Commonality in Liquidity of an Open Electronic Limit Order Book Market

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This paper examines the existence of commonality in liquidity of an open electronic limit order book market which is the market design of National Stock Exchange, India. We calculate impact cost as the proxy for liquidity. It captures the trade size information as well as price information. It is better than the highly popular proxy, bid-ask spread, as it provides information beyond the inside quotes. As commonality in liquidity is stronger during bear market, portfolio managers face more challenges in altering their holdings during bear market state. We also find that commonality in liquidity follows weekly and monthly pattern.

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1 Introduction

Commonality in return and risk are already well established concepts in finance literature. Recently, efforts have also been made to establish commonality in liquidity. Commonality in liquidity can be defined as common factors influencing liquidity of stocks. The early pioneers to document the concept of commonality in liquidity were Chordia, Roll & Subrahmanyam (2000), Huberman & Halka (2001), Hasbrouck & Seppi (2001). Chordia, Roll & Subrahmanyam (2000) observed that individual stock's liquidity changes are positively and significantly related to broad-market liquidity changes. Financial crises such as the market crash of October 1987, the 1997 Asian crisis,and many other smaller incidents indicate that the rise and fall of individual stock liquidity are tied together by common economic causes. In this paper, we explore the issue of commonality in liquidity of an open electronic limit order book market, which is the market design of National stock exchange, India.

Since the traders cannot hedge the commonality in liquidity, they may demand return. If time varying commonality in liquidity cannot be anticipated, the more sensitive an asset is to such risk, the greater must be its expected return. Giouvris (2003) and Acharya & Pedersen (2004) link the commonality in liquidity to expected returns.

Commonality in liquidity has been discussed both theoretically and empirically. There are few theoretical papers, which consider commonality in liquidity and the transmission of liquidity shocks across assets. By taking the common liquidity shocks across investors and assets, Fernando (2003) shows that liquidity shocks cannot be transmitted in the case of uncorrelated returns. Wantanabe (2003) further constructs stochastic co-variations of liquidity by means of correlated informational process and documents that liquidity, trading volume and variance become stochastic in the case of endogenous information acquisition.

Empirically, the major contributions in this area are from Chordia, Roll & Subrahmanyam (2000), Huberman & Halka (2001) and Hasbrouck & Seppi (2001). Their findings are mixed; the first two studies detect commonality in liquidity while the latter observes no decisive evidence. Brockman & Chung (2002), Sujoto, Kalev & Faff (2004), Bauer (2004) and Kempf & Mayston (2005) have found evidence on commonality in limit order book market. Bauer (2004) and Kempf & Mayston (2005) have reported intra day patterns in commonality of liquidity. These studies are limited to a short span of time and have also not considered the impact of days of week, and months of year on the correlation with market liquidity. We consider five years span to document commonality of liquidity and also check whether there is any weekly as well as monthly patterns.

During 1997-2001 Indian stock markets have gone through policy reforms, introduction of derivative products of both stock and market index. Market also faced scams and crises. Thus along with weekly and monthly patterns, we also analyse the impact of different years on commonality in liquidity.

It is well documented fact that correlation among returns behave differently in bull and bear markets. Fabozzi & Francis (1977) were the first to study the stability of alpha and beta of market model of return during bull and bear phases. Trading behaviour and trading strategies could be different under bull and bear market. Arrival or composition of informed traders as well as noise traders in stock market depends upon the state of market. Hence we examine the asymmetrical commonality in liquidity during bull and bear market. Kempf & Mayston (2005) splitted the sample period on the basis of moving average rule of returns and observed that commonality in liquidity is stronger in falling market than in rising market. But we employ more general definition of bull and bear market as proposed by Sperandeo (1990) and Lunde & Timmermann (2000).

Stocks may exhibit asymmetry in commonality while moving up or down together. They may widen in liquidity more often than shrink in liquidity together. We explore the relative strength of commonality when market liquidity moves up or down.

Questions we seek to address in this paper:

- Is there commonality in liquidity of National Stock Exchange, India?
- Are there days of week and months of year pattern in commonality in liquidity?
- Whether commonality in liquidity is stable across different years?
- Does asymmetrical commonality in liquidity exhibit during bull and bear market?
- What is the relative strength of commonality when market liquidity moves up/down?

This paper is organized as follows: In section 2 we describe how to measure liquidity in an open electronic book market. We briefly outline data in section 3. Section 4 provides empirical results on the existence of commonality in liquidity. The impact of days of week and months of year are explored in section 5. We report results pertaining to commonality during bull and bear market in section 6. Finally the relative strength of commonality during market liquidity is moving up/down is documented in section 7.

2 Measurement of Liquidity

The concept of liquidity is well understood in the literature. In a seminal paper Kyle (1985) proposed the three concepts of liquidity viz, tightness, depth and resiliency. Tightness is defined as the difference between the trade price and the efficient price. This is measured by the bid-ask spread. In case of perfect liquidity with respect to tightness, the spread would be zero and traders can buy or sell at the same price. Depth is defined as the absorptive power of order queues at every price grid. There would be infinite depth available at the market price in the perfectly liquid market. Resiliency is defined as the speed of the convergence to efficient price from the price level which has been brought by trade execution. If there is no information impact on price, price would bounce back to the old price which was available before the random shocks or the transaction of a large orders. Alternatively, in case of information impact during the trading process, price will attain new the efficient price eventually. Hence in highly liquid market, with respect to resiliency, price moves back immediately to their efficient level.

There is no the consensus on quantitative measure of liquidity. The bid-ask spread has been used as proxy for liquidity. Bid-ask spread is the difference between the best available price to sell and buy a given quantity of assets. As quantity does not enter in computation of this proxy, it does not provide any information about the depth of the financial market. This proxy does not reflect the liquidity supply beyond the inside quotes. Although this proxy is an ex ante measure of liquidity, it is not suitable to measure the liquidity for large orders. Other set of proxies like ask/bid depth only indicate about the depth available at any particular price. All these proxies are measured at a given point of time.

A better proxy of liquidity should

- provide the ex ante information on the price change after trade of a particular quantity at any point of trading time.
- indicate how measurements change when desired quantity changes or time changes.

Liquidity of stock and market overall can also be measured by impact cost (Irvine, Benston & 2000 (2000), Domowitz & Wang (2002), Coppejans, Domowitz & Madhavan (2001)) if whole limit order book of open electronic limit order book (OELOB) market is available. The impact cost (henceforth IC) combines both price and quantity information. It is ex ante measure of liquidity at a given quantity. The impact cost can be calculated as the percentage difference between the weighted average execution price and the pre-trade midpoint

$$\text{impact cost} = \frac{\sum p_i q_i - P_m Q}{P_m Q} \tag{1}$$

where $\sum q_i = Q$, there are q_i stocks at p_i price and P_m is the the midpoint of the bid-ask spread at the time of the trade. Irvine, Benston & 2000 (2000) define the cost of round trip as the sum of impact cost of ask side and impact cost of bid side.

$$\text{Cost of Round Trip} = \text{Impact cost of Ask side} + \text{Impact cost of Bid side} \tag{2}$$

2.1 Calculation of Impact Cost

- First of all, we calculate the mid point (P_m) which is the average of best bid price and best ask price.
- We compute the number of shares that corresponds to the rupees amount R.

$$\text{Number of shares (Q)} = \frac{R}{P_m} \tag{3}$$

- On using expression (1), we get the impact cost at a particular trading size. We compute the impact cost for both sides (ask and bid) of order book at trade size of Rs 10000. We have chosen Rs 10000, because it is the mean trade size in National stock exchange India.

In the calculation of IC, one may face missing data problem. There are following situations when one can not get the value of IC at particular trade size.

- Limit orders may not be available after certain trade size at given point of time.
- There may not be a single active limit order available at given point of time.

We drop the negative impact cost and missing data.

3 Market Structure and Data

The electronic equity trading at NSE started on 3rd Nov. 1994. It's growth since then has been phenomenal, from an annual turnover of Rs. 8509 crore in 1995-1996, to Rs. 1,770,458 crore in 2000-2001. It adopted the open electronic limit order book market design. The five best ask quotes and bid quotes are displayed on the trading screen in real time. Once the orders are entered, computer matches them on a price-time priority basis. It follows the anonymous system, in which trader's identity is not revealed. The trading window at NSE is 09:55:00 - 15:30:00, Monday to Friday. The trading cycle in the erstwhile system was Wednesday open - Tuesday close with a T+5 settlement period (Pre - July 2001). This has since been revised to a rolling settlement system.

NSE releases a CD of data every month which contains datasets of everyday trading activity, intra day trades files and limit order book snapshots taken at different time points of a trading day. The sample period is from Jan 1997 to Dec 2002. There are three limit order snapshots taken at 12pm, 1pm and 2pm during years 1997 and 1998, at 11 am, 1pm, and 2pm from 1999 to Feb 2000 and since March 2000 limit order data is available at four time points - 11am, 12pm, 1pm, and 2pm. This data consists of complete limit orders stacked on the basis of increasing limit price. All orders are time stamped to seconds. Prices are denominated in Indian currency - Rupees (Rs). The volume is given in number of shares.

We compute impact cost at different time stamps for 355 stocks. The daily time series of impact cost is created by taking median of intra day impact cost. These are logarithmic transformed for further econometric analysis. $\mathrm{LnIC}_{i,t}$ is the logarithmic transformation of daily impact cost.

4 Existence of Commonality in Liquidity

In empirical literature, researchers have mainly explored three paths to detect commonality in liquidity. Huberman & Halka (2001) formed the random portfolios out of 240 stocks. After computing liquidity proxies: bid-ask spread, depth, spread price ratio for each mutually exclusive portfolio, they examined the residuals of the autoregressive processes that are fitted to the time series of the liquidity proxies. The presence of positive correlation in these residuals of different portfolios is taken as an evidence of a common factor affecting liquidity across different stocks[1].

Hasbrouck & Seppi (2001) considered bid-ask spread, log spread, log size, quote slope, log quote slope and effective spreads of 30 Dow stocks. They performed a principal component analysis on these liquidity proxies. Their finding suggests that only log quote slope is affected by commonality in liquidity.

Chordia, Roll & Subrahmanyam (2000) proposed the market model approach in which individual asset's liquidity changes is regressed on market liquidity changes after controlling for market return and stock's volatility. They included lead and lag of market liquidity to capture lagged adjustment in commonality due to non synchronous trading. The positive beta supports the idea of commonality in liquidity. We adopt the market model methodology for our analysis in this paper.

Brockman & Chung (2002), Bauer (2004) and Kempf & Mayston (2005) found evidence on commonality in limit order book markets. Brockman & Chung (2002) and Sujoto, Kalev & Faff (2004) implemented Chordia, Roll & Subrahmanyam (2000) approach for Stock Exchange of Hong Kong and Australian Stock Exchange respectively. After filtering out the trend in liquidity proxies, Bauer (2004) fitted autoregressive processes to compute residuals which were input to the principal component analysis as well as market model.Kempf & Mayston (2005) removed the intra day patters in liquidity proxies: bid-ask spread, depth and price impact function before estimation of market model and principal component analysis.

Like Huberman & Halka (2001), Hasbrouck & Seppi (2001), Bauer (2004) and Kempf & Mayston (2005), we consider commonality in liquidity in level forms. Huberman & Halka (2001) notes that liquidity proxies are not characterized by unit root processes. We do not have evidences on the non stationarity of impact costs. Unlike Chordia, Roll & Subrahmanyam (2000), we consider liquidity in level for the market model methodology to analyse commonality.

[1]We implement this methodology and find there is positive correlation in residuals of random portfolios.

$$
\begin{aligned}
\mathrm{LnIC_{i,t}} = \alpha + \beta_1 \mathrm{LnIC_{m,t}} + \beta_2 \mathrm{LnIC_{m,t-1}} + \beta_3 \mathrm{LnIC_{m,t+1}} \\
+\beta_4 \mathrm{r_{m,t}} + \beta_5 \mathrm{r_{m,t-1}} + \beta_6 \mathrm{r_{m,t+1}} \\
+\beta_7 \mathrm{Vol_{m,t}} + \sum_{\mathrm{j} \epsilon \{\mathrm{tues,wed,thur,fri}\}} \gamma_\mathrm{j} \mathrm{D_j} + \epsilon_{\mathrm{i,t}}
\end{aligned} \tag{4}
$$

where $\mathrm{LnIC_{m,t}}$ is logarithm transformation of market impact cost $\mathrm{IC_{m,t}}$. $\mathrm{IC_{m,t}}$ is calculated by taking cross-sectional average of impact cost, where stock i is excluded. Hence $\mathrm{IC_{m,t}}$ is slightly different for each security's time series regression 4.

The $\mathrm{r_{m,t}}$ and $\mathrm{vol_{m,t}}$ act as control variables which isolate the commonality in stock liquidity due to comovement in return and volatility. We take care of day of week effects by including dummies variables for Tuesday, ... ,Friday. Monday dummy variable is not included in regression (4), as it is the base day for comparison. The equation (4) is estimated with newey-west autocorreletion and heteroskedascity correction.

The lead and lag of market liquidity are included to capture lagged adjustment in commonality due to non synchronous trading. As concurrent market impact cost $\mathrm{LnIC_{m,t}}$ has greater role in movement of stock impact cost, the β_1 of concurrent market impact cost $\mathrm{LnIC_{m,t}}$ will be greater than β_2 of lag of market liquidity and β_3 of lead of market liquidity.

The positive and significant value of β_1 is interpreted as evidence of the existence of commonality in liquidity. The Sum $\equiv \beta_1 + \beta_2 + \beta_3$ is better measure of commonality for the stocks which are not traded frequently[2].

Table 1 reports the estimation results of equation (4). Panel A notes that mean and median of β_1 of all firms are 0.75 and 0.73 respectively. Though this coefficient is positive in all stocks, 94% are positive and significant. Chordia, Roll & Subrahmanyam (2000) have found 85% positive in quoted spread and percentage quoted spread of NYSE. Brockman & Chung (2002) have reported that 26.1% out of 725 stocks are positive and significant in absolute spread of Honkong Stock Market. The β_1 are 70% significant positive in cost of illiquidity measure (Bauer (2004)) of Swiss Stock Exchange. Sujoto, Kalev & Faff (2004) have documented that 88% of stocks are positively correlated in percentage spread of Australian Stock Exchange. Kempf & Mayston (2005) have reported that commonality in price impact function of 93% of stocks is positive and significant in Xetra trading system of the Frankfurt Stock Exchange.

The mean and median of β_2 and β_3 are negative and positive respectively, but are very small in magnitude. 31% of β_2 are negative significant. The β_3 are positive and significant in 6% of stocks. Chordia, Roll and Subrahmanyam (2000), Kempf and Mayston (2005) have found positive mean and median of β_2 and β_3.

[2]Dimson (1979) discussed about it in estimation of systematic risk. He also discussed that sign of β_2, coefficient on the lagged market return, would be negative (positive) for highly (infrequently) traded security, but converse is true for β_3, coefficient on the lead market return.

We test whether the median of the Sum $\equiv \beta_1 + \beta_2 + \beta_3 = 0$ by sign test. The p value is 0.00 which indicates that median of the sum of these coefficients is different from zero. These results provide evidences on the existence of commonality in impact cost of Indian stock market.

We report the results of regression (4) for different size quitinles. The β_1 decreases with firm size. Brockman & Chung (2002) and Kempf & Mayston (2005) have got the similar results for relative spreads. We observe the sum is also highest for small firms, whereas Chordia, Roll & Subrahmanyam (2000) have reported that the sum increases monotonic with firm sizes for most of liquidity proxies. The mean and median of β_2 of large firms and mid-cap firms are negative, but these are positive for small firms[3]. The mean and median of β_3 of small firms are greater than large and mid-cap firms. We note that the mean and median of β_2 of small firms are higher than mean and median of their β_3.

Next, we explore the commonality in liquidity of stocks among groups based on firm size. We try to find out whether the commonality in liquidity among the large firms is higher than rest of the stocks in the market. To capture this, we modify the above equation (4):

$$\begin{aligned} \mathrm{LnIC_{i,t}} = \alpha + \beta_1 \mathrm{LnIC_{g,t}} + \beta_2 \mathrm{LnIC_{g,t-1}} + \beta_3 \mathrm{LnIC_{g,t+1}} \\ + \beta_4 \mathrm{r_{m,t}} + \beta_5 \mathrm{r_{m,t-1}} + \beta_6 \mathrm{r_{m,t+1}} \\ + \beta_7 \mathrm{vol_{m,t}} + \sum_{\mathrm{k\epsilon\{tues,wed,thur,fri\}}} \gamma_\mathrm{j} \mathrm{D_j} + \epsilon_\mathrm{i,t} \end{aligned} \quad (5)$$

where $\mathrm{LnIC_{g,t}}$ is logarithmic transformation of group impact cost $\mathrm{IC_{g,t}}$. $\mathrm{IC_{g,t}}$ is calculated by taking cross-sectional average of impact cost, where stock i is excluded. The positive and significant value of β_1 is interpreted as evidence of the existence of commonality in liquidity.

Table 2 indicates that existence of commonality in liquidity within groups. The β_1 are 0.77, 0.67 and 0.63 for large firms, mid-cap firms and small firms respectively. These coefficients are positively significant in 97% of large firms, 95% of mid-cap firms and 98% in small firms. The β_2 are positive for mid-cap firms and small firms whereas these are negative for large firms. The Sum $\equiv \beta_1 + \beta_2 + \beta_3$ is higher for small firms than large firms and mid-cap firms. The p values are zero for sign test for all these groups. This indicates that there is commonality in liquidity within groups as well. On the basis of the Sum, small firms are highly correlated within the groups, although β_1 are higher for large firms.

5 Calendar effects

Liquidity of individual security varies during trading hours. It is different across days, months and years. Similarly commonality in liquidity may exhibit patterns during calendar

[3]Dimson (1979) found similar results in the estimation of systematic risk.

Table 1 Commonality in impact cost

This table presents summary of estimates of 4. Cross-sectional mean, median, standard deviation (Std Dev) of coefficients are reported. The coefficients associated with $\mathrm{LnIC_{m,t}}$, $\mathrm{LnIC_{m,t-1}}$ $\mathrm{LnIC_{m,t+1}}$ are referred as 'Concurrent', 'Lag' and 'Lead'. The percentage of positive coefficients are denoted in 'Poc' column. 'SC' provides the percentage of significant positive (negative) coefficients. 'Sum' refers to summation of Concurrent, Lag and Lead. 'Sign Test' column notes the p value of null hypothesis median of Sum == 0.

Variables	Mean	Median	Std. Dev	PoC	SC	Sign Test
Panel A: All Firms						
Concurrent	0.75	0.73	0.22	100	94 (00)	
Lag	-0.10	-0.07	0.38	46	12 (31)	
Lead	0.06	0.04	0.20	58	6 (02)	
Sum	0.71	0.76	0.55	90	—	0.00
Panel B: Large Firms						
Concurrent	0.66	0.66	0.19	100	86 (00)	
Lag	-0.46	-0.46	0.26	06	01 (75)	
Lead	0.01	-0.03	0.18	46	03 (03)	
Sum	0.20	0.15	0.32	75	—	0.00
Panel C: Mid-cap Firms						
Concurrent	0.72	0.72	0.20	100	97 (00)	
Lag	-0.05	-0.02	0.29	48	7 (18)	
Lead	0.09	0.05	0.20	58	12 (2)	
Sum	0.75	0.78	0.45	97	—	0.00
Panel D: Small Firms						
Concurrent	0.87	0.87	0.23	100	99 (00)	
Lag	0.22	0.20	0.24	84	30 (01)	
Lead	0.10	0.12	0.20	69	4 (02)	
Sum	1.18	1.16	0.34	100	—	0.00

Table 2 Commonality in impact cost within groups based of market size

This table presents summary of estimates of 5. Cross-sectional mean, median, standard deviation (Std Dev) of coefficients are reported. The coefficients associated with $LnIC_{g,t}$, $LnIC_{g,t-1}$ $LnIC_{g,t+1}$ are referred as 'Concurrent', 'Lag' and 'Lead'. The percentage of positive coefficients are denoted in 'Poc' column. 'SC' provides the percentage of significant positive (negative) coefficients. 'Sum' refers to summation of Concurrent, Lag and Lead. 'Sign Test' column notes the p value of null hypothesis median of Sum == 0.

Variables	Mean	Median	Std. Dev	PoC	SC	Sign Test
Panel A: Large Firms						
Concurrent	0.77	0.80	0.24	99	97 (00)	
Lag	-0.01	-0.05	0.27	41	15 (20)	
Lead	0.08	0.06	0.24	58	27 (09)	
Sum	0.84	0.76	0.65	93	—	0.00
Panel B: Mid-cap Firms						
Concurrent	0.67	0.65	0.19	100	95 (00)	
Lag	0.05	0.07	0.28	58	15 (19)	
Lead	0.14	0.13	0.20	80	24 (02)	
Sum	0.85	0.85	0.48	97	—	0.00
Panel C: Small Firms						
Concurrent	0.63	0.64	0.20	100	98 (00)	
Lag	0.17	0.14	0.20	82	26 (01)	
Lead	0.14	0.14	0.17	81	16 (00)	
Sum	0.93	0.89	0.31	100	—	0.00

time. Bauer (2004) and Kempf & Mayston (2005) have documented intra day patterns in commonality in liquidity. It is higher during start and close of trading session. Liquidity moves more independently during middle of trading session. They have not considered other calendar effects like days of week or months of year or various years. We explore these patterns in this section.

5.1 Days of week effects

NSE used to follow the trading cycle of Wednesday to Tuesday. Wednesday is the first day of trading cycle. Prior to rolling settlement regime, due to carry forward system many investors used to carry over their positions to the next trading cycle. This trading cycle may affect the correlated trading behaviours, in turn, the commonality in liquidity may vary across different days of week. We explore this by estimating

$$\begin{aligned}\mathrm{LnIC_{i,t}} = \alpha + (\beta_1 + \sum_{\mathrm{j}\epsilon\{\mathrm{Tues},...,\mathrm{Fri}\}} \beta_\mathrm{j}\mathrm{D_j})\mathrm{LnIC_{m,t}} + (\beta_2 + \sum_{\mathrm{j}\epsilon\{\mathrm{Tues},...,\mathrm{Fri}\}} \beta_\mathrm{j}\mathrm{D_j})\mathrm{LnIC_{m,t-1}} \\ +(\beta_3 + \sum_{\mathrm{j}\epsilon\{\mathrm{Tues},...,\mathrm{Fri}\}} \beta_\mathrm{j}\mathrm{D_j})\mathrm{LnIC_{m,t+1}} + \beta_4\mathrm{r_{m,t}} + \beta_5\mathrm{r_{m,t-1}} + \beta_6\mathrm{r_{m,t+1}} \\ +\beta_7\mathrm{vol_{m,t}} + \sum_{\mathrm{k}\epsilon\{\mathrm{tues,wed,thur,fri}\}} \gamma_\mathrm{j}\mathrm{D_j} + \epsilon_{\mathrm{i,t}}\end{aligned} \tag{6}$$

where Monday is the base day for the comparison with rest of week. We test whether $\mathrm{j}\epsilon\{\mathrm{Tues},...,\mathrm{Fri}\}\beta_\mathrm{j}$ are different from zero. The mean and median of coefficient of Monday are 0.80 and 0.82 respectively. 52% of all stocks are positive and significant. The coefficients of day of week dummies are negative. Thursday coefficient is highest in magnitude. 48% of Tuesday dummies, 51% of Wednesday dummies, 52% of Thursday dummies and 42% of Friday dummies are negative and significant. We observe that the sum of rest of week days are less than Monday. The sum of Friday dummy is more negative than others. Except Wednesday dummy, the sum is statistically different than zero, as p value is less than 5%.

5.2 Months of year effects

Commonality in liquidity may be affected by some unobserved factors which may vary across the months of the year. There may be correlated behaviour among portfolio managers for window dressing at the end of the quarters or at the end of the tax years (Lakonishok & Maberly (1990)). Months before or after earning announcements or government of India budget announcement or macroeconomic announcements may have different commonality in liquidity pattern. We capture this effect by taking dummy variables for the months of year. We take January as the base month.

Table 3 Days of week effect

This table presents summary of estimates of 7. Cross-sectional mean, median, standard deviation (Std Dev) of coefficients are reported. The coefficients associated with $\text{LnIC}_{m,t}$, $\text{LnIC}_{m,t-1}$ $\text{LnIC}_{m,t+1}$ are referred as 'Concurrent', 'Lag' and 'Lead'. The coefficients for days of week dummies are reported as 'Comcurrent (days)', 'Lead (days)' and Lag (days)'. The percentage of positive coefficients are denoted in 'Poc' column. 'SC' provides the percentage of significant positive (negative) coefficients. 'Sum' refers to summation of Concurrent, Lag and Lead. 'Sign Test' column notes the p value of null hypothesis median of Sum == 0.

Coefficients	Mean	Median	Std. Dev	PoC	SC	Sign Test
Panel A: All Firms						
Concurrent	0.80	0.82	0.51	93	52 (08)	
Concurrent (Tues)	-0.10	-0.07	0.81	47	43 (48)	
Concurrent (Wed)	-0.06	-0.07	0.74	46	44 (51)	
Concurrent (Thurs)	-0.33	-0.32	0.83	35	33 (52)	
Concurrent (Fri)	-0.001	0.04	0.84	52	47 (42)	
Lag	-0.08	-0.07	0.72	48	35 (38)	
Lag (Tues)	-0.03	-0.10	0.78	43	38 (50)	
Lag (Wed)	-0.02	-0.01	0.70	49	46 (44)	
Lag (Thurs)	0.11	0.08	0.73	56	46 (41)	
Lag (Fri)	-0.02	-0.08	0.70	46	43 (50)	
Lead	0.01	-0.02	0.36	49	47 (47)	
Lead (Tues)	0.11	0.14	0.56	60	56 (38)	
Lead (Wed)	0.07	0.052	0.52	55	53 (45)	
Lead (Thurs)	0.20	0.23	0.51	66	62 (33)	
Lead (Fri)	-0.003	0.01	0.48	50	48 (46)	
Sum	0.73	0.77	0.56	90	—	0.00
Sum (Tues)	-0.01	-0.01	0.12	45	—	0.04
Sum (Wed)	-0.01	-0.01	0.11	45	—	0.07
Sum (Thurs)	-0.02	-0.02	0.12	45	—	0.04
Sum (Fri)	-0.03	-0.03	0.12	38	—	0.00

$$
\begin{aligned}
\mathrm{LnIC_{i,t}} = \alpha + (\beta_1 + \sum_{\mathrm{1j\epsilon\{Feb,...,Dec\}}} \beta_{\mathrm{1j}}\mathrm{D_{1j}})\mathrm{LnIC_{m,t}} + (\beta_2 + \sum_{\mathrm{2j\epsilon\{Feb,...,Dec\}}} \beta_{\mathrm{2j}}\mathrm{D_{2j}})\mathrm{LnIC_{m,t-1}} \\
+(\beta_3 + \sum_{\mathrm{3j\epsilon\{Feb,...,Dec\}}} \beta_{\mathrm{3j}}\mathrm{D_{3j}})\mathrm{LnIC_{m,t+1}} + \beta_4\mathrm{r_{m,t}} + \beta_5\mathrm{r_{m,t-1}} + \beta_6\mathrm{r_{m,t+1}} \\
+\beta_7\mathrm{vol_{m,t}} + \sum_{\mathrm{k\epsilon\{tues,wed,thur,fri\}}} \gamma_{\mathrm{j}}\mathrm{D_j} + \epsilon_{\mathrm{i,t}}
\end{aligned}
\tag{7}
$$

Table 4 reports the results of equation 7. We find that mean and median of coefficients β_{1j} at Feb, Mar, Jul and Nov are positive. These coefficients are positive in 50% for Feb, 46% for Mar, 62% for Jul and 43% Nov. The sum of Feb is positive and statistically significant at 10% level. Mar and Jul's sum are negative, but statistically insignificant, where as the sum of Nov is highly negative significant.

5.3 Year effects

In last decade, many policy reforms like introduction of rolling settlements, derivatives etc. have taken place. Table 5 reports the list of major events on India's equity market.

These policy reforms may have impact on the commonality in liquidity of stock markets. Indian equity markets also faced following major crises over the years.

- CRB Mutual Fund scam in 1997.
- Market Manipulation involving three stocks (BPL, Sterlite, Videocon) in 1998.
- Dismissal of a BSE president, the dismissal of all elected directors on the Bombay Stock Exchange and the Calcutta Stock Exchange, and payment failures on the Calcutta Stock Exchange in 2001.
- UTI mutual fund fiasco in 2001.
- Ketan Parikh scam in 2001.

Each of these crises may have affect the commonality in liquidity in the market. We take year dummies to capture the years effects.

$$
\begin{aligned}
\mathrm{LnIC_{i,t}} = \alpha + (\beta_1 + \sum_{\mathrm{1j\epsilon\{98,...,01\}}} \beta_{\mathrm{1j}}\mathrm{D_{1j}})\mathrm{LnIC_{m,t}} + (\beta_2 + \sum_{\mathrm{2j\epsilon\{98,...,01\}}} \beta_{\mathrm{2j}}\mathrm{D_{2j}})\mathrm{LnIC_{m,t-1}} \\
+(\beta_3 + \sum_{\mathrm{3j\epsilon\{98,...,01\}}} \beta_{\mathrm{3j}}\mathrm{D_{3j}})\mathrm{LnIC_{m,t+1}} + \beta_4\mathrm{r_{m,t}} + \beta_5\mathrm{r_{m,t-1}} + \beta_6\mathrm{r_{m,t+1}} \\
+\beta_7\mathrm{vol_{m,t}} + \sum_{\mathrm{k\epsilon\{tues,wed,thur,fri\}}} \gamma_{\mathrm{j}}\mathrm{D_j} + \epsilon_{\mathrm{i,t}}
\end{aligned}
\tag{8}
$$

Table 4 Months of year effects

This table presents summary of estimates of 7. Cross-sectional mean, median, standard deviation (Std Dev) of coefficients are reported. The coefficients associated with $\mathrm{LnIC}_{\mathrm{m,t}}$, $\mathrm{LnIC}_{\mathrm{m,t-1}}$ $\mathrm{LnIC}_{\mathrm{m,t+1}}$ are referred as 'Concurrent', 'Lag' and 'Lead'. The coefficients for months of year dummies are reported as 'Comcurrent (month)', 'Lead (month)' and Lag (month)'. The percentage of positive coefficients are denoted in 'Poc' column. 'SC' provides the percentage of significant positive (negative) coefficients. 'Sum' refers to summation of Concurrent, Lag and Lead. 'Sign Test' column notes the p value of null hypothesis median of Sum == 0.

Coefficients	Mean	Median	Std. Dev	PoC	SC	Sign Test
Panel A: All Firms						
Concurrent	0.70	0.71	0.56	90	58 (09)	
Concurrent (Feb)	0.02	0.04	0.71	54	50 (42)	
Concurrent (Mar)	0.07	0.05	0.71	52	46 (45)	
Concurrent (Apr)	-0.05	-0.12	0.69	44	41 (53)	
Concurrent (May)	-0.03	0.02	0.78	50	48 (45)	
Concurrent (Jun)	-0.00	-0.07	0.71	46	44 (50)	
Concurrent (Jul)	0.49	0.50	0.91	71	62 (27)	
Concurrent (Aug)	-0.10	-0.11	0.65	43	42 (53)	
Concurrent (Sep)	-0.17	-0.12	0.79	43	40 (51)	
Concurrent (Oct)	-0.09	-0.09	0.75	45	41 (51)	
Concurrent (Nov)	0.01	0.06	0.88	51	43 (45)	
Concurrent (Dec)	-0.00	0.03	0.75	52	51 (45)	
Sum	0.80	0.76	0.66	92	—	0.00
Sum (Feb)	0.08	0.10	0.87	55	—	0.09
Sum (Mar)	-0.08	-0.07	0.74	47	—	0.29
Sum (Apr)	-0.12	-0.16	0.74	41	—	0.00
Sum (May)	-0.14	-0.16	0.86	41	—	0.00
Sum (Jun)	-0.07	-0.10	0.63	41	—	0.00
Sum (Jul)	-0.01	-0.04	0.55	47	—	0.24
Sum (Aug)	-0.12	-0.16	0.63	39	—	0.00
Sum (Sep)	-0.11	-0.13	0.62	43	—	0.01
Sum (Oct)	-0.12	-0.15	0.63	42	—	0.00
Sum (Nov)	-0.14	-0.12	0.56	40	—	0.00
Sum (Dec)	-0.08	-0.12	0.44	37	—	0.00

Table 5 Chronology of events on Indian equity market

Date	Event
Apr 1996	National Securities Clearing Corporation (NSCC) commenced operations.
8 Nov 1996	National Securities Depository Ltd. (NSDL) commerenced operations.
1999	Securities law modified to enable derivative trading.
12 Jun 2000	Start of equity index futures trading.
4 Jun 2001	Start of equity index options trading.
2 Jul 2001	Major stocks moved to rolling settlement.
2 Jul 2001	start of stock option markets.
2 Jul 2001	Index based market wide circuit breaker system.
2 Jul 2001	VaR 99% based margins system.

We note the estimation results in table 6 of equation 8. The mean and median of β_{1j} of year 1999 and 2001 are positive. These are positively significant for 43% in year 1999 and 51% in year 2001. In case of the sum, only year 2002 is positive, but it is insignificant. The sum of year 1998 and 1999 are negative and significant.

6 Bull Bear market effects

Stock market can be characterized with bull (up) and bear (down) phases. The rising and falling market may have asymmetric affect on commonality in liquidity. Sujoto, Kalev & Faff (2004) and Kempf & Mayston (2005) have explored this issue. After applying threshold on excess market return series, Sujoto, Kalev & Faff (2004) have splitted the sample in up, down and netural market, whereas Kempf & Mayston (2005) have categorised up/down market on the basis of moving average rule.

The definition of bull and bear market is not formalised yet in finance literature. Fabozzi & Francis (1977), Kim & Zumwalt (1979) and Chen (1982) have defined bull market in which returns are greater than a certain threshold value. But Sperandeo (1990) has made an attempt to define as follows:

- *Bull market: A long-term ... upward price movement characterised by a series of higher intermediate ... highs interrupted by a series of higher intermediate lows.*
- *Bear market: A long-term downtrend characterised by a series of lower intermediate lows interrupted by lower intermediate highs* page(102).

Lunde & Timmermann (2000) has used this definition to analyse bull and bear market. Their methodology group full datasets in to mutually exclusive bull and bear subsets after considering upward trend in stock prices. We employ their following way of categorising

Table 6 Year effects

This table presents summary of estimates of 8. Cross-sectional mean, median, standard deviation (Std Dev) of coefficients are reported. The coefficients associated with $LnIC_{m,t}$, $LnIC_{m,t-1}$ $LnIC_{m,t+1}$ are referred as 'Concurrent', 'Lag' and 'Lead'. The coefficients for year dummies are reported as 'Comcurrent (year)', 'Lead (year)' and 'Lag (year)'. The percentage of positive coefficients are denoted in 'Poc' column. 'SC' provides the percentage of significant positive (negative) coefficients. 'Sum' refers to summation of Concurrent, Lag and Lead. 'Sign Test' column notes the p value of null hypothesis median of Sum == 0.

Coefficients	Mean	Median	Std. Dev	PoC	SC	Sign Test
Panel A: All Firms						
Concurrent	0.67	0.69	0.58	87	53 (12)	
Concurrent (1998)	-0.02	-0.04	0.66	48	43 (46)	
Concurrent (1999)	0.01	-0.01	0.70	50	43 (45)	
Concurrent (2000)	-0.09	-0.09	0.72	46	41 (48)	
Concurrent (2001)	0.28	0.23	0.67	64	51 (34)	
Concurrent (2002)	-0.03	-0.00	0.68	50	46 (46)	
Lag	0.02	0.05	0.55	55	52 (41)	
Lag (1998)	-0.10	-0.11	0.66	41	39 (54)	
Lag (1999)	-0.17	-0.21	0.67	38	36 (55)	
Lag (2000)	-0.09	-0.14	0.70	43	40 (53)	
Lag (2001)	-0.23	-0.24	0.69	35	33 (57)	
Lag (2002)	0.01	0.01	0.64	52	49 (46)	
Lead	0.11	0.12	0.49	61	56 (38)	
Lead (1998)	0.02	-0.01	0.69	49	45 (46)	
Lead (1999)	-0.10	-0.12	0.63	42	39 (52)	
Lead (2000)	0.02	-0.02	0.68	49	45 (48)	
Lead (2001)	-0.12	-0.14	0.61	40	38 (53)	
Lead (2002)	0.10	0.60	0.79	53	46 (44)	
Sum	0.81	0.76	0.84	81	—	0.00
Sum (1998)	-0.11	-0.22	1.09	43	—	0.01
Sum (1999)	-0.26	-0.17	1.16	44	—	0.02
Sum (2000)	-0.17	-0.12	1.29	48	—	0.39
Sum (2001)	-0.08	-0.01	1.02	50	—	1.00
Sum (2002)	0.08	0.08	1.05	52	—	0.52

stock markets in bull and bear phases.

Notations

- $I_t = 1$ if stock market is in bull phase at time t.
- $I_t = 0$ if stock market is in bear phase at time t.
- $P_{max} = P[t_m]$ = Stock market is at a local maximum at t_m.
- κ = Threshold by which stock price should fall from P_{max} to move in to bear phase.
- τ = Stopping time for bull or bear market.

Definitions

- $\tau = \min_{i=1,...}\{P[t_m + i] \geq P_{max} \vee P[t_m + i] < (1-\kappa)P_{max}\}$
- The new local maximum in bull phase is achieved if first condition is met and $P_{max} = P[t_m + \tau]$, $t_{max} = t_m + \tau$.
- The bull phase prevails during t_m and $t_m + \tau$ with indicators $I_{t_m} = ... = I_{t_{t_m+\tau}} = 1$.
- Under second condition, bull phase terminates and there is bear phase during t_m and $t_m + \tau$ with indicators $I_{t_m} = ... = I_{t_{t_m+\tau}} = 0$.
- Similarly stopping time for bear market is defined if starting point is bear phase.

Lunde & Timmermann (2000) have taken 10% as κ. Since we have five years of data, we need to have enough data for both phases, we choose 8% as κ. We have taken Nifty index as market index of NSE. Figure 6 depicts the bull-bear phases in NSE. The shaded region in figure 6 is bull phase. Table 7 describes the empirical characteristics of bull and bear phases in Indian stock market. The mean (median) duration of bull and bear markets are 37 (27) days and 26 (18) days respectively. The max (min) duration of bull and bear market are 101 (3) days and 133 (3) days respectively. The mean (median) of log return during bull and bear market are 1.53% (1.41%) and -2.0% (-1.15%) respectively.

To capture the asymmetry effects of bull and bear market, we modify regression 4 by taking dummy variable for bull and bear market. The dummy variable takes value 1 if it is bull market, otherwise it is zero.

$$\mathrm{LnIC}_{i,t} = \alpha + (\beta_1 + \beta_{1bull}D_{bull})\mathrm{LnIC}_{m,t} + (\beta_2 + \beta_{2bull}D_{bull})\mathrm{LnIC}_{m,t-1} + (\beta_3 + \beta_{3bull}D_{bull})\mathrm{LnIC}_{m,t+1} + \beta_4 r_{m,t} + \beta_5 r_{m,t-1} + \beta_6 r_{m,t+1} + \beta_7 \mathrm{vol}_{m,t} + \sum_{k\epsilon\{tues,wed,thur,fri\}} \gamma_j D_j + \epsilon_{i,t} \quad (9)$$

Figure 1 Bull and Bear markets with a stopping rule 8%.

This figure depicts the bull-bear phases in NSE. The shaded region in this figure is bull phase.

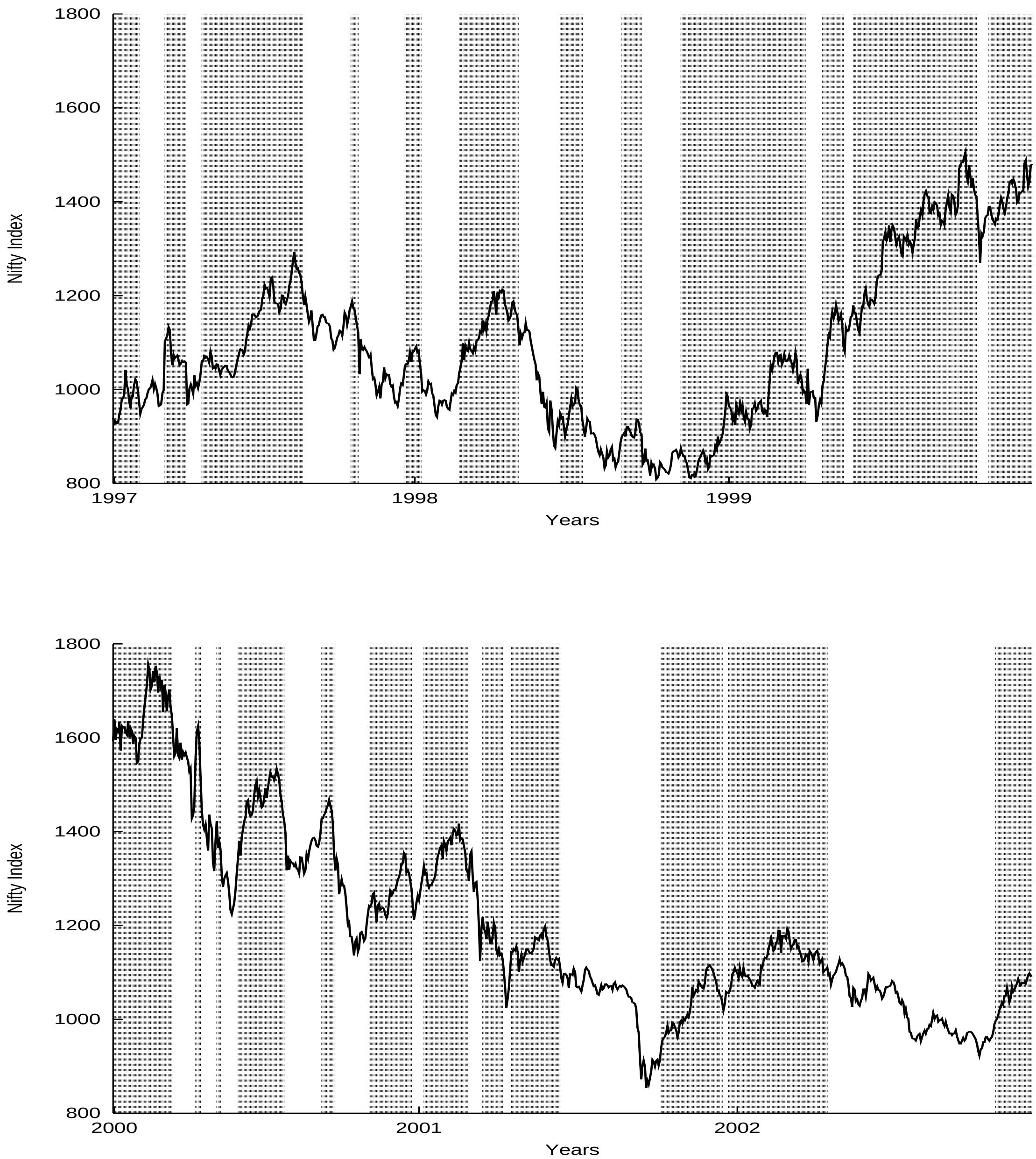

Table 7 Empirical characteristics of bull and bear market

This table presents summary statistics of duration (days) and log return (%) during bull and bear market.

	Mean	Median	Min	Max	Stdev
Panel A: Duration (days)					
Bull market	37	27	3	101	31
Bear market	26	18	3	133	29
Panel B: Log-return (%)					
Bull market	1.53	1.41	-5	10	16
Bear market	-2.0	-1.15	-8	7.5	19

The mean and median of β_1 are 0.84 and 0.82. These coefficients are positive in 100% stocks and significant in 11%. We observe that the mean and median of β_{bull} are -0.18 and-0.17 and negative significant in 60%. Kempf & Mayston (2005) have found similar results for price impact function. The mean (median) of sum = $\beta_{1\text{bull}} + \beta_{2\text{bull}} + \beta_{3\text{bull}}$ is -0.09 (-0.10). The p value indicates that the sum is different than zero. Hence we provide the evidences that commonality in liquidity is lower during bull market than bear market. This is consistent with Kempf & Mayston (2005) finding, but on the contrary Sujoto, Kalev & Faff (2004) have reported commonality in liquidity is higher during bull market in all other proxies except percentage bid-ask spread.

7 Rise and Fall in Market liquidity

The relative strength of commonality in liquidity may be different in rising/falling market liquidity. Stocks may widen in impact cost more often than shrink in impact cost together. Chan (2001) has suggested that this asymmetry may arise due to correlated noise trading. He has reported that this asymmetry is more prevalent in large firms due to high correlated noise trading with comparison to small firms. According to him, there is rise in noise trading during bull market in the year 1998. He has documented that large firms falls in bid-ask spread together more often than they rise in bid-ask spread together in the year 1998.

Unlike Chan (2001), we take five years of data and we do not split these years in to bull or bear markets. We try to find out relative strength of commonality in liquidity by taking whole five years sample. The growth in market impact cost is computed. The dummy variable takes value 1 if growth in market impact cost is positive otherwise it is zero. To test the hypothesis of asymmetry in commonality, we modify regression (4) by taking dummy variable.

Table 8 Bull and bear market effects

This table presents summary of estimates of equation 9. Cross-sectional mean, median, standard deviation (Std Dev) of coefficients are reported. The coefficients associated with $LnIC_{m,t}$, $LnIC_{m,t-1}$ $LnIC_{m,t+1}$ are referred as 'Concurrent', 'Lag' and 'Lead'. The coefficients for bull market dummy are reported as 'Concurrent (bull)', 'Lead (bull)' and 'Lag (bull)'. The percentage of positive coefficients are denoted in 'Poc' column. 'SC' provides the percentage of significant positive (negative) coefficients. 'Sum' refers to summation of Concurrent, Lag and Lead. 'Sign Test' column notes the p value of null hypothesis median of Sum == 0.

Coefficients	Mean	Median	Std. Dev	PoC	SC	Sign Test
Panel A: All Firms						
Concurrent	0.84	0.82	0.25	100	11 (00)	
Concurrent (Bull)	-0.18	-0.17	0.33	31	30 (60)	
Lag	-0.13	-0.12	0.40	42	37 (40)	
Lag (Bull)	0.04	0.05	0.31	56	54 (43)	
Lead	0.04	0.02	0.27	52	46 (46)	
Lead (Bull)	0.05	0.04	0.32	55	52 (43)	
Sum	0.75	0.79	0.54	93	—	0.00
Sum (Bull)	-0.09	-0.10	0.20	29	—	0.00

$$\begin{aligned} \mathrm{LnIC_{i,t}} = \alpha + (\beta_1 + \beta_{1up}\mathrm{D_{up}})\mathrm{LnIC_{m,t}} + (\beta_2 + \beta_{2up}\mathrm{D_{up}})\mathrm{LnIC_{m,t-1}} + (\beta_3 + \beta_{3up}\mathrm{D_{up}})\mathrm{LnIC_{m,t+1}} \\ + \beta_4 \mathrm{r_{m,t}} + \beta_5 \mathrm{r_{m,t-1}} + \beta_6 \mathrm{r_{m,t+1}} + \beta_7 \mathrm{vol_{m,t}} + \sum_{k\epsilon\{tues,wed,thur,fri\}} \gamma_j \mathrm{D_j} + \epsilon_{i,t} \end{aligned} \tag{10}$$

We present the estimation results of 10 in table 9. The median of β_1 is 0.40 and it is positive significant in 46% stocks. The mean and median of β_{up} are 0.60 and 0.54 respectively. 52% of these coefficients are positive and significant. The mean and median of the sum $\beta_1 + \beta_2 + \beta_3$ are 0.72 and 0.76 respectively, whereas the sum $\beta_{1up} + \beta_{2up} + \beta_{3up}$ is negative with mean of -0.02. These sum are significantly different than zero, as p value of sign test is zero.

Next, we explore whether the firms move together more often when their group (based firm sizes) liquidity is going down. We replace market impact cost of equation 10 by group impact cost and then reestimate it. Table 10 shows that the median of sum $\beta_{1up}+\beta_{2up}+\beta_{3up}$ is positive for large firms, whereas it is negative for mid-cap firms and small firms. These are significantly different from zero for large firms and mid cap firms. This shows that impact cost of large firms rise together more often than they fall together. But opposite holds true for small firms.

Table 9 Rise and fall in market liquidity

This table presents summary of estimates of equation 10. Cross-sectional mean, median, standard deviation (Std Dev) of coefficients are reported. The coefficients associated with $\mathrm{LnIC}_{m,t}$, $\mathrm{LnIC}_{m,t-1}$ $\mathrm{LnIC}_{m,t+1}$ are referred as 'Concurrent', 'Lag' and 'Lead'. The coefficients for rising market impact cost dummy are reported as 'Concurrent (up)', 'Lead (up)' and 'Lag (up)'. The percentage of positive coefficients are denoted in 'Poc' column. 'SC' provides the percentage of significant positive (negative) coefficients. 'Sum' refers to summation of Concurrent, Lag and Lead. 'Sign Test' column notes the p value of null hypothesis median of Sum == 0.

Coefficients	Mean	Median	Std. Dev	PoC	SC	Sign Test
Panel A: Small Firms						
Concurrent	0.40	0.40	0.57	74	46 (25)	
Concurrent (up)	0.60	0.54	0.81	77	52 (22)	
Lag	0.22	0.23	0.34	74	65 (26)	
Lag (up)	-0.62	-0.52	0.82	22	20 (52)	
Lead	0.09	0.05	0.29	59	48 (38)	
Lead (up)	-0.01	0.001	0.36	50	47 (45)	
Sum	0.72	0.76	0.55	91	—	0.00
Sum (up)	-0.02	-0.02	0.08	38	—	0.00

8 Conclusions

This paper provides the evidences on existence of commonality in liquidity of National Stock Exchange, India. Most of the stocks are influenced by market wide liquidity. These stocks also comove within the groups based on firm sizes. We extend the growing literature on commonality in liquidity by observing weekly and monthly pattern. Stocks comove strongly in the month of February, before Indian Government budget announcement. Stocks may widen in impact cost more often than shrink in impact cost together. We find that impact cost of large firms falls together more often than they rise together. But opposite holds true for small firms.

Trading behaviour and trading strategies could be different under bull and bear market. Arrival or composition of informed traders as well as noise traders in stock market depends upon the state of market. We follow most general definition of bull and bear market. There are bull and bear market states in Indian stock market. We examine the asymmetrical commonality in liquidity during bull and bear market. Commonality in liquidity is higher during bear market condition when market falls. The implication of this finding is that portfolio managers face more challenges in altering their holdings during bear market state.

Table 10 Rise and fall in group liquidity

This table presents summary of estimates of 10. Cross-sectional mean, median, standard deviation (Std Dev) of coefficients are reported. The coefficients associated with $\mathrm{LnIC_{g,t}}$, $\mathrm{LnIC_{g,t-1}}$ $\mathrm{LnIC_{g,t+1}}$ are referred as 'Concurrent', 'Lag' and 'Lead'. The coefficients for rising market impact cost dummy are reported as 'Concurrent (up)', 'Lead (up)' and Lag (up)'. The percentage of positive coefficients are denoted in 'Poc' column. 'SC' provides the percentage of significant positive (negative) coefficients. 'Sum' refers to summation of Concurrent, Lag and Lead. 'Sign Test' column notes the p value of null hypothesis median of Sum == 0.

Coefficients	Mean	Median	Std. Dev	PoC	SC	Sign Test
Panel A: Large Firms						
Sum	0.80	0.70	0.72	92	—	0.00
Sum (up)	0.03	0.03	0.04	77	—	0.00
Panel A: Midcap Firms						
Sum	0.84	0.82	0.48	96	—	0.00
Sum (up)	0.01	-0.01	0.87	47	—	0.52
Panel A: Small Firms						
Sum	0.94	0.91	0.31	100	—	0.00
Sum (up)	-0.02	-0.02	0.57	35	—	0.00

References

Acharya, V. V. & Pedersen, L. H. (2004), 'Asset pricing with liquidity risk', *Journal of Financial Economics* **forthcoming**.

Bauer, W. (2004), 'Commonality in liquidity in pure order driven markets'.

Brockman, P. & Chung, D. Y. (2002), 'Commonality in liquidity: Evidence from an order driven market structure', *Journal of Financial Research* pp. 521–539.

Chan, J. S. P. (2001), 'Asymmetry in the common liquidity of markets'.

Chen, S. N. (1982), 'An examination of risk return relationship in bull and bear markets using time varying betas', *Journal of Financial and Quantitative Analysis* **17(2)**, 265–286.

Chordia, T., Roll, R. & Subrahmanyam, A. (2000), 'Commonality in liquidity', *Journal of Financial Economics* **56**, 3–28.

Coppejans, M., Domowitz, I. & Madhavan, A. (2001), liquidity in automated auction, Technical report, Duke University.

Dimson, E. (1979), 'Risk measurement when shares are subject to infrequent trading', *Journal of Financial Economics* **7**, 197–226.

Domowitz, I. & Wang, X. (2002), Liquidity, liquidity commonality and its impact on portfolio theory, Technical report, Pennsylvania State University.

Fabozzi, F. J. & Francis, J. C. (1977), 'Stability tests for alphas and betas over bull and bear market conditions', *Journal of Finance* **32(4)**, 1093–1099.

Fernando, C. (2003), 'Commonality in liquidity: Transmission of liquidity shocks across investors and securities', *Journal of Financial Intermediation* **12**, 233–254.

Giouvris, E. (2003), 'Commonality in liquidity and expected returns: Evidence from the london stock exchange'.

Hasbrouck, G. & Seppi, J. (2001), 'Common factor in prices, order flows, and liquidity', *Journal of Financial Economics* **59**, 383–411.

Huberman, G. & Halka, D. (2001), 'Systametic liquidity', *Journal of Financial Research* pp. 161–178.

Irvine, P., Benston, G. & 2000, E. K. (2000), Liquidity beyond the inside spread: measuring and using information in the limit order book, Technical report, Emory University.

Kempf, A. & Mayston, D. (2005), 'Commonalities in the liquidity of a limit order book'.

Kim, M. K. & Zumwalt, J. K. (1979), 'An analysis of risk in bull and bear markets', *Journal of Financial and Quantitative Analysis* **14(5)**, 1015–1025.

Lakonishok, J. & Maberly, E. (1990), 'The weekend effect: Trading patterns of individual and institutional investors', *Journal of Finance* **45**, 231–243.

Lunde, A. & Timmermann, A. G. (2000), 'Duration dependence in stock prices: An analysis of bull and bear markets'.

Sperandeo, V. (1990), *Principles of professional speculation*, John wiley.

Sujoto, C., Kalev, P. S. & Faff, R. W. (2004), 'Commonality in liquidity: futher australian evidence'.

Wantanabe, M. (2003), 'A model of stochastic liquidity'.