Volatility Persistence and the Feedback Trading Hypothesis: Evidence from Indian Markets

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Abstract

The relationship between feedback trading and volatility persistence has been well-documented in Finance with evidence largely in favour of their significant joint presence. This suggests that feedback traders are capable of bearing a destabilizing influence over securities' prices, an issue of key importance especially in the emerging markets' context due to those markets' incomplete regulatory frameworks and vulnerable structures. We study the feedback trading dynamics in Indian capital markets on the premises of five indices (BSE30/BSE100/BSE200/S&P CNX500/NIFTY50) during the post-liberalization (1992-2008) period in order to gauge whether feedback traders there can be associated with the underlying volatility. Our results indicate that while volatility remains significant throughout the period, feedback trading becomes depressed after 1999 and we interpret these results in light of the evolutionary transformation of Indian capital markets during the post-1999 period.

JEL Classification: G10; G15

Keywords: Feedback trading; Volatility; Indian markets

I. Introduction

The concept of feedback trading refers to the investment practice whereby traders rely upon historical prices in their conduct; contingent upon which direction investors trade in with respect to past returns, feedback trading can be either *positive* (co-directional) or *negative* (counter-directional). Feedback trading, thus constitutes an umbrella-term encompassing several price-based modes of investment widely researched in Finance, including contrarian trading (e.g. De Bondt and Thaler, 1985; 1987), momentum trading (e.g. Jegadeesh and Titman, 1993; 2001) and technical analysis (e.g. Lo et al, 2000).

A fact that has been empirically established in the Finance literature relates to the association between feedback trading and volatility persistence. A series of studies, both in developed (Sentana and Wadhwani, 1992; Koutmos, 1997; Watanabe, 2002; Bohl and Reitz, 2004; Antoniou et al, 2005b; Bohl and Reitz, 2006) as well as emerging (Koutmos and Saidi, 2001; Nikulyak, 2002; Malyar, 2005; Koutmos et al, 2006) capital markets have shown that positive feedback trading induces negative return-autocorrelation whose magnitude grows as volatility increases. What is more, positive feedback trading appears to be associated with the well-documented asymmetric behavior of volatility (Bollerslev et al, 1994) since it has been found to be more significant during market declines as opposed to market upswings.

The issue of the relationship between feedback trading and volatility bears an interesting connotation in terms of financial regulation, as the dominance of feedback traders in the market can well lead to destabilizing phenomena with prices deviating wildly from their fundamental values (De Long et al, 1990). This appears to be more appealing in the case of emerging capital markets, whose incomplete regulatory environments (Antoniou et al, 1997) tend to impact adversely upon areas, such as corporate disclosure and information quality, thus compromising the transparency (Gelos and Wei, 2002) of those markets and encouraging phenomena of trend-chasing behavior.

Interestingly enough, although India constitutes one of the fastest growing emerging markets, the issue of feedback trading and its relationship to volatility has largely been overlooked in its context. To that end, we aim at covering this gap by studying the behavior of feedback trading in Indian capital markets on the premises of several market indices (BSE30/BSE100/BSE200/S&P CNX500/S&P CNX NIFTY50) for the January 1992 – March 2008 period. The choice of the latter was motivated by the fact that 1992 was the year that marked the start of the country's financial liberalization process and thus would allow us the opportunity of studying the behavior of feedback trading in an evolutionary fashion for the entire period of the liberalization of Indian capital markets.

We believe our study to serve three particular objectives: a) to produce an original contribution to the Finance literature by investigating the relationship between feedback trading and volatility from a market's evolutionary perspective (something which to the best of our knowledge has never been attempted before), b) to test (for the first time) internationally established facts regarding feedback trading in the Indian markets' context and c) to gauge whether the evolutionary behavior of feedback trading raises any issues of regulatory nature with regards to Indian markets.

Our paper is structured as follows: section II includes a review of the literature relevant to feedback trading and section III contains a brief overview of the evolution of Indian capital markets. Section IV discusses the data (IV. a) and the methodology (IV. b) employed to conduct our empirical investigation and presents some descriptive statistics (IV. c). Section V presents and discusses the results and section VI concludes.

II. Literature Review

The study of feedback trading has been at the core of a considerable amount of research, more so following the advent of behavioural finance in the 1980s. In general, feedback traders formulate their investment strategies on the premises of recognized patterns, i.e. trends (De Long et al, 1990). If they buy (sell) following recent price rises (falls), they are said to be positive feedback traders; if on the other hand they buy (sell) when prices fall (rise), they are said to be negative feedback traders. In other words, the very foundations of feedback trading lie in the perception that prices maintain some sort of inertia in the market (Farmer, 2002), in the sense that they tend to produce directional patterns (trends) for certain periods of time, a fact that places feedback trading at odds with the efficient markets' hypothesis (Fama, 1970).

Feedback trading can be reflected in a variety of widely researched trading strategies, such as: a) *momentum trading* (Jegadeesh and Titman, 1993; 2001;

Chordia and Shivakumar, 2002; Antoniou et al, 2007) whereby investors sell "losers" (stocks that have performed poorly) and buy "winners" (stocks that have performed well) on the basis of their performance throughout the year; b) *contrarian trading* (De Bondt and Thaler, 1985; 1987; Mun et al, 1999; Antoniou et al, 2005a) when investors are trading contrary to the prevalent trend suggested by past prices and according to which they buy past "losers" and sell past "winners"; and c) *technical analysis* (Bessembinder and Chan, 1995; Ito, 1999; Ratner and Leal, 1999; Lo et al, 2000; Fong and Yong, 2005) whereby investors use an array of price-based, trading rules (e.g. moving averages) to predict future prices by extrapolating from their historical movements.

The roots of feedback trading can be traced in a series of considerations of both "irrational" as well as "rational" nature. On the "irrational" side, one can refer to several behavioural biases documented in the literature as being relevant to both positive as well as negative feedback trading.

Regarding positive feedback trading, Barberis et al (1998) demonstrated how the interplay of the *representativeness heuristic* (i.e. drawing conclusions about a general population by overweighting a sample of recent observations and considering it as representative of its properties) and the *conservatism bias* (i.e. the slow updating of beliefs in light of new evidence) are capable of leading investors towards "seeing" trends in stock prices. *Overconfidence* (Odean, 1998) as a bias is also relevant with respect to positive feedback trading; if one were to follow a certain pattern of trading and events were to confirm its credibility, then one would have every reason to feel overtly "proud" as to the fact that his "mode" of trading is the "right" one. As a result, this may lead him to attribute his success to his foresight ("*self-attribution*" bias; see Barberis and Thaler, 2002) and believe (ex post) that he had somehow managed to predict this development before it even occurred. The latter, known as the "*hindsight-bias*" (Barberis and Thaler, 2002), is expected to furnish him with the belief that he is able to predict the future as well. This will boost his purported overconfidence, thus leading him to trade more aggressively (Odean, 1998) and as such can reinforce positive feedback trading tendencies by encouraging more traders to trade in the same direction aiming at replicating his success (Shiller, 1990).

With respect to negative feedback trading, a behavioural bias that can facilitate its practice (Brown et al, 2006) is the so-called *disposition-effect* documented by Shefrin and Statman (1985). The latter advocates the sale of stocks that have recently performed well and the holding of stocks that have recently performed poorly due to anticipation of a mean-reversion for "winner" stocks (hence the consideration here is to sell them before their price starts declining) and a price-rebound for "loser" ones (hence, hold onto them until their prices exhibit a rise). As a result, the prevalence of the disposition-effect in the market can foster a more widespread manifestation of contrarian trading.

However, feedback trading need not necessarily be founded upon behavioural considerations alone. If the impact of noise traders in the market grows large enough to drive prices away from fundamentals ("noise trader risk"; see Barberis and Thaler, 2002), De Long et al (1990), Farmer (2002), Farmer and Joshi (2002) and Andergassen (2003) showed that this may prompt rational speculators to resort to feedback strategies in order to take advantage of this mispricing. As rational speculators have been primarily identified with institutional investors (De

Long et al, 1990) in capital markets (more so in view of their leverage[1]), much research has been devoted to the examination of their investment patterns with results being suggestive of them exhibiting a strong preference towards positive feedback trading internationally (Brennan and Cao, 1990; Lakonishok et al, 1992; Grinblatt et al, 1995; Jones et al, 1999; Nofsinger and Sias, 1999; Wermers, 1999; Iihara et al, 2001; Griffin et al, 2003; Sias, 2004; Voronkova and Bohl, 2005; Do et al, 2006; Walter and Weber, 2006).

Examples of feedback strategies often employed by rational speculators include *portfolio insurance* (Luskin, 1988) and *stop-loss orders* (Osler, 2002); these strategies are aimed at protecting these traders from possible stock mispricing. If prices, for instance start falling and investors wish to minimize their losses, then the activation of stop-loss orders at a pre-determined price-level can lead them to endure reduced losses. These strategies are capable of bearing an impact over securities' prices, as they can push them even further down in case of a market decline, thus exacerbating positive feedback tendencies in the market. This, in turn would suggest that positive feedback trading would be expected to be more pronounced during market downturns, a fact confirmed in a series of empirical papers (Sentana and Wadhwani, 1992; Koutmos, 1997; Koutmos and Saidi, 2001; Watanabe, 2002; Antoniou et al, 2005b).

Perhaps more importantly, this asymmetric behaviour of feedback trading has been shown to be related to asymmetries in the volatility structure; the latter relate to the well-documented phenomenon (Bollerslev et al, 1994) whereby volatility exhibits larger increases following negative returns compared to (equally large) positive returns. In other words, the above studies imply a simultaneous presence of

[1] See Wermers (1999) and Sias (2004).

significant positive feedback trading and higher volatility during market slumps. What is more, these studies suggest that the relationship between feedback trading and volatility is also a function of the underlying return-autocorrelation. More specifically, positive feedback trading has been found (Sentana and Wadhwani, 1992; Koutmos, 1997; Koutmos and Saidi, 2001; Bohl and Reitz, 2004; Antoniou et al, 2005b; Bohl and Reitz, 2006; Koutmos et al, 2006) to induce negative return autocorrelation, the magnitude of which increases with volatility. This is in line with several studies (Le Baron, 1992; Campbell et al, 1993; Säfvenblad, 2000; Laopodis, 2005; Faff and McKenzie, 2007) whose evidence indicates that autocorrelation tends to decrease as volatility increases.

The relationship between feedback trading and volatility as depicted above, poses an issue of substantial interest to the regulatory authorities, since the dominance of positive feedback trading can exacerbate volatility and lead to destabilizing market outcomes (De Long et al, 1990). This is more so in emerging market jurisdictions, which are characterized by the presence of incomplete regulatory frameworks (Antoniou et al, 1997) and low levels of transparency (Gelos and Wei, 2002). Under these conditions, corporate disclosure is bound to exhibit deficiencies, thus compromising the credibility of public information and rendering investors more susceptible to trend-chasing practices.

Despite the large amount of international evidence on the feedback trading hypothesis in relation to volatility persistence, this issue appears to have been largely overlooked in the Indian context, even though India constitutes one of the fastest growing emerging markets internationally. In view of this gap, our study aims at addressing this hypothesis in Indian markets in order to provide a comprehensive picture of their feedback trading dynamics.

III. A brief overview of Indian capital markets

Indian capital markets trace their roots back to the 19^{th} century, yet it was not before the 1990s that they opened their doors to foreign investment (Kotha and Marisetty, 2006). The liberalization process that commenced in 1992 allowed foreign investors to invest directly in the stock markets and enjoy certain tax benefits (e.g. dividend tax was abolished after 1997). Excluding the 21 regional exchanges, the two key ones, namely the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE) are based in Mumbai and dominate the equity-trading activity in India. Following the Asian crisis (1997-8), Indian markets embarked onto a period of fundamental transformation expressed through the introduction of several innovations including futures (June 2000), options (June 2001) and exchange-traded funds (January 2002) and the launch of online trading (February 2000). The market recovered from the Dot Com crash in 2001 and by 2002 began a rally that saw it rising over six times by December 2007. That period also coincided with a dramatic rise in the trading activity of foreign institutional investors with net investments well in excess of USD$50 billion between January 2002 and December 2007[2].

IV. Data and Methodology

IV.a Methodology

To investigate the relationship between feedback trading and volatility persistence, we shall rely upon the empirical framework introduced by Sentana and

[2] Source: Securities and Exchange Board of India (SEBI).

Wadhwani (1992), whose model assumes two types of traders: “rational speculators”, who maximize their expected utility and “feedback traders” who trade on the basis of historical prices. The demand function of the rational speculators is as follows:

$$Q_t = \frac{E_{t-1}(r_t) - \alpha}{\theta \sigma_t^2} \tag{1}$$

where Q_t represents the fraction of the shares outstanding of the single stock (or, alternatively, the fraction of the market portfolio) held by those traders, $E_{t-1}(r_t)$ is the expected return of period t given the information of period t-1, α is the risk-free rate (or else, the expected return such that $Q_t = 0$), θ is a coefficient measuring the degree of risk-aversion and σ_t^2 is the conditional variance (risk) at time t.

The demand function of the feedback traders is expressed as:

$$Y_t = \gamma r_{t-1} \tag{2}$$

where γ is the feedback coefficient and r_{t-1} is the return of the previous period (t-1) expressed as the difference of the natural logarithms of prices at periods t-1 and t-2 respectively. A positive value of γ implies the presence of positive feedback trading, while a negative value indicates the presence of negative feedback trading.

According to Sentana and Wadhwani (1992) all shares must be held in equilibrium:

$$Q_t + Y_t = 1 \tag{3}$$

Substituting the corresponding demand functions in equation (3) we have:

$$E_{t-1}(r_t) = \alpha - \gamma r_{t-1}\,\theta\,\sigma_t^2 + \theta\,\sigma_t^2 \tag{4}$$

To transform equation (4) into a regression equation, we set:

$r_t = E_{t-1}(r_t) + \varepsilon_t$, where ε_t is a stochastic error term and by substituting into equation (4) the latter becomes:

$$r_t = \alpha - \gamma r_{t-1}\,\theta\,\sigma_t^2 + \theta\,\sigma_t^2 + \varepsilon_t \tag{5}$$

where r_t represents the actual return at period t and ε_t is the error term. To allow for autocorrelation due to non-synchronous trading or market frictions, Sentana and Wadhwani (1992) develop the following empirical version of equation (5):

$$r_t = \alpha + \left(\phi_0 + \phi_1\sigma_t^2\right)r_{t-1} + \theta\sigma_t^2 + \varepsilon_t \tag{6}$$

where ϕ_0 is designed to capture possible non-synchronous trading effects and $\phi_1 = -\theta\gamma$.

As equation (5) shows, return autocorrelation in this model rises with the risk in the market (σ_t^2) as indicated by the inclusion of the term $\gamma r_{t-1}\,\theta\,\sigma_t^2$; as a result, the higher the volatility grows, the higher the autocorrelation. Regarding the sign of this autocorrelation, it will be a function of the sign of the feedback trading prevalent; if positive (negative) feedback traders prevail, then the autocorrelation will be negative (positive) as equation (5) shows.

To control for possible asymmetric behavior of feedback trading contingent upon the market's direction, Sentana and Wadhwani (1992) extend equation (6) as follows:

$$r_t = \alpha + \left(\phi_0 + \phi_1 \sigma_t^2\right) r_{t-1} + \theta \sigma_t^2 + \phi_2 \left| r_{t-1} \right| + \varepsilon_t \tag{7}$$

As the above equation suggests, positive values of ϕ_2 (ϕ_2 > 0) indicate that positive feedback trading grows more significant following market declines as opposed to market upswings. Thus, the coefficient on r_{t-1} now becomes:

$$\begin{array}{lll} \phi_0 + \phi_1 \sigma_t^2 + \phi_2 & if & r_{t-1} \geq 0 \\ \phi_0 + \phi_1 \sigma_t^2 - \phi_2 & if & r_{t-1} < 0 \end{array}$$

In order to test for feedback trading with the Sentana and Wadhwani (1992) model, we have to specify the conditional variance (indicated by the σ_t^2) in equation (7). The conditional variance σ_t^2 is modeled here as an Asymmetric GARCH (AGARCH) process (Glosten et al, 1993):

$$\sigma_t^2 = \omega + \beta\ \varepsilon_{t-1}^2 + \gamma \sigma_{t-1}^2 + \delta S_{t-1} \varepsilon_{t-1}^2 \tag{8}$$

Here δ captures the asymmetric responses of volatility during positive versus negative innovations. S_t is a binary variable equalling one if the innovation at time *t* is negative and zero otherwise. If δ is positive and statistically significant then negative innovations increase volatility more that positive innovations. The aim here is to use a conditional variance model capable of capturing the well-documented asymmetric effects of volatility and allow us to examine any link between those effects and the asymmetric behaviour of feedback trading tested for through equation (7).

Finally, to examine whether the behaviour of feedback trading (and its concomitant relationship with volatility persistence) exhibits differences over time, we will rely upon the employment of the rolling windows' technique, in line with

Antoniou et al (2005b) by running equation (7) using 2-, 3- and 4-year rolling windows in order to establish the robustness of our results.

IV.b Data

Our data involves daily[3] closing prices from five market indices[4]: three from the Bombay Stock Exchange (BSE30, BSE100, BSE200) and two from the National Stock Exchange (S&P CNX500, S&P CNX NIFTY50); the data have been obtained from the DataStream database and the National Stock Exchange (NSE) website. Our sample covers the period between 1/1/1992 and 31/3/2008 and was chosen with the intention of covering the period of financial liberalization of Indian markets which commenced in 1992.

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[3] The employment of data at the daily frequency is made here in order to minimize the amount of noise in the data. The stock market is a trading mechanism where there exists continuous flow of information, reflected in the prices. Lower-frequency (e.g. weekly, monthly, quarterly, annual) data essentially capture less detail of the price-formation process compared to daily data. In the absence of the availability of intra-day data, we believe that the employment of daily data allows us the best possible depth in the price-formation process to study the presence of feedback trading.

[4] We choose to work on the premises of market indices rather than individual stocks due to several considerations. The fact that new stocks are listed and existing ones are delisted from the market inevitably implies that, were we to use individual stocks in the present study, we would probably come across the survivorship bias. Including only those stocks with available data for the 1992-2008 period would mean excluding a substantial number of stocks, many of which went public at some point during the period (especially during the market rally of 2002-7), thus extracting an incomplete picture of the feedback trading dynamics in India. On the other hand, including these stocks would probably mean that we would be testing for feedback trading using different testing windows for stocks with different data-availability; we believe that this would be detrimental for the consistency of our results. Issues of data availability for several stocks might further compound this problem.

What is more, as the Indian markets are highly concentrated, thin trading would be expected to prevail among several stocks and as Antoniou et al (1997) have shown, its presence has the potential of inflating autocorrelation in returns. This in turn would produce biased estimates for feedback trading (since the model-framework we are using captures feedback trading via return-autocorrelation) and would require correcting for thin trading using some established methodology. However, this would raise the issue of setting a criterion to distinguish between "thin" and "heavily" traded stocks which again would be subject to value judgement. Further to the above, the Sentana and Wadhwani (1992) model has thus far been applied only to market indices, not individual stocks; using market indices to test for feedback trading on its premises here can only be beneficial for our work in the interest of comparability with other studies.

IV. c Descriptive Statistics

Descriptive statistics for the daily log-differenced returns of the BSE30/BSE100/BSE200/S&P CNX500/NIFTY50 indices are provided in Table 1. The statistics reported are the mean (μ), the standard deviation (σ), measures for skewness (S) and kurtosis (K) and the Ljung–Box (LB) test statistic for ten lags. The skewness and kurtosis measures indicate departures from normality (returns-series appear significantly negatively skewed[5] and highly leptokurtic).

Rejection of normality can be partially attributed to temporal dependencies in the moments of the series. It is common to test for such dependencies using the Ljung–Box portmanteau test (LB) (Bollerslev et al., 1994). The LB-statistic is significant for the returns-series of all five indices. This provides evidence of temporal dependencies in the first moment of the distribution of returns, due to, perhaps nonsynchronous trading or market inefficiencies. However, the LB-statistic is incapable of detecting any sign reversals in the autocorrelations due to positive/negative feedback trading. It simply provides an indication that first-moment dependencies are present. Evidence on higher order temporal dependencies is provided by the LB-statistic when applied to squared returns. The latter is significant and always higher than the LB-statistic calculated for the returns, suggesting that higher moment temporal dependencies are pronounced.

Table 1: Sample Statistics

	BSE30	BSE100	BSE200	S&P CNX 500	NIFTY 50
μ	0.04904516948	0.05209441039*	0.04947760677	0.04381505624	0.05367369434

[5] The skewness for the BSE30 and BSE100 appears negative yet statistically insignificant.

σ	1.68968602172	1.66270940371	1.65738871581	1.63944592857	1.73511994336
S	0.06551	-0.01329	-0.09800**	-0.50687**	-0.20708**
K	8.72088**	7.33290**	9.74771**	7.91296**	5.86193**
LB(10)	61.18148218**	82.88337143**	106.5164231**	120.1586296**	88.19472402**
$LB^2(10)$	461.640477**	650.538794**	915.7534587**	967.7522844**	1271.083145**

(= 5% sign. Level, ** = 1% sign. Level).μ = mean, σ = standard deviation, S = skewness, K = excess kurtosis, LB (10) and LB^2 (10) are the Ljung-Box statistics for returns and squared returns respectively distributed as chi-square with 10 degrees of freedom. Sample window: 1/1/1992 – 31/3/2008.*

V. Results - Discussion

We now turn to the presentation of our empirical findings from the Sentana and Wadhwani (1992) model. As Table 2 indicates, the coefficients describing the conditional variance process, ω, β, γ and δ, are statistically significant (5 percent level) in most cases.

We notice that δ is positive for all five indices implying that negative innovations tend to increase volatility more than positive ones[6]; however, its significance is confined to the BSE30, BSE100 and NIFTY50 indices. For additional insight into the asymmetric behaviour of volatility, we construct the asymmetric ratio ($(\beta+\delta)/\beta$)in line with Antoniou et al (2005b)[7]; results indicate that the indices of our sample are more volatile during market slumps as opposed to market upswings, since the value of the ratio is above unity. It is further interesting to note, however, that the size of the ratio's value is a function of the significance of δ; the two indices

[6] Similar findings in favour of asymmetric volatility in India are reported by Kaur (2004) and Pandey (2005).

[7] As Antoniou et al (2005b) show, the contribution of a positive innovation is reflected in β while the contribution of a negative innovation by the sum of $\beta+\delta$. An asymmetric ratio value greater than unity, would illustrate that negative innovations contribute more to market volatility than positive ones.

(BSE200, S&P CNX 500) with insignificant δ–values are those with the smaller asymmetric ratio values. Thus, our evidence suggests that volatility asymmetries do exist in Indian markets, yet appear weaker for broader indices (BSE200, S&P CNX500).

The β and γ coefficients are significant in all five cases, indicating that volatility exhibits high autocorrelation and persistence, respectively; in other words, contemporaneous volatility appears to be significantly affected by both squared innovations as well as volatility one day back (since we are using the Glosten et al (1993) asymmetric GARCH (1,1) specification at the daily frequency). High volatility persistence for Indian indices is documented in a series of studies, such as Kaur (2004), Karmakar (2005) and Pandey (2005).To illustrate the persistence of volatility, we calculate the half-life of volatility as HL = ln (0.5)/ln($\beta + \gamma + \delta$ /2), in line with Harris and Pisedtasalasai (2005) and Li et al (2006) and in view of the Glosten et al (1993) asymmetric GARCH (1,1) framework. Our results indicate that volatility is highly persistent, since it is found to last anywhere between 26 days (the case of the NIFTY50) and 75 days (the case of the S&P CNX500). In general, the value of the half-life is a straight function of the size of the autoregressive component of volatility; the higher the value of γ, the more volatility is shown to last.

The ϕ_0 coefficient is reflective of significant positive first-order autocorrelation for all indices, a fact that could be associated perhaps to non-synchronous trading or market frictions. The feedback coefficient (ϕ_1) is indicative of statistically significant positive feedback trading for our five indices. This is in line with a series of studies that have tested for feedback trading in various international settings (Sentana and Wadhwani, 1992; Koutmos, 1997; Koutmos and Saidi, 2001; Nikulyak, 2002; Watanabe, 2002; Bohl and Reitz, 2004; Antoniou et al, 2005b; Malyar, 2005;

Bohl and Reitz, 2006; Koutmos et al, 2006) and confirms the feedback trading hypothesis as regards volatility persistence in India. It is worth noting, however, that feedback trading in India is not characterized by directional asymmetry; although the ϕ_2 coefficient is positive for all our tests, it never exhibits statistical significance.

Table 2: Maximum likelihood estimates of the Sentana and Wadhwani (1992) model

Conditional Mean Equation: $r_t = \alpha + (\phi_0 + \phi_1\sigma_t^2)r_{t-1} + \theta\sigma_t^2 + \phi_2|r_{t-1}| + \varepsilon_t$

GJR Conditional Variance Specification: $\sigma_t^2 = \omega + \beta\ \varepsilon_{t-1}^2 + \gamma\sigma_{t-1}^2 + \delta S_{t-1}\varepsilon_{t-1}^2$

Parameters	BSE30	BSE100	BSE200	S&P CNX 500	NIFTY 50
α	0.0668 (0.0372)	0.0454 (0.0326)	0.0513 (0.0413)	0.0410 (0.0338)	0.0538 (0.0313)
ϑ	-0.0206 (0.0140)	-0.0135 (0.0144)	-0.0071 (0.0133)	0.0068 (0.0165)	-0.0167 (0.0128)
ϕ_0	0.1583 (0.0219)**	0.2266 (0.0241)**	0.2182 (0.0187)**	0.2197 (0.0254)**	0.1876 (0.0197)**
ϕ_1	-0.0119 (0.0043)**	-0.0184 (0.0042)**	-0.0141 (0.0033)**	-0.0171 (0.0065)**	-0.0113 (0.0029)**
ϕ_2	0.0302 (0.0266)	0.0249 (0.0293)	0.0077 (0.0324)	-0.0178 (0.0297)	0.0368 (0.0279)
ω	0.0510 (0.0208)*	0.0609 (0.0189)**	0.0722 (0.0320)*	0.0304 (0.0193)	0.0920 (0.0277)**
β	0.0717 (0.0170)**	0.0863 (0.0184)**	0.0888 (0.0208)**	0.0589 (0.0148)**	0.0960 (0.0155)**
γ	0.8941 (0.0203)**	0.8664 (0.0191)**	0.8641 (0.0308)**	0.9202 (0.0251)**	0.8398 (0.0272)**
δ	0.0398 (0.0176)*	0.0631 (0.0316)*	0.0461 (0.0413)	0.0235 (0.0201)	0.0746 (0.0319)*
($\beta+\delta$)/β	1.5550	1.7308	1.5192	1.3980	1.7774
Half-Life	48.3	43.5	28.4	75.2	25.5

(= 5% significance level, ** = 1% significance level). Parentheses include the standard errors of the estimates; sample period: 1/1/1992-31/3/2008.*

To test for the robustness of our results over time, we run the Sentana and Wadhwani (1992) model using rolling windows of two, three and four years' length rolled every 30 days. For illustration purposes, we present a synthesis of the significance-areas of feedback trading from our rolling windows' tests in Figures 1-5 for each of the five indices of our sample. Our results reveal that all five indices are characterized by persistent positive feedback trading throughout the sample

Figure 1: Positive Feedback Trading Significance for the BSE30

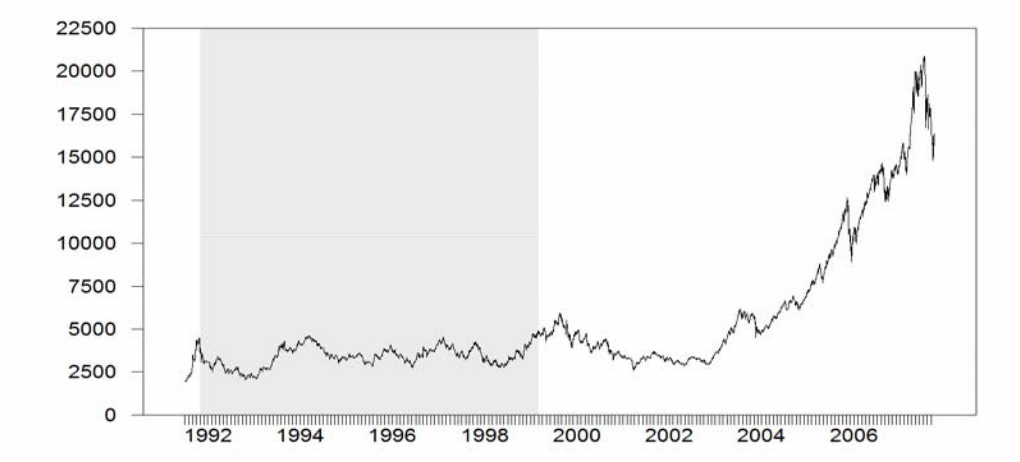


Figure 2: Positive Feedback Trading Significance for the BSE100

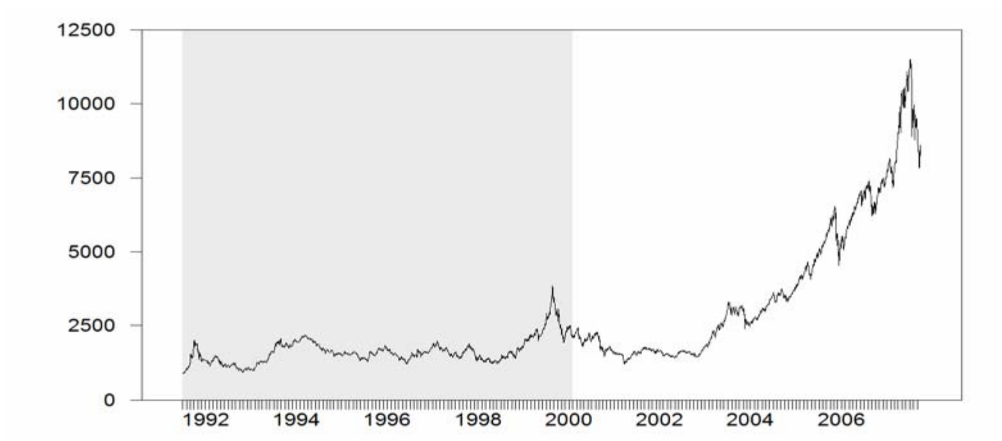


Figure 3: Positive Feedback Trading Significance for the BSE200

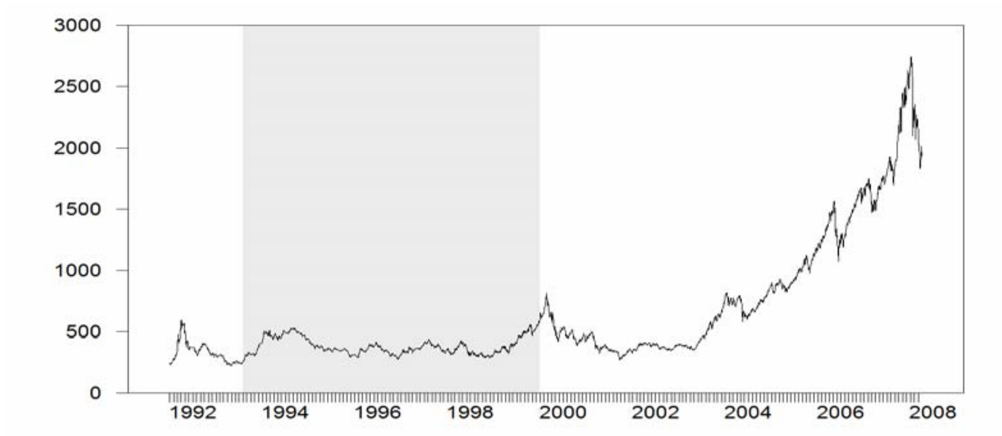


Figure 4: Positive Feedback Trading Significance for the S&P CNX500

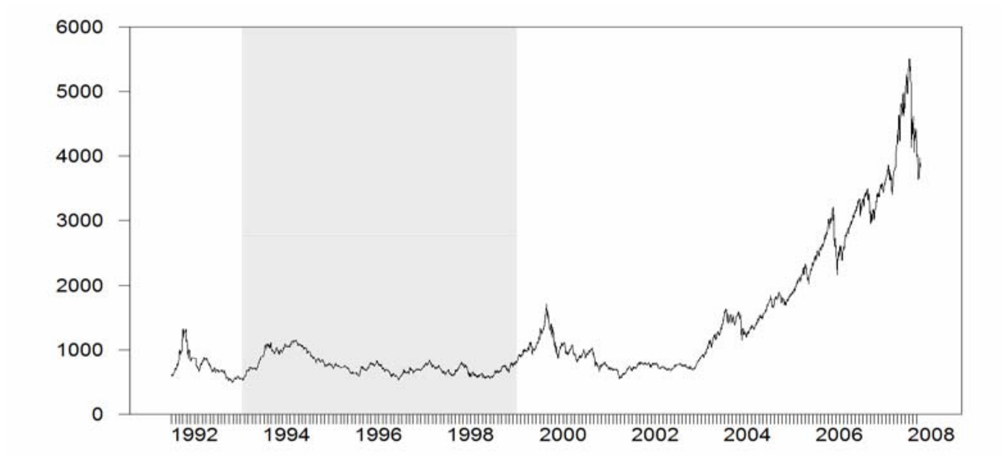
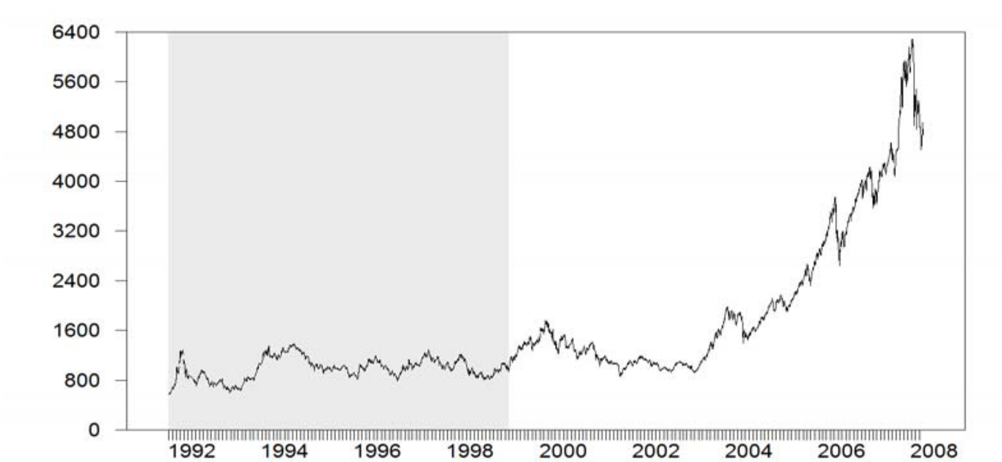


Figure 5: Positive Feedback Trading Significance for the NIFTY50



period. However, it appears that the significance (5 percent level) of it manifests itself only during the first half of the 1992-2008 period, as it begins to gradually dissipate following the summer of 1999[8] for all indices. Moreover, results further confirm the presence of significant (5 percent level), albeit declining[9], positive autocorrelation (reflective through the ϕ_0 coefficient) during our sample period and the absence of directional asymmetry in the manifestation of feedback trading, as the ϕ_2 coefficient exhibits scant significance for all indices. As per volatility, its persistence remains significant (5 percent level) throughout the whole period, while volatility asymmetries were found to be more prevalent (and significant at the 5 percent level) after year 1995, suggesting that they have constituted an inherent property of Indian indices for the bulk of the post-liberalization years.

Let us now try to synthesize our results in order to come up with an integrated picture of our findings. First of all, the demise of the positive feedback trading significance after 1999 combined with the uninterrupted significance of the volatility's persistence and asymmetries during the 1992-2008 window suggests that the feedback trading hypothesis relative to volatility originally confirmed by our global sample results (Table 2) appears to be period-sensitive. This raises interesting issues, since the post-1999 period was characterized by a marked transformation of Indian markets with the expansion of the domestic mutual funds' industry, the introduction of new investment instruments (futures; options; exchange-traded

[8] The point in time where positive feedback trading starts becoming insignificant is (indices' names in brackets): May 1999 (NIFTY50); June 1999 (S&P CNX500); September 1999 (BSE30); January 2000 (BSE200); August 2000 (BSE100).
[9] Our rolling windows' tests reveal that the autocorrelation coefficient's values, although always significant, tend to descend over time, ranging from approximately 0.4 in the earlier periods to approximately 0.1 in the later ones.

funds) and online trading that helped render Indian markets more complete, as they allowed for additional channels of information-transmission into the market. What is more, that period also witnessed a surge in the trading activity in Indian markets, mostly due to foreign institutional investors (Ananthanarayanan et al, 2005), that fuelled the markets' rally between 2002 and 2007. A reasonable assumption here would be that the above broadened investors' participation, enhanced the quality of information (through the attraction of more sophisticated traders) and the information-flow (by boosting the volume of trade), and, therefore, led to the reduction of the impact of noise traders. If this were to be the case, the alleged improvements in the informational environment would probably be accompanied by an increase in market efficiency following year 1999.

Indeed, as mentioned previously, the size of the autocorrelation coefficient (ϕ_0) tends to decline over time, thus indicating a decline in the persistence of (positive) return autocorrelation as we move from 1992 to 2008. Such a decline could be attributed (Antoniou et al, 1997) to the reduction in the temporal dependencies of the time-series of Indian indices due to the intertemporal increase in the volume of trade[10] that allows for the incorporation of more information in prices. Since the Indian market is generally characterized by limited free-float, and given the large position foreign institutional investors command in its turnover (Ananthanarayanan et al, 2005), it is only reasonable to assume that their rising participation over time has contributed to efficiency by making prices more informative. Of course one should keep in mind that the ϕ_0 coefficient remains significant throughout our sample period thus, indicating that although Indian

[10] The idea here is that thin trading would inflate the autocorrelation of a time series due to the presence of several observations equalling zero.

markets have experienced a gradual reduction in the departures from efficiency over time, these inefficiencies have not disappeared.

Overall, our results indicate that the feedback trading hypothesis has ceased to hold for Indian indices following the post-1999 evolutionary transformation of the BSE and NSE; while the impact of feedback trading in Indian markets appears to have diminished from 2000 onwards, volatility is characterized by significant persistence throughout the 1992-2008 period. Whether the significance of volatility prior to 1999 was due to the impact of feedback traders and later, after 1999, the result of the introduction of new markets (e.g. derivatives or ETFs) and the unprecedented foreign institutional participation that accelerated the incorporation of information into the market remains an open question. It is further worth noting that while volatility exhibits significant asymmetries for most of the period under investigation (1996-2008), evidence on the asymmetric behaviour of feedback trading appears very weak. The above suggest that the significance and nature of volatility in India are independent of feedback trading. The rapid evolution of Indian markets following year 2000 appears to have conferred gradual improvements upon efficiency, yet seems to have produced no impact over volatility.

From the perspective of regulatory authorities and policymakers, our findings suggest that the evolutionary transformation of Indian markets has born beneficial effects as it has succeeded in curbing trend-chasing and generating a favourable (yet not significant) impact over market efficiency. However, the absence of change in the level and nature of volatility over the 1992-2008 window indicates that the risk-profile of these markets has not been affected and this is bound to raise serious concerns relative to risk management both from regulators/policymakers as well as the wider investment community.

VI. Conclusion

The relationship between volatility persistence and feedback trading has been widely investigated in Finance with results largely confirming its validity. As the impact of feedback traders rises, so does the potential for price volatility and destabilization, which is particularly concerning for emerging markets with regulatory structures still in the making. Despite the amount of work undertaken for several emerging markets on this issue, Indian markets have largely been overlooked. Our study addresses this gap by testing for the feedback trading hypothesis in five Indian indices during the post-liberalization (1992-2008) period of India.

Results indicate that positive feedback trading is evident throughout the period yet becomes insignificant after 1999; contrary to that, volatility exhibits significance in its persistence throughout the period. Volatility is found to maintain significant asymmetries during most (1996-2008) of the period under examination, yet the same cannot be argued for feedback trading whose directional asymmetries appear insignificant. As a result, our findings suggest that both the level and the nature of volatility manifest themselves independently from the significance of feedback trading. Consequently, the feedback trading hypothesis is confirmed only for the first half of our sample period. We attribute our findings to the evolutionary transformation in Indian markets from year 2000 onwards that, together with the increased participation of foreign institutional investors, contributed to the reduction of the impact of noise trading and paved the way towards the gradual enhancement of the markets' informational efficiency.

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