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The Microstructure Approach to Exchange Rate in India: Evidence from Technical Trading

Rajiv Ranjan, Sarat Dhal and Bhupal Singh*

This paper explores the role of market microstructure in explaining the short-run movement in exchange rate in India. It examines the interdependence of intra-day high, low and closing exchange rates within the framework of parametric technical trading strategy combined with vector error correction and cointegration model. The closing exchange rate shows more or less symmetric response to high and low exchange rates. Market participants seem to be bound by a long-run bid-ask spread. Macroeconomic factor such as liquidity, foreign interest rate and stock return have differential impact on the daily high, low and close exchange rates.

JEL Classification : D4, F31

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Introduction

Convincing explanation on what drives the short run movement in exchange rate has eluded academic and policy research in the past two decades. Conventional models of exchange rate determination such as the purchasing power parity (PPP) theory, the monetary approach to exchange rate and the portfolio balance approach were based on the macroeconomic explanations such as changes in prices, money demand, interest rate, trade balance, output and employment. However, these models could not provide satisfactory answers to short-term movements in exchange rate during the flexible exchange rate regime that followed after the break down of the Bretton Woods system in the early 1970s. The liberalisation of capital account and the surge in international capital flows during the 1990s added further complexity to the understanding of exchange rate movement over

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shorter horizon. The seminal works of Messe and Rogoff (1983) and Frankel and Rose (1994), which brought to the fore the weakness of macroeconomic models in forecasting exchange rate movements, opened the vistas of new research in the exchange rate literature focusing on the institutional aspects relating to microstructure of foreign exchange market (Lyons, 1995; Neely, 1997). The microstructure literature endeavours to explain exchange rate through the understanding of trading mechanism and the behaviour of market agents in terms of market activity (turnover), expectations, technical analysis and bid-ask spread. Among the elements of market microstructure, technical analysis or technical trading is recognized as one of the important ways to explain exchange rate movements. Cheung, Chinn and Marsh (2004) on the basis of a survey of the UK market observed that the non-fundamental factors dominate the short-term exchange rate movements. Similarly, Taylor and Allen (1992) found that in the London exchange market, technical analysis was used by more than 90 per cent of the dealers for their trading decisions.

In the Indian context, there is a dearth of research on the market microstructure and trading strategies with respect to foreign exchange market. A survey based study by Bhanumurthy (2005) confirms the existence of technical trading in the Indian foreign exchange market. The author finds that in the short-run the microstructure variables have relatively large influence on exchange rate than the fundamentals. Over a five year horizon, the share of technical trading increased from 33 per cent to 62 per cent. A majority of the market traders determine their bid-ask spread of the quotations based on the market convention. Furthermore, fundamentals were found to play insignificant role in the intra-day trading.

We examine the role of market microstructure in explaining the short-term movements in exchange rate based on the interaction among the intra-day high, low and close exchange rates. We use a vector error correction model (VECM). The study is organized into four sections. Section I presents a a brief review of literature. The methodology is discussed in Section II. Section III contains the empirical findings. Section IV concludes.

Section I

The Review of Literature

Technical analysis is described as the use of past price behaviour to guide trading decisions in the asset markets (Neely, 1997). According to Pring (2002), the objective of technical analysis is to identify a trend reversal at a relatively early stage and ride on that trend until the weight of the evidence shows that the trend has reversed. Technical trading comprises a set of rules that result from parameterizations and each trading rule generates trading signals (long, short, or out of market) according to the parameter values (Park and Irwin, 2004). Technical analysis is built on three essential principles: market action discounts everything (such fundamentals as inflation, interest rates), prices move in trends, and the traders react similarly under similar conditions. Foreign exchange chart patterns have been recognized and categorized for over 100 years, and the manner in which many patterns are repeated leads to the conclusion that human psychology shows little change. Since patterns have worked well in the past, it is assumed that they will continue to work well into the future. Technical analysis includes a variety of forecasting techniques (Neely, 1997; Park and Irwin, 2004). Several trading strategies can co-exist since financial markets are not homogenous in respect of the dimension, market participants and instruments. Early studies show the use of chart analysis such as filters (Alexander,1961, 1964; Fama and Blume, 1966; Levy 1971; Sweeney, 1986), stop-loss orders (Gray and Nielsen, 1963; Houthakker, 1961), moving averages (Cootner, 1962; Dale and Workman, 1980; James, 1968; Van Horne and Parker, 1968), channels (Irwin and Uhrig, 1984), momentum oscillators (Smidt, 1965) and relative strength indicators (Jensen and Benington, 1970; Levy, 1967a, 1967b). Advanced methods such as head and shoulders model (Chang and Osler, 1998), trade range breakout rules (Brock *et al.,* 1992; Lukac *et al.,* 1988), genetic programming (Neely *et al.*,1996), neural network (Tenti, 1996), stochastic oscillator and parametric trading rules (Fiess and MacDonald, 1999) are also gaining popularity in more complex financial markets.

Early literature rejected the trading rules, claiming that these lacked economic theory. Inspired by Samuelson (1965), Fama and Blume (1966) and Fama (1970), economists vigorously believed in the efficient market hypothesis; competitive financial markets are generally driven by macroeconomic fundamentals and market participants cannot make profits from technical trading. Since the mid-1990s, however, economists seem to have softened their stance on the efficient market hypothesis. Following Messe and Rogoff (1983) and Frankel and Rose (1995), there have been a spate of studies explaining exchange rate movements through the process of technical trading strategies, order flows and price formations (Curcio *et al.*, 1997; Cheung *et. al.*, 2004; Cheung and Wong, 2000; Cornell and Dietrich, 1978; Dooley, 1983; Evans and Lyons, 2002; Frankel and Froot, 1990; Lee and Mathur, 1996; Lee *et al.*, 2001; Levich and Thomas, 1993; Lukac *et al.*, 1988; Maillet and Michel, 2000; Martin, 2001; Menkhoff, 1997; Menkhoff and Schlumberger, 1995; Neely, 1997; Osler, 2003; Osler and Chang, 1995; Park and Irwin, 2004; Shafer, 1983; Sweeney, 1986; Taylor, 1986; Taylor and Allen, 1992; Yao, 1998). A key finding of the copious literature is that trading strategies have been more successful in the foreign exchange market than other financial markets. The widespread use of technical trading, especially since the mid-1990s, can be attributable to the rapid progress in financial markets, spurred by globalisation, liberalisation and information technology (Park and Irwin, 2004).

Studies have also conjectured about the correlation of technical trading strategies with central bank's open market operation (Davutyan and Pippenger, 1989; Dooley and Shafer, 1983; Levich and Thomas, 1993; Lukac *et al.*, 1988; Silber, 1994; Sweeney, 1986). Economic intuitions behind such relationship are given by Szakmary and Mathur (1997) and Saacke (2002). After an exogenous shock to fundamentals, the exchange rate, without the central bank intervention, jumps to a new equilibrium level, similar to the Dornbusch type overshooting effect. However, a sharp adjustment in the exchange rate may fuel uncertainties and adversely affect balance sheets of producing sectors as well as the financial intermediaries,

which in turn may engender unsustainable macroeconomic outcomes and financial instability. In order to contain such volatility and facilitate smooth operation of foreign exchange market, central banks may lean against the wind by preventing sharp fluctuation in the exchange rate. In this process, they delay the adjustment of exchange rate. If adjustment is delayed, exchange rates would display a trend during the phase of adjustment. This trend may be exploited by trend-following forecasters. LeBaron (1999) shows that when a typical moving average rule generates buy signals for a foreign exchange rate, the Federal Reserve in the US tends to support the dollar the next period. This finding is consistent with a 'leaning against the wind' policy. LeBaron's (1999) findings are generally confirmed by others including Neely (2002), Neely and Weller (2001), Sapp (2004), Sosvilla-Rivero et al. (2002), and suggest that technical trading rules precede interventions and interventions do not generate technical trading but rather respond to strong trends in exchange rates. However, Saacke (2002) stresses that trading strategies on days that neither coincide with nor preceded by intervention periods are also quite substantial, strongly suggesting that interventions are not the only source of technical trading in the foreign exchange markets. The key finding of the above studies is that central bank open market operations may be related to technical trading in some way; however, such relationship need not be construed as the causal relationship.

The research studies on financial markets no longer seem to be preoccupied with the dichotomous debate whether markets rally around fundamentals or trading strategies generate profits. Financial markets may not fully operate under the rules of economic theory. However, the departure of markets from fundamentals cannot be solely attributed to the existence of technical trading. Similarly, trading strategies can remain in vogue, even if market participants find them unprofitable over time. Thus, economists are comfortable with an information perspective on financial markets, relying on several analytical models encompassing market microstructure as well as economic fundamentals for a better understanding of financial markets.

Section II

The Methodology

Empirical works show that finest data on forex microstructure are confined to the transactions data (Goohart and Payne, 1996; Goodhart *et al.,* 2006; Evans, 2001; Evans and Lyons, 1999; Rime, 2000). Studies on optimal bid-ask spread suggest that the order flow dynamics can be analysed with volume information, related prices or both. Since transaction data are hardly available on a high frequency basis in the Indian context, we work with a trading strategy based on the micro-structure of daily exchange rate, *i.e.* intra-day high, low and close exchange rates. According to the literature, each of these exchange rates can provide useful insights about market participants and demand and supply factors (Fiess and MacDonald, 1999). Illustratively, intra-day high and low exchange rates constitute the two extremes of price discovery in the market. They can be related to the bid-ask quotes of dealers and reflect the order flow underlying the demand-supply forces that determine the behavior of foreign exchange market (Evans and Lyons, 1999, 2002; Lyons, 2001). According to Evans and Lyons (1999), intra-day high and low exchange rates can relate to order flow, which is a measure of buying/ selling pressure.[1] Buoyant demand for foreign currency would accentuate depreciation pressure on the domestic currency, leading exchange rate to reach the intra-day peak level. Similarly, higher supply of foreign currency would accentuate appreciation pressure, taking the exchange rate to intra-day low. The closing exchange rate will respond to demand and supply of foreign currency transactions and the open market operations of the central bank towards preventing market instability as it evolves through intra-day high and low levels of the exchange rate. Given the profit objective of foreign exchange traders, it could be possible that most transactions occur at a bid-ask rates corresponding to the intra-day high-low exchange rate rather than the closing exchange rate (Neely, 2002; Neely and Weller, 2001). However, the closing exchange rate may be related to the central banks' assessment of macroeconomic fundamentals. In other words, intra-day high, low and close exchange rates can be identified with

the three types of economic forces: demand, supply and policy actions. Accordingly, investors would form expectations about the subsequent demand and supply conditions and price discovery process in the foreign exchange market based on the available information. Investors would devise suitable trading strategies, which may exclusively rely on historical information on the closing exchange rate or in a dynamic setting, on the past information on all the three exchange rates *i.e.*, intra-day high, low and close.

The empirical models encompass a mix of the parametric trading and fundamentals within the framework of VECM (Bask and Fidrmuc, 2006; Fiess and MacDonald, 1999, 2002). The parametric trading rule encompasses intra-day exchange rates as endogenous variables in the VECM for characterizing the long-run trajectory of the exchange rate (Feiss and MacDonald, 1999). The closing exchange rate (E_C) is related to the expected high (E_H) and low (E_L) exchange rates through a parametric rule trading signal 'μ' as below.

$$\mu = \frac{E_c - E_L}{E_H - E_L} \tag{2.1}$$

In linear form, the trading rule in 2.1 can be specified as:

$$E_C = \mu E_H + (1 - \mu) E_L \tag{2.1a}$$

The trading rule specified in equation 2.1a entails that the closing exchange rate is a weighted average of expected high and low exchange rates. Expected high and low exchange rates can be defined as the local maximum and the local minimum over the past values of intra-day high and low exchange rates over 'k' period as:

$$E_H = \max (e_H, k)$$

$$E_L = \min (e_L, k)$$

For μ=1, the closing exchange rate equals to the intra-day high exchange rate, implying that the foreign exchange market favours a depreciation trend in the exchange rate over longer horizon. On the other hand, for μ=0, the closing exchange rate equals to the intra-day low exchange rate; implying that the market favours exchange rate appreciation. Since equation 2.1a characterizes a long-run path associating three variables, E_C, E_H, E_L, the parameter μ can be

estimated using a suitable model. Given this long-run path, the variables can also exhibit simultaneous relationship in the short-run. Moreover, the variables can exhibit non-stationary trend. Thus, we follow the co-integration approach.

Given a single co-integrating vector, the co-integrating path can be identified without any restriction on the long-run coefficients, excepting the normalized restriction. However, in the presence of more than one co-integrating relationships among the variables, the empirical model would need further identification. In our case, for three exchange rate variables, there can be a maximum of two co-integrating relationships. One co-integrating path can be related to equation 2.1a:

$$E_C = \beta_{C,H} E_H + \beta_{C,L} E_L \quad (2.2)$$

The second co-integrating vector can be identified against high or low exchange rate. Fiess and MacDonald (1999, 2002) suggest that the second long-run vector can characterize bid-ask price relationship in the foreign exchange market and take the following form:

$$E_H = \beta_{H,L} E_L + \alpha \quad (2.3)$$

Together, these two co-integration vectors constitute an exactly identified system as they involve two restrictions (other than the normalized restrictions): (i) $\beta_{C,L} = 1 - \beta_{C,H}$ in equation 2.2 and (ii) the zero restriction on the parameter ($\beta_{H,C}$) for the long-run response of bid-ask price relationship with respect to the closing exchange rate in equation 2.3. In order to examine whether the bid-ask spread can be assumed constant in the long-run, the co-integration model can be put to over-identification test as to whether the parameter $\beta_{H,L}$ equals unity.

Apart from the micro structure of exchange rate, we also include the relevant macroeconomic variables for which high frequency data are available. These include liquidity, foreign interest rate, and asset return as exogenous variables affecting the short-run dynamics of exchange rate in the VECM. The liquidity variable is defined as the spread of inter-bank call money rate over the repo rate. The foreign

interest rate is represented by changes in the US federal funds rate, to account for the changing external financial environment. Asset market development is characterized through the stock return. We use daily for the period April 1995 to September 2007.

Section III

Empirical Analysis

The Augmented Dicxey - Fuller (ADF) unit root tests of intra-day high, low and closing exchange rates suggest that these variables are non-stationary in logarithm-levels but stationary in the first difference (Table 1). In the first difference form, these exchange rate series show statistically significant contemporaneous correlation among themselves.

The closing exchange rate series has more or less similar correlation with the high and the low exchange rates (Table 2). The sample mean of daily variation in the three exchange rate series is more or less similar. However, these indicators can be different from

Table 1: Unit Root Test of Exchange Rate

Variables	ADF Stat	Probability	Critical Value (5 per cent level)	Lag Order (SIC)
Logarithm Transformed	With Intercept			
E_C	-2.33	0.16	-2.86	5
E_H	-2.36	0.15	-2.86	4
E_L	-2.50	0.12	-2.86	0
	With Intercept and Trend			
E_C	-0.40	0.99	-3.41	5
E_H	-0.33	0.99	-3.41	4
E_L	-0.18	0.99	-3.41	0
First Difference Series	With Intercept			
ΔE_C	-19.55	0.00	-2.86	4
ΔE_H	-24.02	0.00	-2.86	3
ΔE_L	-50.09	0.00	-2.86	0

SIC: Schwartz Information Criterion.

Table 2: Correlation of Intra-day High, Low and Close Exchange Rates

	ΔE_C	ΔE_H	ΔE_L
ΔE_C	1.00	0.61	0.65
ΔE_H	0.61	1.00	0.53
ΔE_L	0.65	0.53	1.00

each other in terms of volatility as measured by the standard deviation (Table 3).

In line with the theoretical prediction, there are two co-integrating relationship among the trading strategy indicator and intra-day high and low exchange rates (Annex). Table 4 presents the estimated cointegrated relations based on the alternative VECM. The first co-integrating vector for Model 1 shows that the underlying trading strategy assigns more or less equal weight to the intra-day high and low exchange rates, respectively. In other words, in the long-run, the closing exchange rate can be the middle rate of intra-day high and low exchange rates. The second vector, which is identified against the intra-day high exchange rate, has the coefficient of intra-day low exchange rate closer to unity. This implies that the high and the low exchange rates share a long-run bid-ask spread relationship. The cointegrating relations are almost similar in Model 2 when the 5-day maximum and minimum of high and low exchange rates, respectively, are used. For Model 3 and Model 4, which take into account 22-day and 60-day maximum and minimum of intra-day high and low

Table 3: Statistical Properties of Exchange Rates

(Annualised Variation in Daily Exchange Rate in Per cent)

	ΔE_C	ΔE_H	ΔE_L
Mean	1.248	1.263	1.250
Standard Deviation	55.81	61.21	58.05
Skewness	-1.10	1.20	-1.33
Kurtosis	37.03	22.60	31.88

Note: Daily annualized variation in exchange rate is defined as first difference of logarithm transformed exchange rate multiplied by 100 and 250 (*i.e.,* number of trading days in a year)

Table 4 : Parametric Trading Strategy: Co-integration of Intra-day High, Low and Close Exchange Rates

Model 1 (E_C , E_H , E_L)			Model 3 (E_C , E_H^{22}, E_L^{22})		
Variables (coefficients)	**Co-integrating Vector 1**	**Co-integrating Vector 2**	**Variables (coefficients)**	**Co-integrating Vector 1**	**Co-integrating Vector 2**
1	2	3	4	5	6
E_C (β1)	-1.0000	0.0000	E_C (β1)	-1.0000	0.0000
E_H (β2)	0.4805	-1.0000	E_H (β2)	0.3888	-1.0000
	(0.0088)			(0.0129)	
E_L (β3)	0.5195	0.9980	E_L (β3)	0.6112	0.9810
	(0.0088)	(0.0012)		(0.0129)	(0.0125)
Intercept (β4)	0.0000	0.0099	Intercept (β4)	0.0018	0.0863
χ2 Statistic (H0: β2=β3)	0.06 (0.81)		χ2 Statistic (H0: β2=β3)	1.49(0.22)	
χ2 Statistic (H0: β3=1)		2.72(0.26)	χ2 Statistic (H0: β3=1)		2.23 (0.33)
Model 2 (E_C , E_H^5, E_L^5)			Model 4 (E_C , E_H^{60}, E_L^{60})		
E_C (β1)	-1.0000	0.0000	E_C (β1)	-1.0000	0.0000
E_H (β2)	0.4695	-1.0000	E_H (β2)	0.4298	-1.0000
	(0.0078)			(0.0314)	
E_L (β3)	0.5305	0.9941	E_L (β3)	0.5702	0.9592
	(0.0078)	(0.0038)		(0.0314)	-0.0315
Intercept (b4)	0.0002	0.0283	Intercept (b4)	0.0030	0.1816
χ2 Statistic (H0: β2=β3)	0.17(0.68)		χ2 Statistic (H0: β2=β3)	0.15(0.69)	
χ2 Statistic (H0: β3=1)		2.23 (0.33)	χ2 Statistic (H0:β3=1)		1.53(0.47)

Note: Figures in parentheses indicate asymptotic standard error of the coefficients

E_C, E_H and E_L are intra-day close, high and low exchange rates transformed into natural logarithm scale.

E_H^5, E_H^{22} , E_H^{60}, are the maximum values of intra-day high exchange rates over 5-day, 22-day and 60-day period, respectively.

E_L^5, E_L^{22} , E_L^{60}, are the minimum values of intra-day low exchange rates over 5-day, 14-day and 60-day period, respectively.

exchange rates, respectively, the intra-day close exchange rate shows higher response to the intra-day low exchange rate than the intra-day

high exchange rate. The symmetric response of the close exchange rate to high and low exchange rates was not statistically rejected as suggested by chi-square test. Thus, the VECM model suggests two key characteristics of exchange rate dynamics. First, the closing exchange rate can have similar long-run response to intra-day high and low exchange rate or to the underlying demand and supply shocks affecting the foreign exchange market. Second, market participants may be guided by a long-run average bid-ask spread.

Short-run Adjustment Process in the VECM

The estimated error correction equations for alternative VECM corresponding to different local maximum of intra-day high and local minimum of intra-day low exchange rate show differential adjustment of high and low exchange rate to shocks to the two co-integrating vectors; the first co-integrating vector characterizing the trading strategy and the second co-integrating vector characterizing excess demand or bid-ask spread (Table 5). Intra-day high and low exchange rate exhibit substantial short-run adjustment to trading strategy when

Table 5: Short-run Adjustment of Exchange Rates (Coefficient of Error Correction Terms)

	Exchange Rates		
	ΔEc	**ΔE_H**	**ΔE_L**
5-day Window			
Co-integration Equation 1	-0.03 (-0.46)	-0.45 (-10.10)	-0.38 (-10.31)
Co-integration Equation 2	0.01 (0.94)	0.05 (8.29)	-0.06 (-11.44)
22-day Window			
Co-integration Equation 1	0.05 (2.29)	-0.08 (-4.96)	-0.10 (-8.43)
Co-integration Equation 2	0.00 (-0.53)	0.01 (4.83)	-0.01 (-7.77)
60-day Window			
Co-integration Equation 1	-0.01 (-2.60)	-0.03 (-8.66)	-0.02 (-8.49)
Co-integration Equation 2	0.00 (-0.87)	0.01 (4.09)	-0.01 (-5.70)

Figures in bracket indicate 't' statistic.

the trading rule model involves a short-horizon of 5-day local maximum and local minimum of high and low exchange rate, respectively. In this model, excess demand shock in the foreign exchange market, has significant short-run impact on high and low exchange rate with appropriate sign condition. However, for the trading strategy which involves relatively longer horizon local maximum and local minimum of high and low exchange rate, short-run adjustment of exchange rates to trading strategy and excess demand shock appear sluggish.

Impact of Fundamentals

The parametric trading VECM also reveal some interesting insights of the role of domestic liquidity, foreign interest rate and asset markets on the exchange rate dynamics (Table 6). First, in the error correction equations for the exchange rate variables, the spread of call money rate over the repo rate, reflecting domestic liquidity condition, showed statistically significant inverse relationship with intra-day close and low exchange rate but statistically insignificant positive effect on intra-day high exchange rate. This implies that domestic liquidity induced changes in interest rate can affect demand side factors but not supply side factors in the foreign exchange market. Second, the external financial environment reflecting the change in the US federal funds rate (with a lag of 5-day) could have statistically significant positive impact only on the intra-day high exchange rate. This could be attributable to the linkage between foreign interest rate and capital flows.[3] However, positive impact of higher foreign interest rate on intra-day high exchange rate of Indian rupee with respect to the US dollar does not culminate in to a similar impact on intra-day close exchange rate. Third, an increase in the return on equity market, which reflects the impact of foreign capital flows, mainly through the foreign institutional investors, showed significant inverse relationship with all the three intra-day high, low and close exchange rates. This finding is in line with macroeconomic models, which emphasize the key role of capital flows in the floating exchange rate regime.

Variance Decomposition Analysis

The variance decomposition analysis reveals key features of exchange rate dynamics. First, with respect to the ordering sequence of close, high and low exchange rates, the shock to close exchange rate explained most of the variation in high and low exchange rates. However, for alternate ordering of high, low, and close exchange rate, the variation in intra-day high exchange rate accounted for a major

Table 6: Impact of Select Macroeconomic Variables on Exchange Rate in the Trading Strategy Models

Models	Exchange Rates		
	ΔEc	ΔE_H	ΔE_L
Model 2			
Fundamentals			
SCMR	-0.00608	0.000796	-0.00239
	(-6.12)	(1.05)	(-3.79)
ΔFFR(5)	0.07730	0.19150	0.03400
	(0.87)	(2.81)	(0.61)
BSER	-3.19460	-3.08070	-0.43850
	(-3.78)	(-4.78)	(-0.81)
Model 3			
SCMR	-0.0062	0.000588	-0.00121
	(-6.33)	(0.82)	(-2.26)
ΔFFR(5)	0.0524	0.1578	-0.0147
	(0.59)	2.46	(-0.31)
BSER	-3.0565	-2.4756	0.0435
	(-3.63)	(-4.03)	(0.09)
Model 4			
SCMR	-0.00629	0.00087	-0.00121
	(-6.34)	(1.27)	(-2.23)
ΔFFR(5)	0.0593	0.1709	-0.0268
	(0.68)	(2.83)	(0.56)
BSER	-2.7641	-2.0801	-0.1907
	(-3.31)	(-3.61)	(-0.41)

SCMR = Spread of call money rate over the repo rate DFFR (5) = changes in the US federal funds rate with a lag of 5 days, BSER = return on BSE SENSEX equity index.

Note: Model 2,3 and 4 correspond to trading strategy defined over 5-day, 22-day, and 60-day local maximum and minimum of intra-day high and low exchange rates, respectively.

Figures in bracket indicate 't' statistic.

share (about 50 per cent) of variation in the closing exchange rate. The impact of intra-day low exchange rate on the closing exchange rate could be much lower than that of intra-day high exchange rate. This type of short-run adjustment in exchange rate could be reflection of the preference to depreciation pressure than the appreciating pressure.

Section IV

Conclusion

This study explored whether technical trading strategies can be useful in explaining the movement in short-term exchange rate in India. The key findings are as follws. First, the interdependence of intra-day high, low and close exchange rates encompassing trading strategies, associated with the demand and supply conditions in foreign exchange market exists. Second, the close exchange rate can have symmetric long-run response to intra-day high and low exchange rates. Third, trading strategy models coupled with macroeconomic fundamentals are useful for ascertaining the impact of a particular macroeconomic shock on the demand or supply conditions. The domestic liquidity shock can significantly influence the intra-day low and close exchange rate but not the intra-day high exchange rate. A rise in foreign interest rate may affect intra-day high but not the low and close exchange rates. Stock return can affect all the three components of exchange rate, *i.e.*, intra-day high, low and close. Thus, trading signals characterizing the underlying demand and supply conditions and their likely influence on investors in the foreign exchange market can be ascertained by using the past history of intra-day exchange rates. From a policy perspective, these aspects of the microstructure of exchange rate contain useful information for exchange rate management.

Annex: Cointegration Rank Test: Johansen's VECM

Null Hypothesis/ No. of Cointegrating Relations	Trace Statistic	Critical Value (5%)	Level of Significance
Model 1 (E_C, E_H,E_L) Cointegration Rank Test (Trace)			
None	476.67	29.80	0.00
At most 1	218.71	15.49	0.00
At most 2	1.23	3.84	0.27
Cointegration Rank Test (Maximum Eigen value)			
None	257.96	21.13	0.00
At most 1	217.49	14.26	0.00
At most 2	1.23	3.84	0.27
Model 2 (E_C, E_H^5,E_L^5) Unrestricted Cointegration Rank Test (Trace)			
None	467.42	29.80	0.00
At most 1	189.75	15.49	0.00
At most 2	1.06	3.84	0.30
Unrestricted Cointegration Rank Test (Maximum Eigen value)			
None	277.67	21.13	0.00
At most 1	188.70	14.26	0.00
At most 2	1.06	3.84	0.30
Model 3 (E_C, E_H^{22},E_L^{22}) Unrestricted Cointegration Rank Test (Trace)			
None	211.43	29.80	0.00
At most 1	71.38	15.49	0.00
At most 2	1.20	3.84	0.27
Unrestricted Cointegration Rank Test (Maximum Eigen value)			
None	140.06	21.13	0.00
At most 1	70.18	14.26	0.00
At most 2	1.20	3.84	0.27
Model 4 (E_C, E_H^{60},E_L^{60}) Unrestricted Cointegration Rank Test (Trace)			
None	204.78	29.80	0.00
At most 1	51.96	15.49	0.00
At most 2	2.05	3.84	0.15
Unrestricted Cointegration Rank Test (Maximum Eigen value)			
None	152.82	21.13	0.00
At most 1	49.91	14.26	0.00
At most 2	2.05	3.84	0.15

E_C E_H, E_L are daily close, high and low exchange rates. E_H^5,E_H^{22} E_H^{60} are the maximum of daily high exchange rate over 5-days, 22-days and 60-days, respectively. Similarly, E_L^5,E_L^{22} and E_L^{60} are the minimum of daily low exchange rate over 5-days, 22-days and 60-days, respectively.

Note :

[1] The order flow is a measure of the net of buyer-initiated orders and seller initiated orders. In a dealer market such as the spot foreign exchange, it is the dealers who absorb this order flow, and they are compensated for doing so.

[2] An increase in foreign interest rate would moderate capital flows, accentuate demand side relative to supply side factors in foreign exchange market and thus, exert upward (depreciation) pressure on exchange rate, which may be favorable for exports and economic activity.

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How Persistent is Indian Inflationary Process, Has it Changed?

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Using monthly data for the period 1982:4 to 2008:3, the study analyses the inflation persistence in India in terms of autoregressive properties and lag response of inflation to systematic monetary policy. It finds inflation persistence to be on the lower side, particularly when allowed for the break in the mean of inflation observed around the second half of the 1990s. In general, with the decline in mean rate of inflation, persistence in most of the inflation measures also declined. The impact of money supply on various measures of inflation is mostly positive and had its maximum impact with a much longer lag during the higher inflationary period before the mid-1990s than during the succeeding lower inflationary environment. Interest rate have a negative impact on all the inflation series and, in general, had its maximum impact on inflation with a much longer lag than that of change in money supply.

JEL Classification : J31, J52

Keywords : Inflation Rate, Inflation Persistence,

Introduction

Inflation has far-reaching economic implications in terms of economic efficiency and wealth distribution. In the past couple of decades, there has been a renewed emphasis by the monetary authorities in keeping the rate of inflation low and stable. For many monetary authorities, maintaining price stability is now a clear mandate under the inflation targeting framework, while for several others even without such a specific mandate, price stability is the prime objective. In achieving this objective, monetary authority needs to understand and monitor the properties of the inflation dynamics. One such characteristics of inflation dynamics is the degree of inflation persistence, which could be defined as the tendency

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of inflation to converge towards the monetary authority's inflation objective or the underlying trend following a shock. Broadly, the literature analyses three types of inflation persistence. First type is in terms of the positive serial correlation or the autoregressive properties of the inflation series. The second type refers to the number of periods it takes for the systematic component of monetary policy to have its maximum effect on the rate of inflation. Third type is the number of lags with which rate of inflation respond to a policy shock.

When inflation persistence is high, a positive shock to inflation would keep the inflation rate at an elevated level, while with a low inflation persistence, it will converge soon to its underlying trend.[1] It is also important to recognize the difference in the nature of persistence among the price disaggregates and also the difference between persistence at disaggregate and aggregate level. For the industrialised countries, it is found that the degree of persistence diverge significantly among the components and the level of persistence is higher at the aggregate level than at the disaggregate level [Clark (2003) and Lunnemann and Matha (2004)]. Thus, understanding the process of inflation persistence is relevant for the purpose of forecasting, as that would help the authority to predict the pattern of absorption to a shock in inflation process and also help understand how pre-emptive they should be to curb inflationary pressure with minimum output loss. As the response to monetary policy action could vary among disaggregates and the source of general inflationary trend could arise from one of the components, the persistence at the disaggregate level would further provide additional understanding to the monetary authority on the course of policy action.

While there is a growing volume of literature in this area for the industrialized countries, it is lacking for developing countries. This paper analyses two among the three of types of inflation persistence mentioned above for India *viz.,* i) the autoregressive property of the inflation series and ii) the maximum lag impact of systematic monetary policy on rate of inflation on monthly price series for the period 1982:4: to 2008:3, both at the aggregate and disaggregate level.[2] We consider various measures of prices in India *viz.,* WPI, consumer price index for industrial workers (CPI-IW), consumer price index for urban non-manual labour (CPI-UNML) and consumer price index for agricultural labour (CPI-

AL), along with the disaggregates of the WPI and food component of CPI-IW.

The rest of the paper is organized as in the following. Section II is a brief review of the literature. The stylised fact of the inflationary trend during the period under review is provided in Section III. The definitions of inflation persistence and the models estimated are discussed in Section IV. In Section V, the results and its interpretation are laid out. The final section contains the concluding remarks.

Section II

A Brief Review of Literature

Theories of aggregate inflation persistence postulate that inflation should exhibit low or even negative persistence. This follows as these theories are derived from the microeconomic models of price setting such as time-dependent models, limited information models and menu-cost or state-dependent models, which imply high persistence in the price level, and therefore, translate into low or even negative persistence in the rate of price change *i.e.*, inflation. In contrast to the above theorisation, a number of empirical estimates in the literature for the postwar US inflation and OECD countries found a high level of inflation persistence [Nelson and Plosser (1982), Fuhrer and Moore (1995), Nelson (1998) and Clarida *et al* (1999)]. Consequently, it was viewed that high inflation persistence is a stylised fact for the industrialised countries.

A more recent alternative view, however, argues that inflation persistence may not be a structural characteristic of industrialised countries, but would vary with the monetary policy regimes [Taylor (1998, 2000) and Sargent (1999)]. They argue that with the increasing focus of monetary policy on achieving low inflation and less on exploiting short-run output gains, the credibility of monetary policy has increased leading to anchoring inflation expectations at a low rate of inflation. Consequently, inflation expectation of economic agents is unlikely to adjust to temporary increases in inflation rate thereby reducing the persistence to shocks to both the price level and the inflation rate.

Another view, which is more of a technical in nature pertaining to

the estimation procedure of the persistence parameter, is that neglecting the structural break in the mean of inflation would exaggerate the persistence parameter (Perron, 1989). Therefore, the high inflation persistence observed in earlier studies could be due to neglect of shift in the mean of inflation. However, the empirical findings of the ensuing studies addressing this issue remained varied and inconclusive.

Batini (2002) finds that despite a sizeable downward shift in the mean inflation, the inflation persistence at the aggregate Euro area level and at the country level, except German, remained high and varied only marginally since the 1970s. Thus, it was concluded that Euro area inflation persistence could well be an intrinsic phenomenon rather than a statistical fluke due to aggregation. O'Reilly and Whelan (2004) also find that for the Euro area there appears to be no structural break in the mean of inflation since 1970 and the stability of high inflation persistence cannot be rejected. Hondroyiannis and Lazaretou (2004) for Greece during 1975 to 2003 find that while the mean inflation declined significantly since the beginning of the 1990s, persistence remained high with only a small shift.

On the other hand, Batini and Nelson (2001) show that inflation persistence in the US declined sharply after 1984 under the Volker-Greenspan monetary policy regime, while for the UK the decline was dramatic after the adoption of explicit inflation targeting in 1992. Gadzinski and Orlandi (2004) taking account of intercept dummies in the underlying inflation models on 79 inflation series find that inflation persistence in the EU countries, the Euro area and the US was moderate across the board. Similarly, Levin and Piger (2004) for twelve industrial countries find that allowing for break in intercept, the inflation measures generally exhibit relatively low inflation persistence and concludes that high inflation persistence is not an inherent characteristic of industrial economies. Cecchetti and Debelle (2004) for 16 industrialised countries since the 1990 find that the conventional wisdom of high level of inflation persistence is not robust, as controlling for break in mean of inflation considerably lowers the measure of inflation persistence. However, change in monetary policy frameworks contributed in lowering the mean of inflation, but have little impact on the already low inflation persistence.

There is also a growing volume of literature on analysing inflation persistence at the disaggregate level in order to identify the key drivers of aggregate inflation persistence. This interest to analyse inflation persistence at the disaggregate level followed from the theoretical finding that aggregate inflation persistence is predominantly driven by the most persistence disaggregate inflation components. In the US, for the period 1959 to 2002, Clark (2003) found that the average persistence in disaggregate inflation rates was consistently lower than the aggregate persistence, with virtually the persistence in all the disaggregate series lower than the aggregate. Among the disaggregates, those which account for larger shares of the consumer spending viz., durable goods, non-durable goods and services have higher persistence, without any significant difference between them. Further, while many of the disaggregate components display sizable reductions in persistence, the declines were larger in those components receiving relatively smaller weights. Similarly, for the EU15 countries using 1400 price indices during January 1995 to December 2003, Lunnemann and Matha (2004) could reject the notion of disaggregate inflation exhibiting a high degree of persistence. Thus, they also found the aggregate inflation exhibiting a larger degree of persistence than the weighted average of the disaggregate series. Among the individual indices, indices affected by sales (seasonal food) and some services exhibited low degrees of persistence, while 'gas', 'energy' and 'telephone equipments' showed higher persistence. Category-wise, 'durables' and indices affected by sales as well as services showed less inflation persistence than processed 'food' and 'alcohol'.

Section III

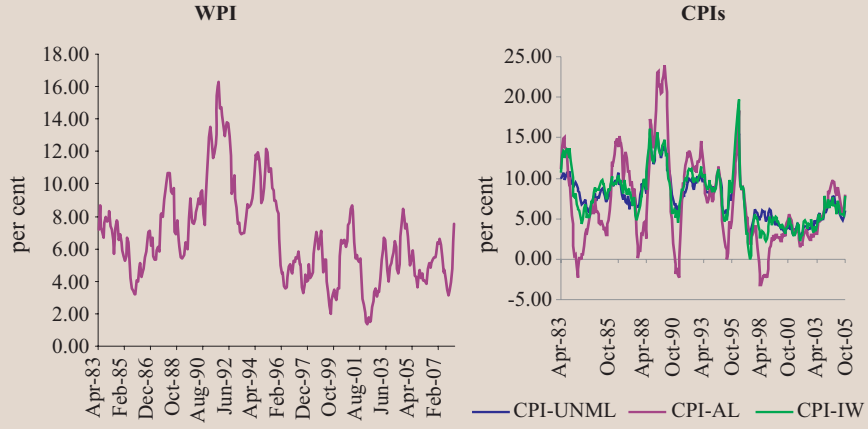
Inflationary Trend-Some Stylised Facts

In the developing country context, inflation on year-on-year basis in India had been on the lower side. Chart 1 plots the year-on-year inflation rate of WPI and CPI measures on monthly frequency since 1983:4. It can be seen that there has been different phases of inflation for different measures of inflation. Broadly, inflation rate declined during the first half of the 1980s, but started picking up in the second half to a peak in the early 1990s, when the country faced an external payment crisis. Since

then the mean WPI inflation rate followed a declining trend up to the mid-1990s. From around the mid-1990s, inflation rate has fluctuated around a lower trend despite intermittent shocks emanating from both domestic and external front. While a similar picture can be discerned in the various CPI measures of inflation, due to food price shock around the end of 1998, there was spurt in CPIs inflations. Among the alternative measures of CPIs, CPI-IW and CPI-UNML inflation broadly overlaped, while CPI-AL inflation was more volatile due larger food component and diverged from the other two measures on number of occasions, particularly during 1991-92, when it recorded the highest increase during the period under review.

Testing for a break in the mean rate of inflation employing Quandt-Andrews unknown break point test, table-1 presents the mean and volatility of inflation rate in WPI, CPIs and their components during the pre-break and post-break sample as well as for the full sample period. First, it is found that a statistically significant break in the inflation rate had taken place in all the aggregate measures of WPI and CPIs. At the disaggregate level also mean break is observed in all, except for 'fuel' components of WPI. It is, however, observed that there are divergences in the break date among the components, though, expectedly, the divergence is much less between the major component and the aggregate. Second, the mean inflation rate declined in the post-break period, barring

Chart 1: 12-Month Inflation Rate of WPI and CPI Measures



that of 'metal' component of WPI. Thus, inflation rates in the components of WPI which ranged between 6.4 to 9.5 percent during the pre-break period averaged less than 5.0 percent in the post-break period, with many of the components averaging less than 4.0 percent. Third, while the inflation rate of WPI was lower than the CPI measures of inflation during the pre-break period, the reverse was the case in the post-break period. Fourth, volatility in inflation rate also declined along with the decline in the mean inflation rate, barring the case of 'metal' components of WPI.

This trending down in the rate of inflation which has been associated with significant reduction in volatility, despite episodes of intermittent domestic and external shocks, is indicative of well-anchored inflation expectation in India (Reddy, 2007). The questions are: How persistent had been the inflationary process in India and has there been a decline? What had been the behavior at the disaggregated level and how have they contributed to the persistence at the aggregate level?

Table 1: Mean and Volatility of WPI, CPIs and Components

(In percent)

Variable	Mean Inflation			Volatility			Break
	Full Period	Before Break	After Break	Full Period	Before Break	After Break	Date
1	2	3	4	5	6	7	8
I. WPI	6.54*	8.08*	4.97*	5.77	5.9	5.19	1995:6
II. Primary	6.79*	8.26*	4.16*	12.36	12.93	10.83	1998:12
Food	7.03*	9.05*	3.46**	15.77	17.1	12.36	1998:12
Non-food	6.68*	9.54*	3.8*	18.32	20.16	15.8	1995:5
III. Fuel	8.31*	–	–	15.4	–	–	–
IV. Manufacturing	5.95*	7.98*	3.82*	5.49	5.49	4.63	1995:8
Food	6.29*	8.12*	3.08*	13.3	14.0	11.33	1998:11
Textile	3.80*	7.60*	-0.17	11.4	10.84	10.71	1995:8
Chemical	5.5*	6.43*	3.1*	7.94	8.7	4.78	2001:1
Metal	7.95*	6.67*	12.5*	14.48	9.54	24.8	2002:8
Machine	5.31*	7.83*	3.60*	7.06	8.53	5.21	1992:11
V. CPI-IW	7.4*	9.2*	4.24*	7.1	7.23	5.62	1998:12
Food	7.25*	9.5*	2.91**	11.1	11.3	9.43	1998:12
VI. CPI-AL	6.64*	8.36*	3.58*	9.78	11.1	5.84	1998:12
VII. CPI-UNML	7.28*	8.81*	4.58*	5.26	5.30	3.96	1998:12

* and ** denote significance at 1% and 5%, respectively.

Section IV

Definitions of Inflation Persistence

In the literature, inflation persistence is interpreted in different ways. Batini and Nelson (2001) and Batini (2002), however, distinguish between three types of persistence. First type is the positive serial correlation in the price series, as the underlying pricing process, the conduct of monetary policy and the expectations' formation process of price-setting agents would influence the autocorrelation properties of inflation. Thus, this type of inflation persistence is considered as a reduced-form property of inflation.

The second type of inflation persistence, pioneered by Friedman (1972), refers to the number of periods it takes for the systematic component of monetary policy to have its maximum effect on the rate of inflation. Batini and Nelson (2001) point out that this type of persistence is the most relevant for monetary policy making as it determines the costs of disinflation. When the policy makers know the lag in the peak effect of policy action they can have pre-emptive response to private sector shocks and minimise the variability in output gap.

The third type of inflation persistence relate to the number of lags it takes for inflation rate to respond to a policy shock such as in the analysis of VAR evidence on the effect of monetary policy shocks.

Here we consider only the first two types of inflation persistence. For the first type (type-I) of inflation persistence, in the classical formulation, the autocorrelation properties of inflation is considered by an AR (k) process for the price series of the following type,

$$\Delta p_t = C + \sum_{j=1}^{k} \alpha_j \Delta p_{t-j} + u_t \qquad (1)$$

where Δp_t is rate of inflation[3], α_j is the autoregressive coefficient and u_t is a serially uncorrelated, but possibly heteroskedastic random error term. Andrews and Chen (1994) advocate that the best scalar measure of persistence is the sum of the AR coefficients, $\rho \equiv \sum \alpha_j$. To measure persistence in terms of the sum of AR coefficients, equation (1) can be re-written as

$$\Delta p_t = C + \rho \Delta p_{t-1} + \sum_{j=1}^{k-1} \beta_j \Delta\Delta p_{t-j} + u_t \qquad (2)$$

where ρ is the persistence parameter, while β_t parameters are transformations of AR coefficients in equation (1), $\beta_{k-1} = -\alpha_k$. If ρ takes a value close to unity, the inflation process has a unit root or behaves like a random walk so that when inflation goes up it stays up. On the other hand, if ρ is significantly lower than unity, a shock on inflation has only a temporary effect on inflation and will soon revert back to its trend level. The lag lengths are selected on the basis of Schwarz Bayesian Criterion (SBC) or Akaike Information Criterion (AIC).

As mentioned above, Perron (1989), however, had demonstrated that the persistence as measured by the above autocorrelation properties of inflation series will be exaggerated if the presence of structural breaks in the mean in not considered. Therefore, we conduct tests for the presence of structural break in the mean using Quandt-Andrews unknown break point test. If we find a structural break, the persistence parameter allowing for a break in the mean at the identified point is estimated by using the following equation,

$$\Delta p_t = c_0 + c_1 D_t + \rho \Delta p_{t-1} + \sum_{j=1}^{k-1} \beta_j \Delta\Delta p_{t-j} + u_t \qquad (3)$$

D_t equals zero for $t < T$ and 1 for $t \geq T$.

Further, in the above estimates of persistence, Hansen (1999) shows that if the estimated coefficients are close to one (*i.e.*, follow a unit root process) the point estimates can be biased downwards for which he provides a bootstrap procedure to calculate the estimates of persistence as well as their confidence interval. As will be seen below, given the relatively lower absolute value of the estimated persistence parameters, this is not a major issue in our context.

We measure the second type of inflation persistence (type-II) by the correlation of monthly year-on-year inflation rate with corresponding change in the measure of systematic monetary policy $k \geq 0$ periods earlier, denoted by a statistic $\rho_{pm}(k)$.[4] This provides us a means to identify whether inflation responds to systematic monetary policy with a delay or not *i.e.*, the number of periods it takes for a change in monetary policy to have its peak effect on inflation. However, neither the selection of systematic stance of monetary policy nor the appropriate statistic to calculate is a straightforward issue. Drawing on the literature [for examples, Friedman

(1972) and Batini and Nelson (2001)], we first consider the change in broad money (M3) as one measure of the systematic stance of monetary policy. In selecting the change in monetary aggregates as the stance of monetary policy, Batini (2002) points out that one does not take any stand on whether money has special role in the transmission mechanism, but only views it as a quantity-side measure of the monetary conditions induced by central bank through interest rate policy or other measures. It is, however, noted that if monetary policy adjusts completely and successfully to offset non-policy shocks, there should be no observed relation between policy measures and inflation.

Second, we use the monthly weighted average call rate as the other measure of policy stance in order to capture the idea that liquidity adjustment facility (LAF) operation under the repo and reverse repo window signals the intent of monetary policy in India. For this, we confine our sample period from April 2001 onwards when LAF was introduced to monitor the call rate within the corridor set by the repo and reverse-repo rate. Here, it may be noted that the operating policy rate between repo and reverse repo rate had been dependent on the prevailing liquidity condition in the market. In the deficit mode in the system requiring injection of liquidity, the operating policy rate has been the repo rate with the call rate being gravitated towards this rate. In the case of surplus mode requiring liquidity withdrawal, reverse repo rate has been the operating rate with call rate gravitating towards it. However, due to extreme liquidity conditions, there have been instances when the call rate either exceeded that repo rate or was lower than the reverse repo rate.

Section V

Empirical Results

Type-I Inflation Persistence

Based on the lag lengths selected by SBC/AIC, there are two groups of results on persistence. In half of the cases, the optimal lag length selected by the two criterions differs. While SBC selects mostly an AR(1) process, AIC favours mostly AR(2 to 3) process. The results presented in table-2 reveal the following. First, without mean break, the persistence

is on the lower side as compared to the persistence found in several industrialised countries reported by the studies referred above. At the aggregate level, the persistence based on SBC range from 0.322 for WPI to 0.42 for CPI-AL (from 0.29 for CPI-IW to 0.67 for CPI-NML based on AIC) *i.e.*, CPI measures of inflation are more persistent than WPI. In other words, if the inflation deviates from its long-term trend due to a shock, 60 to 70 percent of the deviation would be corrected in each of the following period. This lower level of inflation persistence implies that the degree of adjustment in inflation expectation by economic agents in India due to temporary increases in inflation rate is fairly low. At the disaggregate level of WPI, the degree of persistence is the highest for 'manufacturing' [0.383 (SBC) and 0.665 (AIC)], and within it that of 'machine' (0.56). 'Food' and 'fuel' exhibit a lower level of persistence than 'non-food', 'textile' and 'machine'. In other words, similar to those found in industrialised countries where persistence is higher for

Table 2: Persistence of WPI, CPI and Components

Variable	Persistence with lag length based on SBC				Persistence with lag length based on AIC			
	No break	One Break	Break At	Lag length	No break	One Break	Break At	Lag length
1	2	3	4	5	6	7	8	9
A. WPI	**0.322***	**0.264***	1995:5	1	–	–	–	1
I. Primary	0.237*	0.216*	1998:12	1	–	–	–	1
Food	0.073	0.025	1998:12	2	–	–	–	2
Non-food	0.334*	0.317*	1995:5	1	–	–	–	1
II. Fuel	0.129**	–	–	1	0.423*	–	–	9
III. Manufacturing	0.383*	0.266*	1995:8	1	0.665*	0.431*	1995:6	6
Food	0.08	0.05	1998:11	1	0.115	0.01	1998:11	3
Textile	0.428*	0.355*	1995:7	1	0.553*	0.441*	1995:5	3
Chemical	0.221*	0.192*	2001:1	1	0.307*	0.243*	2001:1	3
Metal	0.273*	0.252*	2002:8	1	–	–	–	1
Machine	0.56*	0.47*	1992:11	3	–	–	–	3
B. CPI-IW	**0.336***	**0.25***	1998:12	1	0.29*	0.145**	1998:12	2
Food	0.303*	0.245*	1998:12	1	–	–	–	1
C. CPI-AL	**0.42***	**0.39***	1998:12	1	0.533*	0.481*	1998:12	3
D. CPI-UNML	**0.322***	**0.203***	1998:12	1	0.67*	0.295**	1998:12	2

* and ** denote significance at 1% and 5%, respectively.

disaggregates which account for larger share of consumer spending, components with larger weights in WPI tend to have higher persistence in India. However, it is also interesting to note that unlike found for industrialised countries, the persistence at the disaggregate level is not consistently lower than at the aggregate level.

Second, allowing for a mean break, the persistence declines for all inflation series, including the components. As found in the literature, the results highlight the importance of controlling for mean break in estimating inflation persistence, which otherwise would lead to exaggeration of the estimated persistent parameters. At the aggregate level, it range from 0.2 to 0.39 by SBC (0.15 to 0.48 by AIC). In other words, the correction to the equilibrium level in each of the succeeding period following a shock ranges from 60 to 80 percent. CPI-AL and 'manufacturing' inflation continue to be the most persistent among the aggregates and the major components of WPI, respectively. Within the manufacturing component, 'machine' again is the most persistent. Even after allowing for mean break, the persistence at the disaggregate level is also not consistently lower than the aggregates, and 'food' and 'fuel' continue to exhibit lower persistence than 'non-food, 'textile' and 'machine'.

Has the Persistence Declined?

To check for the change in persistence, we employ two methods. First we estimate persistence for two sample periods, *viz.*, the pre-mean break and the post-mean break. Second, we employ rolling regressions technique to observe the change in persistence parameter over time.

Table-3 presents the estimated persistence coefficients for the two sample periods. At the aggregate level, the persistence in the post-break period declined in all, except WPI. Within WPI, the persistence in 'primary' and 'machine' was higher in the post-break period. For CPI-UNML, the persistence is nil in the post break period. In other words, barring WPI, fall in the mean rate of inflation has been associated with decline in their persistence.

In above, splitting the sample period into two allows us to compare only two point estimates and cannot observe the evolving trend in the

Table 3: Change in Persistence of WPI, CPI and Components

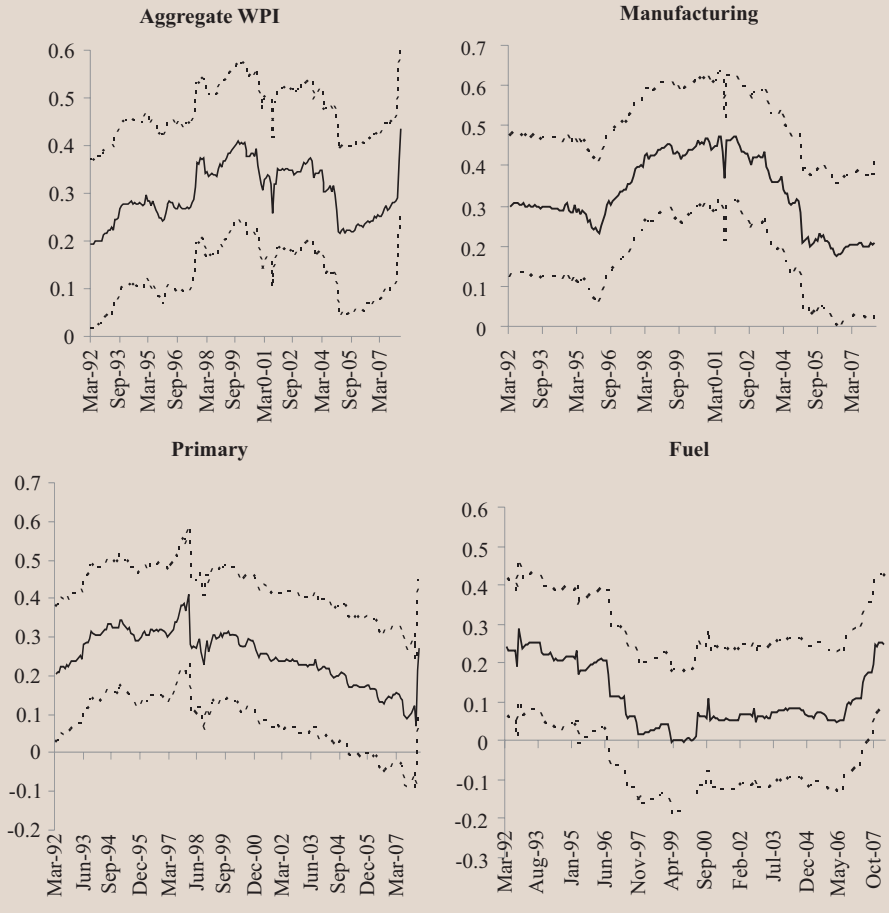
Variable		Persistence with lag length based on SBC		Persistence with lag length based on AIC	
		Before Mean Break	After Mean Break	Before Mean Break	After Mean Break
	1	2	3	4	5
I.	**WPI**	0.227*	0.313*	–	–
II.	**Primary**	0.208*	0.237*	–	–
	Food	0.10	-0.26**	–	–
	Non-food	0.322*	0.31*	–	–
III.	**Fuel**	–	–	–	–
IV.	**Manufacturing**	0.292*	0.217**	0.45*	0.41*
	Food	0.04	0.06	0.05	0.04
	Textile	0.346*	0.364*	0.484*	0.407*
	Chemical	0.20*	0.118	0.263**	0.127
	Metal	0.385*	0.13	–	–
	Machine	0.45*	0.50*	–	–
V.	**CPI-IW**	0.274*	0.17***	0.173**	0.05
	Food	0.258*	0.21**	–	–
VI.	**CPI-AL**	0.389*	0.362*	0.51*	0.317*
VII.	**CPI-UNML**	0.21**	-0.04	0.286*	-0.08

* and ** denote significance at 1% and 5%, respectively.

persistence parameter. Further, for the series where no break in the mean was observed, even the comparison of two point estimates cannot be carried out. It is also possible that the persistence in some of these series had undergone a gradual change without having any significant structural break at any distinct point of time. Therefore, in the following, the persistence coefficients along with their 95 per cent confidence intervals represented by the dotted line from time varying rolling regressions of 120 window sizes are presented for AR process based on SBC.[5]

It is observed from the rolling regression coefficients that the persistence in aggregate WPI initially increased followed by a declining trend before suddenly increasing towards the end of the sample period. Among the major components, the persistence in 'manufacturing', whose weight in the aggregate is about 64 percent, show a stable trend at the beginning and end part of the sample period, but the stable level is lower in the later part. In the middle part, the persistence initially increased sharply and declined in a similar fashion. With regard to 'primary' and 'fuel' component, in the former the persistence increased initially and declined, while in the latter an opposite trend is observed. However, both the components show a stiff increase towards the end of the sample

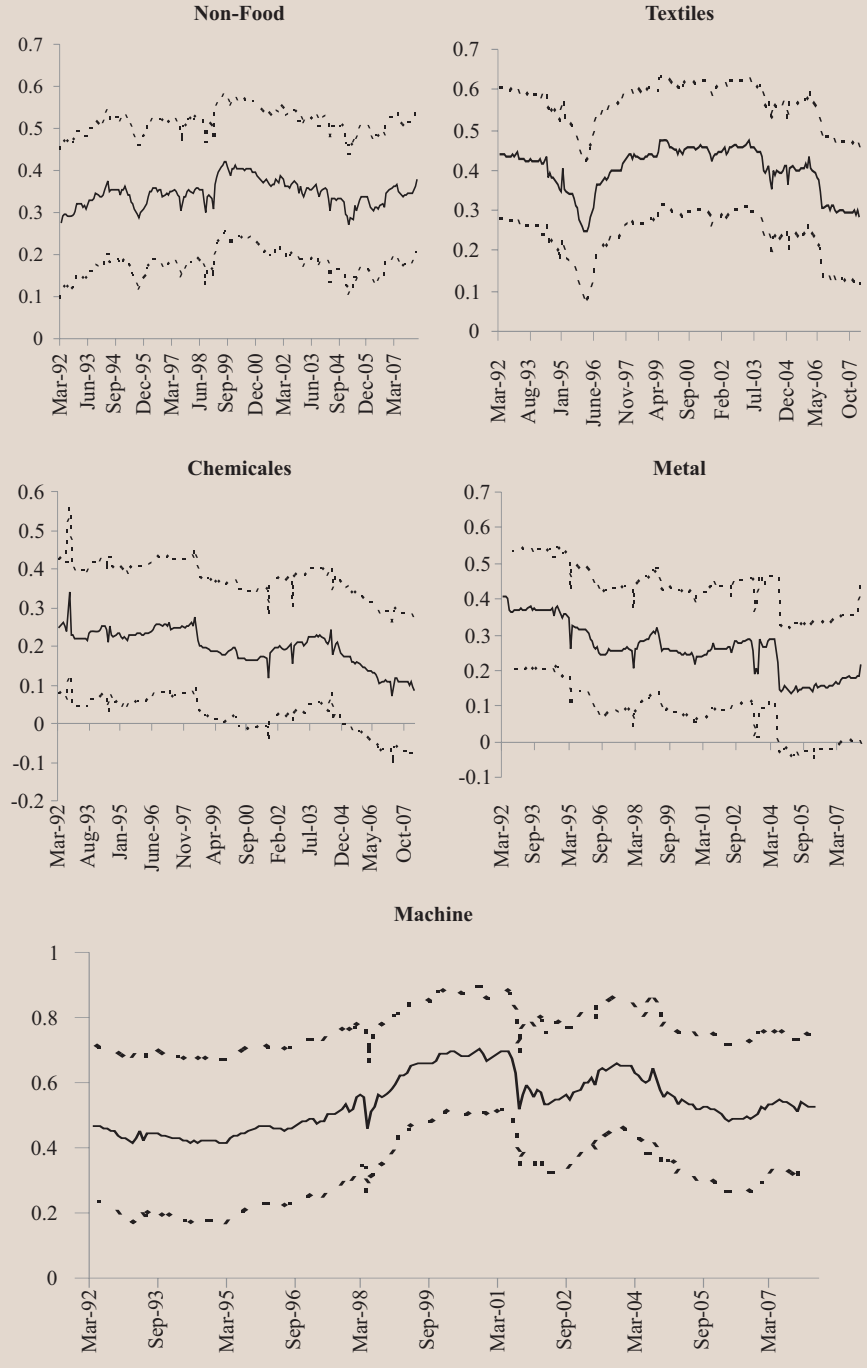
Chart-2:Rolling Estimates of Persistence in WPI and Its Major Components



period similar to the stiff increase in the aggregate WPI (Chart 2).

Among the sub-components, the persistence in ‘non-food’ shows an overall slowly increasing trend. The persistence in ‘textiles’ and ‘chemicals’ have tended to decline in the more recent period after exhibiting fluctuations around a slowly declining trend. ‘Metals’ after showing a low and stable persistence towards the later part of the sample period appears to have experienced some jump in the level of persistence in the most recent period. The persistence in ‘machine’ increased initially and followed an overall declining trend. However, some increase is

Chart-3: Rolling Estimates of Persistence in Sub-Components in WPI



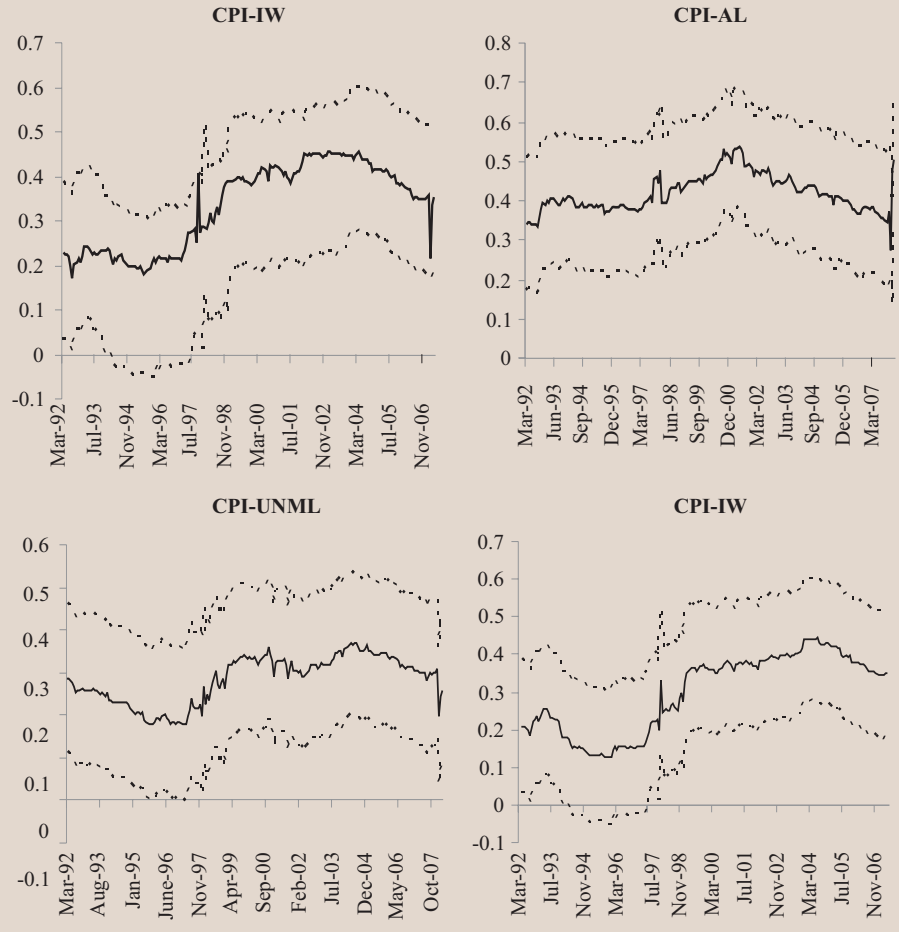
discerned in the more recent period that it is at an elevated level than at the beginning of the sample period (Chart 3).

The broad trends in the persistence of aggregate CPIs indicate an overall increase during a longer part of the sample period followed by slow declines that they remain higher than at the beginning of the sample period. However, we find some sharp swings towards the end of the sample period. The trend in the persistence of CPI-IW is more or less mirror imaged in its major component viz., 'food' (Chart 4).

Type-II Inflation Persistence

As mentioned above, we measure this type of inflation persistence

Chart-4: Rolling Estimates of Persistence of CPIs and Components



by estimating the lag at which the response of monthly year-on-year inflation to 1) corresponding growth in M3 and 2) monthly weighted average call rate is the maximum.

Table 4 presents the results for different sub-periods. The sub-periods have been selected based on the different monetary policy framework adopted during the period under consideration. Literature suggests that different monetary policy regime may alter the velocity of money, and consequently, the lag response of inflation to systematic monetary policy could change. Thus, estimation across sub-sample allows for changes in steady-state velocity growth due to regime changes (Batini, 2002). One, the period up to 1997:3 is considered as the period of monetary targeting. As monetary targeting with feedback began from 1985-86, we considered two overlapping sub-periods coinciding with this framework: i) 1983:4 (beginning of the sample period) to 1997:3 (end of formal monetary targeting); and ii) 1985:4 beginning of monetary targeting to 1997:3 (end of formal monetary targeting). Second, the period beginning with 1997:4 is treated as the period with multiple indicator approach framework. Third, as mentioned above, for call rate as the measure of systematic monetary policy, the period since 2001:4 (introduction of LAF) only is considered.

As would be expected, it is seen that the relationship between growth in money supply and inflation is positive and statistically significant in almost all the inflation series (aggregate as well as the components). For the full sample period, the correlation coefficients are not very large ranging from 0.176 (manufactured food) to 0.341 (CPI-UNML food). The maximum lag impact of money growth is about 29 months on WPI, while on the CPIs the maximum impact is felt instantaneously. Among the components of WPI, the maximum lags are on ‘fuel’, ‘manufactured food’ and ‘textile’ (29 to 36 months). On manufacturing inflation, the maximum impact is felt after three months, though within its sub-components it ranges from 0 to 36 months and no impact (‘metal’). Full sample period, as mentioned above, may not allow for changes in steady-state velocity growth due to regime shifts, and therefore, could differ from the behavior during the sub-periods.

It is seen that the maximum lag impact in general turns out to be much longer during the monetary targeting framework, which at the aggregate level range from 25 months for CPI-IW to 32 months for WPI. Further, money growth in general had a longer lag impact on food items (both manufactured and non-manufactured components). As a result,

Table 4: Correlations Between Various Measures of Inflation and Change in Systematic Monetary Policy (Growth in M3 and Call rate) (maximum positive and negative value)

Components	Growth in M3				Call rate
	Full Sample	**1983:4 to 1997:3**	**1985:4 to 1997:3**	**1997:4 to 2008:3**	**2001:4 to 2008:3**
1	2	3	4	5	6
I. WPI	0.243 (k=29) (4.24)	0.206 (k=32) (2.56)	0.244 (k=32) (2.72)	0.106 (k=27) (1.09)	-0.527 (k=8) (-6.28)
II. Primary	0.281 (k=0) (5.27)	0.236 (k=29) (2.93)	0.244 (k=29) (2.76)	0.517 (k=1) (8.01)	-0.362 (k=35) (-2.86)
Food	0.242 (k=0) (4.44)	0.261 (k=29) (3.28)	0.295 (k=29) (3.43)	0.539 (k=1) (8.63)	-0.397 (k=28) (-3.46)
Non-food	0.179 (k=0) (3.19)	0.175 (k=0) (2.15)	0.171 (k=0) (2.09)	0.173 (k=1) (2.03)	-0.351 (k=44) (-2.48)
III. Fuel	0.273 (k=25 (4.87)	0.234 (k=22) (2.97)	0.233 (k=23) (2.95)	0.341 (k=25) (3.95)	-0.471 (k=7) (-5.24)
IV. Manufacturing	0.246 (k=3) (4.49)	0.399 (k=3) (6.06)	0.428 (k=3) (6.18)	0.106 (k=0) (1.22)	-0.371 (k=8) (-3.70)
Food	0.176 (k=29) (2.98)	0.274 (k=27) (3.49)	0.287 (k=27) (3.35)	0.07 (k=0) (0.8)	-0.276 (k=0) (-2.70)
Textile	0.202 (k=36) (3.41)	-0.276 (k=0) (6.25)	0.405 (k=3) (5.71)	0.18 (k=30) (1.86)	-0.233 (k=0) (-2.23)
Chemical	0.30 (k=6) (5.63)	0.351 (k=32) (4.63)	0.394 (k=32) (5.40)	0.493 (k=6) (11.13)	-0.266 (k=32) (-2.02)
Metal	none	0.274 (k=6) (3.45)	0.245 (k=6) (3.04)	none	-0.461 (k=8) (-5.04)
Machine	0.229 (k=0) (4.17)	0.235 (k=0) (3.20)	0.288 (k=0) (4.05)	0.21 (k=0) (2.50)	-0.273 (k=16) (-2.40)
V. CPI-IW	0.318 (k=0) (6.11)	0.244 (k=25) (3.08)	0.313 (k=25) (3.75)	0.486 (k=1) (7.23)	-0.429 (k=29) (-3.83)
Food	0.305 (k=0) (5.81)	0.239 (k=26) (3.0)	0.293 (k=26) (3.45)	0.574 (k=0) (9.76)	-0.435 (k=35) (-3.68)
VI. CPI-AL	0.305 (k=0) (5.81)	0.265 (k=27) (3.48)	0.342 (k=27) (4.15)	0.551 (k=1) (8.98)	-0.413 (k=35) (-3.41)
VII. CPI-UNML	0.341 (k=0) (6.66)	0.239 (k=27) (2.99)	0.289 (k=27) (3.38)	0.563 (k=0) (9.4)	-0.444 (k=35) (-3.79)

Notes: Figure in lower parentheses is t-statistics.

the CPIs in which the weight of food is the maximum, monetary policy worked with longer lags.

During the period of multiple indicator framework, however, the maximum impact of growth in money supply on most of inflation series was felt with a much shorter lag than compared to the earlier period and in many of the WPI components, notably the major component 'manufacturing', the correlation turned insignificant. As a result, the correlation between money supply and the aggregate WPI inflation was much weaker and statistically insignificant in the post monetary targeting framework. On the CPIs with large component of food, the maximum impacts were either instantaneous or after one month and with much higher correlation coefficients. The same phenomenon is also evident in the food component (both manufactured and non-manufactured) of WPI.

The correlation between inflation and weighted monthly average call rate is also expectedly negative and statistically significant in all. At the aggregate level, the maximum impact of call rate on WPI is felt after 8 months. On the other hand, the maximum impact on CPIs is after 29 to 35 months. At the disaggregate level, the maximum impacts of interest rate on 'primary', 'chemicals', 'machine' in WPI and 'food' in CPI-IW are felt with a much longer lag ranging from 16 to 44 months. The maximum impact is instantaneous on 'manufactured food' and 'textile', while on 'fuel' and 'manufacturing' (within it 'metal') they ranged from 7 to 8 months. It is observed that during the comparable period, inflation series, in general, respond to interest rate with a much longer lag than change in money supply.

Section VI

Concluding Remarks

Using monthly data for the period 1982:4 to 2008:3, the behaviour of persistence in the alternative measures of inflation in India was analysed, both at the aggregate and disaggregate level. Drawing on the literature, we employed two measures of inflation persistence *viz.,* the autoregressive property of the inflation series and the number of periods it takes for the systematic monetary policy to have its maximum effect on inflation rate. It is revealed from the autoregressive properties that,

irrespective of the alternative inflation measures, the level of inflation persistence in India is relatively on the lower side. Conforming to the results found in the literature, this lower level of inflation persistence in India is particularly evident when allowed for break in the mean rate of inflation observed mostly around the second half of the 1990s. However, unlike observed in several industrialised countries, the persistence in disaggregates is not consistently lower than the aggregates. Among the components of WPI, 'manufacturing' inflation is the most persistent. 'Food' and 'fuel' exhibit a lower level of persistence than manufacturing and its components.

With the general decline in the mean rate of inflation since the mid-90s, persistence in most of the inflation measures also declined. However, due to rise in the persistence in some of its components, persistence in WPI inflation did not show a commensurate fall. The rolling regressions reveal sharp rise in the persistence of WPI in the more recent period due to 'primary', 'fuel' and 'metal' components. With regards to CPIs, the persistence increased during a longer part of the sample period followed by slow declines.

Change in money growth has statistically significant impact on almost all the inflation series. In general, the maximum lag impact of money growth was much longer during the higher inflationary period up to the mid-1990s (coinciding with monetary targeting regime) than the period thereafter with lower inflationary environment (coinciding with multiple indicator approach). During the period of higher inflation, the maximum lag impact of money supply was much longer on food items than non-food items, but shortened substantially with the decline in inflation rate. On the other hand, monthly weighted average call rate is found to have a statistically significant negative impact on all the inflation series. It is also observed that, in general, the maximum impact of interest rate on inflation is felt with a much longer lag than that of change in money supply.

Notes

[1] However, persistence in high inflation periods has negative connotation, which may not be the case with periods of low inflation. In the period of high inflation there is the vicious circle of high inflation accompanied by high inflation in future, while in the case of disinflation or price stability the circle is virtuous with the inertial of inflation expectation breaking down and inflation steadily falling (Hondroyiannis and Lazaretou, 2004).

[2] For 'food' component of CPI-IW, the time period is from 1982:4 to 2007:6 due to non-availability of data in the source material. We chose the beginning of the sample period from 1982:4, as this was one of the revised base year in the past.

[3] In our context, since we use monthly data series, the rate of inflation is the annualized month-to-month inflation rate obtained from the price series adjusted for seasonality. This is in conformity with the standard practices in the literature. Further, the problem of base effect associated with inflation measured on year-on-year basis, as the property of such series tends to alter with the frequency of data, would be largely absent.

[4] It may be noted that, in contrast to type-I persistence, the measure of inflation rate here is on year-on-year basis.

[5] No significant differences in the trend of the estimated persistence parameters are observed when the window size of the rolling regression was 108. However, they are not reported in order to conserve space.

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The Inflation Rate in India: Some Applied Issues

Janak Raj and Sarat Dhal[1]

Abstract

This study addresses some applied issues pertaining to the two alternative indicators of wholesale price inflation rate, *i.e.* the month-over-month inflation rate and the year-on-year or the annual inflation rate in the Indian context. Based on various empirical exercises pertaining to the relationship of inflation with money, output growth, interest rate and asset price variation, the study finds evidence that the standard year-on-year inflation rate could be more meaningful than the monthly inflation rate.

JEL Classification : E31, E310

Keywords : Inflation, Price Level.

Introduction

Economists' interest on how to construct the appropriate aggregate price index and measure the inflation rate has the history of a century long period. Over this period, paradigm shifts are evident from the literature moving across the spectrum of views. The early literature shows that Irving Fisher (1906) was in favour of a broad transaction price metric or the aggregate price index, comprising prices of goods, services and assets in order to reflect on the price level as implied by the broader equation of exchange and guide the authorities in determining the price of monetary unit. However, Fisher maintained that the appropriateness of any price index could be contextual; different problems necessitating different indices due to differences in the comparative places or comparative times under investigation (Bryan, *et.al.* 2002). Deriving from Fisher (1906) and Samuelson (1961), Alchian and Klein (1973) and Shubiya (1992) worked on the dynamic price index consistent with inter-temporal consumption optimization by the households. The dynamic price index did not receive general support due to various practical problems

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(Goodhart and Hofmann, 2000, Shiratsuka, 1999). During the 1980s and the 1990s, economists developed two variants of the core inflation indicator; one was consistent with the long-run supply curve (Eckstein, 1981) and the other better connected with monetary aggregates (Bryan and Cecchetti,1993,1994). The *threshold inflation rate*, owing to Tobin (1965), came into prominence with the works of Barro (1992), Sarel (1999) and Clark (1995). Some economists brought the concept of 'hedonic prices' to account for the impact of changes in product quality (Rosen,1974, Shiratsuka,1995). In the wake of low commodity price inflation condition and the surge in asset prices supported by technology stocks and the housing market during the second half of the 1990s through the first half of the current decade, economists again turned skeptical about the existing aggregate price indices with the argument that these indicators did not include services and assets. Thus, the large literature evolved on asset prices and their implications for policy (Saxton, 2003, Roubini,2006).

In the Indian context also, economists have addressed various conceptual and measurement issues pertaining to the general price index such as the choice of commodities, the relative importance accorded to them, the method of aggregation and the quality of price data (Srinivasan,2008, Raipuria,2003). Samanta and Mitra (1998) addressed the issue of divergence between wholesale and consumer price indices. Mohanty, *et.al.*(2000) estimated the 'core' inflation rate excluding sensitive commodities using the statistical trimmed mean methodology. Jalan (2003) made a reflection on policy implications of the core inflation [1]. The 'threshold' inflation rate (Vasudevan, 1998, Vasudevan, Bhoi and Dhal, 1999, Kannan and Joshi, 1999) became popular in an environment of increasing focus on price stability during the reform period. Later, the threshold inflation rate became associated with the 'informal inflation target' (Reddy, 2007). Of late, economists are less concerned with services, assets prices, product quality and money induced inflation in an environment of declining housing and equity markets and the rapid developments in global commodity prices. Instead, they are concerned with data mining aspects, i.e., whether to measure the inflation rate weekly, monthly, quarterly or annual basis from the existing price

indices. Some economists including Bhattacharya, Patnaik and Shah (2008) have argued that the month-over-month inflation rate (the rate of increase in the existing wholesale price index between two consecutive months) could be a better indicator than the year-on-year (y-o-y) inflation rate, i.e., the percentage increase in the price index between the current month and the corresponding period of the previous year[3].

In this context, several pertinent questions arise. What should be the standard approach for deriving the inflation rate indicator from the general price index? Should the standard approach be the one which produces low inflation rate? Whether the statistical approach to derive the inflation rate from the aggregate price index should be isolated from applied issues in monetary economics? Thus, the major motivation for the study is to address some applied issues relating to alternative inflation indicators in the Indian context. In what follows, the study comprises four sections. Section I provides a brief discussion on the conceptual and measurement issues. Section II addresses various applied issues for policy analysis. Section III provides empirical evidence. Section IV concludes.

Section I

Conceptual and Measurement Issues

The concept of inflation is defined variously. General purpose dictionaries such as the one published by Orient Longman defines inflation as ‘ a fall in the value of money’; not as a rise in the consumer price index as remarked by Goodhart (2000). According to the Merriam-Webster dictionary, inflation is ‘a continuing rise in the general price level usually attributed to an increase in the volume of money and credit relative to available goods and services’. According to online economics dictionaries such as ‘investopedia.com’, inflation is defined as a sustained increase in the general level of prices for goods and services. It is measured as an annual percentage increase. It also reflects on the declining purchasing power of money. Deriving from various macroeconomic textbooks, the wikepedia.com states that the term inflation refers to the persistent increase in the average price level, as reflected in the general price index such as the consumer price index or the wholesale price

index in the economy over time[4]. This does not mean that prices of all commodities constituting the general price index increase the same and that all prices necessarily increase. Some prices might increase a lot, others a little and still other prices decrease or remain unchanged. This modern definition differs from the original definition propounded by classical economists, according to which inflation means increase of the money supply.

From a generalised perspective, the inflation rate is not directly observed. It could be defined as the rate of increase in the observed general price index between two time periods. As such there can be several ways of deriving the inflation rate from the general price index data available with different frequencies. In practice, the inflation rate is usually expressed as the annual percentage change of the general price index [5]. According to the Bank of England, "the inflation rate is a measure of the average change in prices across the economy over a specified period, most commonly 12 months -the annual rate of inflation. If, say, the annual rate of inflation in January this year was 3 per cent, then prices overall would be 3 per cent higher than in January last year. So a typical basket of goods and services costing, say, GBP 100 last January would cost GBP 103 this January"[6]. A similar definition of inflation rate is provided by the European Central Bank, Bank of Canada [7] and several other central banks.

Generally, information is available for prices of various commodities, constituting the basket for the general price index. The latter is constructed as the weighted average of prices of various commodities. In this regard, measurement issues pertain to (i) the construction of aggregate price index and (ii) the derivation of inflation rate from the general price index. For the price index, there are broadly four issues: choice of commodities, the relative importance (weight) accorded to them, the method of aggregation, *a la*, Laspeyrs and Paschee Indices, and the quality of price data (Lebow and Rudd,2006, Srinivasan,2008). Once the price index is constructed, then the issue arises how to measure the rate of increase in the price index. For elucidation, we begin with the Indian context. The

wholesale price index data are available on weekly basis, from which monthly, quarterly and annual price indices are constructed. Statistically, it is possible to derive the inflation rate at various frequencies. Let the aggregate price index, after natural logarithm transformation, is denoted as 'p'. The inflation rate indicator, generally defined as the percentage increase in the price index between two time periods, can be derived in following ways from weekly, monthly and quarterly price index data:

$$\pi^{w}_{w,t} = (p^{w}_{t} - p^{w}_{t-1}) * 100 * 52 \quad (1)$$

$$\pi^{w}_{y,t} = (p^{w}_{t} - p^{w}_{t-52}) * 100 \quad (2)$$

$$\pi^{m}_{m,t} = (p^{m}_{t} - p^{m}_{t-1}) * 100 * 12 \quad (3)$$

$$\pi^{m}_{y,t} = (p^{m}_{t} - p^{m}_{t-12}) * 100 \quad (4)$$

$$\pi^{q}_{q,t} = (p^{q}_{t} - p^{q}_{t-1}) * 100 * 4 \quad (5)$$

$$\pi^{q}_{y,t} = (p^{q}_{t} - p^{q}_{t-4}) * 100 \quad (6)$$

Taking into account the seasonal effect on commodity prices, studies prefer monthly and quarterly price indices. This study deals with the monthly wholesale price index series. For the latter, there are two measures of the inflation rate: (i) the annual inflation rate (π_y) defined as the increase in the price index in the current month of the current year over the corresponding period of the previous year as shown in the equation 4 and (ii) the monthly inflation rate (π_m) defined as the increase in the price index between two consecutive months (the current month and the adjacent previous month), which is then multiplied by 1200 to arrive at the annualised inflation rate, as shown in the equation 3. Illustratively, the annual or the y-o-y inflation rate for the January 2008 would be estimated as the rate of increase in the price index for the month of January 2008 over the price index prevailing in January 2007. On the other hand, the monthly inflation rate for January 2008 would be estimated as the rate of increase in the price index for January 2008 over December 2007, which would then be multiplied by 12 to arrive at the annualised inflation rate. The monthly inflation rate shares an interesting

relationship with the annual inflation rate, when the former is presented in terms of its moving average. Illustratively, for any point of time (or any month), let us take the moving average of the monthly inflation rate over 12 adjacent previous months:

$$\sum \pi^{m}_{m,t} = \frac{1}{12}\left(\pi^{m}_{m,t-1} + \pi^{m}_{m,t-2} + \cdots + \pi^{m}_{m,t-12}\right) \quad (7)$$

Now substituting the monthly inflation rate for each month in terms of changes in the price index (in logarithm form) as shown in the equation 3, we have

$$\sum \pi^{m}_{m,t} = \frac{1}{12}\left[\left(p^{m}_{t-1} - p^{m}_{t-2}\right) + \left(p^{m}_{t-2} - p^{m}_{t-3}\right) + \cdots + \left(p^{m}_{t-12} - p^{m}_{t-13}\right)\right. \quad (8)$$

which can be solved to the following:

$$\sum \pi^{m}_{m,t} = \pi^{m}_{y,t-1} = \left(p^{m}_{t-1} - p^{m}_{t-13}\right) \quad (9)$$

Thus, for any particular month, the 12-month moving average of the monthly inflation rate based on the average of 12 adjacent previous months would be the one-month lag of the annual or inflation rate. Suppose we specify a regression equation, with the annual inflation rate depending on the 12-month moving average of the monthly inflation rate. Such a regression would replicate a first order autoregression model of the annual inflation rate, i.e. the annual inflation rate depending upon its own lag terms. This is demonstrated as follows:

$$\pi^{m}_{y,t} = \alpha + \beta\left(\sum \pi^{m}_{m,t}\right) = \alpha + \beta\pi^{m}_{y,t-1} \quad (10)$$

In general, the moving average of the monthly inflation rate of any window size would be related to the corresponding lag of the annual inflation rate. Therefore, in principle, the moving average of the monthly inflation rate indicator would not provide any extra information as compared with the lags of the annual inflation rate for predicting the annual inflation rate through a suitable auto-regressive distributed lag model. Another notable point here is that by construct, the monthly inflation rate (π_m) refers to the first difference whereas the annual inflation rate (π_y) is measured as the seasonal difference of the

logarithm transformed aggregate price index. Therefore, these two inflation rate indicators are likely to be different in terms of their stochastic properties. Now the pertinent question arises: Should π_m be preferred to π_y? In what follows, we address various applied issues before taking up statistical exercises.

Section II

Some Applied Issues

From the perspective of policy objectives such as price stability, sustained growth and financial stability, authorities have to manage inflation expectations and inflation risks for various reasons. First, a low and stable price inflation environment is regarded as an essential condition for improving the growth and productive potential of the economy (Rangarajan,1997). Second, for risk pricing of financial products, the inflation expectation and the inflation risk premium form crucial components. According to the popular Fisher's interest parity condition, the nominal return on a financial asset should equal to the sum of the real return and the expected inflation. The expectation of higher inflation and risks would be reflected in higher nominal interest rates (Berument,1999). Okun (1971) and Friedman (1977) argue that inflation is positively associated with inflation uncertainty, which is confirmed by a large body of empirical literature (Berument and Yuksel,2002, Ball, *et.al.*1992). As regards alternative inflation indicators, they may be associated with varying expectation and risk components, and thus, have implications for the volatility in financial markets. Moreover, a particular inflation rate indicator associated with greater expectation and risk than others may require frequent adjustment of policy instruments. Such a strategy may exacerbate uncertainties further with adverse consequences for investment and productive activities. According to Rangarajan (1997), volatility in prices creates uncertainty in decision making. Rising prices adversely affect savings while they make speculative investments more attractive. Second, the relationship of inflation rate with policy instruments and intermediate target variables such as monetary aggregates assumes critical importance. For authorities would be interested in knowing whether and to what extent the inflation

condition is a monetary phenomenon. In this regard, deriving from Friedman's view that 'inflation is a monetary phenomenon', price stability is understood in terms of monetary stability (Issing, 2000, Rangarajan, 1997). From the latter perspective, there are two important applied issues. One, whether alternative inflation rate indicators would show differential relationship with monetary variables? Second, the choice pertaining to a particular inflation rate indicator is two dimensional with respect to alternative inflation indicators and alternative monetary aggregates. Illustratively, inflation indicators may show differential correlation with narrow money than broad money aggregates. The narrow money comprising currency and demand deposit components reflects upon the transaction demand for money (Gauge, 1992). On the other hand, the broad money aggregate, apart from transaction demand, includes interest sensitive time deposits. Some researchers use the broad money aggregate to account for the wealth effect on consumption demand, apart from the transaction demand for money (Bredin and Cuthbertson, 2001). Third, the structural aspect of the inflation rate indicator, particularly, the inflation persistence, relating to the flexibility or the rigidity in the price setting behavior of producing sectors could also be another key issue for policy purposes. More persistent inflation may require more aggressive policy (Cecchetti and Debelle, 2004). Fuhrer and Moore (1995) show that when inflation is persistent, the output loss associated with disinflation is larger than when there is no persistence. Bordo and Haubrich (2004) find that the key factor in the yield curve's ability to predict output growth is the persistence of inflation. They provide theoretical and empirical evidence that the yield curve has better predictive ability in regimes with high inflation persistence. According to Bilke and Stracca (2007), given the medium term perspective, authorities should put more emphasis on the more lasting movements and disregard the shocks that are likely to be soon reverted. Putting this idea into practice, this would imply excluding or giving less weight to the less persistent inflation processes. Blinder (1997) stated that it is important for policy to consider "what part of each monthly observation on inflation is durable and what part is fleeting". Thus, the choice between alternative inflation

rate indicators in terms of variance and persistence measures becomes extremely complex (Bilke and Stracca, 2007). A key lesson arising from the literature is that it is not the inflation variance and persistence, *per se,* which are important. Rather the implications of inflation persistence for economic fundamentals relating to financial markets, aggregate demand and growth are relevant. These considerations may entail that an inflation rate indicator which is smooth and less volatile be preferred to a more volatile indicator.

On the empirical plane, several stylised facts and time series properties of alternative inflation indicators could be exploited for policy analysis. First, for measuring inflation expectation and risks, a mute question here is how economic agents form expectations about future inflation condition. Before formal models such as adaptive expectation (Friedman, 1968) and rational expectation (Lucas, 1972) models were developed, economists believed in agents forming expectations based on the historical mean of the inflation rate observed over a sample period of medium-longer time horizon consistent with the maturity of benchmark financial instrument such as the ten-year treasury bond or the length of a typical business cycle. In recent years, economists use a variety of time series models to measure time varying inflation expectations in line with the alternative expectation models. Illustratively, the auto regressive integrated moving average (ARIMA) model is used widely to measure adaptive expectation component of the inflation rate. Second, as regards the measure of inflation risk, a commonly adopted measure of inflation risk is the unconditional standard deviation of inflation rate over a sample period preferably over medium-longer horizon. Since economic agents engage in dynamic financial risk pricing in a modern financial environment, the conditional or time varying inflation risks based on generalised auto regressive conditional heteroscedacity (GARCH) models for the inflation rate are becoming popular. Third, for gauging the inflation persistence, empirical studies have adopted various approaches such as lagged correlation of inflation, the correlation of inflation with the growth rate of monetary variables, Box-Jenkin's ARIMA model and Granger's spectral density analysis.

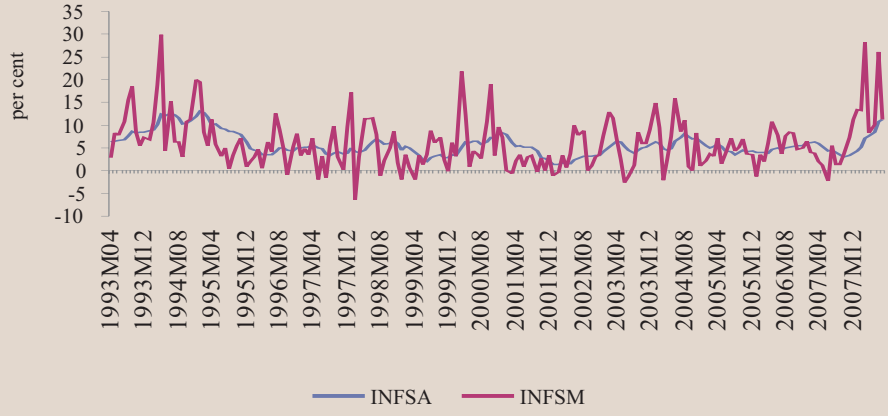
The following section dwells on empirical exercises based on the above time series models.

Section III

Empirical Evidence

Chart 1 shows the two measures of inflation rate i.e., annual inflation rate (INFSA) and the monthly inflation rate (INFSM), derived from the seasonal adjusted (using X12 method) wholesale price index over the sample April 1993 to July 2008. It is evident that the annual inflation rate is smoother than the monthly inflation rate series. The latter is more or less symmetrically distributed around the former. This is evident from the monthly inflation rate being lower than the annual inflation rate for 97 months or 53 per cent of the sample period comprising 184 months data. At the same time, the monthly inflation rate was above the annual inflation rate for 87 months or 47 per cent of the sample. The monthly inflation rate is highly volatile; at times, it could be higher than 20-30 per cent on annualised basis and such high rates generally being followed by low or negative values. The monthly inflation rate was negative for 18 months during the sample period; the lowest was at -6.4 per cent in February 1998. But the annual inflation rate was never negative during the same period. The monthly inflation rate was above 10 per cent for 44 months out of

Chart 1: Year-on-Year Inflation (INFSA) and Monthly Inflation (INFSM)



184 months. On the other hand, the annual inflation rate was above 10 per cent for 17 months out of 184 months. The monthly inflation rate was above 6 per cent for 80 months whereas the annual inflation rate was above 6 per cent for 70 months. However, the two inflation indicators had a contemporaneous correlation at 0.44, implying that they did not move perfectly in tandem with each other.

III.1 Stylised Facts

Table 1 provides summary statistics of two inflation indicators. During April 1993 to July 2008, the mean of annual inflation rate was lower mean than the mean of monthly inflation rate by 25 basis points. However, the formal test with the null hypothesis about the equality of means of the two inflation indicators produced insignificant F statistic 0.28 with the level of significance at 0.59; thus, suggesting that the two inflation indicators could not have statistically different mean statistic. Unlike the mean statistic, the median of annual inflation rate was somewhat higher by 28 basis points than the median of the monthly inflation rate, though statistically the medians of both the indicators could not be different from each other. On the contrary, the standard deviation of inflation rate, reflecting upon the unconditional measure of inflation risk, was significantly high for the monthly inflation rate as compared with the annual inflation rate. Here, various formal tests suggested that the variance of the two

Table 1: Descriptive Statistic of Wholesale Price Inflation Rate
April 1993-July 2008

Statistic	Monthly Inflation Rate	Annual Inflation Rate
Mean	5.99	5.74
Median	4.93	5.21
Maximum	29.93	13.00
Minimum	-6.38	1.39
Standard Deviation	5.69	2.49
Skewness	1.33	0.98
Kurtosis	5.87	3.69
Jarque-Bera Statistic	117.74	33.19
(Probability)	0.00	0.00

Table 2: Test for Equality of Variances of Monthly and Annual Inflation Rates

Method/Statistic	Degree of freedom	Value	Probability
F-test	(183, 183)	5.22	0.00
Siegel-Tukey: X^2 test		8.29	0.00
Bartlett : X^2 test	1	112.66	0.00
Levene: F test	(1, 366)	60.04	0.00
Brown-Forsythe: F test	(1, 366)	52.34	0.00

inflation indicators could be significantly different from each other (Table 2). Furthermore, the skewness, kurtosis and Jarque - Berra test statistic suggest that both the inflation rates cannot follow the normal distribution.

III.2 Inflation Expectation and Persistence

The persistence of an economic indicator, *prima facie*, is gauged from its auto-correlation (ACF) and partial auto correlation (PACF) functions, which form a part of identification of a suitable ARIMA model. Chart 2 shows the autocorrelation of two inflation rate indicators over 24 months. The auto correlation of annual inflation indicator is statistically significant up to 13 lags, as it remains away from 2 asymptotic standard errors band. The partial auto correlation of annual inflation rate could be statistically significant only for two lags. The behavior of ACF and PACF of the annual inflation indicator suggests that the variable could be modeled with a first order ARIMA model. On the other hand, for the monthly inflation rate, the auto-correlation is significant up to 3-lags while the partial auto correlation is significant for 1-lag (Chart 2). Moreover, the lagged correlations of the monthly inflation rate are significantly low as compared with the lagged correlations of the annual inflation rate. Thus, the correlogram of annual inflation and monthly inflation rates suggests that the former could be more persistent than the latter. However, such inference about the nature of persistence in two inflation indicators could be erroneous without consideration of stochastic properties of the variables (Cochrane, 1988).

Chart 2A: Autocorrelation and Partial Autocorrelation of Year-on-Year Inflation Rate

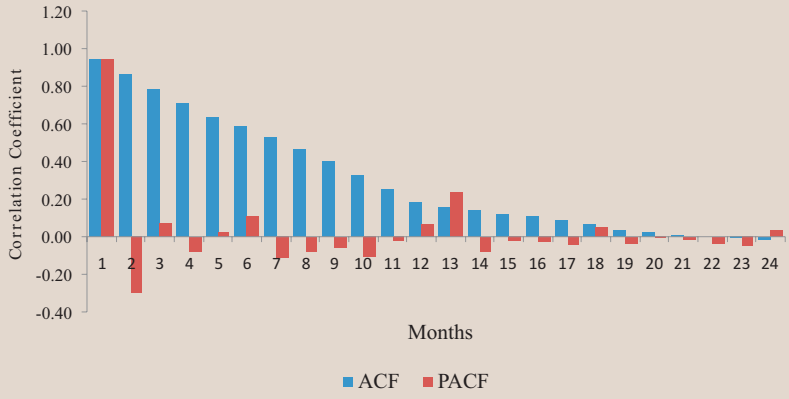
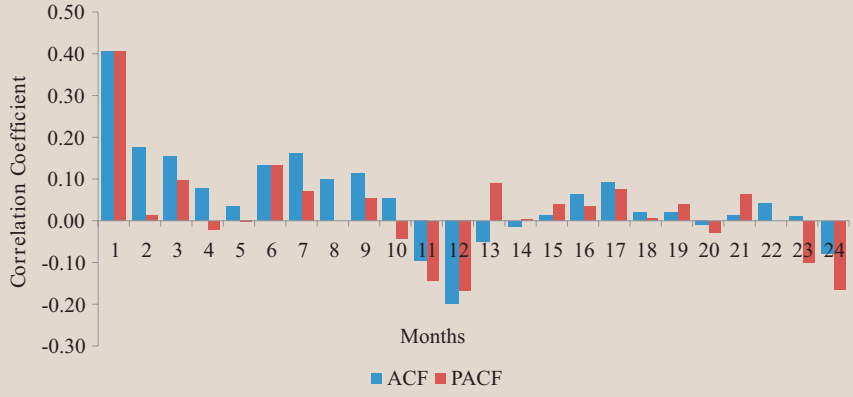


Chart 2 B: Autocorrelation and Partial Autocorrelation of Monthly Inflation Rate



Is the Inflation Rate a Stationary Process?

Nelson and Plosser (1981) showed that the behavior of an economic variable in response to various shocks depend critically on its stochastic nature, which is reflected in the random walk component and analysed through the unit root test. They showed that unanticipated shocks do not affect the permanent or long-run trend component of a stationary economic variable, and thus, such a variable would be least persistent. According to Cochrane (1988), the long-range forecast for a stationary series tends to converge with its historical mean. Of particular interest to the inflation

rate, research shows that the measures of expectation, persistence and permanent components cannot be analysed without first-hand knowledge whether the inflation rate is a stationary series. Table 3 presents result of the unit root for the two inflation indicators under investigation. It is evident from various unit root tests that the monthly inflation rate, which is the first difference of log-transformed price index, is a stationary process, a finding most common to the empirical literature. On the other hand, various unit root tests do not provide a unique answer to whether the annual inflation rate is a stationary process. The Kwzatkowkz, Phillips, Schmidt and Shin (KPSS) and Eliot, Rothenberg and Stock - Dickey - Fuller generalised least square (GLS) tests suggest that annual inflation rate is a stationary process while the conventional Augmented Dickey - Fuller (ADF) and Phillips-Perron (PP) tests provide the contrasting evidence. An interesting observation here is that the choice of the sample period could play an important role for the existence of unit root in the annual inflation rate. Illustratively, the ADF test rejects the annual inflation rate as a stationary variable for the sample April 1993 to July 2008. However, the same test could prove the annual inflation rate as a stationary process for the sample period April 1995 to July 2008 (up to July), excluding the episodes of high inflation rates during April 1993-March 1995.

Table 3 : Unit Root test of Inflation Rate

Tests (lags)	Null Hypothesis	Annual Inflation rate	Monthly Inflation rate	5 % critical value
ADF (13)	Has Unit Root	-1.97	8.72	-2.88
PP (13)	Has Unit Root	-2.1	-8.89	-2.88
ERF-DF-GLS (13)	Has Unit Root	-0.8	-8.73	-1.94
KPSS	Stationary	0.28	0.23	0.46
ERS (Bartlett window)	Stationary	3.03	0.45	3.16
ERF-DF-GLS (1 lag)	Has Unit Root	-2.31	-8.73	-1.94
Sample 1995:4 -2008:7				
ADF (13)	Has Unit Root	-3.21	-8.64	-2.88

ADF : augmented Dickey-Fuller test

At a formal level, inflation persistence can be measured in various ways. First, as shown by Levin and Pinger (2004) and Cecchetti and Debelle (2005), the measure of persistence (s) in the inflation rate can be estimated from the auto-regressive distributed lag model such as the following:

$$\pi_t = \alpha + \sum_{j=1}^{k} \beta_j \pi_{t-j}$$

$$\rho = \sum \beta_j$$

Alternatively, following Levin and Pinger (2004), the above equation can be reformulated to obtain the persistence (s) estimated directly from the following regression for the inflation rate variable:

$$\pi_t = \alpha + \rho \pi_{t-1} \sum_{j=1}^{k-1} \beta_j \Delta \pi_{t-j}$$

Second, Campbell and Mankiew (1988) suggested that the popular ARMA (p, q) model can also be used to estimate the persistence parameter (s). Illustratively, from the first order ARMA (1, 1) model, the persistence measure can be estimated as higher the autoregressive coefficient, higher the persistence and higher the moving average parameter, lower the persistence. Table 4 presents the estimated first order ARMA (1, 1) model for two inflation indicators. The coefficients of AR and MA terms suggest that the annual inflation is more persistent than the monthly inflation rate. The intercept term in the ARMA model suggests more or less similar mean for both the inflation rates. However, it is evident from the coefficient of determination R2 that the ARMA (1, 1) model fits well with the annual inflation rate but not the monthly inflation rate. Also, in terms of inflation forecasts out of sample for 7 months during January-July 2008, the ARMA model performs better for the annual inflation rate than the monthly inflation rate, which is evident from various forecast error statistics reported in the Table 4. Thus, inflation expectation can be gauged

Table 4: Inflation Expectation: ARMA(1,0,1) Model

	Annual Inflation Rate	Monthly Inflation Rate
Constant	6.14	6.02
	(4.92)	(8.80)
AR(1)	0.95	0.49
	(34.24)	(3.05)
MA(1)	0.39	-0.11
	(5.62)	(-0.58)
R^{-2}	0.93	0.16
SE	0.65	5.22
DE	1.91	1.99
Forecast Performance (January-July 2008)		
Root mean square error	1.16	11.02
Minimum absolute prediction error	10.9	50.7
Theil Inequality	0.07	0.40

Figures in bracket are estimates of the 't' statistic. 5% significant 't' statistic is about 2.0

better with the annual inflation rate than the monthly inflation rate. Tables 5a and 5b present the results of the ARDL model for analysing persistence in the annual and monthly inflation rates respectively. The

Table 5a :Persistence of the Annual Inflation Rate : the ARDL model

Variable (COEFFICIENTS)	Coefficient	Standard Error	t-Statistic	Significance
Intercept	0.25	0.12	2.06	0.04
INFSA(-1)	0.96	0.02	46.75	0.00
DINFSA(-1)	0.42	0.08	4.95	0.00
DINFSA(-2)	0.00	0.07	-0.04	0.97
DINFSA(-3)	0.06	0.07	0.86	0.39
DINFSA(-4)	0.01	0.06	0.14	0.89
DINFSA(-5)	-0.04	0.06	-0.65	0.52
DINFSA(-6)	0.06	0.07	0.96	0.34
DINFSA(-7)	0.08	0.08	1.01	0.32
DINFSA(-8)	0.01	0.07	0.09	0.93
DINFSA(-9)	0.11	0.07	1.61	0.11
DINFSA(-10)	-0.01	0.07	-0.21	0.83
DINFSA(-11)	-0.03	0.07	-0.41	0.68
DINFSA(-12)	-0.47	0.07	-7.06	0.00
DINFSA(-13)	0.22	0.09	2.60	0.01
R^2	0.95	Mean dependent variable		5.66
R^{-2}	0.95	S.D. dependent variable		2.44
S.E. of regression	0.54	Akaike info criterion		1.70
Sum squared residual	48.95	Schwarz criterion		1.97
Log likelihood	-138.22	F-statistic		244.53
Durbin-Watson	1.87	Probability (F-statistic)		0.00

Table 5b :Persistence of the Monthly Inflation rate : the ARDL model

Variable	Coefficient	Standard Error	t-Statistic	Significance
C	3.20	0.95	3.38	0.00
INFSM(-1)	0.47	0.17	2.84	0.01
DINFSM(-1)	-0.12	0.17	-0.71	0.48
DINFSM(-2)	-0.12	0.18	-0.65	0.52
DINFSM(-3)	0.01	0.19	0.04	0.97
DINFSM(-4)	-0.01	0.18	-0.03	0.98
DINFSM(-5)	-0.01	0.19	-0.07	0.94
DINFSM(-6)	0.12	0.16	0.77	0.44
DINFSM(-7)	0.22	0.16	1.39	0.17
DINFSM(-8)	0.19	0.14	1.40	0.16
DINFSM(-9)	0.28	0.10	2.89	0.00
DINFSM(-10)	0.30	0.07	4.27	0.00
DINFSM(-11)	0.22	0.09	2.57	0.01
R^2	0.25	Mean dependent variable		5.99
R^{-2}	0.20	S.D. dependent variable		5.69
S.E. of regression	5.08	Akaike info criterion		6.16
Sum squared residuals	4415.63	Schwarz criterion		6.38
Log likelihood	-553.46	F-statistic		4.86
Durbin-Watson	1.96	Probability (F-statistic)		0.00

coefficient of the first order autoregressive component of the inflation rate, which reflects on persistence, for the annual inflation rate is twice that of the monthly inflation rate. The Wald test suggested that null hypothesis of unity persistence coefficient for the annual inflation rate could be rejected at five per cent level of significance. Interestingly, both the equations in Table 5a and 5b suggest similar long-run expected inflation for the annual and the monthly inflation rates at 5.6 per cent.

Power Spectrum of Inflation Rates

Following Granger's (1966) work on spectral density function of economic variables, several empirical studies have used this methodology to measure persistence (Levy and Dezhbakhsh, 2003) According to Granger (1966), "the long -term fluctuations in economic variables, if decomposed into frequency components, are such that the amplitude of the components decreases smoothly with decreasing period"Cochrane (1988) suggested that the persistence of a stationary series can be measured by the power spectrum at zero frequency. In other words, if the spectral density function for an inflation rate indicator

were to follow a downward sloping curve, then the behavior of inflation rate would be driven by long-term economic fundamentals. In such a situation, inflation would be less volatile and highly persistent. Otherwise, for an upward sloping spectral density curve, the inflation rate would be driven by various short-term factors and it would be highly volatile and less persistent, with little role for economic fundamentals. Chart 3A shows the spectral density function of annual and monthly inflation rates, based on Bartlet's window. The SDF of both annual and monthly inflation rates falls through low to high frequencies or long to shorter time horizons. However, at zero frequency, the estimated power spectrum of the annual inflation rate is three times larger than that of the monthly inflation rate. For business cycle and shorter period frequencies (above >=0.8), the estimate of power spectra for the monthly inflation is much larger than the annual inflation rate. Thus, it can be inferred that the permanent or the long-term component could be larger for the annual inflation rate than the monthly inflation rate. Interestingly, if the annual inflation rate were to be considered a stationary process in the first difference form (DINFSA), then its spectral density function would show the power spectrum at zero frequency lower than the monthly inflation rate (Chart 3B).

Chart 3A: Spectral Density of Annual Inflation (INFSA) and Monthly Inflation (INFSM) Rates

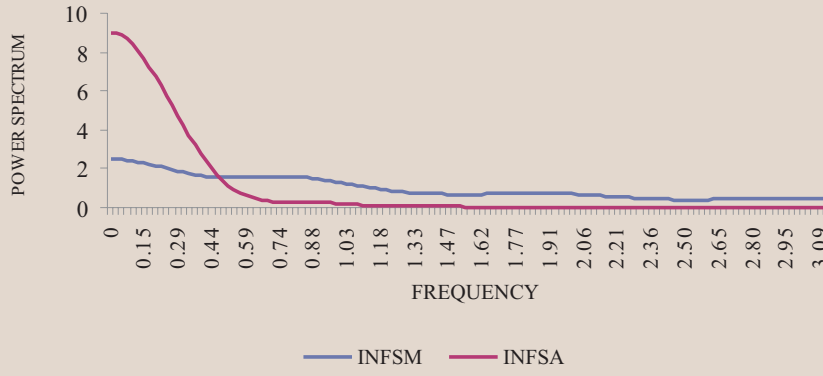
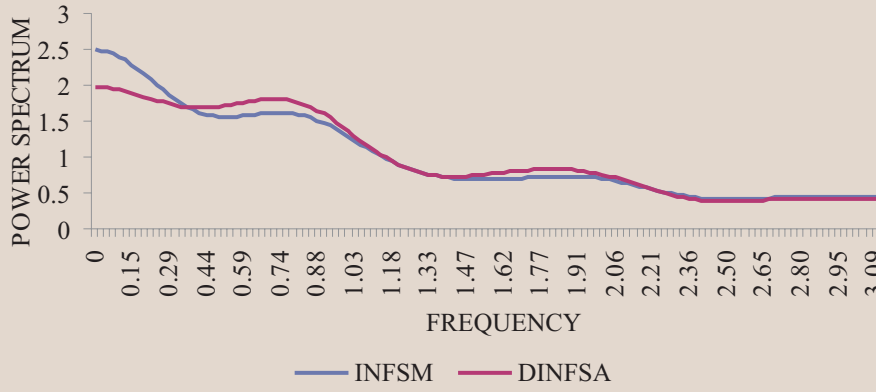


Chart 3B:Spectral Density of Annual Inflation (INFSA) and Monthly Inflation (INFSM) Rates



III.3 Inflation Volatility

Alluding to the discussion earlier, it is important to understand the inflation dynamics in terms of the interaction between inflation expectation and risk components. In this regard, we examined various GARCH models with the annual and the monthly inflation rates. Empirical exercises revealed that it is the annual inflation rate rather than the monthly inflation rate, which could be useful in terms of predictive power of the alternative GARCH models. Illustratively, the suitable GARCH model for the annual inflation rate had the adjusted R-squared estimate at 0.78 (Table 6). A similar GARCH model had the adjusted R-squared estimate at 0.14 for the monthly inflation rate. Thus, the annual inflation rate is suitable for analysing the interaction between inflation expectation and risk components. Moreover, the GARCH model for the annual inflation rate reveals various interesting insights. First, the long-run expected inflation, as reflected in the intercept term or the mean in the expectation equation, was 6.2 per cent, closer to the threshold inflation rate reported by the literature in the Indian context. Second, a notable finding here is that inflation expectation and variance have significant positive relationship, as evident from the statistically significant positive coefficient of the GARCH variance term in the inflation mean equation, a finding in line with the mainstream theoretical and

Table 6: GARCH (1,1) Model of Inflation

	Coefficient	Std. Error	z-Statistic	Prob.
Mean Equation				
LOG (Variance)	3.42	0.22	15.65	0.00
Intercept	6.21	0.34	18.37	0.00
Variance Equation				
Intercept	0.18	0.02	8.77	0.00
ARCH (1)	0.41	0.06	6.81	0.00
Threshold	-0.45	0.06	-7.25	0.00
GARCH (1)	0.57	0.01	48.19	0.00
GED Parameter	1.84	0.26	7.03	0.00
R^2	0.79	Mean dependent Variable		5.36
R^{-2}	0.78	S.D. dependent variable		2.20
S.E. of regression	1.02	Akaike criterion		2.62
Sum squared residual	169.76	Schwarz criterion		2.75
Log likelihood	-214.21	F-statistic		102.91
Durbin-Watson stat	1.21	Probaility (F-statistic)		0.0

empirical literature. During 1995-96 to 2006-07, the conditional standard deviation of the annual inflation rate remained more or less stable, hovering around 1.0 per cent. Thus, the inflation volatility did not have perceptible impact on medium term inflation expectation during this period. Of late, inflation volatility has increased sharply; the conditional variance of inflation rising to about 4.5 per cent during the second and third quarter of 2008-09 before declning sharply thereafter.

III.4 Inflation and Money Growth Relationship

Table 7 presents the contemporaneous correlation of inflation rate (INFSA) with growth rates of reserve money (GRMSA), narrow money (GM1SA) and broad money (GM3SA) aggregates in the hierarchy of liquidity. There are a couple of interesting insights emerging from the correlation analysis. First, it is evident that the annualised

Table 7: Contemporaneous Correlation of Inflation Rate with Money Growth Rates

Monthly money growth rates	Monthly inflation rate	Annual money growth rates	Annual inflation rate
GRMSM	0.12	GRMSA	0.38
GM1SM	-0.03	GM1SA	0.47
GM3SM	-0.07	GM3SA	0.17

inflation rate has significant correlation with the annual growth rates of reserve money, narrow money and broad money aggregates. However, the monthly inflation rate does not have significant contemporaneous correlation with the monthly growth rates of monetary aggregates.

Recognising the transmission lags, Table 8 presents the correlation of inflation rate with lags in the growth rate of monetary aggregates. It is evident that the correlation of annual inflation rate with lags of growth rates of reserve money and narrow money are significant up to 13 months. The correlation of annual inflation with the lags of the growth rate of broad money is significant up to eight months and in terms of magnitude, it is weaker than the narrow money aggregate. On the other hand, the monthly inflation rate does not show significant correlation with lags of the growth rate of narrow and broad monetary aggregates.

Table 8: Correlation of Inflation with Monetary Aggregates

	Correlation of annual inflation rate with annual growth rates of monetary aggregates						Correlation of monthly inflation rate with monthly growth rates of monetary aggregates					
	GRMSA		GM1SA		GM3SA		GRMSM		GM1SM		GM3SM	
Leads	lag	lead	lag	lead	lag	lead	lag	lead	lag	lead	lag	lead /lags
1	0.36	0.38	0.48	0.47	0.18	0.15	0.09	-0.02	0.08	-0.05	0.09	-0.04
2	0.34	0.39	0.49	0.48	0.2	0.14	-0.06	0.13	0.14	0.17	0.12	0.1
3	0.33	0.39	0.48	0.47	0.2	0.12	-0.02	-0.01	0.11	0.05	0.11	0
4	0.34	0.4	0.46	0.45	0.17	0.1	0.08	0.14	0.14	0.03	0.09	-0.05
5	0.33	0.38	0.43	0.43	0.14	0.1	0.09	0.01	0.04	0.03	0	0.04
6	0.32	0.38	0.39	0.41	0.11	0.08	0.13	0	0.08	0.07	0.05	-0.03
7	0.3	0.36	0.35	0.38	0.07	0.07	0.04	0.01	0.03	-0.05	-0.03	-0.01
8	0.29	0.35	0.3	0.37	0.04	0.06	0.13	0.03	0.05	0.08	0.1	0.02
9	0.26	0.34	0.25	0.36	0.01	0.06	0.05	0.09	-0.03	0.07	-0.01	0.01
10	0.25	0.3	0.21	0.33	-0.01	0.05	-0.01	0.12	0	0.02	-0.01	-0.03
11	0.23	0.25	0.19	0.3	-0.03	0.04	0.07	0.02	-0.01	0.03	-0.09	0.07
12	0.22	0.2	0.17	0.27	-0.04	0.03	0.11	-0.01	0.18	0	0.21	-0.08
13	0.21	0.13	0.13	0.23	-0.07	0.01	0.08	0.05	0.06	0.02	-0.01	0.04
14	0.2	0.06	0.08	0.19	-0.08	0	0.1	0.04	0.02	0.04	-0.01	0.01
15	0.17	-0.01	0.04	0.16	-0.08	-0.01	0.01	-0.04	-0.05	0.01	-0.11	0.01
16	0.16	-0.06	0.01	0.13	-0.06	-0.01	-0.03	-0.03	0.04	0.05	0.01	0.03
17	0.15	-0.1	-0.02	0.09	-0.03	-0.02	0.02	-0.02	-0.05	-0.02	-0.01	-0.07
18	0.15	-0.14	-0.04	0.06	-0.01	-0.01	0.06	-0.07	0	0	0.03	-0.02
19	0.13	-0.16	-0.05	0.02	0.02	-0.01	0.01	-0.04	-0.05	0.08	0	0.06
20	0.12	-0.18	-0.05	-0.02	0.04	0	0.01	-0.06	0.02	0.04	0.05	0.03
21	0.12	-0.19	-0.06	-0.07	0.06	0	0.11	0	0.09	-0.06	0.08	-0.03
22	0.11	-0.2	-0.07	-0.1	0.07	0	0.06	0.05	0.06	-0.08	0.04	-0.1
23	0.09	-0.22	-0.09	-0.13	0.07	0.02	0.01	-0.02	-0.06	-0.05	-0.05	0.02
24	0.08	-0.24	-0.1	-0.15	0.08	0.02	0	-0.11	-0.01	-0.02	0	-0.01

Beyond correlation analysis, it is useful to study the formal Granger causality between inflation rate and money growth indicators (Table 9). The causal relationship between inflation rate and money growth indicators is shown for various lags in line with various lag selection criteria. Illustratively, in the two-variable VAR framework, the Swarzt-Bayes and the Hannan-Quinn criteria suggested 1-2 lags. On the other

Table 9 Granger Causality between Inflation and Money Growth

Causality between the monthly inflation rate and the monthly growth rates of monetary aggregates			Causality between the annual inflation rate and the annual growth rate of monetary aggregates		
Null Hypothesis:	F-Statistic	Probability	Null Hypothesis:	F-Statistic	Probability
X does not Granger Cause Y			X does not Granger Cause Y		
1 Lag			1 Lag		
GRMSM - INFSM	0.51	0.48	GRMSA - INFSA	0.08	0.77
INFSM - GRMSM	0.03	0.87	INFSA - GRMSA	2.41	0.12
GM1SM - INFSM	1.98	0.16	GM1SA - INFSA	3.3	0.07
INFSM - GM1SM	0.77	0.38	INFSA - GM1SA	4.88	0.03
GM3SM - INFSM	3.09	0.08	GM3SA - INFSA	3.29	0.07
INFSM - GM3SM	0.6	0.44	INFSA - GM3SA	0.25	0.62
2 Lags			2 Lags		
GRMSM - INFSM	1.49	0.23	GRMSA - INFSA	0.32	0.73
INFSM - GRMSM	2.05	0.13	INFSA - GRMSA	1.27	0.28
GM1SM - INFSM	3.53	0.03	GM1SA - INFSA	2.95	0.05
INFSM - GM1SM	4.53	0.01	INFSA - GM1SA	2.15	0.12
GM3SM - INFSM	2.99	0.05	GM3SA - INFSA	2.42	0.09
INFSM - GM3SM	1.65	0.19	INFSA - GM3SA	0.05	0.95
3-Lag			3 Lags		
GRMSM - INFSM	1.03	0.38	GRMSA - INFSA	3.81	0.01
INFSM - GRMSM	1.51	0.21	INFSA - GRMSA	1.41	0.24
GM1SM - INFSM	3.18	0.03	GM1SA - INFSA	2.79	0.04
INFSM - GM1SM	2.94	0.03	INFSA - GM1SA	2.57	0.06
GM3SM - INFSM	2.62	0.05	GM3SA - INFSA	2.34	0.07
INFSM - GM3SM	1.15	0.33	INFSA - GM3SA	1.06	0.37
12-lag			12 Lags		
GRMSM - INFSM	1.36	0.19	GRMSA - INFSA	1.41	0.17
INFSM - GRMSM	1.2	0.29	INFSA - GRMSA	1.38	0.18
GM1SM - INFSM	2.17	0.02	GM1SA - INFSA	2.01	0.03
INFSM - GM1SM	1.01	0.44	INFSA - GM1SA	1.85	0.04
GM3SM - INFSM	2.26	0.01	GM3SA - INFSA	1.55	0.11
INFSM - GM3SM	0.61	0.83	INFSA - GM3SA	1	0.45
13-lag			13 Lags		
GRMSM - INFSM	1.24	0.25	GRMSA - INFSA	1.37	0.18
INFSM - GRMSM	1.15	0.32	INFSA - GRMSA	1.17	0.31
GM1SM - INFSM	2.12	0.02	GM1SA - INFSA	2.1	0.02
INFSM - GM1SM	0.9	0.56	INFSA - GM1SA	1.4	0.16
GM3SM - INFSM	2.1	0.02	GM3SA - INFSA	1.91	0.03
INFSM - GM3SM	0.59	0.86	INFSA - GM3SA	0.97	0.48

hand, the final prediction error, Akaike information and modified likelihood ratio criteria suggested for higher order lags up to 12 or 13 months. First, for lower order lag model such as 1-month lag, the annual inflation significantly Granger causes narrow money growth rate at 5 per cent level of significance and the narrow money growth could Granger cause annual inflation rate vice versa but at a higher 10 per cent level of significance. For the same lag order, there is no causal relationship between annual inflation and reserve money growth rates. The broad money growth rate Granger causes the annual inflation rate *albeit,* at higher 10 per cent level of significance, but the annual inflation rate does not Granger cause the broad money growth rate. On the other hand, the monthly inflation does not have causal relation with monthly growth of reserve money and narrow money indicators. Only the monthly growth rate of broad money could Granger cause the monthly inflation rate but at higher 10 per cent level of significance. As we increase the lag length to 2 to 3 months, there is a significant change in the causal nexus between inflation and narrow money growth indicator. For 2-3 lags, the annual growth rate of narrow money significantly Granger causes the annual inflation rate, not *vice versa*, which was observed in the case of 1-month lag case. However, in terms of monthly variation, both narrow money growth and inflation rate Granger cause each other. On the other hand, the causal relationship between the broad money growth and the inflation rate remains more or less similar for lower order lags of 1-3 months. Reserve money growth does not cause inflation for similar lower order lags. Second, for higher order lags such as 12 to 13-months, annual narrow money growth and inflation rates show simultaneous granger causal relationship. In terms of monthly variation, however, it is the narrow money growth which causes the inflation rate. On the other hand, both monthly and annual variations in broad money Granger cause the inflation rate and the latter does not cause the former.

Though the causal analysis shown in the Table 9 provides some useful information, it cannot substantiate the strength of the relationship between inflation and monetary aggregates, especially

with respect to the models involving monthly and annual inflation rates. In this regard, we engage in two more statistical analyses as follows. First, we examine the coefficient of determination of inflation and money growth equations arising from the VAR models underlying the Granger causal analysis (Table 10). A key finding in terms of coefficient of determination is that the VAR model involving annual inflation and money growth indicators significantly outweighs the similar model involving monthly inflation and money growth indicators. Second, as shown in Reddy (1998), we undertake non-nested regression analysis to know whether it is the narrow money or the broad money growth indicators which is more informative for explaining the monthly or annual inflation rates. The results of nested regression analysis are presented in Table 11. Two crucial findings emerge. One, the monthly growth of broad money could be preferred to the monthly growth of narrow money for predicting monthly inflation rate. Two, the annual growth rate of narrow money could be preferred to the annual growth rate of broad money for predicting the annual inflation rate. Thus, it can be inferred that annual inflation has better correlation with annual growth of monetary variable, especially, the narrow money aggregate, which

Table 10 The VAR Model of Inflation and Money Growth: Adjusted R square estimates

Models / lags	Equations	
Model 1	Annual Inflation rate	Annual Narrow money Growth rate
2-lags	0.94	0.78
13-lags	0.95	0.84
Model 2	Monthly Inflation rate	Monthly Narrow Money Growth rate
2-lags	0.2	0.15
13-lags	0.35	0.27
Model 3	Annual Inflation rate	Annual Broad money Growth rate
2-lags	0.94	0.81
13-lags	0.96	0.85
Model 4	Monthly Inflation rate	Monthly Broad money growth rate
2-lags	0.19	0.08
13-lags	0.35	0.19

Table 11: Money and Inflation Relationship: Non-Nested Regression Analysis

A. Monthly Inflation and Monthly Growth of Money

Model 1: $INFSM_T = CONSTANT + \sum_{i=1}^{n} \beta_i INFSM_{T-i} + \sum_{i=1}^{n} \phi_i GMSS_{T-i}$

Model 2: $INFSM_T = CONSTANT + \sum_{i=1}^{n} \beta_i INFSM_{T-i} + \sum_{i=1}^{n} \phi_i GMSS_{T-i}$

Test Statistic	M1 against M2	M2 against M1
N-Test	-5.12[0.00]	-3.31[0.00]
NT-Test	-1.88[0.06]	-0.95[0.34]
W-Test	-1.81[0.07]	-0.93[0.35]
J-Test	3.49[0.00]	2.69[0.01]
JA-Test	2.31[0.02]	1.48[0.14]
Encompassing F(12, 146)	1.09[0.37]	F(12, 146) 0.76[0.69]

Model M1:	DW	1.9322	;R-Bar-Squared	.24628	;Log-likelihood	-83.8910
Model M2:	DW	1.9089	;R-Bar-Squared	.26534	;Log-likelihood	-81.5473
Model M1+M2:	DW	1.9096	;R-Bar-Squared	.25164	;Log-likelihood	-76.0108

Akaike's Information Criterion of M1 versus M2 = -2.3437 favours M2
Schwarz's Bayesian Criterion of M1 versus M2= -2.3437 favours M2

B. Annual Inflation and Annual Growth of Money

Model 1: $INFSA_T = CONSTANT + \sum_{i=1}^{n} \beta_i INFSA_{T-i} + \sum_{i=1}^{n} \phi_i GMSA_{T-i}$

Model 2: $INFSA_T = CONSTANT + \sum_{i=1}^{n} \beta_i INFSA_{T-i} + \sum_{i=1}^{n} \phi_i GMSA_{T-i}$

Test Statistic	M1 against M2	M2 against M1
N-Test	-2.70[0.01]	-6.0207[.00]
NT-Test	-0.67[0.50]	-2.2159[.03]
W-Test	-0.67[0.50]	-2.1263[.03]
J-Test	2.86[0.00]	4.3448[.00]
JA-Test	0.49[0.62]	1.5188[.13]
Encompassing F(12, 144)	1.18[0.30]	F(13, 144) 1.7618[.05]

Model M1:	DW	1.8017	;R-Bar-Squared	.95149	;Log-likelihood	-133.0427
Model M2:	DW	1.7547	;R-Bar-Squared	.94914	;Log-likelihood	-137.9635
Model M1+M2:	DW	1.8465	;R-Bar-Squared	.95216	;Log-likelihood	-124.4582

Akaike's Information Criterion of M1 versus M2= 3.9208 favours M1
Schwarz's Bayesian Criterion of M1 versus M2= 2.3161 favours M1
Note: *figures in bracket indicate level of significance for the test statistic.*

reflects upon the transaction balance relation of money with inflation.

III.5 Inflation and Growth Causal Nexus

How do alternative measures of the inflation rate affect economic growth? In this regard, Tables 12(a) and (b) present the results of Granger causality between inflation rate and the growth of industrial production (seasonally adjusted) based on two-variable VAR model. It is evident that for 1-lag model, the annual inflation rate Granger causes the annual and the monthly growth rates of industrial production but not *vice versa* (Table 12a). For 12-month lag model, the annual inflation rate Granger causes the annual industrial production growth but not *vice versa* (Table 12b). However, there exists no Granger

Table 12(a): Granger Causality: Inflation and Growth

lags: 1		
Null Hypothesis	F-Statistic	Probability
GQSM does not Granger Cause GQSA	20.69	0.00
GQSA does not Granger Cause GQSM	0.11	0.74
INFSA does not Granger Cause GQSA	5.17	0.02
GQSA does not Granger Cause INFSA	0.05	0.82
INFSM does not Granger Cause GQSA	1.14	0.28
GQSA does not Granger Cause INFSM	0.98	0.32
INFSA does not Granger Cause GQSM	3.26	0.07
GQSM does not Granger Cause INFSA	0.23	0.62
INFSM does not Granger Cause GQSM	1.35	0.24
GQSM does not Granger Cause INFSM	0.01	0.91

causal relationship between the monthly inflation rate and the monthly growth of industrial production for both 1-lag and 12-lag models. Such empirical findings were also evident for various other lags.

III.6 Inflation and Financial Markets

Table 13 presents Granger causal relationship between monthly and annual inflation rates and the variation in yield on benchmark 10-year Government bonds (DG10) and 91-day Treasury bills (DG91). Using three lags the variables in the estimation, it was found that Granger causal

Table 12(b): Granger Causality : Inflation and Growth

lags: 12		
Null Hypothesis	F-Statistic	Probability
GQSM does not Granger Cause GQSA	13.60	0.00
GQSA does not Granger Cause GQSM	1.56	0.10
INFSA does not Granger Cause GQSA	2.03	0.02
GQSA does not Granger Cause INFSA	0.86	0.58
INFSM does not Granger Cause GQSA	1.63	0.08
GQSA does not Granger Cause INFSM	0.67	0.77
INFSA does not Granger Cause GQSM	1.16	0.31
GQSM does not Granger Cause INFSA	0.97	0.47
INFSM does not Granger Cause GQSM	1.00	0.44
GQSM does not Granger Cause INFSM	0.97	0.47

Table 13: Granger Causality between Inflation and Interest Rates (Sample: 1996M04 2009M03)

Null Hypothesis:	F-Statistic	Probability
D(G10) does not Granger Cause INFA	0.52	0.67
INFA does not Granger Cause D(G10)	2.96	0.03
D(G91) does not Granger Cause INFA	1.25	0.29
INFA does not Granger Cause D(G91)	0.88	0.45
D(G10) does not Granger Cause INFM	1.29	0.28
INFM does not Granger Cause D(G10)	2.30	0.08
D(G91) does not Granger Cause INFM	1.17	0.32
INFM does not Granger Cause D(G91)	0.94	0.42

relationship could run only from the annual inflation rate to the variation in 10-year yield. The short-term 91-day yield and inflation rate did not have significant causal relationship. The monthly inflation rate and yield rates do not share significant causal relationship.

Table 14: Correlation of Inflation rate with Variation in Equity Prices

	Annual variation		Monthly variation	
Lags/leads (months)	Lag-Correlation	Lead Correlation	Lag-Correlation	Lead Correlation
0	-0.04	-0.04	-0.19	-0.19
1	-0.09	0.05	-0.21	-0.07
2	-0.10	0.13	-0.06	0.03
3	-0.10	0.20	0.06	0.14
4	-0.11	0.26	-0.01	0.04
5	-0.11	0.31	-0.02	0.03
6	-0.11	0.35	-0.06	0.07
7	-0.12	0.38	-0.14	0.18
8	-0.11	0.40	0.00	0.22
9	-0.11	0.40	-0.05	0.12
10	-0.09	0.39	0.00	0.12
11	-0.08	0.37	-0.02	0.01
12	-0.08	0.33	-0.01	-0.02
13	-0.09	0.27	0.06	0.00
14	-0.11	0.22	0.06	0.06
15	-0.14	0.16	0.04	0.03
16	-0.15	0.11	0.02	0.07
17	-0.18	0.06	-0.06	-0.01
18	-0.19	0.00	-0.10	0.01
19	-0.20	-0.04	-0.06	0.07
20	-0.21	-0.08	0.04	0.05
21	-0.21	-0.12	0.02	-0.03
22	-0.22	-0.13	-0.07	-0.04
23	-0.22	-0.13	-0.09	-0.03
24	-0.21	-0.14	-0.06	-0.13

Table 14 presents the correlation of annual and monthly inflation rates with annual and monthly variation in equity prices respectively. The lags in annual inflation rate do not have significant correlation with the annual variation in equity prices. On the contrary, the correlation of lags in annual variation in equity prices with the annual inflation rate becomes significant after 3 months and this continues up to about a year. Thus, the annual inflation rate and the annual variation in equity prices share Granger causal relationship. However, the monthly inflation rate and the monthly variation in asset prices do not have significant correlation and Granger causal relationship.

Section IV

Conclusion

The inflation rate indicator is not directly observed; it is derived as the percentage increase in the observed aggregate price indices between two time periods. Generally, the inflation rate defined as the rate of increase in the aggregate price index between two discrete time period can be derived statistically for various frequencies such as weekly, monthly, quarterly and annual basis. However, in practice, central banks measure the inflation rate as the year-on-year percentage increase in the price index. This study discussed various applied issues associated with two alternative measures of the inflation rate indicator such as the monthly (month-over-month) and the annual (year-on-year) changes in the wholesale price index in India. Empirical results provide a couple of insights pertaining to these inflation rates and their association with monetary aggregates, output, interest rate, and equity prices. First, the sample means of these two inflation rates could not be statistically different from each other. However, the volatility of the monthly inflation rate could be significantly different from the volatility of the annual inflation rate. Second, the annual inflation rate could be more persistent than the monthly inflation rate, attributable to the long-term component. From the perspective of policy objectives such as price stability, a smoothed and less volatile annual inflation rate would be more useful than the highly volatile monthly inflation rate. Third, the ARMA model, which is often used for

gauging inflation expectation and persistence, could fit the annual inflation rate better than the monthly inflation rate. A similar finding also emerged for the GARCH model, which is used for analysing the interaction between inflation expectation and volatility components. Fourth, the correlation of the annual inflation rate with the annual growth rate of monetary aggregate was stronger than the correlation of monthly inflation rate with monthly growth rates of monetary aggregates. The order of liquidity effect, as reflected in the narrow and broad money aggregates, had differential causal effect on the inflation rate. Narrow money growth had stronger correlation with inflation, in line with the standard transaction demand for money hypothesis. Fifth, the annual inflation rate showed statistically significant Granger causal relation with the annual growth rate of industrial production. However, such causal relationship did not exist between the monthly inflation and output growth rates. Overall, these findings support that the standard year-on-year inflation rate could be more useful than the monthly inflation rate for policy analysis.

Notes

1 Dr. Bimal Jalan, the former Reserve Bank Governor, pointed out that the core inflation does not reflect the Indian scenario, as it accounts for just 30 per cent of the actual inflation rate, excluding rising prices of food and petroleum products: http://inhome.rediff.com/money/2003/oct/03jaswant.htm?zcc=rl

2 See the press interview of Dr. Y.V. Reddy, Governor, Reserve Bank of India in the Hindus Business Line, April 7, 2007: http://www.thehindubusinessline.com/2007/04/27/stories/2007042700480800.htm

3 See "IMF paper moots new method, puts inflation at 4.7 pc" Hindustan times May 21 2008 also in AsiaViews, Edition: 17/V/Mayl/2008, and http://www.indianexpress.com/story/22926.html.

4 Michael Burda and Charles Wyplosz(1997), Macroeconomics: A European text, 2nd ed., p. 579 (Glossary). Olivier Blanchard (2000), Macroeconomics, 2nd ed., Glossary. Robert Barro (1993), Macroeconomics, 4th ed., Glossary. Andrew Abel and Ben Bernanke (1995), Macroeconomics, 2nd ed., Glossary. Ludwig von Mises, The Theory of Money and Credit, Jesus Huerta de Soto, Money, Bank Credit, and Economic Cycles.

5 www.economist.com

6 http://www.bankofengland.co.uk/education/targettwopointzero/inflation/whatsInflation.htm

7 http://www.cbc.ca/news/background/economy/inflation.html

8 See Chapter IV in the "Report of the Working Group on Money Supply Analytics and Methodology of Compilation" Chairman Dr Y V Reddy Reserve Bank of India 1998

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Evolution of the Basel Framework on Bank Capital Regulation

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This paper covers the major developments in the efforts towards harmonisation of bank capital standards by the Basel Committee on Banking Supervision (BCBS) *viz.*, the Basel Accord of 1988, the 1996 amendment to the Basel Accord, the Basel II framework and the subsequent refinements. Though capital regulation in banking had existed in some form or the other even before the signing of Basel Accord in 1988, the Accord marked a watershed in the efforts towards harmonisation of bank capital regulation across nations. More than 100 countries adopted the Basel I regulatory requirement of capital at eight per cent of risk-weighted assets. The high pace of financial innovations, however, brought into light the deficiencies of Basel I framework and the need for a more flexible and more risk-sensitive capital standards. After years of intense consultations and modifications, the revised capital framework, popularly known as Basel II was released by the BCBS in June 2004. While the implementation of Basel II is in progress in several countries across the globe, soundness and stability of the international banking has been severely challenged by the outbreak of the sub-prime crisis in the US mortgage market in 2007. The crisis has spread across sectors and across nations without showing any signs of abatement, and by now has taken the shape of an international financial market crisis. This has brought into sharp focus the need for faster implementation of Basel II. At the same time, further refinements in the Basel II framework are being mooted with a view to ensuring that the banking sector serves its traditional role as a shock absorber to the financial system, rather than an amplifier of risk between the financial sector and the real economy. The issues being re-examined include *inter alia* strengthening the risk capture on trading book and off-balance sheet exposures, dampening procyclicality, strengthening framework to assess liquidity at banks, and globally coordinated supervisory follow-up exercises. The Basel framework on capital regulation thus continues to evolve in response to the changing circumstances, and has come to be established at the core of the assessment of soundness and stability of the banking system.

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Introduction

The forces of globalisation and deregulation brought about sweeping changes in the banking sector across countries. While new

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vistas opened up for augmenting revenues of banks, increased competition in the wake of new products, new processes and technological progress exposed banking to higher risks. This gave renewed emphasis to efforts towards harmonisation of international capital standards which gained momentum under the aegis of Bank for International Settlement (BIS). The setting up of the Basel Committee on Banking Supervision (BCBS)[1] in 1975, following the failure of Bankhus I. D. Herstatt in Cologne, Germany, was a significant contribution of the BIS towards international harmonisation of supervisory standards. The BCBS contributed to supervisory standards through issuance of 'best practices' papers. Although these standards are not legally binding, they have made substantial impact on banking supervision, in general, and bank capital regulation, in particular. Robust risk management and strong capital position have come to be recognised to be crucial to ensuring safety and soundness of individual banking organisations as also for fostering stability in the financial system.

Though capital regulation in banking existed even before the Basel Accord of 1988, there were vast variations in the method and timing of its adoption in different countries. In the pre-Basel phase, the use of capital ratios to establish minimum regulatory requirements was being tested for more than a century. In the US, between 1864 and 1950s, the supervisors : (i) tried to make use of a variety of capital adequacy measures such as static minimum capital requirements based on the population of each bank's service area, ratios of capital-to-total deposits and capital-to-total assets; (ii) adjusted assets for risk; and (iii) created capital-to-risk-assets ratios, but none was universally accepted at that time. Even the banking sector was in favour of a more subjective system where the regulators could decide which capital requirements were suited for a particular bank as a function of its risk profile (Laurent, 2006). The emergence of more bank failures and diminishing bank capital triggered a regulatory response in 1981 when, for the first time, the federal banking agencies in the US introduced explicit numerical regulatory capital requirements. The adopted standards employed a leverage ratio of primary capital (which consisted mainly of equity and loan loss reserves) to average total assets. However, each regulator had a different view as to what exactly constituted bank capital.

Over the next few years, regulators worked to converge upon a uniform measure. The inadequate capitalisation of Japanese banks and differing banking structures (universal banks of Germany *vis-à-vis* narrow banks of US) and varying risk profile of individual banks made agreement on capital standards difficult. The Congress in the US passed legislations in 1983, directing the federal banking agencies to issue regulations addressing capital adequacy. The legislation provided the impetus for a common definition of regulatory capital and final uniform capital requirements in 1985. By 1986, regulators in the US were concerned about the failure of primary capital ratio to differentiate among risks and not providing an accurate measure of the risk exposures associated with innovative and expanding banking activities, most notably off-balance-sheet activities at larger institutions. Regulators in the US began studying the risk-based capital frameworks of other countries – France, the UK and West Germany had implemented risk-based capital standards in 1979, 1980 and 1985, respectively. The agencies also revisited the earlier studies of risk-based capital ratios. Leading the initiative in 1987, the US joined the UK in announcing a bilateral agreement on capital adequacy, soon to be joined by Japan (buoyed by a booming stock market in raising capital). Subsequently in December 1987 'international convergence of capital measures and capital standards' was achieved. In July 1988, the Basel I Capital Accord was created.

As regards banking companies, the primary functions of capital are to support banks' operations by absorbing losses and changes in asset values, and thereby maintaining solvency. A comfortable bank capital level boosts depositors' confidence, encourages shareholders' interest in governance of bank and provides protection to creditors in the event of liquidation. Bank capital acts as an insurance against uncertainty.

The Basel Core Principles[2], as a framework of minimum standards for sound supervisory practices considered universally applicable, emphasise capital adequacy and risk management process as one of the significant prudential regulation and requirements. According to the BCBS core principles, supervisors must set prudent

and appropriate minimum capital adequacy requirements for banks that reflect the risks that the bank undertakes, and must define the components of capital, bearing in mind its ability to absorb losses. At least for internationally active banks, these requirements must not be less than those established in the applicable Basel requirement. Supervisors must be satisfied that banks and banking groups have in place a comprehensive risk management process (including Board and senior management oversight) to identify, evaluate, monitor and control or mitigate all material risks and to assess their overall capital adequacy in relation to their risk profile. These processes should be commensurate with the size and complexity of the institution.

This paper deals in the supervisory and regulatory framework governing the capital adequacy of international banks as evolved by the BCBS over the years. The paper is organized into four sections. Section 1 elaborates the Basel Accord of 1988, and the 1996 amendment relating to market risk, which was the most important modification in the Basel norms on capital regulation before the introduction of Basel II framework. Section I also deals with the criticisms of the Basel Capital Accord, 1988. Section II presents the Basel II framework, followed by a discussion of a few conceptual and implementation issues relating to the new capital adequacy framework. Section III outlines the initiatives taken by the Basel Committee in response to the recent financial turmoil. Section IV concludes.

Section I

The Basel I Framework

The Basel Capital Accord, 1988

As discussed earlier, the BCBS has been making efforts over the years to secure international convergence of supervisory regulations governing the capital adequacy of international banks. The Committee adopted a consultative process wherein the proposals are circulated not only to the central bank Governors of G-10 countries, but also to the supervisory authorities worldwide. The major milestones in the

Basel norms of capital measurement and capital standards are: Capital Accord of 1988, market risk amendment of January 1996, New Capital Adequacy framework of June 2004. The two fundamental objectives of the Committee's work on regulatory convergence are: (i) the framework should serve to strengthen the soundness and stability of the international banking system; and (ii) the framework should be fair and have a high degree of consistency in its application to banks in different countries with a view to diminishing an existing source of competitive inequality among international banks.

The Basel Accord was endorsed by 12 countries (all G-10 countries plus Luxembourg and Switzerland) in July 1988 under the chairmanship of W P Cooke (Bardos, 1988). As many banks were undercapitalised at that time, a target of 7.25 per cent was set to be met by the end of 1990, and the 8 per cent requirement was to be achieved by the end of 1992. Since then, the Basel Accord has been subjected to several amendments and has itself been evolving under a consultative framework. The Accord has been endorsed by many countries other than G-10 countries, and applied to many banks other than those conducting significant international business. The Accord was phased in by January 1993, and currently more than hundred countries have adopted the Basel Norms.

The main features of Basel I are documented in 'International Convergence of Capital Measurement and Capital Standards'[3] over three sections (BCBS, 1998). While the first two describe the framework in terms of the constituents of capital and the risk weighting system, the third section deals with the target ratio. The framework provides a framework for fair and reasonable degree of consistency in the application of capital standards in different countries, on a shared definition of capital. The central focus of this framework is credit risk and, as a further aspect of credit risk, country transfer risk.

Capital as per Basel Accord, better known as regulatory capital, is sum of Tier I and Tier II capital which a bank is required to maintain in relation to its risk-weighted assets. Under both Basel I and Basel II,

the regulatory definition of capital is comprised of three levels (or 'tiers') of capital. An item qualifies for a given tier if it satisfies the specific criteria. Tier 1 Capital (or 'core capital') comprises only those elements which have the highest capacity for absorbing losses on an ongoing basis. Tier 2 Capital (or 'supplementary capital') is made up of a broad mix of near equity components and hybrid capital/debt instruments, the total of which is limited to 100 per cent of Tier 1 Capital. It is subdivided into two categories: (i) Upper Tier 2 comprises items closer to common equity, like perpetual subordinated debt; (ii) Lower Tier 2 comprises items closer to debt than of equity. It also includes various types of reserves whose values and/or availability are more uncertain than disclosed reserves. Tier 3 Capital (or 'additional supplementary capital') was added in 1996 and can only be used to meet capital requirements for market risk.

The Committee recommended a weighted risk ratio in which capital is related to different categories of asset or off-balance-sheet exposure, weighted according to broad categories of relative riskiness, as the preferred method for assessing the capital adequacy of banks - other methods of capital measurement are considered to be supplementary to the risk-weighted approach. The risk weighted approach has been preferred over a simple gearing ratio approach because: (i) it provides a fairer basis for making international comparisons between banking systems whose structures may differ; (ii) it allows off-balance-sheet exposures to be incorporated more easily into the measure; (iii) it does not deter banks from holding liquid or other assets which carry low risk. There were inevitably some broad-brush judgements in deciding which weight should apply to different types of asset and the framework of weights has been kept as simple as possible with only five weights being used for on balance-sheet items *i.e.*, 0, 10, 20, 50 and 100 per cent (Table 1). Government bonds of the countries that were members of the Organisation for Economic Cooperation and Development (OECD) (which includes all members of the Basel Committee) were assigned a zero risk weight, all short-term interbank loans and all long-term

Table 1: Risk Weights by Category of On-balance Sheet Assets

Risk Weight	Categories of Asset
0%	(a) Cash (b) Claims on central governments and central banks denominated in national currency and funded in that currency (c) Other claims on OECD, central governments, and central banks (d) Claims collateralised by cash of OECD central-government securities or guaranteed by OECD central governments
0, 10, 20 or 50% (at national discretion)	Claims on domestic public-sector entities, excluding central government, and loans guaranteed by or collateralised by securities issued by such entities
20%	(a) Claims on multilateral development banks (IBRD, IADB, AsDB, AfDB, EIB, EBRD) and claims guaranteed by, or collateralised by securities issued by such banks (b) Claims on banks incorporated in the OECD and claims guaranteed by OECD incorporated banks (c) Claims on securities firms incorporated in the OECD subject to comparable supervisory and regulatory arrangements, including in particular risk-based capital requirements,6 and claims guaranteed by these securities firms (d) Claims on banks incorporated in countries outside the OECD with a residual maturity of up to one year and claims with a residual maturity of up to one year guaranteed by banks incorporated in countries outside the OECD (e) Claims on non-domestic OECD public-sector entities, excluding central government, and claims guaranteed by or collateralised by securities issued by such entities (f) Cash items in process of collection
50%	Loans fully secured by mortgage on residential property that is or will be occupied by the borrower or that is rented
100%	(a) Claims on the private sector (b) Claims on banks incorporated outside the OECD with a residual maturity of over one year (c) Claims on central governments outside the OECD (unless denominated in national currency - and funded in that currency) (d) Claims on commercial companies owned by the public sector (e) Premises, plant and equipment and other fixed assets (f) Real estate and other investments (including non-consolidated investment participations in other companies) (g) Capital instruments issued by other banks (unless deducted from capital) All other assets

interbank loans to banks headquartered in OECD countries a 20 per cent risk weight, home mortgages a 50 per cent risk weight, and most other loans a 100 per cent risk weight.

Off-balance sheet contingent contracts, such as letters of credit, loan commitments and derivative instruments, which are traded over the counter, needed to be first converted to a credit equivalent and then assigned appropriate risk weights (Table 2).

The initial standards required internationally active banks to meet two minimum capital ratios, both computed as a percentage of the risk-weighted (both on- and off-balance sheet) assets. The minimum Tier 1 ratio was 4 per cent of risk-weighted assets, while total capital

Table 2: Credit Conversion Factors for Off-balance Sheet Items

Instruments	Credit Conversion Factors (Per cent)
1. Direct credit substitutes, for example, general guarantees of indebtedness (including standby letters of credit serving as financial guarantees for loans and securities) and acceptances (including endorsements with the character of acceptances)	100
2. Certain transaction-related contingent items (for example, performance bonds, bid bonds, warranties and standby letters of credit related to particular transactions)	50
3. Short-term self-liquidating trade-related contingencies (such as documentary credits collateralised by the underlying shipments)	20
4. Sale and repurchase agreements and asset sales with recourse,1 where the credit risk remains with the bank	100
5. Forward asset purchases, forward deposits and partly-paid shares and securities, which represent commitments with certain drawdown	100
6. Note issuance facilities and revolving underwriting facilities	50
7. Other commitments (for example, formal standby facilities and credit lines) with an original maturity of over one year	50
8. Similar commitments with an original maturity of up to one year, or which can be unconditionally cancelled at any time	0

(tiers 1 and 2) had to exceed 8 per cent of risk-weighted assets. The three major principles of the Basel Accord are as follows:

(1) A bank must hold equity capital to at least a fixed per cent (8 per cent) of its risk-weighted credit exposures as well as capital to cover market risks in the bank's trading account.

(2) When capital falls below this minimum requirement, shareholders may be permitted to retain control, provided that they recapitalize the bank to meet the minimum capital ratio.

(3) If the shareholders fail to do so, the bank's regulatory agency is empowered to sell or liquidate the bank.

Capital adequacy is just one of the several factors for assessing the strength of banks, and therefore capital ratios, judged in isolation, may provide a misleading guide to relative strength. Much also depends on the quality of a bank's assets and, importantly, the level of provisions a bank may be holding outside its capital against assets of doubtful value. Recognising the close relationship between capital and provisions, monitoring the provisioning policies by banks in member countries and convergence of policies in this field as well has come to engage the attention of the Basel Committee. The fiscal treatment and accounting presentation for tax purposes of certain classes of provisions for losses and of capital reserves derived from retained earnings, which differ for different countries, may to some extent distort the comparability of the real or apparent capital positions of international banks. Convergence in tax regimes, though desirable, lies outside the purview of the Committee, though tax considerations also need to be reviewed to the extent that they affect the comparability of the capital adequacy. Another issue of relevance is the ownership structures and the position of banks within financial conglomerate groups. The capital requirement should be applied to banks on a consolidated basis, including subsidiaries undertaking banking and financial business. The ownership structures should not be such as to weaken the capital position of the bank or expose it to risks stemming from other parts of the group.

Most regulatory authorities have adopted allocation of capital to risk assets ratio system as the basis of assessment of capital adequacy which takes into account the element of risk associated with various types of assets reflected in the balance sheet as well as in respect of off-balance sheet assets.

With due regard to particular features of the existing supervisory and accounting systems in individual member countries, the capital adequacy framework allowed for a degree of national discretion in the way in which it is applied. It also provided for a transitional period so that the existing circumstances in different countries can be reflected in flexible arrangements that allow time for adjustment.

The 1996 Amendment to the Basel Accord

The Basel Capital Accord of July 1988 was amended in January 1996 with the objective of providing an explicit capital cushion for the price risks to which banks are exposed, particularly those arising from their trading activities (BCBS, 1998). The amendment covers market risks arising from banks' open positions in foreign exchange, traded debt securities, traded equities, commodities and options. A companion paper describing the way in which G-10 supervisory authorities plan to use 'backtesting' (*i.e.*, *ex-post* comparisons between model results and actual performance) in conjunction with banks' internal risk measurement systems as a basis for applying capital charges was also released.

The novelty of this amendment lied in the fact that it allowed banks to use, as an alternative to the standardized measurement framework originally put forward in April 1993, their internal models to determine the required capital charge for market risk. The standard approach defines the risk charges associated with each position and specifies how these charges are to be aggregated into an overall market risk capital charge. The minimum capital requirement is expressed in terms of two separately calculated charges, one applying to the 'specific risk' of each security, whether it is a short or a long position, and the other to the interest rate risk in the portfolio (termed 'general market risk') where long and short positions in different securities or instruments can be offset.

The internal models approach, in contrast, allows a bank to use its proprietary in-house models to estimate the value-at-risk (VaR) in its trading account, that is, the maximum loss that the portfolio is likely to experience over a given holding period with a certain probability. The market risk capital requirement is then set based on the VaR estimate as the higher of the following two: (i) the previous day's value-at-risk; and (ii) three times the average of the daily value-at-risk of the preceding sixty business days. This amendment also defined a Tier 3 capital to cover market risks, and allowed banks to count subordinated debt (with an original maturity of at least two years) in this tier.

Criticisms of Basel I

The major achievement of the Basel Capital Accord 1988 has been introduction of discipline through imposition of risk-based capital standards both as measure of the strength of banks and as a trigger device for supervisors' intervention under the scheme of prompt corrective action (PCA). The fundamental objective of the 1988 Accord has been to develop a framework that would further strengthen the soundness and stability of the international banking system while maintaining sufficient consistency that capital adequacy regulation will not be a significant source of competitive inequality among internationally active banks. The design of the Accord, however, has met with severe criticisms which are discussed in detail in this Section.

First, the standards have not been able to meet one of the central objectives, *viz*., to make the competitive playing field more even for international banks. For example, in a comparison of the competitiveness of banks in the United States and Japan after the implementation of Basel Accord, it was found that the Accord had no impact on competitiveness (Scott and Iwahara, 1994). The authors also showed that other factors such as taxes, accounting requirements, disclosure laws, implicit and explicit deposit guarantees, social overhead expenditures, employment restrictions, and insolvency laws, also affect the competitiveness of an institution. Consequently, imposing the same capital standard on all institutions that differ

with regard to those other factors is unlikely to enhance competitive equity.

The other fundamental objective of the Accord in terms of increasing the soundness and stability of the banking system need not necessarily be met. Capital adequacy regulation in some contexts could even accentuate systemic risk. Therefore, under international financial integration, a simple coordination on some parts of banking regulation (uniform capital requirements), but not others (the forbearance in supervisor's closure policies), could give rise to international negative externalities that destabilize the global system. Furthermore, a design of capital adequacy requirements, based only on individual bank risk, as the actual proposed in the Basel Accord, is showed to be suboptimal in both papers. All the above arguments suggest the need for an analysis of how banks set their capital to assets ratio.

The bank capital adequacy regulation as in Basel I is also criticised for imposing the same rules on all banks even within a country. The simple 'one-size-fits-all' standard under Basel I encouraged transactions using securitisation and off-balance sheet exposures, whose principal aim was to arbitrage bank capital. The Basel rules encouraged some banks to move to high quality assets off their balance sheet, thereby reducing the average quality of bank loan portfolios. Furthermore, banks took large credit risks in the least creditworthy borrowers who had the highest expected returns in a risk-weighted class (Kupiec, 2004).

Perhaps the most fundamental problem with the Basel I standards stems from the fact that they attempt to define and measure bank portfolio risk categorically by placing different types of bank exposures into separate 'buckets'. Banks are then required to maintain minimum capital proportional to a weighted sum of the amounts of assets in the various risk buckets. That approach incorrectly assumes, however, that risks are identical within each bucket and that the overall risk of a bank's portfolio is equal to the sum of the risks across the various buckets. But, most of the times, the risk-weight classes did not match realised losses. In an examination of loan charge-offs and

delinquency rates for banks, it was found that the 1988 Capital Accord risk weights did not accurately track the credit experience in the US. Collateralised loans had the least risk. Commercial loans appear to be under-burdened by the Basel I weights and mortgages were overburdened. All activities or loans within a particular category do not have the same market-based credit risk. For example, not all mortgages are exactly or even approximately half as risky as all commercial loans (reflecting the assigned risk weights).

Securitisation of banks' credit portfolios has become a widespread phenomenon in industrialized countries. At first, banks used to sell their mortgage loans, for such loans represented accurately evaluated risks. But since the advent of e-finance, it is now possible to expand this activity to other types of loans, including those made to small businesses. This type of activity also allows banks to have a much more liquid credit-risk portfolio and, in theory, to adjust their capital ratio to an optimal economic level rather than sticking to the ratio decreed by the Basel Committee.

Moreover, diversification of a bank's credit-risk portfolio is not taken into account in the computation of capital ratios. The aggregate risk of a bank is not equal to the sum of its individual risks - diversification through the pooling of risks can significantly reduce the overall portfolio risk of a bank. Indeed, a well-established principle of finance is that the combination in a single portfolio of assets with different risk characteristics can produce less overall risk than merely adding up the risks of the individual assets. The Accord does not take into account the benefits of portfolio diversification.

The standards have also been criticized for failing to assign 'correct' risk weights and for failing to promote bank safety effectively. Although the risk weights attempt to reflect credit risk, they are not based on market assessments but instead favor claims on banks headquartered in OECD countries and OECD Governments, and on residential mortgages. The 1988 standards also assign a zero risk weight to all sovereign debt issued by countries belonging to the OECD. Although sovereign debt was not at the center of the Asian

financial crises, it played a central role in the earlier Mexican financial and currency crisis of 1994-1995. Illustratively, Mexico and South Korea, both of which experienced substantial bank insolvencies, are now members of the OECD; and hence, the bonds issued by their Governments are subject to the zero risk weight.

Cosmetic changes in bank capital are possible because the measures of both capital and risk are imperfect proxies for the economically relevant variables. Regulators cannot construct perfect measures as long as bank managers have private information about the value or risk of their portfolios. However, even granting the impossibility of perfect measures, the crudeness of current measures offers substantial measures for cosmetic changes in capital ratios. Capital-to-total asset measures (leverage standards) are easily defeated by reducing low-risk, high-liquidity assets and substituting a smaller quantity of higher risk, lower liquidity assets. The existing risk-based standards are slightly more sophisticated, but numerous flaws remain. The standards (i) require that most commercial and consumer loans carry the same risk weighting and do not allow for differential asset quality within asset classes, (ii) do not allow for risks other than credit risks and (iii) do not account for diversification across different types of risk or even across credit risks. Banks, can therefore, exploit accounting conventions by accelerating the recognition of gains on assets with market value greater than book value, while slowing the recognition of losses on assets with market value less than book value.

The problems are compounded by the fact that the Basel standards are computed on the basis of book-value accounting measures of capital, not market values. Accounting practices vary significantly across the G-10 countries and often produce results that differ markedly from market assessments.

The Subgroup of the Shadow Financial Regulatory Committees of Europe, Japan, Latin America and the United States observed that problems inherent in assigning risk weights in the Basel standards are compounded by the inappropriate division of bank capital into different ‘tiers’. In the process, the Basel Committee implicitly favors

equity over other forms of capital, specifically, subordinated debt. The preference for equity not only is unwarranted but also may be counterproductive since subordinated debt, which is included in Tier 2 capital, but not in Tier 1, often can be superior to equity from a regulatory standpoint.

The financial crises of the 1990s involving international banks have highlighted several additional weaknesses in the Basel standards that permitted and in some cases even encouraged, excessive risk taking and misallocations of bank credit. Notably, Asian banks' short-term borrowing of foreign currencies was a major source of vulnerability in the countries most seriously affected by the Asian financial crisis. The current Basel standards contributed to that problem by assigning a relatively favorable 20 per cent risk weight to short-term interbank lending - only one-fifth as large as the weight assigned to longer-term lending or to lending to most private non-bank borrowers. Putting aside the important issue of whether the standards should have assigned different risk weights for short-term lending to banks in the developed and in the developing world–a distinction not captured by the current system of weighting asset risks– it is clear that the much lower risk weight given to interbank lending than to other types of bank loans encouraged some large internationally active banks to lend too much for short durations to banks in Southeast Asia. Those banks reloaned the funds in domestic currency at substantially higher rates and assumed large foreign exchange rate risk. One would expect those distortions to be most pernicious for banks that are capital-constrained. Therefore, it is not surprising that Japanese banks, which have been weakly capitalized throughout the 1990s, had accumulated the heaviest concentrations of claims on faltering Asian banks.

As noted in the document itself, the risk weights do not attempt to take account of risks other than credit risk, *viz.*, market risks, liquidity risk and operational risks that may be important sources of insolvency exposure for banks. The Basel Committee itself has recognised the validity of many of the above-mentioned criticisms.

These shortcomings seem to have distorted the behaviour of banks and this makes it much more complicated to monitor them. In fact, it is not even clear that the higher capital ratios observed since the introduction of this new form of capital regulation necessarily lower risks.

Section II

The Revised Framework: Basel II

The Basel II framework entails a more comprehensive measure and minimum standard for capital adequacy that national supervisory authorities are working to implement through domestic rule-making and adoption procedures. It seeks to improve on the existing rules by aligning regulatory capital requirements more closely to the underlying risks that banks face, *i.e.*, trend towards convergence of the regulatory and economic capital, which is especially evident in the advanced approaches. In addition, the Basel II framework is intended to promote a more forward-looking approach to capital supervision, one that encourages banks to identify the risks they may face, today and in the future, and to develop or improve their ability to manage those risks. As a result, it is intended to be more flexible and better able to evolve with advances in markets and risk management practices.

The fundamental objective of the Committee's work to revise the 1988 Accord has been to develop a more comprehensive approach towards addressing risks, and, thereby, improve the way regulatory capital requirements reflect underlying risks, *i.e.*, better risk sensitivity. The review of the Accord was designed to better address the financial innovations that have occurred in recent years, for example, asset securitisation structures. The review was also aimed at recognising the improvements in risk measurement and control that have occurred.

In June 1999, the BCBS released for comments its proposal to introduce a new capital adequacy framework for International Convergence of Capital Measurement and Capital Standards, more popularly known as the Basel II. The BCBS held three quantitative

impact studies[4] apart from several rounds of consultations and discussions with the member countries, and the final version of the New Basel Norms was released by the BIS on June 26, 2004, which would replace the 1988 Capital Accord by year-end 2007. In March 2005, the Basel Committee on Banking Supervision re-discussed the schedules for national rule-making processes within member countries and decided to review the calibration of the Basel II framework in spring 2006. In November 2005, the Committee issued an updated version of the revised framework incorporating the additional guidance set forth in the Committee's paper, 'The Application of Basel II to Trading Activities and the Treatment of Double Default Effects' (July 2005). In July 2006, the Committee issued a comprehensive version of the Basel II framework, which is a compilation of the (i) June 2004 Basel II framework, (ii) the elements of the 1988 Accord that were not revised during the Basel II process, (iii) the 1996 Amendment to the Capital Accord to Incorporate Market Risks, and (iv) the 2005 paper on the Application of Basel II to Trading Activities and the Treatment of Double Default Effects. No new elements have been introduced in this compilation. The key elements of the 1988 capital adequacy framework that were retained in the revised framework include the general requirement for banks to hold total capital equivalent to at least 8 per cent of their risk-weighted assets and the definition of eligible capital. The Committee also proposed to develop capital charges for risks not taken into account by the 1988 Accord, such as interest rate risk in the banking book and operational risk. The greater risk sensitivity under Basel II would be achieved by linking each bank's capital requirements to empirically based measures of credit and operational risk as determined in part by risk parameters estimated by that organisation, such as a loan's probability of default and its expected loss given default.

Basel II consists of three mutually reinforcing pillars: minimum capital requirements, supervisory review process and market discipline. Within the three pillar approach, minimum capital requirement seeks to develop and expand on the standardised rules

set forth in the 1988 Accord, supervisory review of a bank's capital adequacy and internal assessment process, and effective use of market discipline as a lever to strengthen disclosure and encourage safe and sound banking practices, has been designed to strengthen the international financial architecture.

The First Pillar – Minimum Capital Requirements

In the revised capital framework, the importance of minimum regulatory capital requirements continues to be recognized as the first pillar of the framework[5]. The measures for credit risk are more complex, market risk is the same, while operational risk is new.

Credit Risk

With regard to minimum capital requirements for credit risk, a modified version of the existing Accord has come to be known as the 'standardised' approach. The alternative methodology, which is subject to the explicit approval of the bank's supervisor, would allow banks to use their internal rating systems for credit risk. For some sophisticated banks, use of internal credit ratings and, at a later stage, portfolio models could contribute to a more accurate assessment of a bank's capital requirement in relation to its particular risk profile. The capital treatment of a number of important credit risk mitigation techniques, risk reducing effects of guarantees, credit derivatives, and securitisation, is also provided under Pillar 1, thus improving regulatory capital incentive for banks to hedge portfolio credit risks.

The Standardized Approach

Under the standardised approach, one of the main innovations relative to the 1988 Accord is the use of external ratings agencies to set the risk weights for corporate, bank and sovereign claims. More specifically, the new proposals include tables defining 'buckets' of ratings for corporate and for sovereign credits to translate a particular rating into a risk weight. The approach is most clear for corporates. The rules for claims on banks are slightly more complex than those of corporates. One alternative allows banks to be rated one notch worse (*i.e.*, one risk weight category higher) than the sovereign but with a cap at a risk.

For sovereigns, there are slightly different buckets in the basic approach but there are also some special rules that apply. For example, at national discretion, there is a special rule for claims on the sovereign of the country where the bank is incorporated where the claim is denominated in the currency of the sovereign and also funded in that currency (*i.e.*, loans to sovereigns funded and lent in the domestic currency). At first sight this allows banks in emerging countries to lend to their Governments (or hold bonds in an investment account) with a zero or low capital charge. However, in many emerging countries such loans and bonds are often expressed in dollars or other non -local currencies, and these would not then attract this special treatment. In this case, credit extended to a Government of an emerging country would attract the capital charge given the rating of the sovereign. It is not entirely clear what the treatment would be in Ecuador, El Salvador or Panama (3 dollarized countries) or for that matter for the countries of EMU. If the special treatment exists because the 'credit risk' of a local currency claim will, in general, be less than that of a foreign currency claim when there is a devaluation or sharp depreciation of the local currency then this suggests the special treatment should not be extended to dollarized countries or members of EMU and this takes as a given that any currency risk mismatch is treated in an appropriate manner separately. The view that local currency claims are different because of the existence of a lender of last resort appears to confuse 'credit risk' with liquidity considerations and suggests that banks' capital requirements should explicitly reflect the fact that Governments would deflate away debts that goes against any credible commitment to, say, an inflation target.

Internal Rating Approach

Under the internal rating approach banks may employ their own opinions regarding borrowers in setting capital requirements. More specifically, there are a set of basic parameters that banks may estimate and then feed into a formula to determine actual risk weights. Two crucial parameters required are the probability of default (PD) and the loss given default (LGD). Two alternative approaches are proposed (1) a foundation and (2) an advanced approach. Under the foundation approach banks determine the probability of default and all other

parameters are essentially set by supervisory rules. Under the advanced approach, banks may also determine the loss given default (LGD). Other parameters also important for the calculation of the actual risk weight, including in some cases the maturity of the transaction and the exposure at default (EAD) are determined by supervisory rules under both alternatives.

Besides, proposals to develop a capital charge for interest rate risk in the banking book for banks, where interest rate risk is significantly above average, have also been provided.

Operational risk

Operational risk has been defined as the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events. This definition includes legal risk, but excludes strategic and reputational risk, whereby legal risk includes, but is not limited to, exposures to fines, penalties, or punitive damages resulting from supervisory actions, as well as private settlements. The framework outlines three methods for calculating operational risk capital charges in a continuum of increasing sophistication and risk sensitivity: (i) the Basic Indicator Approach; (ii) the Standardised Approach; and (iii) Advanced Measurement Approaches (AMA). Banks are encouraged to move along the spectrum of available approaches as they develop more sophisticated operational risk measurement systems and practices.

The Second Pillar – Supervisory Review Process

Pillar 2 (Supervisory Review Process) requires banks to implement an internal process for assessing their capital adequacy in relation to their risk profiles as well as a strategy for maintaining their capital levels, *i.e.*, the Internal Capital Adequacy Assessment Process (ICAAP). On the other hand, Pillar 2 also requires the supervisory authorities to subject all banks to an evaluation process and to impose any necessary supervisory measures based on the evaluations.

A significant innovation of the revised framework is the greater use of assessments of risk provided by banks' internal systems as

inputs to capital calculations. Each supervisor is expected to develop a set of review procedures for ensuring that banks' systems and controls are adequate to serve as the basis for the capital calculations. There are three main areas that might be particularly suited to treatment under Pillar 2: risks considered under Pillar 1 that are not fully captured by the Pillar 1 process (e.g. credit concentration risk); those factors not taken into account by the Pillar 1 process (e.g. interest rate risk in the banking book, business and strategic risk); and factors external to the bank (e.g. business cycle effects). A further important aspect of Pillar 2 is the assessment of compliance with the minimum standards and disclosure requirements of the more advanced methods in Pillar 1, in particular the internal rating based (IRB) framework for credit risk and the advanced measurement approaches for operational risk. Supervisors must ensure that these requirements are being met, both as qualifying criteria and on a continuing basis. Four key principles of supervisory review were identified, based on the Core Principles for Effective Banking Supervision and the Core Principles Methodology. First, banks should have a process for assessing their overall capital adequacy in relation to their risk profile and a strategy for maintaining their capital levels. Second, supervisors should review and evaluate banks' internal capital adequacy assessments and strategies, as well as their ability to monitor and ensure their compliance with regulatory capital ratios. Supervisors should take appropriate supervisory action if they are not satisfied with the result of this process. Third, supervisors should expect banks to operate above the minimum regulatory capital ratios and should have the ability to require banks to hold capital in excess of the minimum. Fourth, supervisors should seek to intervene at an early stage to prevent capital from falling below the minimum levels required to support the risk characteristics of a particular bank and should require rapid remedial action if capital is not maintained or restored.

The Third Pillar – Market Discipline

The third pillar is a set of disclosure requirements included in the Basel II framework to allow market participants assess the capital adequacy of the institution based on information on the scope of

application, capital, risk exposures, risk assessment processes, *etc*. Such disclosures are of particular relevance keeping in view the greater discretion allowed to banks in using internal methodologies for assessing capital requirements under Pillar 1. Supervisors have different powers available to them under Pillar 2, ranging from 'moral suasion' to reprimands or financial penalties, that they can use to make banks to make such disclosures. Market discipline can contribute to a safe and sound banking environment, and complement the minimum capital requirements (Pillar 1) and the supervisory review process (Pillar 2).

Banks should have a formal disclosure policy approved by the board of directors that addresses the bank's approach regarding the disclosures they make, and the internal controls over the disclosure process. In addition, banks should implement a process for assessing the appropriateness of their disclosures, including validation and frequency. Several key banking risks to which banks are exposed, such as credit risk, market risk, interest rate risk and equity risk in the banking book and operational risk, and the techniques that banks use to identify, measure, monitor and control those risks such as disclosures relating to credit risk mitigation and asset securitisation, both of which alter the risk profile of the institution, are important factors market participants consider in their assessment of an institution.

Basel II: An Evaluation

Even though implementation of Basel II is in progress with approximately 57 countries adopting all or parts of the framework by end-2008, the major advantages and deficiencies in Basel II have been discussed widely by the practitioners, policymakers and academicians. The main incentives for adoption of Basel II are (a) it is more risk sensitive; (b) it recognises developments in risk measurement and risk management techniques employed in the banking sector and accommodates them within the framework; and (c) it aligns regulatory capital closer to economic capital. These elements of Basel II take the regulatory framework closer to the business models employed in several large banks. In Basel II framework, banks' capital requirements

are more closely aligned with the underlying risks in the balance sheet. Basel II compliant banks can also achieve better capital efficiency as identification, measurement and management of credit, market and operational risks have a direct bearing on regulatory capital relief. Operational risk management would result in continuous review of systems and control mechanisms. Capital charge for better managed risks is lower and banks adopting risk-based pricing are able to offer a better price (interest rate) for better risks. This helps banks not only to attract better business but also to formulate a business strategy driven by efficient risk-return parameters. Marketing of products, thus, becomes more focused/targeted.

The movement towards Basel II has prompted banks to make necessary improvement in their risk management and risk measurement systems. Thus, banks would be required to adopt superior technology and information systems which aid them in better data collection, support high quality data and provide scope for detailed technical analysis. For instance, the framework requires fundamental improvement in the data supporting the probability of default (PD), exposure at default (EAD) and loss given default (LGD). Basel II incorporates much of the latest 'technology' in the financial arena for managing risk and allocating capital to cover risk.

Basel II goes beyond merely meeting the letter of the rules. Under Pillar 2, when supervisors assess economic capital, they are expected to go beyond banks' systems. Pillar 2 of the framework provides greater scope for bankers and supervisors to engage in a dialogue, which ultimately will be one of the important benefits emanating from the implementation of Basel II. The added transparency in Pillar 3 should also generate improved market discipline for banks, in some cases forcing them to run a better business. Indeed, market participants play a useful role by requiring banks to hold more capital than implied by minimum regulatory capital requirements - or sometimes their own economic capital models - and by demanding additional disclosures about how risks are being identified, measured, and managed. A strong understanding by the market of Pillars 1 and 2 would make Pillar 3 more comprehensible and market discipline a more reliable tool for supervisors and the market.

According to a survey published by Ernst & Young, processes and systems are expected to change significantly, alongwith the ways in which risks are managed. Over three-quarters of respondents believed that Basel II will change the competitive landscape for banking. Those organisations with better risk systems are expected to benefit at the expense of those which have been slower to absorb change. Eighty-five per cent of respondents believed that economic capital would guide some, if not all, pricing. Greater specialisation was also expected, due to increased use of risk transfer instruments. A majority of respondents (over 70 per cent) believe that portfolio risk management would become more active, driven by the availability of better and more timely risk information as well as the differential capital requirements resulting from Basel II. This could improve the profitability of some banks relative to others, and encourage the trend towards consolidation in the sector.

Limitations of Basel II

The Basel II framework also suffers from several limitations, especially from the angle of implementation in emerging economies. In its attempt to strive for more accurate measure of risks in banks, the simplicity of the 1988 Capital Accord has been replaced by a highly complex methodology which needs the support of highly sophisticated MIS/data processing capabilities. The complexity of Basel II also arises from several options available. The complexity and sophistication essential for banks for implementing the New Capital Accord restricts its universal application. Consequently, many of the countries that have voluntarily adopted Basel I also view these issues with considerable caution. While it is true that the Basel II framework is more complex, at the same time, it has also been argued that this complexity is largely unavoidable mainly because the banking system and related instruments that have evolved in recent times are inherently complex in nature. The risk management system itself has become more sophisticated over the time and applying equal risk weights (as done in the Basel I accord) may not be realistic anymore.

The more sophisticated risk measures unfairly advantage the larger banks that are able to implement them and, from the same

perspective, that the developing countries generally also do not have these banks and that Basel II will disadvantage the economically marginalized by restricting their access to credit or by making it more expensive.

In the standardised approach for credit risk measurement, rating agencies have been assigned a crucial role. Rating agencies move slowly, and changes in ratings, lag changes in actual credit quality, so that the ratings have a questionable ability to predict default (Altman and Saunders, 2001). Moreover, rating agencies have limited penetration in many emerging countries. In the absence of reliable ratings for different assets, banking industry will not be able to fully exploit the flexibility of Basel II and most credit risks will tend to end up in the unrated 100 per cent category and as a result there will be little change in capital requirements relative to Basel I. It has also been argued that in the case of standardised approach, unrated borrowers will have a lower risk weight (100 per cent) as compared to the lowest graded borrower (150 per cent) and this may lead to moral hazard problem with lower grade borrowers preferring to remain unrated. This may also lead to adverse selection. Concerns have also been expressed about the quality of rating agencies' judgements. Even in the developed economies, the recent sub-prime crisis has highlighted the problems relating to the role of rating agencies which is discussed in the following section.

Under the IRB approaches, greater reliance on banks' own internal risk ratings may be an improvement, but this is also not free from difficulties. Specifically, the proposal does not indicate how regulators will evaluate the accuracy of banks' own internal credit-risk ratings or how they would be translated into capital requirements. Nor does it explain how it would achieve comparability across the variety of internal rating systems in different banks. Most important, the proposal does not explain how regulators will enforce the ratings that banks produce or impose sanctions if the ratings turn out to be inaccurate and capital is insufficient or depleted. In any event, even if an effective enforcement mechanism is put in place, summing across risk buckets is just as deficient when the risk buckets are determined

by internal ratings as when they are determined by external risk ratings or the current arbitrary regulatory distinctions.

The interactions between regulatory and accounting approaches at both the national and international level to reduce, wherever possible, inappropriate disparities between regulatory and accounting standards which can have significant consequences for the comparability of the resulting measures of capital adequacy and for the costs associated with the implementation of these approaches. Keeping this in view, changes in the treatments of unexpected and expected losses, credit risk mitigation, treatment of securitisation exposures and qualifying revolving retail exposures, among others, are being incorporated.

A more serious criticism is that the operation of Basel II will lead to a more pronounced business cycle. This criticism arises because the credit models used for Pillar 1 compliance typically use a one year time horizon. This would mean that, during a downturn in the business cycle, banks would need to reduce lending as their models forecast increased losses, increasing the magnitude of the downturn. Regulators should be aware of this risk and can be expected to include it in their assessment of the bank models used. That the risk-based capital requirements are pro-cycle in nature (more capital is required in recessions because credit risk in banks' portfolios increases in cyclical downturns) was also recognised by the Basel Committee on Banking Supervision (BCBS). In a Consultative Paper issued by the BCBS in 1999, the Financial Stability Forum had raised the question whether several features of the new capital framework discussed by the BCBS could increase the cyclical fluctuations in the economy. In response, the BCBS confirmed that risk-based capital requirements were inevitably pro-cyclical, but could be addressed by different instruments. During the course of consultation, the Basel Committee maintained that various features of the risk weights of the IRB approach under Pillar 1 can be expected to mitigate its pro-cyclical impact. For example, the length of the observation period mandated for estimating PD is at least five years and that for LGD and EAD seven years, with the qualification that if the observations for any of

the sources used span a longer period, then the latter should be used. Basel II requires banks to estimate long run average PD and downturn LGD, which to a great extent reduced the variability of capital requirement with respect to business cycles. The greater allowance for eligible provisions can also be expected to reduce the importance in risk-weighted assets of defaulted loans during cyclical downturns, when such loans increase as a proportion of banks' portfolios. The Committee further recommended that national supervisors could also promote the use of internal models leading to lower pro-cyclicality. Measures such as through-the-cycles rating methodologies could also 'filter-out' the Imapct of business cycle on borrower rating. Supervisors could also prescribe additional capital under Pillar 2 during a business cycle expansion.

Challenges to Effective Implementation of Basel II

Apart from certain deficiencies of Basel II, its implementation presents several challenges, especially in emerging market economies. Data limitation is a key impediment to the design and implementation of credit risk models. Most credit instruments are not marked to market; hence, the predictive nature of a credit risk model does not derive from a statistical projection of future prices based on comprehensive historical experience. The scarcity of the data required to estimate credit risk models also stems from the infrequent nature of default events and the longer term time horizons used in measuring credit risk. Thus, in specifying model parameters, credit risk models require the use of simplifying assumptions and proxy data. One of the major challenges is the availability of long-time series and reliable data and information as also sophisticated IT resources. In view of these constraints, banks in emerging economies are forced to adopt the standardised approach.

Banks need to put in place sound and efficient operational risk management framework since this will be a focus under the Pillar 2. The most important Pillar 2 challenge relates to acquiring and upgrading the human and technical resources necessary for the review of banks' responsibilities under Pillar 1 by the supervisors. Other areas of concern include coordination of home and host supervisors

in the cross-border implementation of Basel II; issues relating to outsourcing; common reporting templates for easy comparability; and external benchmarks to be made available by the regulator, and to be used for comparison/self-evaluation for the risk components/ operational losses.

Aligning supervisory disclosures under Pillar 3 with international and domestic accounting standards has emerged as a major challenge. There are also issues relating to (i) reporting framework/disclosures in the context of risk appetite for the stated business objectives and risk management systems in place; and (ii) providing information, on the risks and the risk management systems in place, in the public domain which could be used for comparison among banks. Market discipline is not possible if counterparties and rating agencies do not have good information about banks' risk positions and the techniques used to manage those positions.

Full implementation of Basel II would require upgradation of skills both at the level of supervisory authority and the banks. Banks would be required to use fully scalable state of the art technology, ensure enhanced information system security and develop capability to use the central database to generate any data required for risk management as well as reporting. The emphasis on improved data standards in the revised accord is not merely a regulatory capital requirement, but rather it is a foundation for risk-management practices that will strengthen the value of the banking franchise.

The validation of credit risk models is also fundamentally more difficult than the backtesting of market risk models. Where market risk models typically employ a horizon of a few days, credit risk models generally rely on a timeframe of one year or more. The longer holding period, coupled with the higher target loss quantiles used in credit risk models, presents problems to model-builders in assessing the accuracy of their models. A quantitative validation standard similar to that in the Market Risk Amendment would require an impractical number of years of data, spanning multiple credit cycles.

The costs associated with Basel II implementation, particularly costs related to information technology and human resources, are

expected to be quite significant for both banks and supervisors. Even in the absence of Basel II, well managed financial institutions and regulatory authorities would have continued to update and improve their IT systems and risk management practices simply to keep pace with the evolving practices in the marketplace. However, Basel II has pushed banks and supervisors for development of human resource skills and IT upgradation. In this context, the challenge that banks are likely to face will have many facets, *viz*., assessing requirements, identifying and bridging the gaps, identifying talents, putting the available talents to optimum use, attracting fresh talents, retention of talents and change management.

Though, the Basel II framework aims to achieve common standards, its implementation also requires closer cooperation, information sharing and co-ordination of policies among supervisors. The existence of separate supervisory bodies to regulate different segments of the markets within a jurisdiction may create challenges in implementation of Basel II not only within a jurisdiction but also across jurisdictions. This is because when different market participants are regulated by separate supervisors, it is difficult to maintain comparable quality of policy formulation and vigilance. In many developing countries, only the banks are coming under the ambit of Basel II and not other financial services providers, thus creating some scope for regulatory arbitrage. As the main objective of the New Accord is to ensure competitive equality and providing a reasonable degree of consistency in application, it is necessary that supervisors across the globe should have a common definition of internationally active banks. Basel Committee may, therefore, define what constitute internationally active banks. For example, in Indian conditions, those banks with cross-border business exceeding 20-25 per cent of their total business may be classified as internationally active banks. The foreign banks in EMEs are the ones which would be implementing the advanced approaches of Basel II on a world-wide consolidated basis. However, the home-host regulatory and supervisory issues would get accentuated due to the greater scope for multiple regulatory treatments as also the several unresolved cross-border issues under the different Basel II approaches.

The risk weights/implied correlations for different exposures under standardised or IRB approaches are based upon certain assumptions which may not be applicable in the context of emerging economies. For instance, 35 per cent risk weight for mortgage lending is based upon PD estimates and LGD of developed European/US markets and may not be adequate as the losses in secured real estate lending in countries like Taiwan, Thailand and Indonesia have at times exceeded 35 per cent. Thus, the regulators in developing countries need to independently assess whether all the assumptions of Basel II framework are applicable to their domestic markets and modify them suitably, if required.

Countries that have already adopted Basel I and are complying with the reasonable minimum BCP (Basel Core Principles of Effective Banking Supervision), are in a better position to choose among the various alternatives offered under Basel II. In environments where banking supervision is weak as reflected in a poor BCP compliance, implementing sophisticated methods of calculating bank capital may pose challenges for the supervisors that far outweigh the benefits derived from more accurate calculation of bank risk and capital prescribed under Basel II. Furthermore, the thin regulatory resources have a tendency to deflect away from the priority areas. Such countries would need to adopt the BCP more fully and are advised to focus primarily on Basel Pillars 2 and 3. Though there is enough room for country specific adaptations, it should be borne in mind that such adaptations should not take away the essence of a 'standard'. The IMF (jointly with the World Bank), as a part of its financial sector assessment programs, have reviewed countries' compliance with the Basel Core Principles (BCP). In the course of 71 confidential assessments covering 12 advanced, 15 transition and 44 emerging economies, it was found that all advanced economies under consideration complied with the core principles regarding market risk and risk management. In contrast, 66 per cent of emerging economies and 53 per cent of transition economies did not comply with such principles. Given this level of compliance, the challenges that are likely to be faced by the emerging economies in implementing the Basel II framework is daunting indeed.

As countries are moving forward with Basel II implementation, supervisors are closely monitoring its impact on overall bank capital levels. A capital monitoring exercise is in place to track minimum capital requirements, actual capital buffers above the minimum and how the minimum requirements compare to Basel II floors. Analysis of the first data submissions will be available to the BCBS in the first quarter of 2009, and data will continue to be collected on an ongoing semi-annual basis.

Section III

Basel II in the light of the Current Financial Turmoil

In light of recent financial market turbulence, the importance of implementing Basel II capital framework and strengthening supervision and risk management practices, and improving the robustness of valuation practices and market transparency for complex and less liquid products, have assumed greater significance. Moreover, it has become indispensable to have robust and resilient core firms at the centre of the financial system operating on safe and sound risk management practices. The Basel II plays an important role in this respect by ensuring the robustness and resilience of these firms through a sound global capital adequacy framework along with other benefits including greater operational efficiencies, better capital allocation and greater shareholder value through the use of improved risk models and reporting capabilities.

The recent financial turmoil exhibited that even such technical analysis have their limitations, such as incomplete data or assumptions that have not been tested across business cycles. Therefore, quantitative assessment of risks also needs to be supplemented by qualitative measures and sound judgement.

The Financial Stability Forum (FSF)[6] made comprehensive proposals that were ratified in early April 2008 by the G-7 to be implemented over the next 100 days. The proposals include *inter alia* full and prompt disclosure of risk exposures; urgent action by setters

of accounting standards and other relevant standard setters to improve accounting and disclosure standards for off-balance sheet or entities and to enhance guidance on fair value accounting, particularly on valuing financial instruments in periods of stress; strengthening of risk management practices, supported by supervisors' oversight, including rigorous stress testing; and strengthening of capital positions as needed. In addition, the FSF emphasised on a number of proposals for implementation by end-2008 which include *inter alia* strengthening prudential oversight of capital, liquidity, and risk management under Basel II, especially for complex structured credit instruments and off-balance sheet vehicles; enhancing transparency and valuation for off-balance sheet entities, securitisation exposures, and liquidity commitments under the Basel Committee's guidance; enhancing due diligence in the use of ratings.

As part of its capital monitoring exercise, the BCBS would be tracking on an ongoing basis the impact of Basel II on bank capital levels. This will shed light on the effects of the proposed amendments to Basel II and help determine whether additional efforts are needed to strengthen capital in the banking system. In addition, BCBS members regularly exchange information on how supervisors are implementing the various aspects of Basel II and conducting model approvals in practice.

The BCBS has also launched a joint undertaking with the FSF to examine the impact of Basel II on the cyclicality of capital requirements and possible measures for mitigating it. The FSF will report to the G7 on progress with this work in April 2009.

The BCBS announced a comprehensive strategy on November 20, 2008 to address the fundamental weaknesses revealed by the financial market crisis related to the regulation, supervision and risk management of internationally-active banks. The primary objective was to strengthen capital buffers and help contain leverage in the banking system arising from both on- and off-balance sheet activities. The key building blocks of the Committee's strategy include the following:

- strengthening the risk capture of the Basel II framework (in particular for trading book and off-balance sheet exposures);
- enhancing the quality of Tier 1 capital;
- building additional shock absorbers into the capital framework that can be drawn upon during periods of stress and dampen procyclicality;
- evaluating the need to supplement risk-based measures with simple gross measures of exposure in both prudential and risk management frameworks to help contain leverage in the banking system;
- strengthening supervisory frameworks to assess funding liquidity at cross-border banks;
- leveraging Basel II to strengthen risk management and governance practices at banks;
- strengthening counterparty credit risk capital, risk management and disclosure at banks; and
- promoting globally coordinated supervisory follow-up exercises to ensure implementation of supervisory and industry sound principles.

Under Basel II, though liquidity risk is not reckoned explicitly as Pillar 1 risk, it is provided that a bank's Pillar 2 assessment should cover the full range of risks facing an institution, including liquidity risks. Effective liquidity risk management usually emerges as a challenge during periods of financial stress, when many markets become less liquid, making it difficult for some entities to fund themselves. In recent months, some of the well-known challenges associated with liquidity risk management became evident in the light of the US sub-prime crisis and the failure of the Northern Rock bank in the UK. Even banks with strong capital base experienced liquidity problems as they did not have a strong liquidity risk management system in place. The adequate stress and scenario testing for potential asset expansions arising from liquidity shocks becomes crucial to

communicate to market participants about their risk profiles. The BCBS has already initiated the process of assessment of the weaknesses identified by the recent crisis with a view to setting global standards for liquidity risk management and supervision, and integrating it more closely with other risk management disciplines. After issuing a public consultation document in June, the BCBS released in September Principles for Sound Liquidity Risk Management and Supervision. The Principles materially raise standards for sound liquidity risk management and measurement – including the capture of off-balance sheet exposures, securitisation activities and other contingent liquidity risks that were not well managed during the turmoil. The Principles underscore the importance of establishing a robust liquidity risk management framework that is well integrated into the bank-wide risk management process. Key elements of a bank's governance of its liquidity risk management are also emphasised. Moreover, the document sets out principles to strengthen the measurement and management of their liquidity risk, which include *inter alia*, the requirement of a bank to: (i) maintain a cushion of unencumbered, high quality liquid assets as insurance against a range of stress scenarios; (ii) actively manage its intraday liquidity positions and risks to meet payment and settlement obligations on a timely basis under both normal and stressed conditions, and thus contribute to the smooth functioning of payment and settlement systems; (iii) conduct regular stress tests for a variety of short-term and protracted institution-specific and market-wide stress scenarios and use the outcomes to develop robust and operational contingency funding plans; and (iv) ensure the alignment of risk-taking incentives of individual business lines with the liquidity risk exposures the activities create.

The Principles highlight the key role of supervisors, including the responsibility to intervene to require effective and timely remedial action by a bank to address liquidity risk management deficiencies. The Principles also stress the need for regular communication with other supervisors and public authorities, both within and across national borders. They also recommend regular public disclosure that enables market participants to make an informed judgement about

the soundness of a bank's liquidity risk management framework and liquidity position. The guidance focuses on liquidity risk management at medium and large complex banks, but the sound principles have broad applicability to all types of bank. The document notes that implementation of the sound principles by both banks and supervisors should be tailored to the size, nature of business and complexity of a bank's activities. Other factors that a bank and its supervisors should consider include the bank's role and systemic importance in the financial sectors of the jurisdictions in which it operates. The BCBS expects banks and supervisors to implement the Principles thoroughly and quickly, and will assess progress in this area. It will also start to examine possible steps to promote more robust and internationally consistent liquidity approaches for cross-border banks. This will include assessing the scope for further convergence of liquidity supervision.

The Basel Committee on Banking Supervision issued a package of consultative documents to strengthen the Basel II capital framework on January 16, 2009. These enhancements are part of a broader effort the Committee has undertaken to strengthen the regulation and supervision of internationally active banks in light of weaknesses revealed by the financial markets crisis. The proposed changes to capital requirements cover: (i) trading book exposures, including complex and illiquid credit products; (ii) certain complex securitisations in the banking book [for example, collateralised debt obligations (CDOs) of asset backed securities (ABS)]; and (iii) exposures to off-balance sheet vehicles (*i.e.*, asset-backed commercial paper conduits).

The Committee is also proposing standards to promote more rigorous supervision and risk management of risk concentrations, off-balance sheet exposures, securitisations and related reputation risks. Through the supervisory review process, the Committee is promoting improvements to valuations of financial instruments, the management of funding liquidity risks and firm-wide stress testing practices. In addition, the Committee is proposing enhanced disclosure requirements for securitisations and sponsorship of off-balance sheet

vehicles, which should provide market participants with a better understanding of an institution's overall risk profile.

The Committee proposes that the capital requirements for the trading book be implemented in December 2010 while the other improvements, including those related to risk management and disclosures, be introduced by the end of 2009.

The BCBS is developing for consultation by end-2008 proposed guidance to further strengthen Pillar 3 disclosure requirements under Basel II for securitisation and resecuritisation exposures, sponsorship of off-balance sheet vehicles, liquidity commitments to ABCP conduits, valuations with regard to securitisation exposures and pipeline and warehousing risks. This effort is well underway and is also drawing from leading practice risk disclosures that banks are providing in response to the FSF recommendations. The BCBS plans to issue final guidance in 2009.

The BCBS is developing guidance to enhance the supervisory assessment of corporate governance and controls over banks' valuation processes and related risk management and capital adequacy issues. The guidance will reinforce sound bank valuation practices and address approaches supervisors should take when deficiencies are identified. The drafting effort is well underway and further dialogue is planned with securities markets regulators as part of the development process. Furthermore, the BCBS plans to address improved valuation disclosures as part of proposed amendments to the disclosure requirements of Pillar 3 of Basel II. These proposed changes are part of the Committee's broader work programme, as set out in its November 20, 2008 press release, to strengthen in a fundamental way bank capital adequacy, risk management and supervision. In particular, this includes assessing ways to mitigate procyclicality, for example, by promoting capital buffers above the regulatory minimum that can be drawn upon during periods of stress. These efforts are in support of the April 2008 recommendations of the Financial Stability Forum and the G-20's November 2008 action plan.

Section IV

Conclusion

The Capital Accord of 1988, which set global standards for regulation and supervision, has emerged as one of the most significant developments in strengthening the soundness and stability of the international financial system. The biggest contribution of the Basel Accord has been to arrive at a common definition of capital. Though the capital adequacy norms have been adopted in different countries with certain country-specific adaptations, the definition of capital given by the Basel Committee has been adopted almost uniformly across countries and has also been adopted in the new framework. Basel I served regulators and banks well for many years. However, for large and complex banking organisations, it increasingly failed to adequately align regulatory capital required with the underlying risks. There had been growing evidence of reduction in the Accord's effectiveness caused by financial innovations and some risks other than credit risk in the banking business, notably interest rate risk and the investment risk on securities, and operational risk. Subsequently, the Accord was fine-tuned to take in to account factors which were not considered initially for assessing overall capital adequacy. This, together with a better understanding of the conceptual shortcomings in the original Accord, led to a redesign of the framework which finally emerged as Basel II or the New Capital Adequacy Framework.

Basel II represents a fundamental shift in the regulatory capital framework by aligning the capital requirements with underlying risks through enhanced risk measurement techniques and encouraging banks to develop a more disciplined approach to risk management. Recognizing the need for a more broad-based and flexible framework, the new framework calls for better alignment of regulatory capital with underlying risks by replacing the earlier broad-brush approach with preferential risk weighting treatment. The framework provides for explicit capital charge for other risks *viz.*, operational risk and interest rate risk in the banking book for banks where interest rate risks are significantly above average (outliers). The revised framework

also aims at promoting the adoption of stronger risk management practices by the banking industry, and provide for a menu of options to be adopted by the banks and the regulators, the biggest challenge remains that of differential treatment to different groups of financial institutions, while at the same time preserving the benefits of a framework that can be applied as uniformly as possible at the national level.

The Basel II framework is a significant improvement over the Basel I rules in the incentives it provides for sound risk management practices, its alignment of minimum capital requirements with risks banks face, and its flexibility to be adapted to and address evolving risks from financial innovation. It is critical that the minimum capital requirements of the first pillar be accompanied by a robust implementation of the second, including efforts by banks to assess their capital adequacy and by supervisors to review such assessments. The second pillar is aimed at enabling early supervisory intervention if capital does not provide a sufficient buffer against risk. In addition, the disclosures provided under the third pillar of this Framework is intended to enhance the role of market participants in monitoring banks, and thereby ensuring that market discipline serves as an effective complement to the other two pillars. Supervisors should assess the need for additional capital buffers or supplementary measures of capital strength as a complement to risk-based measures. Basel II, therefore, would help in promoting the safety and soundness of the banking system. However, in view of the recent financial market turmoil, a number of modifications have been suggested in the Basel II framework. These measures need to be evaluated in terms of their ability to prevent future crises. Several countries have proposed or are considering such supplementary measures, including in the form of a balance-sheet leverage ratio, to better contain leverage in the system, guard against risk measurement errors and strengthen banks' overall shock absorption capacity. However, the insistence on holding higher capital by banks may lead to deepening of recession, as cautioned by Jean-Claude Trichet, the President of the European Central Bank at the World Economic Forum Meet, 2009. In this context, the observation of the Reserve Bank of India Deputy

Governor 'understanding Basel II concepts is one step away from agreeing to it in principle. Implementing Basel II is another long step away from understanding it' appears to be pertinent[7]. The recent turmoil in credit markets has displayed some of the deficiencies in the Basel II framework, and even after the changes recently announced by the Basel Committee are formalised, it is still uncertain whether the amendments could provide a complete solution for evaluating bank capital objectively. However, as Caprio and Honohan (1999) remind us, 'bank regulation must be seen as an evolutionary struggle and regulatory innovation will remain a constant challenge'.

Note :

[1] It consisted of senior representatives of bank supervisory authorities and central banks from 13 countries, *viz*., Belgium, Canada, France, Germany, Italy, Japan, Luxembourg, the Netherlands, Sweden, Switzerland, the United Kingdom and the United States.

[2] *Core Principles for Effective Banking Supervision*, which the Basel Committee on Banking Supervision (the Committee)1 originally published in September 1997 was revised in October 2006 in view of the significant changes in banking regulation, experience gained with implementing the Core Principles in individual countries, and new regulatory issues, insights and gaps in regulation since 1997.

[3] The revised and updated document was released in 1998 and apart from the July 1988 text of the Basel Capital Accord contains five textual changes reflecting the November 1991 amendment (concerning general provisions);? the July 1994 amendment (concerning the qualification for the OECD risk weighting); ?the April 1995 amendment to Annex 3 (concerning certain off-balance-sheet items) and claims collateralised by securities issued by OECD non-central government public-sector entities; the April 1998 amendment (concerning the list of assets eligible for a 20 per cent risk weighting); and removal of references to transitional and implementation arrangements.

4. The objective of the impact study is to assess whether the Committee has met its goals with regard to the New Basel Capital Accord.

5. (Total capital) / (Credit risk + market risk + operational risk) >= 8 per cent minimum capital ratio.

[6] A forum of select senior representatives of national financial authorities including central banks, supervisory authorities and treasury departments, international financial institutions, international regulatory and supervisory groupings and committees of central bank experts.

[7] Kishori J. Udeshi, Deputy Governor, Reserve Bank of India at the World Bank/ IMF/US Federal Reserve Board 4th Annual International Seminar on Policy Challenges for the Financial Sector : Basel II at Washington on June 2, 2004.

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Powerful Finance and Innovation Trends in a High Risk Economy, Edited by Blandine Leperche and Dimitris Uzunidis, Palgrave Macmillan Publication, 2008, Pages 277, Price £ 60.

Economic history has for long projected entrepreneurs as the primum mobile of economic growth so much so that economic peaks and troughs have been identified partly with peaks and declines of entrepreneurship. However, as Baumol has rightly pointed out, the role of an entrepreneur at a point of time is a function of the relative pay-off structure in the economy. Whether an entrepreneur engages in productive activities like innovation or unproductive pursuits like rent-seeking and organized crime depends on the rules of the game operational at that point in time. Any change in the rules of the game dictates changes in composition and size of entrepreneurs which, in turn, would impact the productivity and growth of the economy *via* the allocation of entrepreneurial resources. In this background of traditional theories on entrepreneurship, innovation and growth developed by eminent economists like Schumpeter, Baumol and Galbraith, the book 'Powerful Finance and Innovation Trends in a High Risk Economy' discusses the emerging relationships between the three variables in a new epoch defined by globalization of markets and financial deregulation.

The book is a collection of 14 chapters divided into two parts of seven each. Part I, consisting of chapters 1 to 7 deals with the historical evolution of the entrepreneur and the incentive structure motivating channelization of entrepreneurial resources into productive and rent-seeking activities including the political economy of R&D in a global financial context.

According to Sophie Boutillier, the wave of economic liberalization, development of financial markets, advent of new technologies coupled with the crisis of the welfare state led to

the emergence of the ‘socialised entrepreneur’ of the 1990s.The author, thus, examines the evolution of the ‘Schumpeterian entrepreneur’ of the 1960s into the ‘socialised entrepreneur’ of today in Chapter 4. The author is credited with the view that with financial innovations like venture capital and public welfare programmes, even a person with a humble background can rise as entrepreneur of today. A socialised entrepreneur may be a founder, manager, owner and innovator of the enterprise and is ranked according to his/her resource potential where the latter is determined by finance, knowledge and social network of relations.

But does the entrepreneur of the 1990’s engage in productive innovation? James Galbraith in his paper, 'Innovation and Predation', answers that the CEO-led corporations, of late like, Enron and World Com focus on obtaining high rate of return through predatory methods better described as 'control fraud' or systematic looting of corporation'. James Sawyer substantiates Galbraiths' argument in Chapter 4 by citing how CEOs of Enron tweaked financial statements to show up consistent earnings performance from quarter to quarter. The author counters that individuals working in their self interest may not lead to common good. Rather, unbridled self interest leads frequently to rent-seeking pseudo capitalist behaviours in which individuals deviate from conventional capitalist relationship of holding capital patiently over the longer term and indulge in 'short termism'.

Such short-term behavior is induced by the political economy of R&D under a global financial order characterised by unregulated financial markets, mobile capital and full capital account convertibility, argues Jerry Courvisanos in Chapter 6. The high risk and fundamental uncertainty arising from such a global system discourage long term R&D projects by large firms, curtail R&D during economic downturns and handicap R&D spending by young firms which depend on external funding. The R&D strategies are driven solely by the motive of marginal incremental

marketing-based improvements which, in turn, limits economic growth. The author, thus, surveys the extant academic literature from the particular focus of R&D's twin roles and implications for financing R&D.

Dimitri Uzunidis in Chapter 2 examines the relations between the variables from a different perspective. The author opines that technologies *per se* cannot explain global economic cycles. Technologies have to be socially appropriated in order to become vectors of growth. The author is of the view that no large scale economic movement would be possible as long as global solvent demand remains low and as long as finance acquires a growing surplus of value and transforms it into rent.

Part II consisting of Chapters 8 to 14, dwells on firm level strategies on innovation and profitability including corporate governance over the firm's industrial life cycle, rapidly changing objective functions of firms in a financially unstable world and innovative behaviour in small and large firms.

Schumpeter had argued that big firms have a competitive advantage over small firms in innovation. In Chapter 12, Francis Munier analyses the relation between the size of the firm and innovation based on the concept of competence to innovate in the French industry using a logit model. The author argues that large firms possess superior competence in sub-contracting or acquiring R&D, recruitment of highly competitive staff and R&D management with third parties. Furthermore they possess 'sale of innovation competencies' whereby they can promote and valorize their innovation on the market.

Similarly, Kraft and Ravix more a question that should the mode of governance also vary with the size of the firm in order to incentivise innovation. The authors are credited with the view that firms cannot be governed with a universal set of rules disregarding their diversity and heterogeneity. Further, age and

size are not the key determinants of innovative behaviour of firms. Hence in Chapter 8, they reconcile the literature on the industry life cycle with the literature on the governance of large and small enterprises and insist that new principles of governance should be proposed for innovative corporations by defining the notion of 'corporate entrepreneurship' within which managers and investors are collectively involved in the coherence and development of small and large innovative firms.

But ultimately why should a firm innovate? Does innovation add to higher profits? Christian Genthon explores the nature of the relationship between innovation and profitability by analyzing the computer industry over an extended period of time in Chapter 10. The author deviates markedly from traditional arguments and demonstrates that there is no relationship between R&D spending and profitability. Instead, the determinants of profits depend on growth and industrial organization.

In Chapter 14, Blandine Leperche takes forward the argument put forth by Jerry Courvisanos in Chapter 6 and pinpoints how the objective function of the firm has turnaround in recent years from profit maximization to 'profitability imperative' where the manager of big globalised corporations try to boost shareholder value in order to retain investment from new institutional investors and concomitantly reduce risk, cost and length of the technological progress. The author explains how a contradiction has developed between socialization of knowledge capital - which is at the base of innovative capacity of firms - and oligopolistic appropriation facilitated by evolving patent laws and practices.

There is no gainsaying that financial innovations like securitisation have exacerbated the instability and the risk of secondary uncertainty in the world which, in turn, has come down heavily on R&D expenditure of firms. But does lack of financial innovations hinder the development of R&D too? Elisa Ughetto in Chapter 13, illustrates how in a bank dominated system like

Italy where non-bank institutions are conspicuous by their absence, innovations are nipped in the bud due to lack of credit. Banks are averse to lend to innovative firms because of low returns to innovation and information asymmetries. Although Basel II allows incorporation of qualitative information in banks' internal rating models, the author has found empirical evidence that innovation-related parameters are not taken into account by Italian banks in a systematic way.

In a nutshell, the book is a repository of contemporary developments in innovation and growth theories and corporate strategies in this direction. The book, thus, educates about the need for innovation, reasons for rapidly disappearing innovative zeal and the new avenues to encourage R&D. The author illuminates that finance is a *sine-qua-non* for a knowledge-based economy of today. However, although financial development in the form of venture capital and private equity coupled with risk management practices like securitisation encourages and enlarges the reach of innovation, instability emerging from financial innovations restricts long-term innovative activities and knowledge accumulation. The book provides cues at how these two contradictory forces could be balanced. The book is a collection of most comprehensively written papers by eminent economists and is a must read for researchers and PhD students working in the area of economic theory, advanced microeconomics and game theory.

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Financial Crises by Franklin Allen and Douglas Gale, The International Library of Critical Writings in Economics, An Elgar Reference Collection, Cheltenham, UK, Northampton, USA, 2008, ISBN: 978 1 84376 424 3, pages 579, price £ 150

The genesis of a financial crisis, its consequent impact and the contagion to other regions are issues that have been in the forefront since the inception of the sub-prime crisis in the United States. The consequences of the crisis have no longer remained confined to any particular sector/economy. The contagion has traversed from the financial to the real sector, from the United States to the whole of Europe and has also affected the emerging economies. Even countries with good fundamentals have not managed to escape the contagion. The decoupling theory has also failed in today's globalised world. This has necessitated an analysis of the current crisis in terms of its origin and characteristics as well as the need to explore where does the present crisis stand in terms of the different types of crisis that have hit the world so far against the background of the available literature on financial crisis. The book on 'Financial Crises' by Allen and Gale is a good reading to start with. This book provides an excellent review of the literature on financial crises. It presents a collection of articles by the authors of the book as well as by other renowned economists on issues related to financial crises.

The book has undertaken the review of the available literature from various aspects: the historical perspective of crises, the empirical studies undertaken, the nature of crises *viz.*, banking crises, currency crises and the process of contagion. While looking at crises from a historical perspective, the period since 1880 has generally been divided into four periods: (i) The Gold Standard Era – 1880-1913, (ii) The Interwar Years – 1919-1939, (iii) The Bretton Woods Period – 1945-1971and (iv) The Recent Period – 1973-1997. Some of the general observations made (Bordo *et al*, 2001) are that Gold Standard

Era has been the most benign of the four periods even though capital markets were globalised then as now. Banking crises did occur in this period, but they were infrequent. Currency crises and twin crises also occurred much less frequently than in subsequent periods. During the Bretton Woods Period, countries either regulated bank balance sheets to prevent them from taking on much risk or achieved the same aim through direct ownership of banks. These measures were successful in suppressing banking crises. Banking crises and currency crises were widespread in the Inter war years. The recent period also appears more crisis-prone than any other period except for the Interwar Years. Over the last 120 years, crises have been followed by economic downturns lasting from two to three years and costing 5 to 10 per cent of GDP, on average. Twin crises are associated with particularly large output losses. Recessions that coincide with crises are more severe than recessions that do not coincide with crises.

Looking at the causes of the crises, two broad approaches have been adopted by economists. First, well expounded by Kindleberger (1978), is that crises occur spontaneously as the result of mob psychology or panic. If everyone expects a crisis and acts as if one is about to occur, then the crisis becomes a self-fulfilling prophecy and *vice versa*. The second view asserts that crises are an intrinsic part of the business cycle and result from shocks to economic fundamentals (Mitchell, 1941). When the economy goes into a recession or depression, asset returns are expected to fall. Borrowers have difficulty repaying loans. Depositors, anticipating an increase in defaults or non-performing loans, try to protect their wealth by withdrawing banks deposits. Banks are caught between the illiquidity of their assets of their liabilities and may become insolvent. This results in panic though actual cause is different. Empirical evidence on the cause of crises is mixed. While some support the panic view (Friedman and Schwarz, 1963), many counter it (Calomiris and Gorton, 1991 Calomiris and Mason, 2003).

Recognising that financial crises impose heavy costs on the real economy, empirical studies have tried to estimate the average present value of losses in a number of different ways. The mean loss empirically estimated has varied between 63 percent and 302 per cent of the value of real per capita GDP in the year before the crisis starts (Boyd, Kwak and Smith, 2005). The range of losses has also been large with the loss, for example, amounting to almost 1041 per cent of the value of real output the year before the crisis of 1997 in Hongkong.

The relationship between banking crises and currency crises has also been explored in number of empirical studies (Kaminsky and Reinhart, 1999). It has been observed that in the 1970s, when financial systems were highly regulated, currency crises did not coincide with banking crises. Post financial liberalisation of the 1980s, currency crises and banking crises have become intertwined. Although banking crises typically precede currency crises, the common cause of both is usually a fall in asset values caused by a recession or weakness in the economy. Often the crisis is part of a boom-bust cycle that follows financial liberalisation.

The authors then move on to give a detailed analysis of the literature on banking crises and currency crises separately. The first models of banking crises developed assume a continuum of consumers with random demand for liquidity (Bryant, 1980; Diamond and Dybvig 1983). Optimal insurance against these liquidity shocks can be provided by deposit contracts that promise depositors a fixed payment depending on whether they withdraw early or late. The deposit insurance model was, however, considered sub-optimal if depositors have access to capital markets (Cone, 1983; Jacklin, 1987) or if there are regulatory restrictions (Wallace, 1988). An article by Calomiris and Kahn, 1991 listed in the book provides justification for demand deposits by showing that they provide depositors with an incentive

to monitor the viability of the bank. In case of any problem, the informed depositors out of panic will withdraw their money forcing the bank to liquidate all of its assets. Hence, the bank has to always maintain the value of its assets and avoid taking excessive risks. In contrast to the pure panic based models, literature has also focused on bank runs that are a natural outgrowth of the business cycle (Allen and Gale, 1998).

The book also lists out a couple of articles illustrating the global games approach in the context of currency crises to obtain a unique equilibrium. The panic-based and fundamental-based approaches have been linked using the global games approach to show how the probability of a crisis depends on the fundamentals (Morris and Shin, 2003). Rochet and Vives, 2004 use the unique equilibrium resulting from their global games approach to undertake policy analysis. They consider the role of *ex ante* regulation of solvency and liquidity ratios and *ex post* provision of liquidity by the central bank. The global games approach has also been used to show how the probability of panic based runs can be made endogenous and related to the parameters of the banking contract (Goldstein and Pausner, 2005).

The normative aspects of banking crises have been captured through a general equilibrium framework, objective being to investigate the welfare properties of financial systems and to discover conditions under which regulation might improve the allocation of resources (Allen and Gale, 2004). An interesting feature of the Allen-Gale framework is that it explicitly models the interaction of banks and markets. Financial institutions are the main players in financial markets, which allow banks and intermediaries to share risks and liquidity. Individuals do not have direct access to markets; instead, they access markets indirectly by investing in intermediaries. Financial intermediaries and markets play important but distinct roles in the model. Intermediaries provide consumers with insurance against

idiosyncratic liquidity shocks. Markets allow financial intermediaries and their depositors to share risks from aggregate liquidity and asset return shocks.

The book also explores the relationship between banking crises and asset price bubbles (Allen and Gale, 2000). Financial liberalization, by expanding the volume of credit and creating uncertainty about the future path of credit expansion, at times lead to a bubble in asset prices. When the bubble bursts, either because returns are low or because the central bank tightens credit, banks are put under severe strain. While many of their liabilities are fixed their assets fall in value. Depositors and other claimants may decide to withdraw their funds in anticipation of problems to come resulting in bank runs. The book also has one paper by Diamond and Rajan, 2006 that takes into account the role of money into the models of banking crises and further investigates whether monetary policy can help avert bank failures. The model developed in this paper essentially deals with the role of banks in the transmission of monetary policy.

Apart from banking crises, the book has also separately to analysed the currency crises to explain the problems experienced by a number of Latin American countries in the 1970s and early 1980s. Not too long ago, currency crises were generally being explained in terms of a balance of payments crises model (Krugman 1979 and Flood and Garber 1984) that shows that fiscal imbalances coupled with a fixed exchange rate leads to a currency crisis. With any speculative attack, Government finds it difficult to defend the exchange rate and currency depreciates. But this first generation view has fallen out of fashion because in many crises the crucial fiscal disequilibria were absent. And, as Obstfeld [1994] has argued, currency crises have sometimes occurred even though central banks had more than enough resources to prevent them, as in the Exchange Rate Mechanism crisis of 1992.

Obstfeld (1996) put forward a second generation view in which central banks may decide to abandon an exchange rate peg when the unemployment costs of defending it become too large. This new perspective implied that crises could be driven by self-fulfilling expectations, since the costs of defending the peg may themselves depend on anticipations that the peg will be maintained. But Obstfeld's emphasis on mounting unemployment and domestic recession, while appropriate for the ERM 1992 crisis, was at odds with the facts in Mexico in 1994 and East Asia in 1997. Asian countries, in particular, were growing quickly until shortly before their financial meltdown. Instead of fiscal imbalances or weakness in real activity, recent crises in emerging markets have featured troubled local financial institutions and sudden reversals of short-term international capital flows. In most cases, the currency crashed along with the financial system. This suggests that a third generation model of crises should assign a key role to financial structure and financial institutions.

Having discussed the nature of financial crisis, the book has also touched upon the issue of financial contagion, the process by which a shock in one part of the financial system spreads to other parts through a series of 'linkages'. This is a very important aspect of financial crises in the current juncture considering the increasingly enhanced linkages, both trade and capital, across nations. The channels of contagion discussed in the book include interbank claims and flow of information. A fall in prices on one market may be interpreted as a negative signal about fundamentals. If these fundamentals are common to other markets, the expected returns and hence prices on those markets will also fall. Similarly, if one currency depreciates, other countries with common fundamentals may find that their currency also depreciates. Besides, considering that it is optimal for banks to hold deposits in banks in other regions or sectors in order to provide liquidity if demand is unusually high, when one region suffers a banking crisis, the other regions suffer a loss because their claims

on banks in the troubled region fall in value. If this spillover effect is strong enough, it causes a crisis in adjacent regions. The crisis gets stronger as it passes from region to region and becomes a contagion (Allen and Gale, 2000; Eisenberg and Noe, 2001). In addition, multi-asset, rational expectations models have also been used to show how macroeconomic risk factors and country-specific asymmetric information can combine to produce contagion (Kodres and Pritsker, 2002).

On the whole, the book provides a very comprehensive and interesting review of literature, both theoretical and empirical, on the origin and nature of crisis and the contagion. The book has not really touched upon issues related to the impact of a crisis and the lessons to be drawn to avert a future crisis. Issues related to the current sub-prime crisis are also not covered in this book except in the introduction. Nevertheless, the theme of the book is highly topical and relevant in the present context. It presents a very vivid picture of the variety of crises that have hit the world during the period 1880-1997 and thus, lays the framework for analysing the 2007-08 crisis. This well-timed book will find wide readership among policy makers and researchers.

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