt, nominal exchange rate and manufacturing output index. The response is considered significant if confidence intervals do not pass through zero line. For both the periods, the directions of changes observed in the impulse responses are according to economics theory. For first sub-period, the immediate and permanent effect on domestic price level of a one standard deviation shock to net foreign reserves to GDP ratio is positive. A one standard deviation shock to the ratio of money supply to GDP is negative in the short-run; however, it is positive in the long-run. Money market rate, nominal exchange rate, manufacturing output and capital account surplus to GDP ratio have not significant long run effect on domestic prices.

For second sub-period, the net effect of a one standard deviation shock to the ratio of foreign assets to GDP, the ratio of money supply to GDP and the change in level of domestic debt is positive in the short run as well as in the long run. A one standard deviation shock to the ratio of capital account surplus to GDP has a positive effect initially but the permanent effect is negative.

Next we explore the short-run linear causation. Since the variables are cointegrated, using the Vector Error Correction (VEC) model, we test whether the variables individually Granger cause domestic price level in all the four models. For this, we test for the joint significance of the lagged variables of each variable along with the error correction term. The estimated results for the first sub-period are reported in Table 8.

The results indicate, for the first sub-period, that the null hypothesis of no short-run Granger causality is not rejected for net foreign assets to GDP ratio and for foreign reserves to GDP ratio as well. It implies that the foreign capital inflows do not cause (in Granger sense) domestic price level before December 2000. Similarly, we do not receive any significant evidence of the rejection of the null hypothesis of domestic price level is not Granger cause by money market rate in any estimated equation. However, the estimates on money supply to GDP ratio show that the domestic price level is significantly influenced (in Granger sense) by money supply.

It can be observed from the table that the null hypothesis that the capital account surplus does not Granger cause domestic price level is reject at the 5 percent level of significance. Table 16 also shows that there is a significant Granger causality running from the change in level of domestic debt to domestic prices. Finally, regarding exchange rate, there is no significant evidence of the presence of the short-run causal relation between price level and nominal

Table 8

*VEC Granger Linear Causality Test for January 1990 to December 2000*

Null Hypothesis	Number of		Decision ( at the 5% level)
	Lags	$\chi^2 - Square$	
Model I: $LCPI = f(FAR, LMMR, LMPI)$			
LCPI is not Granger Caused by FAR	3	3.089	Do not reject
LCPI is not Granger Caused by LMMR	3	2.356	Do not reject
LCPI is not Granger Caused by LMPI	3	9.178	Reject
Model II: $LCPI = f(FRR, LMMR, MSR, LMPI)$			
LCPI is not Granger Caused by FRR	3	0.129	Do not reject
LCPI is not Granger Caused by LMMR	3	3.188	Do not reject
LCPI is not Granger Caused by MSR	3	10.769	Reject
LCPI is not Granger Caused by LMPI	3	12.994	Reject
Model III: $LCPI = f(CAR, LDC, LNER)$			
LCPI is not Granger Caused by CAR	3	7.908	Reject
LCPI is not Granger Caused by LDC	3	10.232	Reject
LCPI is not Granger Caused by LNER	3	1.150	Do not reject
Model IV: $LCPI = f(FAR, LMMR, LDC, LREER)$			
LCPI is not Granger Caused by FAR	3	4.115	Do not reject
LCPI is not Granger Caused by LDC	3	21.699	Reject
LCPI is not Granger Caused by LMMR	3	5.020	Do not reject
LCPI is not Granger Caused by LREER	3	1.808	Do not reject

exchange rate as well as real effective exchange rate. In sum, we conclude, for the period from January 1990 to December 2000, that the domestic price level is significant caused by capital account to GDP ratio, money supply to GDP ratio and domestic debt, whereas, it is not significantly influenced by net foreign assets to GDP ratio, foreign reserves to GDP ratio, money market rate and both nominal and real effective exchange rate.

The results for the second sub-period are given in Table 9. We found strong evidence to reject the null of hypothesis of no Granger causality for net foreign assets to GDP ratio in Model I and Model II. It implies that the domestic price level is significantly Granger caused by net foreign assets-to-GDP ratio. Similarly, there is strong evidence to reject the null hypothesis of domestic debt does not Granger cause price level.

Regarding Granger causality test for foreign reserves-to-GDP ratio, the estimates show the rejection of the null hypothesis that domestic price level is not Granger caused by the ratio of foreign reserves-to-GDP. In addition to this, the lagged coefficients on the manufacturing output index appeared statistical significant. The results also indicate a significant causal relationship between money supply-to-GDP to domestic price level. It is noteworthy that both the proxies for capital inflows, namely net foreign assets to GDP and foreign reserves to GDP have a significant impact (in Granger sense) on domestic price levels, which is what we expect, during the period from January 2001 to December 2007—a period of large capital surge.

Table 9

*VEC Granger Linear Causality Test for January 2001 to December 2007*

Null Hypothesis	Number of Lags	$\chi^2 - Square$	Decision (at the 5% level)
<i>Model I: LCPI = f(FAR, LMMR, LMPI)</i>			
LCPI is not Granger Caused by FAR	2	7.027	Reject
LCPI is not Granger Caused by LMMR	2	0.693	Do not reject
LCPI is not Granger Caused by LMPI	2	6.870	Reject
<i>Model II: LCPI = f(FRR, LMMR, MSR, LMPI)</i>			
LCPI is not Granger Caused by FRR	2	6.969	Reject
LCPI is not Granger Caused by LMMR	2	1.181	Do not reject
LCPI is not Granger Caused by MSR	2	9.279	Reject
LCPI is not Granger Caused by LMPI	2	8.098	Reject
<i>Model III: LCPI = f(CAR, LDC, LNER)</i>			
LCPI is not Granger Caused by CAR	2	3.826	Do not reject
LCPI is not Granger Caused by LDC	2	13.953	Reject
LCPI is not Granger Caused by LNER	2	5.064	Do not reject
<i>Model IV: LCPI = f(FAR, LMMR, LDC, LREER)</i>			
LCPI is not Granger Caused by FAR	2	11.63	Reject
LCPI is not Granger Caused by LDC	2	9.96	Reject
LCPI is not Granger Caused by LMMR	2	2.61	Do not reject
LCPI is not Granger Caused by LREER	2	2.61	Do not reject

Now we turn to the impact of capital inflows on exchange rate volatility. The volatility of nominal (VNEX) and real effective exchange rates (VREER) has been calculated by using the three-period moving average standard

deviation:  $S.D_t = [(1/m) \sum_{i=1}^m (EX_{t+i-1} - EX_{t+i-2})^2]^{1/2}$ , where  $m = 3$  and  $EX$

denotes exchange rate. In next step, we apply both ADF and KPSS unit root tests to check the time-series properties of the calculated volatility series. The results reported in Table 10 indicate that both volatility series are stationary at their level.

Table 10

*Unit Root Tests for Exchange Rate Volatility*

Volatility Series	January 1990 to December 2000		January 2001 to December 2007	
	ADF	KPSS	ADF	KPSS
VNEX	-5.469*	0.484*	-3.104*	0.497*
VREER	-7.100*	0.119*	-4.773*	0.557*

\*Indicate the series is stationary at the 1 percent level.

Since the exchange rate volatility appeared stationary at its level, we estimate the VAR model for testing the short-run Granger causality between exchange rate volatility and the change in capital inflows. Specifically, the model is defined as follows:

$$Y_t = C + \sum_{i=1}^m \Gamma_i Y_{t-i} + \sum_{j=1}^n \beta_j \Delta Z_{t-j} + \xi_t \quad \dots \quad \dots \quad \dots \quad (6)$$

where  $Y_t$  is a column vector of exchange rate volatility,  $\Delta$  denotes the first difference and the  $Z_t$  is a column vector of capital inflows, market interest rate, capital account to GDP ratio and consumer price index. The term  $C$  is a column vector of constant terms. The term  $\beta$  and  $\Gamma$  are the matrix of coefficient and  $\xi_t$  is a vector of innovations, which has zero mean and constant variance. We say that the change in capital inflows does not Granger cause the exchange rate volatility if the estimated coefficients on the lagged change in capital inflows are jointly not significantly different from zero. This is tested by a joint Wald chi-square test.

The estimates summarised in Table 11 provide evidence that both the nominal and real effective exchange rates volatility is significantly influenced by the change in net foreign reserves to GDP ratio during the period of 1990-2001. However, for the second sub-period from January 2001 to December 2007, we find that the change in capital inflows has significant impact (in Granger sense) only on the volatility of real effective exchange rate. The results show that the change in capital inflows does not have any significant effect on nominal exchange rate volatility.

Table 11

Direction of Causality	January 1990 to December 2000		January 2001 to December 2007	
	$\chi^2 - Square$	Decision ( at the 5% Level)	$\chi^2 - Square$	Decision ( at the 5% Level)
$\Delta FAR \rightarrow VNEX$	7.579 (3)	Do not Reject	0.580 (2)	Reject
$\Delta FAR \rightarrow VRRER$	8.776 (3)	Do not Reject	7.663 (2)	Do not Reject

where the arrow points to the direction of causality. Values in parentheses are optimal lag-length selected by the AIC.

The traditional cointegration (says Johansen' technique, 1990) and Granger causality (says Granger procedure, 1986) tests are unable to find nonlinear causal relations. We apply nonlinear cointegration test developed by Lin and Granger (2004) to explore the nonlinear long-run relations between the variables. We run a bi-variate regression of LCPI on constant and BOX-COX

transform of the said explanatory variables. Specifically, the function is expressed as follows:

$$LCPI_t = \frac{(|X_t|^\theta - 1)}{\theta} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (7)$$

where  $X_t$  denotes explanatory variable. We run the nonlinear least squares (NLS) method to estimate the underlying parameters ( $\hat{\theta}$ ), and then apply the KPSS test to the residual to test the null hypothesis of non-linear cointegration against an alternative hypothesis of no non-linear cointegration. The estimates are given in Table 12.

Table 12

*Pair-wise Non-linear Cointegration Tests*

Variables included in Cointegration Equation	Sample Period: January 1990 to December 2000		Sample Period: January 2001 to December 2007	
	$LM_{KPSS(c)}$	$LM_{KPSS(c+t)}$	$LM_{KPSS(c)}$	$LM_{KPSS(c+t)}$
LCPI and FAR	1.286	0.102*	1.119	0.212*
LCPI and LDC	0.107**	0.098*	0.193**	0.171*
LCPI and MSR	1.261	0.137**	0.657*	0.222*
LCPI and LMMR	1.412	0.238	1.172	0.236
LCPI and NER	1.167	0.546	1.146	0.289

$LM_{KPSS(c)}$  and  $LM_{KPSS(c+t)}$  are the KPSS test statistics for the null of cointegration without and with a trend, respectively in the model for testing. The 1 percent and 5 percent asymptotic critical values are 0.737 and 0.463 for  $LM_{KPSS(c)}$  respectively, and 0.216 and 0.146 for  $LM_{KPSS(c+t)}$  respectively. \* and \*\* denote rejection of the null hypothesis at the 1 percent and 5 percent significant levels, respectively.

The results provide strong evidence of the existing of nonlinear cointegration between domestic price level and net foreign assets-to-GDP ratio, money supply-to-GDP ratio and domestic debt in both the examined period. On the other hand, the estimation shows that there is no significant nonlinear dynamic association between domestic price level and both market interest rate and nominal exchange rate.

To examine the non-linear short-run causality, we use the Hristu-Varsakkeis and Kyrtsov (2006) nonlinear Granger causality test—known as the bi-variate noisy Mackey-Glass model. In first step, since the variables are nonlinearly cointegrated, we estimate the non-linear VEC model (i.e., Equation (4) is estimated using the first differences of the variables and error correction term.), by ordinary least squares, in a specification ( $\tau_1 = \tau_2 = 4$  and  $c_1 = c_2 = 2$ ) selected by Log Likelihood procedure without and with restriction on lagged parameters of explanatory variable. Then we obtain the residual to calculate the test statistics (says  $S_F$ ) for testing non-linear Granger causality between the variables. The estimated  $S_F$  are reported in Table 13.

Table 13

*Pair-wise Non-linear Granger Causality Tests*

Direction of Non-linear Causality	Sample Period: January 1990 to December 2000		Sample Period: January 2001 to December 2007	
	$S_F$ - statistic	Decision ( at the 5% Level)	$S_F$ - statistic	Decision ( at the 5% Level)
	FAR → LCPI	0.364	Reject	8.446
LDC → LCPI	3.283	Do not Reject	3.749	Do not Reject
MSR → LCPI	4.247	Do not Reject	11.305	Do not Reject
NER → LCPI	1.446	Reject	0.003	Reject
LMMR → LCPI	1.318	Reject	0.159	Reject

Where the arrow points to the direction of non-linear causality.

The table clearly shows the non-linear dynamic association between domestic price level and capital inflows for the second sub-period and between inflation and domestic debt level and money supply to GDP ratio for both the sub-periods. The change in domestic price level (inflation) is statistically significantly non-linearly caused by the change in net foreign assets-to-GDP ratio during the second sub-period. For the first sub-period, however, the estimates provide evidence to reject the null hypothesis that the change in net foreign assets non-linearly causes inflation.

For money supply-to-GDP ratio and domestic debt, the analysis indicates that they have significant non-linear impact on inflation during both the examined periods. Finally, for market interest rate and nominal exchange rate, the table reveals that they do not have any non-linear causal link with inflation in either period.

## 5. CONCLUSIONS AND POLICY RECOMMENDATIONS

This paper investigates the inflationary effects of capital inflows using monthly data over the period from January 1990 to December 2007. We have developed an empirical model of the equilibrium prices based on the standard classical quantity theory of demand for money subject to capital inflows. Since the descriptive statistics and graphic analysis of the data provide significant evidence on the existing of non-linearity in the relationship, we use non-linear tests to explore the effects of capital inflows.

The results suggest positive and significant effects of capital inflows on monetary expansion, particularly, during the periods of massive capital inflows from 2001 to 2007.

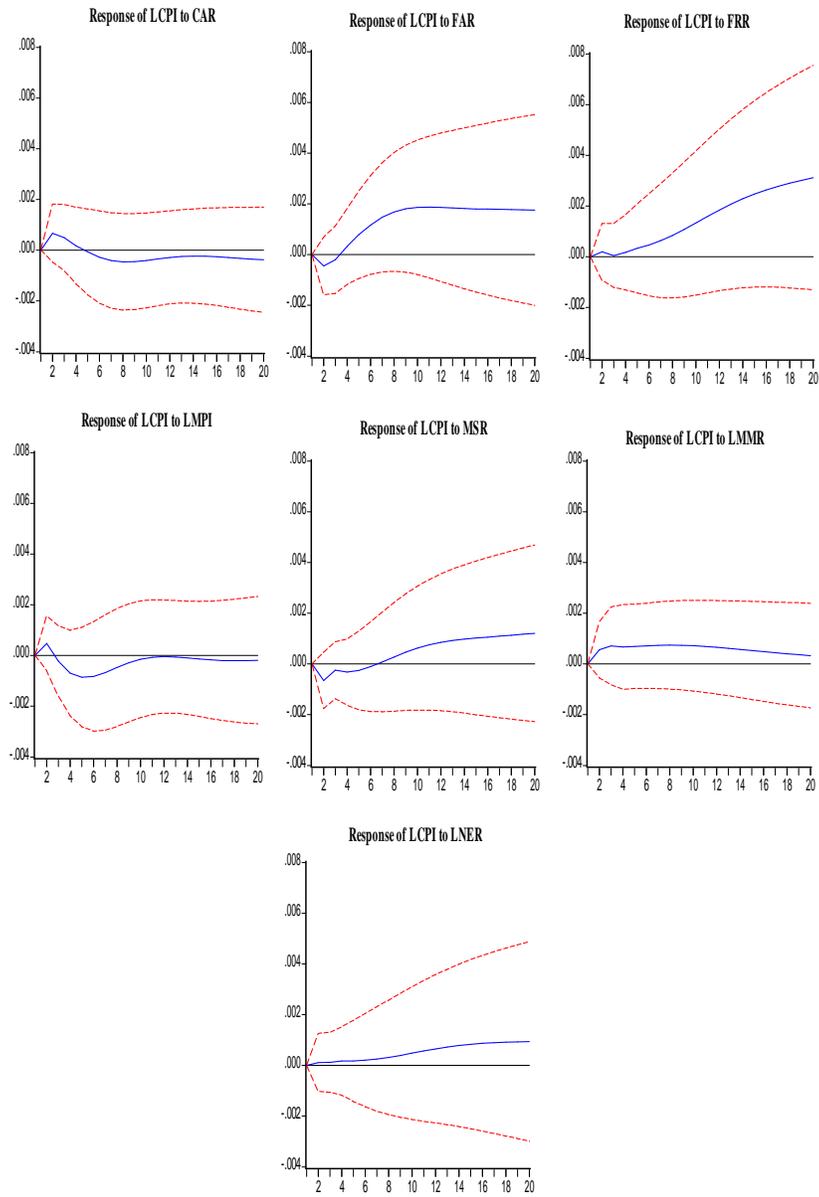
The test for non-linear causality brings new insights on existing of causal links between price level and the other said variables. The results concerning interest rate and exchange rate confirm that they do not have any cause-effect

relation with inflation. It is also confirmed the lack of a causality between capital inflows and domestic price level for the period of 1990-2000. For the period of 2001-2007, the results suggest that the hike in domestic price level is not only linearly but also non-linearly caused by a change in capital inflows.

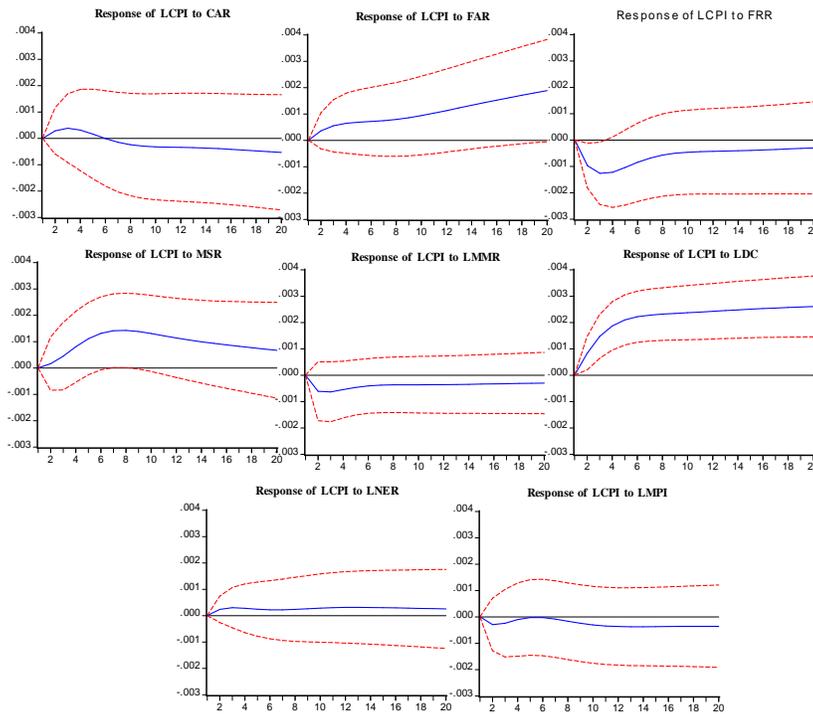
From the policy perspective, the findings are of particular interest to Government authority and SBP. Since the capital inflows has played significant role to pull the domestic price, particularly during the second-sub, the foreign exchange management policy of SBP is questionable. The findings suggest that there is need to absorb the capital inflows in such a way they should neither create an inflationary pressure in the economy nor fuel the exchange rate volatility. The SBP should put the limit to arbitrate in the forex market and should allow to private sector to use the foreign capital for productively to increase the production in the economy rather than just to add to government foreign reserves. The most effective ways to deal with capital inflows would be to deepen the financial markets, strengthen financial system supervision and regulation, where needed, and improve the capacity to design and implement sound macroeconomic and financial sector policies. These actions will help increase the absorption capacity and resilience of the economies and financial systems to the risks associated with the inflows. The analysis may establish useful base for future empirical work in this field and suggests that researchers should also consider non-linearity in modelling for inflationary dynamics.

## Annexure

**Fig. 1. Response of Domestic Price Level One S.D. Innovations  $\pm 2$  S.E., Sample Period: January 1990 to December 2000**



**Fig. 2. Response of Domestic Price Level One S.D. Innovations  $\pm 2$  S.E.,  
Sample Period: January 2001 to December 2007**



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