Order imbalance and returns: evidence from India

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Abstract

Purpose – The purpose of this paper is to study the empirical relationship between order imbalance and returns in the backdrop of structural changes in the Indian market.

Design/methodology/approach – The study makes use of hypothesis testing and dummy variable regression to investigate the relationship between order imbalance and returns during the period 1999-2005, which saw definitive change in the structure of the Indian markets.

Findings – Order imbalance (buying or selling pressure) has significantly reduced post the structural reforms at the daily as well as intra-day intervals across trade, as well as value measures of order imbalance. After controlling for the number of transactions, order imbalance and return correlations have fallen in the post-2002 period as compared to the pre-2002 period, at daily as well as intra-day intervals. Further, after controlling for past high and low returns, order imbalance exhibits day of the week effect in the pre-2002 period while no such effect is seen in the post-2002 period.

Originality/value – The work brings out order imbalance and returns relationship for the Indian market, which has different structure from that of many developed, as well as developing, markets in the backdrop of changes in its own structure. This would provide a richer literature in the area of market structure and design.

Keywords India, Markets, Returns, Trade, Order imbalance, Buyer-seller initiated, Rolling settlement, Pre-2002, post-2002

Paper type Research paper

I. Introduction

Structure of a market plays an important role in its efficiency. It determines the mechanism through which orders are collected and the process through the orders are executed by the exchange, thereby affecting prices and returns. The literature in developed markets has examined the effect of market design on returns and market efficiency. The issue of market efficiency has been examined by using lagged returns or lagged volume as explanatory variables for the current returns. However, volume could be higher in rising as well as in falling market and so it does not show an intuitively appealing relationship with returns (Chordia *et al.*, 2002). The limitation of trading volume could be addressed if it could be separated into the components of buyer-initiated volume and seller-initiated volume. These measures would reveal more information related to returns forecasting since in a rising market the buyer-initiated volume would be higher than the seller-initiated volume thus leading to positive returns while in a falling market the seller-initiated volume would be more than

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buyer-initiated volume leading to negative security returns. The difference between buyer-initiated volume and seller-initiated volume is termed as order imbalance and it intuitively seems a better measure of trading activity than only trading volume.

Chordia *et al.* (2002), using order imbalance to measure trading activity, study its relationship with stock returns and liquidity for the New York Stock Exchange (NYSE). Lee *et al.* (2003) study the association between order imbalance and returns for participants in the Taiwanese Stock Exchange (TSE). The results for the NYSE show that lagged returns and lagged order imbalance are significant and have higher explanatory power for current order imbalance while, for the TSE, the results do not show a higher explanatory power for these lagged measures. The NYSE is a hybrid market (both order-driven as well as quote-driven) involving continuous trading and specialists for each stock. The TSE, on the other hand, follows a call method of trading and has no specialists. The different structures of these markets may be responsible for different results.

The Indian market (National Stock Exchange, hereafter NSE) has a different structure from the NYSE and the TSE and has undergone structural changes, including compulsory rolling settlement and the introduction of internet trading, in the period 1999-2005. This provides an ideal setting to explore order imbalance and returns relationships for a market undergoing structural changes. The NSE introduced compulsory rolling settlement on January 1, 2002. We investigate the order imbalance-returns relationship by dividing the time period of 1999-2005 into pre-2002 (January 1999-December 2001) and post-2002 (January 2002-December 2005) periods. The study provides insight into order imbalance-returns relationships in a changing market structure setting and contributes to the literature in this area.

The paper is organized as follows. Section II reviews the literature, Section III presents the data and variable construction, Section IV describes the methodology, Section V presents the results and Section VI concludes.

II. Literature review

Market design plays a critical role in market efficiency. Majnoni and Massa (2001) and Singh (2010) analyze the impact of stock market reforms on market efficiency. For measuring and determining market efficiency, different variables are used. Nelson (1976) uses inflation, Rozeff (1984) uses dividend yield ratio, Basu (1977, 1983) and Cambell and Shiller (1988) use E/P ratio, Banz (1981) uses firm size and Fama and French (1992) use the book-to-market-value ratio. Apart from these firm-related measures, trading activity measures such as volume and order imbalance are also used to explain returns. Karpoff (1987) surveys studies on the relationship of volume and returns. However, as noted, order imbalance shows a more intuitive relationship with returns. Michayluk and Neuhauser (2008) find that measures such as volume are not affected by the direction of the trade, even though transactions may be solely seller initiated, solely buyer initiated or any combination of these. It makes a strong case for using order imbalance. The order imbalance and returns relationship has been examined in various markets. Blume *et al.* (1989) are among the first to use order imbalance to explain the differences in returns of the S&P 500 and non-S&P 500 stocks on October 19, 1987 (Black Monday). Sias (1997) using weekly NAV for 14 closed-end mutual funds and relative weekly order imbalance for 12 weeks, concludes that relative order imbalance influences closed-end mutual fund returns. Brown *et al.* (1997) find bi-directional causality between order imbalance and returns which do not last beyond a day. They also find that returns adjusted to the order imbalance within

a two-to-three-hour period. Chan and Fong (2000) find that order imbalance in large trade size categories affects the returns more than in smaller trade size categories. Chordia *et al.* (2002) note a significant relationship between contemporaneous returns and order imbalance after controlling for market volume and liquidity. In a subsequent study (2004), they explore the relationship between individual stock returns and order imbalance, finding that order imbalance is useful to predict future returns. They also observe that, subject to low transaction costs, positive abnormal returns can be earned using order imbalance data. Lee *et al.* (2003) examine the aggregate order imbalance of the top 30 stocks in the TSE and explore the relationship with returns. They find that domestic and foreign institutions have more persistence in order imbalance compared to individual traders.

In most of these studies, the order imbalance is estimated since exchanges rarely provide information on the trade direction of buyer- and seller-initiated trades. In the literature, the direction of trading is estimated either using the tick test and reverse tick test (when only information on trades is available), or the quote-based method or Lee and Ready (1991) algorithm (when trade and quote information are available).

The tick test uses successive price changes to infer whether the trade was buyer initiated or seller initiated. Thus, if the next trade occurs at a price higher than the previous trade (uptick), it is termed buyer initiated while if it occurs at a lower price (downtick) it is termed seller initiated. If the price remains the same (zerotick), it is considered buyer initiated if the previous trade was buyer initiated (also called zero uptick) and seller initiated if the previous trade was seller initiated (zero downtick).

The reverse tick test uses successive price changes to classify trades as buyer or seller initiated. However, unlike the tick test, the reverse tick test examines the subsequent price to classify the trade. Thus, if the next trade occurs at a higher price than the current trade, the current trade is classified as seller initiated and vice versa. If the price remains the same then it is termed seller initiated if the next trade is seller initiated (and termed buyer initiated if the next trade is buyer initiated).

Quote-based methods compare the most recent quote with the traded price. If the trade price is equal to or near the mid-point, it is classified as seller initiated and if it is equal to or near the asking price, it is classified as buyer initiated. The trades at the mid-point of the bid and ask are ignored for the purpose of classification.

The Lee and Ready (1991) algorithm is an improvement over the quote-based method since the quote taken to compare with the trade is at least five seconds before the trade time. Lee and Ready's study shows that there was a high probability that the new quotes after the trade were recorded ahead of the trade[1]. They ascribe this to the method followed in recording the quote and trade prices. The trade price is compared to the last bid/ask quote. If the trade price equals the ask quote, it is termed buyer initiated, and if it equals the bid quote it is termed seller initiated. If the trade price lies between the bid and ask, then if it is closer to the bid quote it is termed seller initiated and if it is closer to the ask, then it is termed buyer initiated. If the trade occurs at the mid-point of bid and ask, then the tick test method is used to identify whether the trade is buyer or seller initiated.

The literature is divided on the use of the tick test. Several authors evaluate the classification accuracy of these methods in different markets. Lee and Ready (1991) evaluate the performance of the quote-based method, the tick test and the reverse tick test in classifying trades into buyer and seller initiated. Their study uses data for 150 NYSE stocks and all AMEX stocks for 1988. They show that there is a high degree of agreement between the results of the quote-based method and the tick test, and that

the tick test method outperforms the reverse tick method. They also compare the classification using the recent quote (at least five seconds before the trade time) and the current quote (recorded just before the trade takes place) and conclude that classification based on the current quote is likely to be incorrect and they recommend using quotes which are at least five seconds before the trade time.

Aitken and Frino (1996) evaluate the accuracy of the tick test using Australian data in correctly classifying trades as buyer or seller initiated. For buyer-initiated trades they find an accuracy level of 75.1 percent while for seller-initiated trades the accuracy level is 73.7 percent. For downtick trades the accuracy is 92.8 percent while for uptick trades the accuracy is 90.6 percent. Thus if zerotick trades are removed from the sample the accuracy is above 90 percent.

Finucane (2000) examines the classification accuracy of all three methods: the tick test, the reverse tick test and the Lee and Ready algorithm. The study uses a unique database containing trades, orders and quotes for 144 NYSE firms for a three-month period. The database identifies the direction of trade and thus helps in comparison. The study classifies buyer- and seller-initiated trades using the three methods to determine the accuracy. For the tick test the accuracy level is 83 percent while for the Lee and Ready algorithm it is 84 percent. If the zero ticks are removed, the classification accuracy improves to 95.6 percent for the tick test and 95.8 percent for the Lee and Ready algorithm. The performance of the reverse tick test is 72.1 percent for all the trades and 79.6 percent for non-zero tick trades. The study concludes that the performance of the tick test is the same as the Lee and Ready algorithm and may be used for trade classification.

In the present study we estimate order imbalance using the tick test since continuous quotes data are not available. In the first stage we estimate order imbalance for all NSE stocks which are part of the S&P CNX Nifty Index (the S&P CNX Nifty Index is owned and managed by India Index Services & Products Ltd (IISL), which is a joint venture between CRISIL and NSE, where CNX stands for CRISIL NSE Indices). We aggregate the order imbalance using the market capitalization as weights. We compute order imbalance measures at daily as well as intra-day intervals of 120 and 60 minutes for the S&P CNX Nifty Index using the trade data for component stocks given by NSE. We investigate the changes in these measures for the pre-2002 and post-2002 periods. Next we investigate the changes in the order imbalance variable in the pre-2002 and post-2002 periods as well as its relation with returns in these two periods. Studies of the Indian market find day-of-the-week regularity in returns (Gupta, 2006) in the pre-2002 period while the post-2002 period exhibits no such regularity. This may suggest similar regularity in the order imbalance since order imbalance causes price pressures and ultimately has an impact on returns. We check for the day-of-the-week effect in order imbalance in the pre-2002 and post-2002 periods. Finally we compare the order imbalance-returns correlations in the pre-2002 and post-2002 periods. We expect a decrease in the order imbalance-returns correlation in the post-2002 period compared to the pre-2002 period to reflect improved market design. The next section includes the details of variable construction for this study.

III. Data and variable construction

This study uses data on intra-day trades for the S&P CNX Nifty Index as well as the S&P CNX Nifty component stocks (i.e. 50 stocks) for the January 1999-December 2005 period. The data were obtained from the NSE. In the trades data provided by NSE there is no information on whether a trade was buyer or seller initiated. Researchers must infer the direction of trade using appropriate methods.

Variable construction

Using the tick test, we classify each trade (for each of the 50 stocks) as buyer or seller initiated and aggregate them over the study time interval. We use intra-day trades data and constructs order imbalance and returns variables for the intervals of daily, 120 and 60 minutes for the analysis of the entire period from 1999 to 2005. The aggregate of buyer-initiated trades less the aggregate of seller-initiated trades gives us the order imbalance for a given interval, measured by the number of trades, Oibn (number of buyer-initiated trades less the number of seller-initiated trades) and volume-traded Oibv (buyer-initiated trade value less the seller-initiated trade value). The Oibv measure of order imbalance is broad based. These stockwise order imbalance measures are weighted by the market capitalization of the stock to obtain the weighted order imbalance for the S&P CNX index in line with the method adopted by Chordia *et al.* (2002). Also, for the study period, NSE followed the total float method to compute the indices and we use the same method (NSE shifted to the free float method of index computation from June 26, 2009). Studies on the accuracy of the tick test to determine trade direction suggest that the classification accuracy of the tick test is reduced if zerotick trades are being classified (Lee and Ready, 1991; Aitken and Frino, 1996; Finucane, 2000). In this study we separately classify the non-zero tick trades and then use them in computing the order imbalance. For each stock, all the trades (except the zerotick trades) are classified using the tick test into buyer- and seller-initiated trades. After this, the order imbalance is computed for each of the intervals (daily, 120 and 60 minutes). For each of the intervals the order imbalances are aggregated using the market capitalization of the stocks to compute the weighted order imbalance for the S&P CNX Nifty (for each stock, its last year market capitalization is used to compute the weights). Similarly, the weighted volume and weighted number of transactions are computed for the index. The returns are computed using the S&P CNX Nifty Index trade-to-trade returns for each of the intervals. This series has been selected for the purpose of association with order imbalance since it exhibits nearly zero serial correlation for the period of our study.

We construct the following variables of order imbalance:

- Oibn: order imbalance of number of trades.
- Oibv: order imbalance of value of trades in Rs millions (Rs mn).
- Oibn/Numtrans = ScaledOibn: order imbalance of trades divided by number of transactions.
- Oibv/Numtrans = ScaledOibv: order imbalance of value divided by the number of transactions. The figures for this variable are in thousands.
- Returns: we measure trade-to-trade returns. The figures are in percentages.
- Vol: traded volume in Rs mn.
- Numtrans: number of trades or transactions in a given interval (daily/120 minutes/60 minutes).

IV. Methodology

Studies of the Indian market find day-of-the-week regularity in the returns (Nath and Dalvi, 2005), which may suggest a similar regularity in the order imbalance since order imbalance causes price pressures that ultimately affect returns. We expect a similar

day-of-the-week effect in the order imbalance. Future orders may also be affected by past market returns. However, the effect may be different for positive and negative returns. This behavior in aggregate would be reflected in the net imbalance that the market achieves. Investors choose to buy if they find higher returns in the past and vice versa. To check for different possible responses due to past positive and negative returns, we separate out positive and negative returns in the model.

We use the same model proposed by Chordia *et al.* (2002) to examine the determinants of order imbalance:

$$Oibn_t = \alpha + \sum_{Day=Mon}^{Thu} \beta_{Day} D_{Day} + \sum_{i=1}^{5} \gamma_i Min(0, R_{t-i}) + \sum_{i=1}^{5} \delta_i Max(0, R_{t-i}) + \sum_{i=1}^{5} \chi_i Oibn_{t-i} + \varepsilon_t \quad (1)$$

where $Oibn_t$ denotes the value-weighted order imbalance across all the CNX Nifty at time intervals "t" and "t" each trading day; Ds denote the day-of-the-week dummies. Thus the value of D_{Mon} is 1 on Mondays and "0" on all other days. Similarly D_{Tue} is 1 on Tuesdays and 0 on all other days and similarly D_{Wed} and D_{Thur}. We use Friday as a reference day; $Min(0, R_{t-i})$ denotes the minimum value out of 0 and the returns in "$t-i$" period. These are the Index returns; $Max(0, R_{t-i})$ denotes the maximum value out of 0 and the returns in the "$t-i$" period; ε_t denotes the residual term.

In the above model we expect δ, the coefficient of the positive returns variable, to be positive since if past market returns are positive, investors would indulge in more net buyer-initiated trades ($Oibn > 0$) then. Similarly, we expect γ, the coefficient of the negative returns variable, to be positive since if the past market returns are negative investors would indulge in more net seller-initiated trades ($Oibn < 0$). Chordia *et al.* (2002) use a similar model and find that investors behave as contrarians: i.e. the order imbalance is negatively impacted by lagged positive returns and positively impacted by lagged negative returns. The literature reports herding behavior by investors (Hirshleifer *et al.*, 1994): i.e. excess buy orders are followed by more buy orders, leading to a correlation in the imbalance with its own lags. To control for this behavior we use the lagged order imbalance variables in the model and we expect positive coefficients for lagged order imbalance variables.

Since order imbalance depends on the number of transactions, it is more useful to study an order imbalance variable corrected for the number of transactions – that is, by dividing or scaling the order imbalance variable by the number of transactions. As such, we also estimate the following model:

$$ScaledOibn_t = \alpha + \sum_{Day=Mon}^{Thu} \beta_{Day} D_{Day} + \sum_{i=1}^{5} \gamma_i Min(0, R_{t-i}) + \sum_{i=1}^{5} \delta_i Max(0, R_{t-i}) + \sum_{i=1}^{5} \chi_i ScaledOibn_{t-i} + \varepsilon_t \quad (2)$$

We expect similar signs for the coefficients in model 2 as expected in model 1 as per the reasoning given in the model 1 above.

Apart from order imbalance in number of trades (*Oibn*) and scaled order imbalance in number of trades (*ScaledOibn*) variables, we repeat the same exercise using order imbalance in value (*Oibv*) and also its scaled measure (*ScaledOibv*). Thus, the following models are also estimated for the pre-2002 and post-2002 and the aggregate (1999-2005) periods:

$$Oibv_t = \alpha + \sum_{Day=Mon}^{Thu} \beta_{Day} D_{Day} + \sum_{i=1}^{5} \gamma_i Min(0, R_{t-i}) + \sum_{i=1}^{5} \delta_i Max(0, R_{t-i}) + \sum_{i=1}^{5} \chi_i Oibv_{t-i} + \varepsilon_t \quad (3)$$

$$ScaledOibv_t = \alpha + \sum_{Day=Mon}^{Thu} \beta_{Day} D_{Day} + \sum_{i=1}^{5} \gamma_i Min(0, R_{t-i}) + \sum_{i=1}^{5} \delta_i Max(0, R_{t-i}) + \sum_{i=1}^{5} \chi_i ScaledOibv_{t-i} + \varepsilon_t \quad (4)$$

Since the measures of order imbalance show a high degree of correlation among themselves we expect similar results from the above estimated models, which would make our findings robust.

V. Summary statistics and results

We divided our aggregate period, January 1999-December 2005, into two sub-periods based on the date compulsory rolling settlements were introduced, January 1, 2002. We present our results for each sub-period. Selected descriptive statistics such as mean and standard deviation (SD) for the variables "number of transactions" (Numtrans) and "volume traded" (Vol) for the pre-2002 and post-2002 periods at daily intervals are provided in Table I. The selected descriptive statistics (mean and SD) together with the Augmented Dickey-Fuller (ADF) statistic for the index for the pre-2002 and post-2002 periods are provided in Table II panel A, for intervals of 60 minutes, 120 minutes and daily. Table II panel A also includes the significance level for the difference in the means of variables in the pre-2002 and post-2002[2] periods. Intra-day autocorrelations of returns with each measure of order imbalance are shown in Table II panel B, while the correlations between returns and each measure of order imbalance for the index for the pre- and post-periods are provided in Table II panel C. Table II panel C also reports the sign and significance level for the differences in order imbalance-returns correlations in the pre- and post-periods. Table III (panels A and B) contains the matrices of pair-wise correlations between returns and variables of order imbalance for the pre-2002 and post-2002 periods, respectively, for daily data. We also test for equality of correlations between Numtrans and Vol in the pre- and post-periods and report the results in Table III panel C.

From Table I we find that the traded volume and number of transactions are significantly higher in the post-2002 period compared to the pre-2002 period. The increase in trading volume may be ascribed to the market reforms introduced in

Variable	Pre-2002 Mean	Pre-2002 SD	Post-2002 Mean	Post-2002 SD	Post-pre Sign and significance level for difference in means
Numtrans	3,624	1,838.30	6,190	2,022.92	+**
Vol	322.2	208.27	341.93	132.78	+*

Notes: Mean and standard deviation (SD) for the variables of number of transactions (Numtrans) and volume (Vol) for pre-2002 and post-2002 periods at daily interval. Pre-2002 refers to the period January 1999 to December 2001while post-2002 refers to January 2002 to December 2005.The variables Numtrans and Vol are weighted average of number of transactions and volume, respectively, for National Stock Exchange (NSE) stocks belonging to S&P CNX Nifty Index. The weights are in proportion to the market capitalization at the end of previous year. We test for the difference in mean for the variables of Numtrans and Vol between the pre-2002 and post-2002 periods. The sign and significance level for difference in means is reported in the last column. Vol is in Rs millions. *,**Significant at 5 and 1 percent, respectively

Table I.
Selected descriptive statistics of trading activity

the Indian capital markets which have led to greater accessibility for market participants. The practice of rolling settlements, compulsory trading in dematerialized mode and internet trading may have contributed to this overall increase in trading volume.

Table II panel A shows that for the daily interval, the means of all the order imbalance measures (Oibn, ScaledOibn, Oibv and ScaledOibv) for the pre- and post-periods are negative and significantly different from zero. This indicates that there is selling pressure in both periods. However, the selling pressure as measured through means of Oibn, Oibv and ScaledOibv is significantly less in the post-2002 period compared to the pre-2002 period, indicating increasing market depth where the proportion of buyer-initiated trades is rising in the market.

The mean daily returns are negative for both periods. However, the mean returns for the pre-2002 period are not significantly different from zero while the mean returns for the post-2002 period are significantly different from zero. ADF statistics reveal that all the measures of order imbalance and returns are stationary in level form for the pre-2002 and post-2002 periods.

Thus, for the daily level we find significant differences in the order imbalance and trading activity measures and returns during the pre-2002 and post-2002 periods.

For shorter intervals of 120 and 60 minutes Table II panel A shows that all order imbalance measures have significant negative means for the pre- and post-periods. However, we find significantly reduced selling pressure for the intervals of 120 and 60 minutes as measured by the means of all order imbalance measures (except ScaledOibn), similar to the findings at daily intervals. For the intervals of 120 and 60 minutes, the mean returns in the pre-2002 period are significantly different from the mean returns in the post-2002 period.

In Table II panel B, returns show significant autocorrelation at the shorter intervals of 120 and 60 minutes in the pre-2002 period. The same relationship was not found in the post-2002 period. The absence of autocorrelation in the returns in the post-2002 period indicates that the Indian market has become weak form efficient in the post-2002 period compared to the pre-2002 period. The efficiency can be observed at shorter intervals of 60 minutes also.

We find significant autocorrelation in all the measures of order imbalance in both the pre- and post-periods (except for ScaledObin for the pre-2002 period).

Table II.
Order imbalance and returns – summary statistics

Panel A[a]

		Pre-2002			Post-2002			Post-2002-pre-2002
Interval	Variable	Mean	SD	ADF	Mean	SD	ADF	Sign and significance level for difference in means
Daily	Returns	−0.03	1.6	−8.9**	−0.08*	1.16	−13.9**	−*
	Oibn	−45.6**	114.1	−8.2**	−35.5**	117.4	−11.5**	+*
	ScaledOibn	−0.01**	0.03	−9.95**	−0.01**	0.02	−10.40**	ns
	Oibv	−8.07**	27.20	−9.01**	−3.77**	16.41	−9.96**	+**
	ScaledOibv	−2.10**	5.75	−10.50**	−0.71**	2.52	−9.45**	+**
120 minutes	Returns	−0.03	0.81	−2.95**	−0.03*	0.7	−293**	−*
	Oibn	−15.22**	53.45	−16.4**	−12.0**	58.5	−21.9**	+*
	ScaledOibn	−0.01**	0.04	−17.91**	−0.01**	0.03	−20.85**	ns
	Oibv	−2.68**	12.03	−14.78**	−1.24**	7.51	−18.52**	+**
	ScaledOibv	−2.15**	7.90	−16.51**	−0.69**	3.67	−18.51**	+**
60 minutes	Returns	−0.02*	0.57	−2.9**	−0.01	0.52	−405**	+*
	Oibn	−7.6**	32.72	−21.4**	−6.02**	38.6	−29.2**	+*
	ScaledOibn	−0.01**	0.05	−22.66**	−0.01**	0.04	−28.18**	ns
	Oibv	−1.34**	7.05	−19.00**	−0.62**	4.69	−25.40**	+**
	ScaledOibv	−2.10**	9.62	−21.14**	−0.65**	4.31	−24.80**	+**

Panel B: autocorrelations (AC) in order imbalance and returns[b]

Interval		Pre-2002 AC(1)	Post-2002 AC(1)
Daily	Returns	−0.04	−0.04
	Oibn	0.10**	0.11**
	ScaledOibn	0.03	0.15**
	Oibv	0.24**	0.30**
	ScaledOibv	0.12**	0.31**
120 minutes	Returns	0.08**	−0.02
	Oibn	0.24**	0.15**
	ScaledOibn	0.23**	0.18**
	Oibv	0.31**	0.29**
	ScaledOibv	0.28**	0.29**

(*continued*)

60 minutes	Returns	0.04*	−0.02	
	Oibn	0.26**	0.13**	
	ScaledOibn	0.22**	0.15**	
	Oibv	0.36**	0.27**	
	ScaledOibv	0.29**	0.27**	

Panel C: correlation between returns and measures of order imbalance

Interval		Pre-2002 Correlations	Post-2002 Correlations	No. post-2002 (correlation)-pre-2002(correlations) Sign and significance level for difference in correlations
Daily	Oibn	0.68**	0.72**	+**
	ScaledOibn	0.73**	0.63**	−**
	Oibv	0.46**	0.53**	+**
	ScaledOibv	0.55**	0.46**	−**
120 minutes	Oibn	0.68**	0.72**	+**
	ScaledOibn	0.73**	0.63**	−**
	Oibv	0.46**	0.53**	+**
	ScaledOibv	0.55**	0.46**	−**
60 minutes	Oibn	0.67**	0.71**	+**
	ScaledOibn	0.71**	0.60**	−**
	Oibv	0.44**	0.50**	+**
	ScaledOibv	0.51**	0.45**	−**

Notes: [a]Mean, standard deviation (SD) and Augmented Dickey Fuller Statistic (ADF) for average order imbalance and returns variables for National Stock Exchange (NSE) stocks belonging to S&P CNX Nifty Index. The selected descriptive statistics (mean, SD and ADF) for average order imbalance and returns variables are computed using daily, 120 and 60 minutes interval data for the pre-2002 and post-2002 periods and are presented in panel A. Panel A also includes sign and significance level for difference in means of variables of returns, Oibn, ScaledOibn, Oibv and ScaledOibv between post-2002 and pre-2002 periods for daily, 120 minutes and 60 minutes intervals. Pre-2002 refers to the period January 1999 to December 2001 while post-2002 refers to January 2002 to December 2005. Panel B reports the autocorrelations and significance of autocorrelations for returns and order imbalance variables. Panel C reports the correlations between the variables of order imbalance and returns. We test for the difference in correlations for the pre-2002 and post-2002 periods and report the sign and significance level in the last column of panel C. The order imbalance variables Oibn and Oibv measure the weighted order imbalance in terms of number of transactions and volume. ScaledOibn and ScaledOibv are the corresponding scaled measures of Oibn and Oibv. The weights are in proportion to the market capitalization at the end of previous year. Returns measures the trade-to-trade returns for the S&P CNX Nifty Index at daily, 120 minutes and 60 minutes intervals. The number of observations in the pre-2002 period at the daily, 120- and 60-minute intervals are 594, 1,761 and 3,516, respectively. The number of observations in the post-2002 period at the daily, 120 and 60-minute intervals are 976, 2,930 and 5,850, respectively. ScaledOibv is in Rs thousands. Oibv is in Rs millions. [b]For the aggregate period 1999-2005 the returns autocorrelation at daily interval, 120- and 60-minute interval are −0.04, −0.01 and −0.01, respectively. None of these are significantly different from zero and it implies that returns for the period 1999-2005 shows no autocorrelations. *,**Significant at 5 and 1 percent, respectively

Table II.

	Oibn	ScaledOibn	Oibv	ScaledOibv	Vol	Numtrans
Panel A						
ScaledOibn	0.83**					
Oibv	0.88**	0.66**				
ScaledOibv	0.82**	0.83**	0.89**			
Vol	−0.16**	0.04	−0.18**	−0.04		
Numtrans	−0.22**	0.03	−0.21**	−0.04	0.83**	
Returns	0.68**	0.76**	0.50**	0.60**	−0.03	−0.07
Panel B						
ScaledOibn	0.93**					
Oibv	0.84**	0.77**				
ScaledOibv	0.80**	0.84**	0.94**			
Vol	−0.001	0.15**	0.02	0.16**		
Numtrans	−0.06	0.11**	−0.03	0.12**	0.90**	
Returns	0.85**	0.78**	0.64**	0.60**	−0.07*	−0.07*
Panel C						

	Pre-2002	Post-2002	Sign and significance level for difference in correlations (post-pre)
Corr	0.83**	0.90**	+ **

Notes: Pair-wise correlations as well as their significance levels are reported between average order imbalance, volume, number of transactions and return measures for National Stock Exchange (NSE) stocks belonging to S&P CNX Nifty Index. Oibn and Oibv measures weighted order imbalance in terms of number of transactions and volume traded. Numtrans and Vol are the weighted average of number of transactions and volume, respectively. The weights are in proportion to the market capitalization at the end of previous year. ScaledOibn and ScaledOibv are the corresponding scaled measures of Oibn and Oibv. Returns measures the trade-to-trade returns for the S&P CNX Nifty Index at daily intervals. Panel A reports the correlations for pre-2002 period while panel B reports the correlations for post-2002. Pre-2002 period refers to the period January 1999 to December 2001 while post-2002 refers to January 2002 to December 2005. Panel C reports the correlations as well as their significance levels between the variables of Numtrans and Vol in the pre-2002 and post-2002 periods. The last column of panel C reports the results of the test of equality of correlations between the pre-2002 and post-2002 periods. *,**Significant at 5 and 1 percent, respectively

Table III.
Correlations

The results from the analysis of aggregate periods (as shown in the note to Table II panel B) reveal no autocorrelation in the returns at any of the intervals of daily, 120 and 60 minutes whereas the pre-2002 data show autocorrelation at shorter intervals of 120 and 60 minutes. Thus, using the aggregate period for analysis would not give correct idea of efficiency for the pre-2002 period.

As Table II panel C shows, the order imbalance-returns correlations for the unscaled measures of order imbalance are significantly higher in the post-2002 period compared to the pre-2002 period. However, for scaled measures we find that order imbalance-returns correlations are lower for the post-2002 period compared to the pre-2002 period at all the intervals of daily, 120 and 60 minutes. This shows that, after accounting for the number of transactions, the order imbalance-returns correlations have actually fallen in the post-2002 period.

As Table III panels A and B show, all order imbalance measures continue to show significant positive correlation with each other in both the pre-2002 and post-2002 periods.

The correlation between order imbalance and other measures of trading activity such as traded volume or number of trades displays no clear pattern. While in the

pre-2002 period, the measure of traded volume (Vol) shows a negative correlation with unscaled measures of order imbalance (and no correlation with the scaled measures), in the post-2002 period it shows no correlation with these measures (and shows positive correlation with the scaled measures). Similar behavior is seen for the variable Numtrans. We find that high or low volumes or number of trades provide no accurate indication about the direction of the trade, which is shown through the measures of order imbalance.

Table III panels A and B indicate that measures of traded volume (Vol) and Numtrans show no significant correlation with returns in the pre-2002 period while the relationship becomes significant in the post-2002 period. These measures of trading activity thus have no definitive relationship with returns and do not give precise predictions of future returns.

Table III panel C shows that the correlation between number of trades and traded volume is high and positive in both periods. However, the correlation between these measures is significantly higher in the post-2002 period, indicating that high-volume trades are associated with a higher number of trades in the post-2002 period compared to the pre-2002 period.

We estimated models 1 and 2 separately for the pre-2002, post-2002 and aggregate periods. Using estimated models 1 and 2, the signs and significance levels of the estimated regression coefficients for the pre-2002, post-2002 and aggregate periods are shown in Table IV, which also contains selected goodness-of-fit measures such as adjusted R^2 and p-value of the calculated F-statistic.

Similarly, we estimated models 3 and 4 separately for the pre-2002, post-2002 and aggregate periods. From estimated models 3 and 4, the signs and significance levels of the regression coefficients (apart from selected goodness-of-fit measures of the estimated models such as adjusted R^2 and p-value of calculated F-statistic) for the pre-, post- and aggregate periods are displayed in Table V[3].

Table V gives the results for the pre-2002 period. The intercept coefficient has a significant negative sign, showing that Fridays are associated with net seller-initiated orders. Friday has a significant impact on the order imbalance which is different from Tuesday and Thursday. This confirms the presence of the day-of-the-week effect in the order imbalance for the pre-2002 period. In the pre-rolling settlement period, the settlement on the Bombay Stock Exchange (BSE) was every Friday while on the NSE it was every Tuesday. It is likely that the order flow shifted from BSE to NSE on Fridays as the outstanding position on BSE had to be settled on that day. The sign indicates that more sell order flows were shifting to NSE on Fridays. This shows the day-of-the-week effect in order imbalance in the pre-2002 period.

The negative significant coefficient for the past positive market returns at the first lag indicates that lagged positive returns lead to a fall in the subsequent net buyer-initiated trades. Similarly, the negative significant coefficient for the past negative market returns at the first lag indicates that lagged negative returns lead to a rise in the subsequent net buyer-initiated trades.

A positive significant coefficient for the first lagged measures of order imbalance indicates the persistence behavior in the order imbalance from one day to the next.

The results for Oibn are quite similar to that of ScaledOibn. We note that the presence of the day-of-the-week effect in both unscaled and scaled measures of order imbalance is an indicator that the results are not influenced by the number of transactions.

Table IV.
Determinants of order imbalance

Dependent variable	$Oibn_t$			$ScaledOibn_t$		
Time period	Pre-2002	Post-2002	Aggregate	Pre-2002	Post-2002	Aggregate
Explanatory variable	Sign and significance level of the coefficient			Sign and significance level of the coefficient		
Intercept	−**	ns	−**	−**	ns	−**
Mon	ns	ns	ns	ns	ns	ns
Tue	+**	ns	ns	+**	ns	+**
Wed	ns	ns	ns	ns	ns	ns
Thur	+*	ns	ns	+**	ns	ns
$Max(0, R_{t-1})$	−**	ns	−*	−*	ns	−**
$Max(0, R_{t-2})$	ns	−*	−*	ns	−*	ns
$Max(0, R_{t-3})$	ns	ns	ns	ns	ns	ns
$Max(0, R_{t-4})$	ns	ns	ns	ns	-*	ns
$Max(0, R_{t-5})$	ns	ns	ns	ns	ns	ns
$Min(0, R_{t-1})$	−*	−*	−**	−**	−*	−**
$Min(0, R_{t-2})$	ns	ns	ns	ns	ns	ns
$Min(0, R_{t-3})$	ns	ns	ns	ns	ns	ns
$Min(0, R_{t-4})$	ns	ns	ns	ns	ns	ns
$Min(0, R_{t-5})$	ns	ns	ns	ns	ns	ns
$Oibn_{t-1}/ScaledOibn_{t-1}$	+**	+**	+**	+**	+**	+**
$Oibn_{t-2}/ScaledOibn_{t-2}$	ns	+**	+**	ns	+**	+*
$Oibn_{t-3}/ScaledOibn_{t-3}$	ns	ns	+*	ns	ns	ns
$Oibn_{t-4}/ScaledOibn_{t-4}$	ns	ns	ns	ns	+**	ns
$Oibn_{t-5}/ScaledOibn_{t-5}$	ns	ns	+*	ns	ns	+**
Adjusted R^2	0.09	0.05	0.06	0.06	0.07	0.07
p-value of *F*-statistic	0.00	0.00	0.00	0.00	0.00	0.00

Notes: $Oibn_t$, represents the daily order imbalance measured in number of transactions on a trading day t, while $ScaledOibn_t$ is the scaled order imbalance in number of transactions ($Oibn_t/Numtrans_t$) on a trading day t, where *Numtrans* is the total number of transaction on day t. The variables of $Oibn_t$ and $ScaledOibn_t$ are weighted averages for NSE stocks in S&P CNX Nifty. These are the dependent variables. Each of them is regressed on past positive and negative S&P CNX Nifty returns as well as the day of the week dummies. The sign and significance level of the estimated regression coefficients are reported for the pre-2002 period, post-2002 period and the aggregate period. This table also includes goodness-of-fit measures such as adjusted R^2 and *p*-value of *F*-statistic. Pre-2002 period represents the period from January, 1999 to December, 2001, while post-2002 period represents the period from January, 2002 to December, 2005. The aggregate period represents the period from January 1999 to December 2005. *,**Significant at 5 and 1 percent, respectively

Table V.
Determinants of order imbalance

Dependent variable	$Oibv_t$			$ScaledOibv_t$		
Time period	Pre-2002	Post-2002	Aggregate	Pre-2002	Post-2002	Aggregate
Explanatory variable	Sign and significance level of the coefficient			Sign and significance level of the coefficient		
Intercept	−*	ns	−*	−**	ns	−**
Mon	ns	ns	ns	ns	ns	ns
Tue	+*	ns	ns	+**	ns	+*
Wed	ns	ns	ns	ns	ns	ns
Thur	ns	ns	ns	+[a]	ns	ns
$Max(0, R_{t-1})$	ns	ns	−*	ns	ns	ns
$Max(0, R_{t-2})$	ns	ns	ns	ns	ns	ns
$Max(0, R_{t-3})$	ns	ns	ns	ns	ns	ns
$Max(0, R_{t-4})$	ns	ns	ns	ns	ns	ns
$Max(0, R_{t-5})$	ns	ns	ns	ns	ns	ns
$Min(0, R_{t-1})$	ns	ns	−*	ns	ns	ns
$Min(0, R_{t-2})$	ns	ns	ns	ns	ns	ns
$Min(0, R_{t-3})$	ns	ns	ns	ns	ns	ns
$Min(0, R_{t-4})$	ns	ns	+*	+*	ns	+*
$Min(0, R_{t-5})$	ns	ns	ns	ns	ns	ns
$Oibv_{t-1}/ScaledOibv_{t-1}$	+**	+**	+**	+**	+**	+**
$Oibv_{t-2}/ScaledOibv_{t-2}$	+*	ns	+*	ns	ns	+*
$Oibv_{t-3}/ScaledOibv_{t-3}$	ns	+**	ns	ns	+*	ns
$Oibv_{t-4}/ScaledOibv_{t-4}$	ns	+*	ns	−**	+**	ns
$Oibv_{t-5}/ScaledOibv_{t-5}$	ns	ns	ns	ns	ns	ns
Adjusted R^2	0.10	0.12	0.11	0.06	0.14	0.07
p-value of F-statistic	0.00	0.00	0.00	0.00	0.00	0.00

Notes: $Oibv_t$, represents the daily order imbalance measured in terms of traded volume on a trading day t, while $ScaledOibv_t$ is the scaled order imbalance ($Oibv_t/Numtrans_t$) on a trading day t, where *Numtrans* is the total number of transaction on day t. The variables of $Oibv_t$ and $ScaledOibv_t$ are weighted averages for NSE stocks in S&P CNX Nifty. These are the dependent variables. Each of them is regressed on past positive and negative S&P CNX Nifty returns as well as the day of the week dummies. The sign and significance levels of the estimated regression coefficients are reported for the pre-2002 period, post-2002 period and the aggregate period. This table also includes goodness-of-fit measures such as adjusted R^2 and p-value of F-statistic. Pre-2002 period represents the period from January, 1999 to December, 2001, while post-2002 period represents the period from January, 2002 to December, 2005. The aggregate period represents the period from January 1999 to December 2005. *,**Significant at 5 and 1 percent, respectively

From Table IV we note the following results for the post-2002 period: We find an absence of the day-of-the-week effect in the order imbalance. In the post-2002 period, compulsory rolling settlement was initiated in all stocks on both exchanges so there was no incentive to shift order flow from one exchange to the other because of differences in settlement days.

A negative significant coefficient for the past positive market returns at the second and fourth lags (estimated model 2 for ScaledOibn) brings out contrarian investor behavior. However, for the pre-2002 period we find only the first lag of the positive market returns to be significant while for the post-2002 period we do not find the first lag to be significant. A negative significant coefficient for the past negative market returns at the first lag again brings out contrarian investor behavior similar to the pre-2002 period results both in lags and signs. Positive significant coefficients for a few lagged measures of order imbalance indicate the persistence of order imbalance in the same direction.

The pre-2002 period results are different from the post-2002 period with respect to the day-of-the-week effect. Using a similar model, Chordia *et al.* (2002) do not find any day-of-the-week effect for the US market for the period January 1988-December 1998 while Lee *et al.* (2003) find a day-of-the-week effect for the Taiwanese market for the period September 1996-April 1999. Though no Indian studies examine the day-of-the-week effect in the order imbalance, our results are consistent with Gupta's (2006), which do not find any day-of-the-week effect in the Nifty returns for the period 2002-2005. From the effects of the past positive and negative market returns on order imbalance, we find negative and significant coefficients for both the pre-2002 and post-2002 periods, indicating that investors move against the past market direction; i.e. if the lagged returns are positive, the net order imbalance decreases but if they are negative, then net order imbalance increases. This finding is consistent with the findings of Chordia *et al.* (2002), who document similar behavior on the part of investors in the NYSE. Lee *et al.* (2003) find similar contrarian behavior for the Taiwanese market.

If we examine the aggregate results in Table IV we note that the results for the whole period 1999-2005 would be misleading since they indicate the presence of the day-of-the-week effect in the order imbalance even when it is absent for the post-2002 period. Further, we note that the coefficient of the variable $Oibn_{t-5}$/$Scaled\ Oibn_{t-5}$ is not significant in both the pre-2002 and post-2002 periods but is significant in the aggregate period.

From Table V, we highlight the following results for the pre-2002 period: a day-of-the-week effect in the order imbalance is observed, with Friday being significantly different from Tuesday. We obtained similar results when we used trades measures of order imbalance (Oibn and ScaledOibn) for the same period. Also the sign of the coefficient is negative, indicating that Friday is associated with higher number as well as the value of net seller-initiated trades. Thus, imbalances in the pre-2002 period for both the trades measures and volume measures are influenced by the day-of-the-week.

The past returns (positive or negative) show no significant relation to the order imbalance measures, indicating that the value measures of order imbalance are not influenced by the past positive returns. This result is different for the trades measure of order imbalance in the pre-2002 period, which shows that the past positive market returns have a significant negative impact on order imbalance, leading to reduction in net buyer-initiated trades. Even when the number of net buyer-initiated trades reduces

with high past positive returns, the value of net buyer-initiated trades is not influenced by the past positive market returns.

The past negative market returns show no significant relation to the value measure of order imbalance for all the lags except the fourth lag, indicating that order imbalance is not influenced by past negative market returns. The positive significance for the fourth lag is surprising.

The lagged value of order imbalance has significant positive impact on future order imbalance once again indicating the existence of herding in the order flow from one day to the next day. However, we get a negative sign for the fourth lag of order imbalance indicating that the future order imbalance is negatively impacted by the order imbalance of the fourth day.

The results for the post-2002 period from Table V indicate an absence of day-of-the-week effects in value measures of order imbalance, similar to the results for trades measure of order imbalance. Day-of-the-week influences neither the order imbalance of number of trades nor the order imbalance of value.

We do not find evidence of lagged positive or negative returns having an impact on the value measures of order imbalance. This is different from the results we get for the trades measure of order imbalance where we find that past positive and negative returns significantly impact the trades measure of order imbalance. This again indicates that even though the order imbalance in number of trades is affected by past positive or negative market returns, there is no similar impact on the value measure of order imbalance.

The lagged measure of order imbalance shows a positive significant influence on the future order imbalance, reflecting the phenomenon of herding in the orders. Compared to the pre-2002 period, we do not find any of the lags of order imbalance having significant negative impact on the future order imbalance in the post-2002 period.

VI. Summary and conclusions

We investigate the issue of market efficiency by examining the forecasting ability of past returns. The literature suggests that the order imbalance affects returns. Any reform which reduces the imbalances or eliminates any pattern would not be useful for returns forecasting thereby improving the efficiency of the market. In this paper we find that, following the structural reforms, the order imbalance measures in the post-2002 period have significantly declined compared to the pre-2002 period at the daily as well as the intra-day interval across the trade as well as value measures. A decline in imbalances may also be an indicator of less informed trading and better liquidity, since high imbalances lead to less liquidity. The results indicate that since 2002 less informed trading has created better liquidity than pre-2002. Order imbalance measures do not exhibit any day-of-the-week effect in the post-2002 period, while they do so in the pre-2002 period. This shows that order imbalance is not dependent on any particular day-of-the-week. Since order imbalance ultimately affects the returns, this indicates that returns may not exhibit any day-of-the-week effect in the post-2002 period. These results are consistent with those of Gupta (2006), who does not find any day-of-the-week effect in the returns in the post-2002 period.

The returns-order imbalance correlations show a significant drop in the post-2002 period compared to the pre-2002 period, further indicating that the order imbalance for returns forecasting is declining in the post-2002 period. This is an indicator that the Indian market following structural reforms is becoming more efficient.

To the best of our knowledge this paper is the first of its kind to examine the factors affecting the order imbalances in the Indian market. It shows that structural reforms have had a positive impact in reducing the order flow imbalance as well as order imbalance-returns correlations, increasing the efficiency of the Indian market. Our study contributes to the literature of market design. Further research is needed to examine the ability of the Indian market to absorb imbalances and the speed with which imbalance information is reflected in market prices.

Notes

1. The quotes and trades data are recorded by two different agencies. So sometimes the quotes before but very near to the trades were recorded after the trade time.
2. From here on, pre and post periods would refer to pre-2002 and post-2002 periods.
3. The output of estimated regression models 1 to 4 is available from the authors on request.

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Further reading

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