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Evidence from the Indian Market

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Abstract

The law of one price relies on enforcement by arbitragers who are expected to eliminate price differentials quickly. Arbitragers' activities are constrained by liquidity of markets. However, large price differentials attract arbitrage activity enhancing the liquidity of markets. Using daily data on the NYSE index and related futures contracts, Roll, Schwartz, and Subrahmanyam (2007) document two-way Granger causality between the futures-cash basis and bid-ask spreads for stocks. We examine the issue using intra-day data on Indian single stock futures (SSF) contracts on Indian stocks and also consider the spread on the futures contracts. While the spreads in both the futures and cash markets affect futures-cash basis, we find that the futures-cash basis Granger-causes only the bid-ask spreads for SSFs but not the stocks.

Keywords: Futures-cash basis; Single stock futures; Indian stocks

JEL Classification Codes: G12, G13

Impact of Liquidity on the Futures-Cash Basis: Evidence from the Indian Market

1. Introduction

Arbitragers play a crucial role in financial markets by helping to restore equilibrium relationships between security prices. However, their influence is constrained by market frictions which impede their trading activities. A key friction is market illiquidity, which has played a major role in several financial crises. The role of liquidity in determining asset prices has received increasing attention.[1] Bakshi, Cao, and Chen (2000) find that large bid-ask spreads, a measure of liquidity, induce a breakdown of the relationship between stock and option prices implied by theory. Deville and Riva (2007) use data from the French index options market, and find that higher liquidity is associated with a quicker elimination of deviations from put-call parity. Roll, Schwartz, and Subrahmanyam (2007) (RSS hereafter) examine the two-way relationship between aggregate liquidity and the futures-cash basis using daily data on US index futures. They measure liquidity using the average bid-ask spread on the stocks constituting the index. They argue that larger spreads will induce larger deviations from the equilibrium basis. Larger basis deviations should attract more attention from arbitragers, which in turn can cause order imbalances and contribute to illiquidity. They report evidence for two-way Granger causality between spreads and futures-cash basis.

In this paper, we examine the interaction between bid-ask spreads and the futures-cash basis using intra-day data on Indian single stock futures contracts. The single stock futures market in India is one of the most successful among such markets. Trading

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[1] For instance, see Amihud (2002), Chordia, Roll, and Subrahmanyam (2001, 2002) , Pastor and Stambaugh (2003). Subrahmanyam(2008) provides an overview of related literature.

volume for these futures contracts compares well with the trading volume for the stocks. Our sample consists of all Indian stocks with futures contracts between January 2004 and March 2005. The contracts have a maturity of one-month when they begin trading.

While our approach closely follows RSS (2007), there are important distinctions driven by the data. RSS study index futures, whereas we consider single stock futures which provide three advantages. RSS (2007) examine the impact of aggregate market liquidity, and hence they analyze futures contracts on a market index. They have to deal with potential non-synchronization of prices among the various stocks underlying the index. Some stocks may trade more frequently than others. Although RSS estimate that the potential impact is minimal, we avoid the problem entirely. However, their results are much weaker when they use an exchange-traded index fund (SPIDERs) as the cash instrument, instead of the entire basket of stocks underlying the futures contract. This raises the question whether the illiquidity effects are driven by difficulties in trading across many different securities or perhaps even measurement problems introduced when assessing aggregate market illiquidity by combining individual stock illiquidity measures. In our study, there is a direct one-to-one relationship between the cash and futures instruments.

We can also make more precise adjustments for the dividend yield since we are dealing with individual stocks. Moreover, we can conduct our tests using only the months in which the stocks did not pay a dividend. This procedure ensures that the results are not driven by errors in adjusting for the dividend yield. Next, using a cross-section of individual stocks provides a richer variation in liquidity compared to examining only the market index.

Deville and Riva (2007) note that liquidity in both the stock and derivative markets influence the extent of arbitrage activity. RSS consider only the bid-ask spreads in the stock market. We examine the impact of the bid-ask spreads in both the stock and derivative markets. We also use intra-day data rather than daily data. The higher frequency allows us to estimate the interaction between liquidity and violations of no-arbitrage conditions at shorter-time intervals. Finally, it is instructive to examine the role of liquidity in an emerging market like India compared to the highly developed capital markets in the US.

The results are consistent with the major findings in RSS (2007). There is a two-way interaction between liquidity and deviations from the no-arbitrage relationship between cash and futures prices. These deviations are linked to the liquidity in both the stock and the futures markets. However, we find that the bid-ask spread in the futures market is relatively more important in explaining these deviations compared to the bid-ask spread in the cash market.

The rest of the paper is organized as follows. Section 2 describes the data, outlines the procedure employed by RSS, and notes the modifications we made to accommodate the characteristics of our dataset. Section 3 contains the results of the empirical analysis, while Section 4 presents the conclusion.

2. Data and Methodology

2.1. Trade and Quote Data

This study includes all (56) SSFs traded on the National Stock Exchange (NSE) during January 2004 to March 2005. The trading cycle of the SSFs are the near month (one) contracts, the next month (two) contracts, and the far month (three) contracts. However, the trading in the SSFs is wholly concentrated in one month contracts duration (above 95%). Therefore, we focus on one month SSF contracts in our analysis. The one month SSF contract expires on the last Thursday of the month or the preceding trading day, if the last Thursday is a holiday.

A SSF is allowed to trade on the NSE when it satisfies a defined criterion. It has to be one of the top 500 stocks in terms of average daily market capitalization and daily traded value for the previous six months. This requirement implies that the SSFs and their underlying stocks are the most liquid and actively-traded securities on the exchange.

We obtain trade and quote data for all SSFs and their underlying stocks directly from the exchange. The trade data contains all the trades that occurred on the NSE. The quote data contains snapshots of the limit order book on an hourly basis. We use the snapshots of limit order book for SSFs and their stocks at 11 A.M., 12 noon, 1 P.M., and 2 P.M. The snapshot of the limit order books contains all the outstanding limit orders at that time and includes variables such as order ID number, quantity, price, buy or sell order, and the timestamp. The normal market operation time for SSFs and stocks in the NSE is synchronized, with trading starting at 9:55 A.M. and closing at 3:30 P.M.

2.2. Measurement of Futures-Cash Basis and Bid-Ask Spreads

Futures-cash basis, quoted spreads, and effective spreads are the primary variables in our study. Futures-cash basis reflects the difference in price between the SSFs and their stocks on a given time of the day. Since, both positive and negative deviations from the theoretical value give rise to profit opportunities, we are interested in the absolute deviation. Similar to RSS, we compute the absolute basis defined by MacKinlay and Ramaswamy (1988) as follows:

$$\frac{\left| (F - d)e^{-rt} - S \right|}{S}$$

where *F* and *S* are the SSF and stocks price, respectively, *d* denotes the dividend amount, *r* is the interest rate, and *t* is the time to maturity for the contracts. RSS note that the absolute value of the basis should be zero in a frictionless world. We use the one-month MIBOR rate plus 2 percent to proxy the interest rate *r*, since the SSFs in the sample are one month contracts.[2] The MIBOR rate is a daily closing rate on the NSE for a one-month period. We add 2 percent to MIBOR rate to more closely reflect the effective borrowing rate for traders in the SSF market. We obtain MIBOR and dividend data from the Bloomberg database.

For each trading day, we compute four different bases at 11 A.M., 12 noon, 1 P.M., and 2 P.M in order to align the basis data with the bid-ask data obtained from the snapshots of the limit order book. Similar to the official closing price calculation in the NSE, we use the last 2 minutes of each hour to calculate the mean price for SSFs and stocks.[3] The mean quote price data series for stocks and SSFs are calculated using last 5 minutes of each hour. The exchange does not have market makers who are required to

[2] The MIBOR (Mumbai Interbank Offering Rate) is the minimal rate at which the market intermediaries can borrow, and it is widely used as a benchmark rate for interest rate swaps, forward rate agreements, floating rate debentures, and term deposits. The effective cost of funds for traders will be higher than MIBOR; nevertheless, it should be highly correlated with MIBOR. Thus, MIBOR is a good proxy for the risk-free rate.

[3] At the NSE, the official closing price comes out of a separate session held from 3:35 pm to 3:50 pm (normal trading ends at 3:30 pm). During regular trading, orders are executed immediately, based on a price-time priority. However, in the closing session, the orders are keyed in, and the trading system continuously calculates an equilibrium price. The equilibrium price for a stock at any point of time is the level at which the prevailing demand-supply position in that stock is optimized. Orders are matched only at the end of this session, and all the trades are executed at the equilibrium price.

provide bid and ask quotes simultaneously for a reasonable quantity. The bid-ask quotes are driven entirely by limit orders submitted by traders who may be interested in only one side of the market and may submit orders for small odd-lots. Computing quoted bid-ask spread based on 5-minute averages for the bid and ask quotes provides a more reliable estimate of the bid-ask spread as it incorporates information from more orders.

Effective spread is calculated following standard procedures; it is set equal to twice the absolute difference between trade price and mid-quote price, where mid-quote price is the average price of bid and ask quote prices. The quoted spread is scaled by the bid quote price, while the effective spread is scaled by the trade price. We apply different filters on these variables to remove anomalous data. In the case of basis, we delete observations when the basis is more than 5.00% or less than -2% of the stock price. Similarly, if the quoted spread is more than 10.00% of the trade price, we delete it. We apply this filter to quoted spreads for both the SSFs and stocks. We do not use any filter for effective spreads beyond the filters for basis and quote spreads. We find that both filters remove less than 2.00% of all observations from the final data. To eliminate results being driven by outliers, we winsorize quoted and effective spreads for SSFs and their stocks at 1% and 99%.

2.3. Summary of the Roll, Schwartz, and Subrahmanyam (2007) Study

We closely follow the methods used by the RSS (2007) study to examine the interaction between liquidity and the futures-cash basis. Hence, we provide here a summary of their paper with emphasis on the relevant methods. RSS study primarily the futures-cash basis for the NYSE index, although they examine the S&P 500 index in their robustness tests. They examine futures contracts across three maturities: 3, 6, and 9 months. They use daily data on the futures contracts, specifically the closing price on the futures contracts for the period 1988 - 2002.

Their primary measures of liquidity are the average quoted and effective bid-ask spreads on the stocks constituting the index underlying the futures contract. RSS employ a number of filter rules to clean the data. For instance, they delete all records where the quoted spread exceeds $5 or 40% of the mid-point of the bid and ask quotes. After applying the filter rules to clean the data, they first construct the average spread for a stock on each trading day using all quote and transaction data. The aggregate illiquidity measure for the index is then obtained by calculating the market cap value-weighted average across all stocks. In additional tests, they also examine market depth and also estimate the bid-ask spreads for large order sizes. They do not analyze bid-ask data on the futures contracts.

Before analyzing the interaction between the futures-cash absolute basis and liquidity, RSS adjust these variables for seasonal effects and time-trend variations. The variables used to make the adjustments include a Friday dummy, monthly dummies, a market holiday dummy, dummies to adjust for contracts near expiration, and time-trend variables. In the basis computation, the dividend yield on the index is measured in January and used for the entire calendar year. While adjusting the basis, they include the difference between the risk-free rate and the dividend yield to correct for measurement errors in these variables. For the spread adjustments, they include dummy variables to capture the reduction in spreads following the lowering of the minimum tick size first to $1/16 and then to $0.01. The adjusted R^2 for the absolute basis adjustment for the 3-

month futures contract is 0.048, while the adjusted R^2 for the spread adjustment is very high at 0.96.

RSS present OLS regressions of the futures-cash basis on the lagged quoted and effective spread measures and find positive coefficients. These coefficients are consistent with large deviations from parity when the market is more illiquid. Granger-causality tests reveal that for the 3-month futures contract, there is a two-way effect between spreads and the absolute basis. Estimated impulse response functions are consistent with these results.

RSS conduct several robustness checks of their results. An interesting part of their findings concerns their analysis of the S&P500 index futures contracts. Initially, they replicate their earlier analysis using the S&P 500 index instead of the NYSE index. For the cash price, they consider all the NYSE stocks included in the S&P 500 index. They find clear evidence in the OLS regressions that the absolute basis and the lagged spread variables are positively related as are spread and lagged liquidity. Granger-causality tests reveal a two-way relationship between the absolute basis and effective spreads. With quoted spreads, the absolute basis Granger-causes quoted spread, but the reverse relationship is insignificant. Then, RSS proceed to use the SPIDER (Standard and Poor's Depositary Receipts) contracts as the cash instrument rather than the basket of all the NYSE stocks in the S&P 500 index. The SPIDERs should facilitate arbitrage transactions since only one transaction is needed on the cash portion of the futures-cash basis rather than having to transact individually in each of the stocks in the futures contract.[4] Given the ease of arbitrage, RSS expect smaller illiquidity effects and find evidence consistent

[4] Ackert and Tian (2001), Kurov and Lasser (2002), and Switzer, L., Varson, P. and Zghidi, S. (2000) find that the introduction of index products in the cash market allows for a more efficient price linkage between the index and index derivatives.

with their expectations. Lagged quoted spreads impact the absolute basis, but lagged effective spreads do not affect the basis. Furthermore, absolute basis do not cause larger spreads. Part of the liquidity effects may be captured in the divergence of the SPIDER's value from the value of the underlying basket of stocks. Nonetheless, this evidence raises the question of whether illiquidity affects the futures-cash basis when only one transaction is required in the futures and cash instruments to arbitrage deviations of the basis from the theoretical value as is the case for single stock futures contracts.

2.3. Modifications of the RSS Methods

Though we follow RSS (2007) closely in our study, there are some differences in the methods. While calculating spreads, RSS use the dollar spread to avoid spurious correlation between spread measures and the absolute basis induced by standardization of both variables using the price variable. However, they note that their results remain robust to using scaled spread variables by the price. Our sample consists of a cross-section of 56 SSFs traded during January 2004 to March 2005 on stocks with differing price levels. We use percentage spreads so that the spread measures are comparable across stocks.

We also modify the procedures for adjusting the absolute basis and spread data for seasonalities. RSS use 15 years of data on the index futures contract, whereas we consider single stock index futures contracts for a 15-month period. Given the short-time window, for most of the months we have only one month of data. Consequently, we omit monthly dummy variables. Further, since we directly account for the dividend amount on the stock during each contract month, we omit the variable that RSS include to account for measurement errors in the dividend yield. Given our intra-day data, we use an overnight dummy variable for the first observations used on a trading day. The first observation on each trading day is recorded an hour after the commencement of trading. This helps to purge the effect of overnight news flow on the liquidity variables. Also, we find the absolute basis to be autocorrelated (0.69). We use a linear regression with a first-order autoregressive error for the adjustment of absolute basis.

In addition to the bid-ask spreads for the stocks, we also consider the bid-ask spreads for the single stock futures contracts. Once, we adjust the absolute basis and spreads, we follow the RSS (2007) procedures to examine the interaction between liquidity and the absolute spread. To estimate the impact of the adjustments, we also examine this relationship without making the adjustments for the spreads and the absolute bases.

3. Empirical Analysis

3.1 Preliminary Results

Figure 1 depicts the plot for the futures-cash bases. The daily bases are calculated as an average of the intra-day bases across all sample stocks using data on one month SSF contracts and their underlying stocks. We find that the mean absolute bases are generally close to zero. This implies that the absolute bases are stationary. The graph shows that the bases fluctuate during a short period of time, particularly in the months of January, May, and June. We further verify that absolute bases are stationary by using the augmented Dickey-Fuller test.

Similar to absolute bases, we plot the graphs for quoted and effective spreads (%) for the SSFs and stocks. Figure 2 shows the graphs for both markets. The dark shade in both panels represents effective spreads, while the aggregate level of dark and light shades represent quoted spreads. The graph is plotted using mean quoted and effective spreads (%) for the SSFs and stocks on a daily basis. We find that the quoted and effective spreads for the SSFs are lower than those of stocks. The effective spread movement follows the quoted spreads. The graph further suggests that effective spreads have smaller fluctuations in comparison to the quoted spreads for both the SSFs and stocks. While examining the pattern of absolute bases and bid-ask spreads, we find that bid-ask spreads closely follow the absolute bases. Both quoted and effective spread plots indicate the data to be stationary. Augmented Dickey-Fuller tests confirm the same conclusion.

Table 1 presents the summary statistics for the absolute value of the futures-cash basis and market liquidity variables for SSFs and their underlying stocks. The mean and volatility of the absolute value of futures-cash basis are 0.42% and 0.50%, respectively. The low level of absolute futures-cash basis suggests that arbitrageurs play an active role in maintaining the price equilibrium between SSFs and stocks. The mean quoted and effective spreads for the stocks are 2.32% and 1.34%, respectively. In terms of Indian currency value, the quoted and effective spreads (Rs. 9.23 and Rs. 5.55, respectively) seem to be reasonable. In case of the SSFs, the quoted and effective spreads are 1.55% (Rs. 6.80) and 0.99% (Rs. 4.34), respectively. Thus, we find that quoted spreads are higher in comparison to effective spreads in both markets. These results are consistent with trades occurring within the quoted spread.

3.2 Adjustment of the Absolute Basis and Spreads for Seasonalities

Our primary focus in this study is to examine the dynamic relationship between the futures-cash basis and liquidity variables using vector autoregressions. The futures-cash basis and liquidity measures show calendar regularities and time trends (Gallant, Rossi, and Tauchen (1992)). RSS (2007) suggest that common regularities and time trends can cause spurious conclusion in the joint study of basis and liquidity measures. Following RSS, we use regression models to expunge such effects on the data series of absolute bases, quoted spreads, and effective spreads. The residuals of the regressions become the adjusted data for estimating the vector autoregression models.

We adjust the raw basis as follows:

(a) We use a dummy for the weekend, since the holding period for the cash market increases by two days.

(b) The last Thursday of the contract month is settlement day. Since there is higher trading activity in the settlement week, we use dummies to account for such trading activity for the last four days in the week.

(c) We use a dummy for the day preceding a holiday.

(d) We use a dummy to account for first day of a new contract.

(e) A dummy is used to account for overnight news-flow since we use intra-day data.

Table 2 presents the results of the linear regression model with a AR(1) error term correction. We find that the first day of a new month contracts does not show any significant relationship with the absolute basis. Even the last four remaining days of the maturity do not have significant influence on the absolute basis. The weekend trading day, Friday, is positively related to the absolute basis. But the borrowing cost (MIBOR), dummy for preceding trading day of the holiday, and overnight dummy show negative relationship with the absolute basis. We obtain the adjusted absolute bases from the residuals of the regression.

We use OLS regressions to obtain the adjusted series of quoted and effective spreads for the SSFs and stocks. Table 3 presents the results for quoted and effective spreads for the stocks. It shows that bid-ask spreads are lower in the middle days of the week. The overnight news-flow causes spreads in both markets to be higher at the beginning of the trading day. Similarly, Table 4 provides the adjusted series for quoted and effective spreads for the SSFs. The results are similar to Table 3. However, the regression coefficients for the SSFs are more significant than those of the stocks, although the adjusted R^2 for the regressions in both Tables 3 and 4 are quite low. We obtain the adjusted series of quoted and effective spreads for the SSFs and stocks from the residuals of these regressions.

3.3 Relationship between Adjusted Absolute Basis and Adjusted Spreads

After adjusting the absolute basis and spreads as described above, we examine the interaction between the absolute basis and the spreads. All five adjusted series - adjusted absolute bases, adjusted stock quoted spreads, adjusted stock effective spreads, adjusted SSF quoted spreads, and adjusted SSF effective spreads – are confirmed to be stationary by augmented Dickey–Fuller tests.

Table 5 shows the correlations between the adjusted series. All correlations are statistically significant at the 5% level. We find that among liquidity variables, the effective spreads for the SSFs has the highest correlation (0.082) with the absolute basis. The quoted and effective spreads for the SSFs are highly correlated (0.733). Similarly, the quoted and effective spreads for the stocks are also closely linked, with a correlation coefficient of 0.594. Our results are consistent with the findings of RSS. Further, we segment the adjusted series data into two equal sub-periods. In both sub-periods, we find qualitatively similar correlation results, although the correlations between the absolute basis and the spreads are weaker during the second sub-period. We also check the correlations of the raw data for these variables. The correlation coefficients are qualitatively same; for brevity, we do not report them.

Table 6 presents OLS regressions estimating the relationship between the adjusted series of absolute bases and liquidity variables. In Panel A of Table 6, the absolute basis is the dependent variable and the independent variables are lagged quoted and effective spreads on the stocks. The regression coefficients are positive and significant consistent with larger spreads resulting in larger absolute basis. In Panel B, the independent variables are the spreads on the SSFs; these regressions also indicate that illiquidity as measured by larger spreads is associated with larger absolute basis. Reverse regressions in Panel C using the spreads as dependent variables and the lagged absolute basis as the independent variable show that larger absolute basis leads to larger spreads in both markets.

3.4 VAR Analysis

Next, we use vector autoregressions on the adjusted data to understand the dynamic and time-series relation between the absolute bases and liquidity variables.

Table 7 presents the VAR results of the paired adjusted series. We use 5 lags in the VAR analysis based on the Schwarz information criterion. Panel A of Table 7 shows the pairwise correlations of the VAR innovations. All correlation coefficients are significant at 5% level. As expected, we find higher correlations between quoted and effective spreads for the SSFs and stocks (0.711 and 0.589, respectively). Intuitively, we expect that effective spreads should have higher correlations with the absolute basis as effective spreads are more relevant estimates for the arbitrageurs. The results show that absolute bases have the higher correlations with the effective spreads (0.055 and 0.087 for stocks and SSFs, respectively). Further, they also suggest that SSF market liquidity has greater influence in narrowing of the futures-cash basis compared to the stock market liquidity.

Panel B of Table 7 reports pairwise Granger-causality tests. The results show that the absolute basis Granger-causes only SSF spreads. However, the spreads on both the SSFs and stocks Granger-cause the absolute basis. In case of liquidity effects across the two markets, we find that spreads on stocks Granger-cause the spreads of both the SSFs and stocks. The same is true for the effective spread on SSFs. The quoted spread on SSFs Granger-causes both quoted and effective spreads on stocks. However, it Granger-causes only the effective spread and not the quoted spread on the SSFs.

3.5 Impulse Response Functions

We use impulse response functions (IRF) to further examine the dynamics of the VAR system. An IRF traces the impact of a one-time, unit standard deviation, positive shock to one variable on the current and future values of the endogenous variables. Figures 3 through 6 depict responses of the absolute basis and liquidity measures to a unit standard deviation shock in a particular variable traced forward over a period of 5 days. The impulse responses generally decay over time, confirming the data to be stationary. The IRFs are largely consistent with the Granger-causality results. Innovations in the absolute basis do not have lasting and significant effect on the quoted and effective spreads of the stocks (upper right panel of Figures 3 and 4). Consistent with the VAR results in the Table 7, we find that innovations in the spreads of the stocks have significant effect on the absolute basis (lower left panel of Figures 3 and 4) thereby indicating that the stock market liquidity affects the futures-cash basis. The IRFs for the SSF spreads and absolute basis suggest that the absolute basis forecasts future SSF market liquidity.

3.6 Robustness Checks

The primary results are obtained using adjusted series of absolute basis and market liquidity variables. As a robustness check, we compute the vector autoregressions using the raw / unadjusted series of these variables. Table 8 presents the robustness check for VAR results. We use paired raw series variables in the VAR. We select 8 lag lengths in the analysis based on the Schwarz information criterion. Panel A of Table 8 shows the correlations between VAR innovations of raw series variables and we find qualitatively similar results as in Table 7. Panel B of Table 8 presents the Granger-causality tests. The results show that the absolute basis Granger-causes both bid-ask spreads of the SSFs and stocks. However, only bid-ask spreads of the SSFs Granger-cause the absolute basis. In case of liquidity effects, we find that bid-ask spreads of the stocks Granger-cause the bid-ask spreads of both the SSFs and stocks. The quoted spreads of the SSFs Granger-cause both bid-ask spreads of stocks and its own quoted spreads. Thus, we find these results to be also qualitatively similar to those in Table 7. The results in this table indicate that our primary results are not driven by the adjustment to the variables of interest.[5]

In an alternative robustness check, we examine the impact of adjusting for dividends while computing the basis. If a stock has an ex-dividend day during a particular month, we drop the data corresponding to the stock for that month. Thus, the data is restricted essentially to a sample of zero dividend stocks, and thus there is no need to adjust for dividends in calculating the basis. We find essentially similar results with this sub-sample, suggesting that the dividend adjustment does not induce any errors.

Finally, the intra-day data used in this day are observed at 11 am, 12 pm, 1 pm and 2 pm. The time-difference between successive observations is not equal. To explain the observations of the spreads and the absolute basis observed at 12 pm, 1pm and 2 pm, we use the lagged (one-lag) variables observed at the beginning of the previous trading hour. In contrast, for observations at 11 am on a trading day, the corresponding lagged variables are observed at 2 pm on the previous trading day. This gap corresponds to a trading-time difference of approximately 3½ hours. The adjustments presented in Tables 2, 3, and 4 reveal a significant coefficient for the overnight dummy variable used to identify the 11 am observations. To address the potential impact of using data from the prior trading day, we delete the observations recorded at 11 am and retain only the data observed at the other three time points. We repeat the VAR analysis using the adjusted and raw series of the absolute basis and the spreads. The adjusted series results are qualitatively similar. In the case of the raw series regressions, we find the results are more pronounced and highly significant. Thus, the conclusions remain unaltered.

[5] RSS (2007) also report that the adjustment procedures do not influence their primary results.

4. Conclusion

Liquidity facilitates the arbitrageurs to align prices of related securities. In this paper, we examine the dynamic relationship between the futures-cash basis and liquidity. Our results are consistent with the major findings in RSS (2007).

There is a two-way interaction between liquidity and deviations from the no-arbitrage relationship between cash and futures prices. These deviations are linked to the liquidity in both the stock and the futures markets. However, we find that the bid-ask spread in the futures market is relatively more important in explaining these deviations compared to the bid-ask spread in the cash market.

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Table 1

Summary Statistics of Absolute Basis, Quoted Spreads, and Effective Spreads

This table presents the summary statistics for absolute basis, quoted spreads, and effective spreads. Basis is calculated as a difference between the stock futures prices and their stock prices. Basis is scaled by the stock price. The absolute basis is the absolute value of basis (%). The stock futures price is computed as a $(F - d)e^{-rt}$, where *F* is the SSF price, *d* is the dividend amount, *r* is the interest rate, and *t* is the time to maturity. Absolute basis is the mean absolute basis (%) during the sample period. Quoted spread is the difference between ask quote and bid quote prices. Effective spread is computed as a two times of absolute difference between trade price and midquote price, where midquote price is the average price of bid and ask quote prices. The quoted spread is scaled by the bid quote price, while effective spread is scaled by the trade price. Quoted and effective spreads are shown for the stocks and their SSFs.

Variable	Mean	Median	Standard Deviation
Absolute basis	0.419%	0.277%	0.502%
Quoted spread	2.320%	1.719%	2.286%
Effective spread	1.335%	0.777%	1.860%
SSFs quoted spread	1.553%	1.045%	1.686%
SSFs effective spread	0.990%	0.632%	1.220%
Quoted spread	Rs. 9.225	Rs. 5.493	Rs. 12.475
Effective spread	Rs. 5.548	Rs. 2.494	Rs. 9.110
SSFs quoted spread	Rs. 6.801	Rs. 3.539	Rs. 10.162
SSFs effective spread	Rs. 4.337	Rs. 2.075	Rs. 6.962

Table 2
Estimation of Adjusted Absolute Basis

We use a linear regression model with a first-order autoregreesive error to derive adjusted absolute basis. The absolute basis is a dependent variable in the model. The explanatory variables are interest rate and the dummies for Friday, number of remaining days from contract maturity, preceding day from NSE holidays, imposition day for the securities transaction tax, and overnight indicator. Remaining Day-4 indicates four days to maturity for the SSF contracts. Similarly, Remaining Day-3, 2, 1 represent respective days to maturity for the SSF contracts.

Variable	Coefficient	*t*-value
Intercept	1.601	17.55
Friday	0.053	4.00
Remaining Day-1	-0.029	-1.34
Remaining Day-2	-0.025	-1.12
Remaining Day-3	-0.043	-1.97
Remaining Day-4	-0.036	-1.53
Holiday-1	-0.124	-5.59
Day1	0.005	0.20
MIBOR	-0.169	-12.93
Overnight Dummy	-0.010	-3.88
Adjusted R^2	0.52	

Table 3
Estimation of Adjusted Quoted and Effective Spreads for the Stocks

We use an ordinary least-square linear regression model to obtain quoted and effective spread adjustment for stocks. The left panel shows the results for quoted spread adjustment. The quoted spread is a dependent variable in the model. The explanatory variables are the dummies for weekdays, preceding day from NSE holidays, imposition day for the securities transaction tax, and overnight indicator. Similarly, we compute the effective spread adjustment as shown in the right panel.

	Quoted Spread		Effective Spread	
Variable	Coefficient	*t*-value	Coefficient	*t*-value
Intercept	2.220	87.67	1.317	68.69
Monday	0.037	1.03	0.004	0.15
Tuesday	-0.086	-2.49	-0.082	-3.18
Wednesday	-0.108	-3.09	-0.082	-3.18
Thursday	-0.086	-2.50	-0.030	-1.17
Holiday-1	-0.124	-2.37	-0.092	-2.35
Overnight Dummy	0.584	29.94	0.225	13.19
Adjusted R^2	0.04		0.01	

Table 4

Estimation of Adjusted Quoted and Effective Spreads for the SSFs

We use an ordinary least-square linear regression model to obtain quoted and effective spread adjustment for SSFs. The left panel shows the results for quote spread adjustment. The quoted spread is a dependent variable in the model. The explanatory variables are the dummies for weekdays, preceding day from NSE holidays, imposition day for the securities transaction tax, and overnight indicator. Similarly, we compute the effective spread adjustment as shown in the right panel.

	Quoted Spread		Effective Spread	
Variable	Coefficient	*t*-value	Coefficient	*t*-value
Intercept	1.589	87.97	1.047	74.53
Monday	-0.123	-4.96	-0.123	-6.41
Tuesday	-0.118	-4.89	-0.123	-6.54
Wednesday	-0.197	-8.02	-0.150	-7.85
Thursday	-0.117	-4.84	-0.091	-4.87
Holiday	-0.097	-2.61	0.013	0.46
Overnight Dummy	0.319	21.86	0.169	15.16
Adjusted R^2	0.03		0.03	

Table 5

Correlations between Adjusted Series of Absolute Bases, Quoted Spreads, and Effective Spreads

Correlations between adjusted series of absolute bases, quoted spreads, and effective spreads for the stocks and SSFs are presented in Panel A, B, and C. Panel A presents the correlation coefficients for these variables for the sample period January 2004 to March 2005. Panel B and C present the correlation coefficients for sub-periods (January 2004 to 15th August 2004 and 16th August 2004 to March 2005, respectively). The adjusted series of absolute bases, quoted spreads, and effective spreads are obtained from the regressions used in tables 2-4. All coefficients are significant at the 5% level.

Variable	Absolute Basis %	Quoted Spread %	Effective Spread %	SSFs Quoted Spread %	SSFs Effective Spread %
Panel A: Correlation Coefficients for January 2004 to March 2005					
Absolute Basis %	1.000	0.015	0.051	0.024	0.082
Quoted Spread %	0.015	1.000	0.594	0.121	0.089
Effective Spread %	0.051	0.594	1.000	0.069	0.059
SSFs Quoted Spread %	0.024	0.121	0.069	1.000	0.733
SSFs Effective Spread %	0.082	0.089	0.059	0.733	1.000
Panel B: Correlation Coefficients for January 2004 to 15th August 2004					
Absolute Basis %	1.000	0.018	0.062	0.024	0.097
Quoted Spread %	0.018	1.000	0.588	0.115	0.081
Effective Spread %	0.062	0.588	1.000	0.065	0.056
SSFs Quoted Spread %	0.024	0.115	0.065	1.000	0.731
SSFs Effective Spread %	0.097	0.081	0.056	0.731	1.000
Panel C: Correlation Coefficients for 16th August 2004 to March 2005					
Absolute Basis %	1.000	-0.002	0.026	0.009	0.039
Quoted Spread %	-0.002	1.000	0.594	0.089	0.074
Effective Spread %	0.026	0.594	1.000	0.050	0.047
SSFs Quoted Spread %	0.009	0.089	0.050	1.000	0.727
SSFs Effective Spread %	0.039	0.074	0.047	0.727	1.000

Table 6
Regression Estimates of Adjusted Series

This table presents the results for the OLS regression between adjusted series of absolute bases quoted spreads, and effective spreads. Panel A presents the relationship between adjusted series of absolute bases and one lag adjusted quoted and effective spreads of the stocks. Panel B presents the relationship between adjusted series of absolute basis and one lag adjusted quoted and effective spreads of the SSFs. Panel C presents the relationship between adjusted series of quoted and effective spreads of the stocks and SSFs and one lag adjusted absolute basis. The adjusted series of absolute bases, quoted spreads, and effective spreads are obtained from the regressions used in Tables 2-4. The t-values are presented in the parenthesis. The coefficients in the Panel A and B are multiplied by 100.

Panel A: Dependent Variable: Adjusted Absolute Basis

Dependent Variable	Intercept	Independent Variable: Lag quoted Spread	Independent Variable: Lag Effective Spread
Adjusted Absolute Basis	-0.288	0.292	
	(-1.94)	(4.31)	
	-0.263		0.019
	(-1.74)		(0.23)

Panel B: Dependent Variable: Adjusted Absolute Basis

Dependent Variable	Intercept	Independent Variable: Lag SSFs quoted Spread	Independent Variable: Lag SSFs Effective Spread
Adjusted Absolute Basis	0.062	0.632	
	(0.42)	(6.62)	
	0.100		1.362
	(0.64)		(10.15)

Panel C: Dependent Variable: Quoted Spread or Effective Spread

Dependent Variable	Intercept	Independent Variable: Lag Adjusted Absolute Basis
Quoted Spread	-0.039	0.119
	(-4.01)	(4.28)
Effective Spread	-0.027	0.084
	(-3.32)	(3.56)
SSFs Quoted Spread	-0.042	0.146
	(-6.06)	(7.37)
SSFs Effective Spread	-0.017	0.212
	(-3.25)	(13.58)

Table7

Vector Autoregressions of Adjusted Series

This table presents the results of vector autoregressions. We use paired adjusted series of absolute bases, quoted spreads, and effective spreads in the VAR model. We use 5 lags in the paired series of VAR estimations based on the Schwarz information criterion. The adjusted series of absolute bases, quoted spreads, and effective spreads are obtained from the regressions used in Tables 2-4. Panel A shows the correlation coefficients between VAR innovations of paired adjusted series of absolute bases, quoted spreads, and effective spreads. Panel B presents pairwise Granger-causality tests between the endogenous variables of adjusted series with chi-square statistics and *p*-values (in parenthesis).

Panel A: Correlations between VAR Innovations of Adjusted Series

	Quoted Spread	Effective Spread	SSFs Quoted Spread	SSFs Effective Spread
Adjusted Absolute Basis	0.011	0.055	0.009	0.087
Quoted Spread	-	0.589	0.072	0.065
Effective Spread	-	-	0.042	0.051
SSFs Quoted Spread	-	-	-	0.711
SSFs Effective Spread	-	-	-	-

Panel B: Granger–Causality Tests

	Adjusted Absolute Basis	Quoted Spread	Effective Spread	SSFs Quoted Spread	SSFs Effective Spread
Adjusted Absolute Basis	-	6.85	5.94	14.79	66.79
		(0.23)	(0.31)	(0.01)	(0.00)
Quoted Spread	23.13	-	29.81	333.33	170.02
	(0.00)		(0.00)	(0.00)	(0.00)
Effective Spread	34.03	367.08	-	257.69	121.65
	(0.00)	(0.00)		(0.00)	(0.00)
SSFs Quoted Spread	51.01	398.06	143.95	-	8.83
	(0.00)	(0.00)	(0.00)		(0.12)
SSFs Effective Spread	219.21	269.62	120.57	149.13	-
	(0.00)	(0.00)	(0.00)	(0.00)	

Table8
Robustness Check - Vector Autoregressions of Raw Series

This table presents the results of vector autoregressions. We use paired series of absolute bases, quoted spreads, and effective spreads in the VAR model. We use 8 lags in the paired series of VAR estimations based on the Schwarz information criterion. Panel A shows the correlation coefficients between VAR innovations of raw series. Panel B presents pairwise Granger-causality tests between the endogenous variables of raw series with chi-square statistics and *p*-values (in parenthesis).

Panel A: Correlations between VAR Innovations of Raw Series

	Quoted Spread	Effective Spread	SSFs Quoted Spread	SSFs Effective Spread
Absolute Basis	-0.001	0.061	0.016	0.142
Quoted Spread	-	0.597	0.066	0.057
Effective Spread	-	-	0.038	0.046
SSFs Quoted Spread	-	-	-	0.702
SSFs Effective Spread	-	-	-	-

Panel B: Granger–Causality Tests

	Absolute Basis	Quoted Spread	Effective Spread	SSFs Quoted Spread	SSFs Effective Spread
Absolute Basis	-	21.93	18.20	35.64	127.71
		(0.01)	(0.02)	(0.00)	(0.00)
Quoted Spread	5.61	-	41.95	158.41	85.90
	(0.69)		(0.00)	(0.00)	(0.00)
Effective Spread	10.63	298.06	-	189.80	87.92
	(0.22)	(0.00)		(0.00)	(0.00)
SSFs Quoted Spread	100.99	277.88	110.05	-	8.97
	(0.00)	(0.00)	(0.00)		(0.35)
SSFs Effective Spread	726.70	184.03	88.07	278.65	-
	(0.00)	(0.00)	(0.00)	(0.00)	

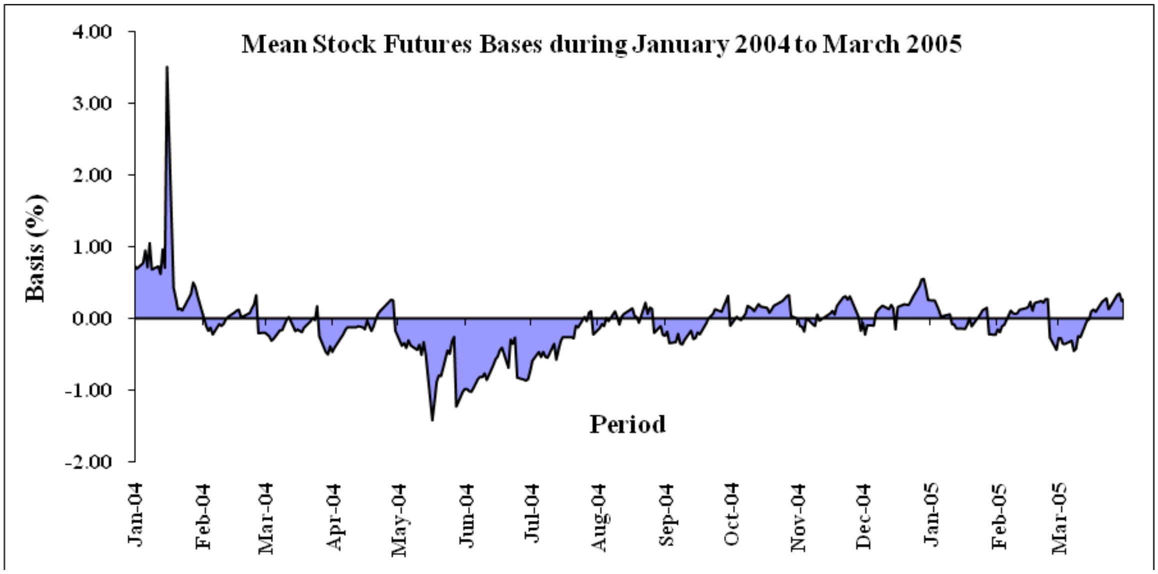
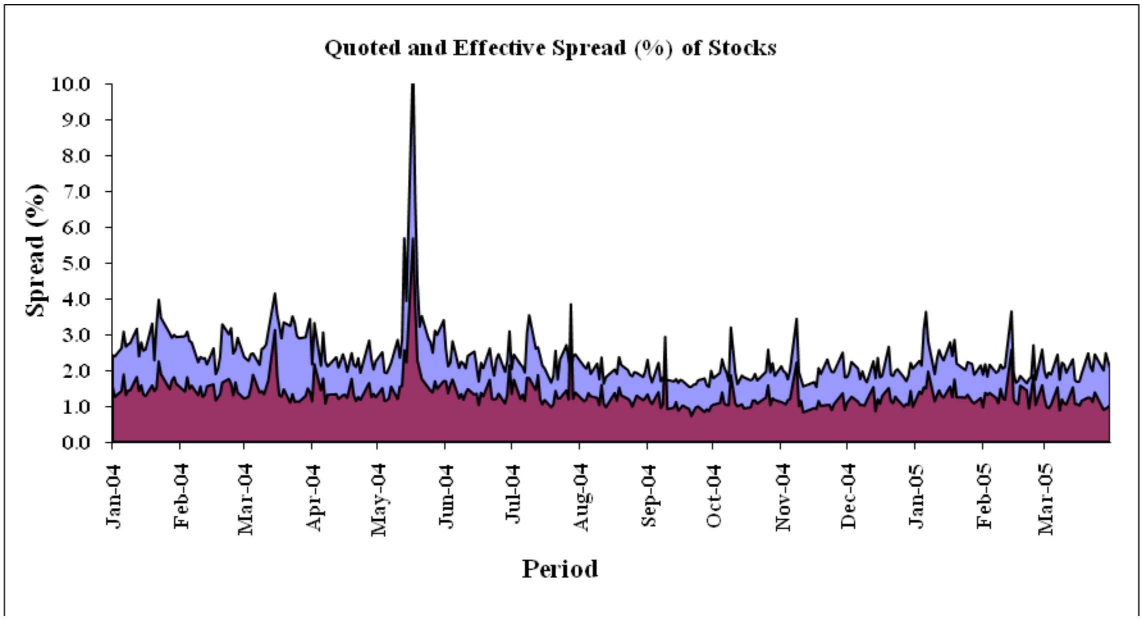


Figure 1
Mean Stock Futures Bases during January 2004 to March 2005
Mean stock futures bases are computed on a daily basis for all single stock futures. The bases (%) are plotted for the period January 2004 to March 2005.

Panel A



Panel B

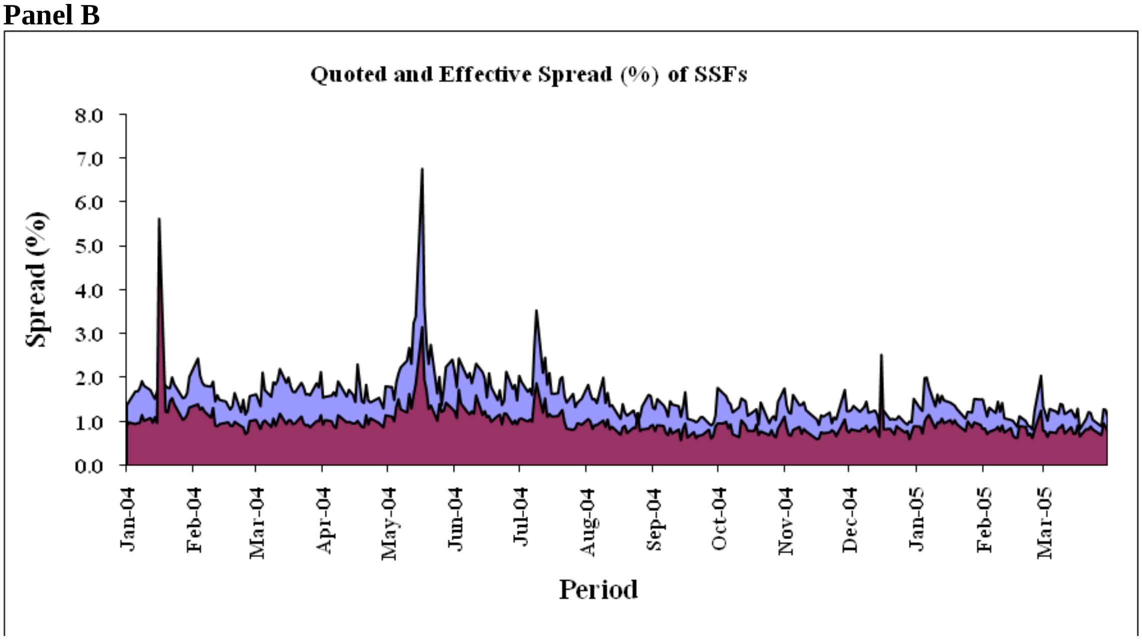


Figure 2
Quoted and Effective Spreads of the Stocks and SSFs

Mean quoted and effective spreads are computed on a daily basis for stocks and their SSFs, respectively. Panel A shows the plot for quoted and effective spreads (%) of stocks. Panel B shows the plot for quoted and effective spreads (%) of SSFs.

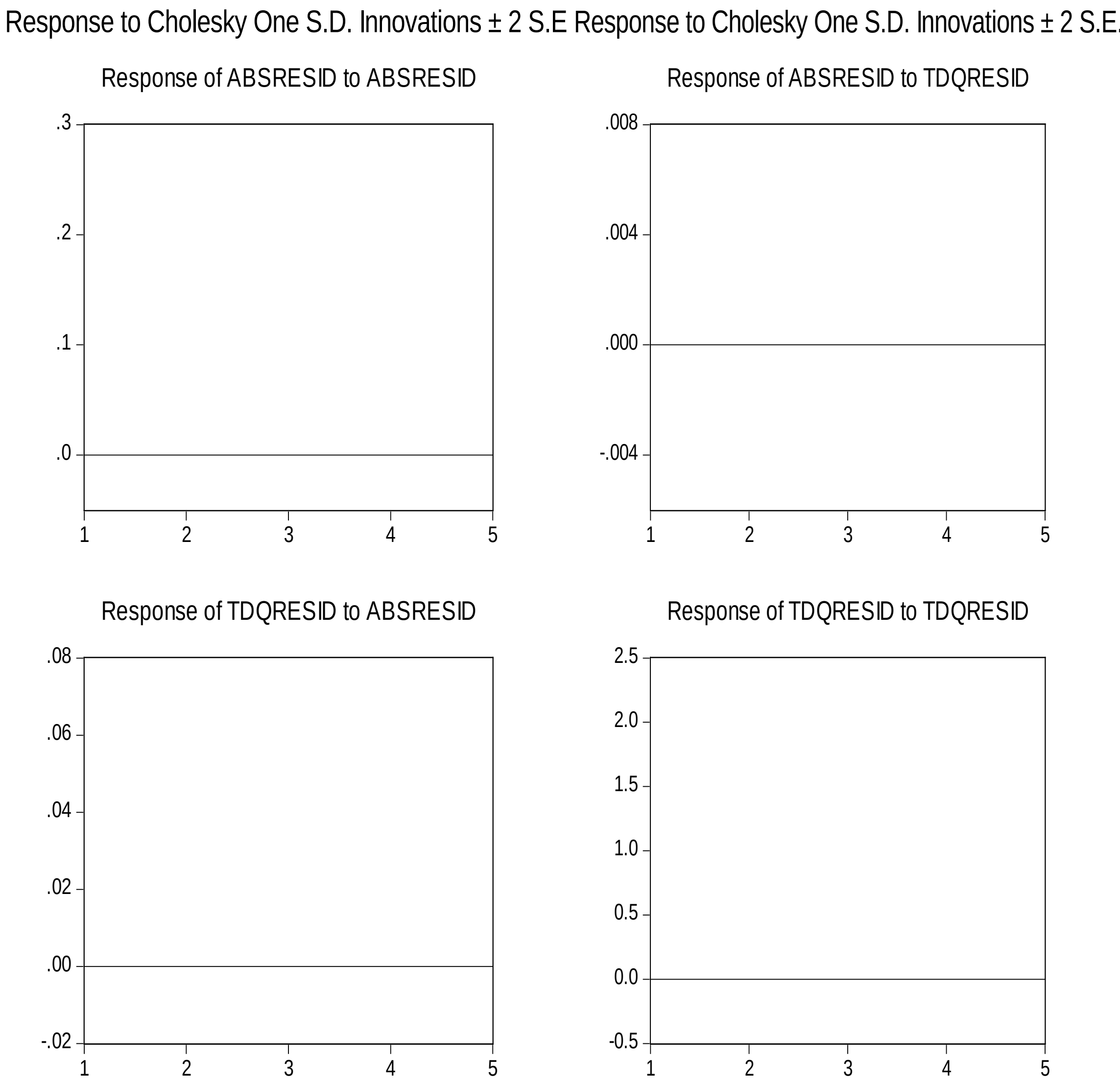


Figure 3

Impluse Response Function between Absolute Basis and Quoted Spreads of Stocks

The bivariate VAR pairs the adjusted series of absolute basis (ABSRESID) and quoted spread (TDQRESID) of stocks. Impulse response function is obtained using Monte Carlo two-standard-error bands (1000 replications for the pair.

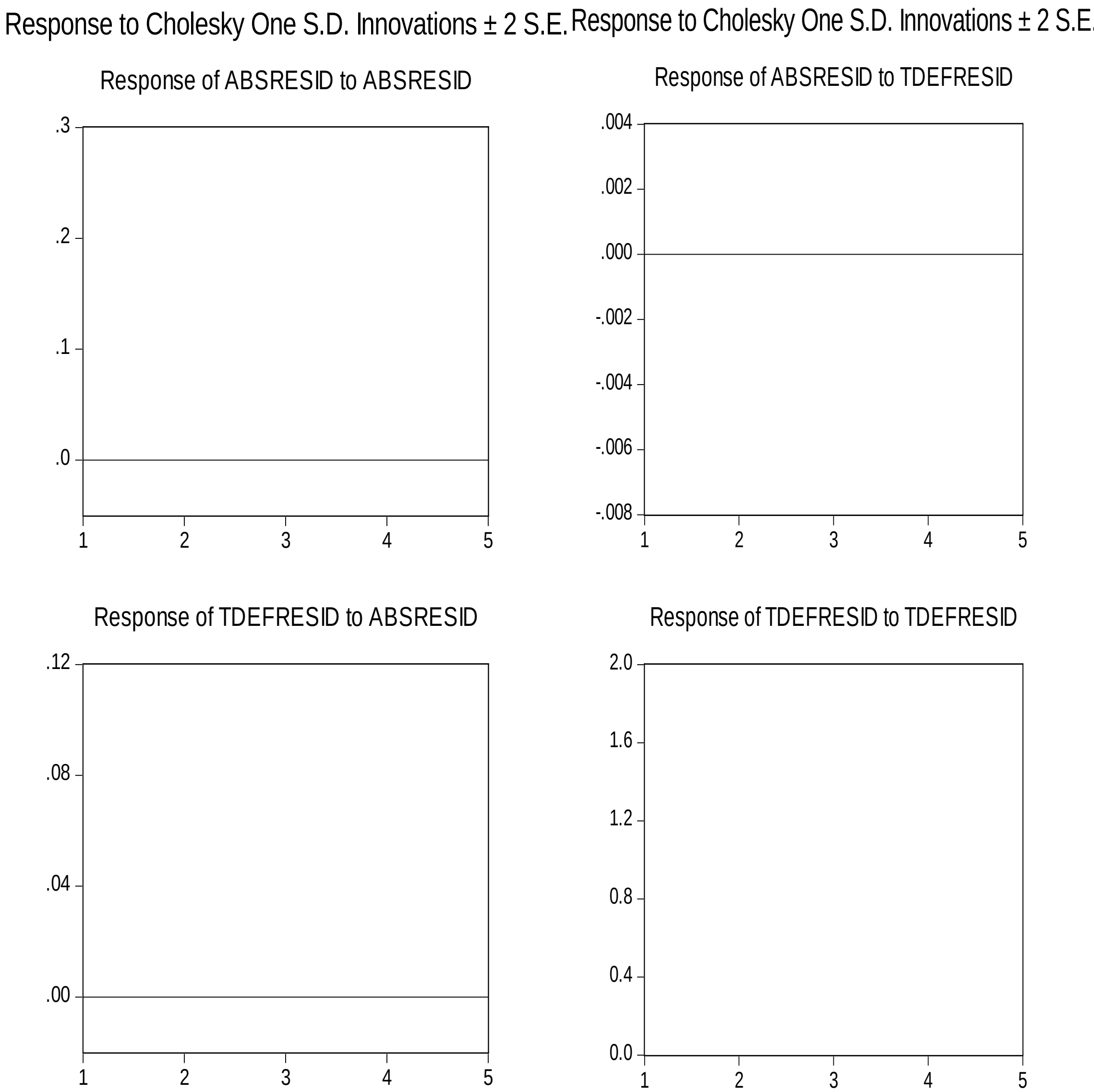


Figure 4

Impluse Response Function between Absolute Basis and Effective Spreads of Stocks

The bivariate VAR pairs the adjusted series of absolute basis (ABSRESID) and effective spread (TDEFRESID) of stocks. Impulse response function is obtained using Monte Carlo two-standard-error bands (1000 replications for the pair.

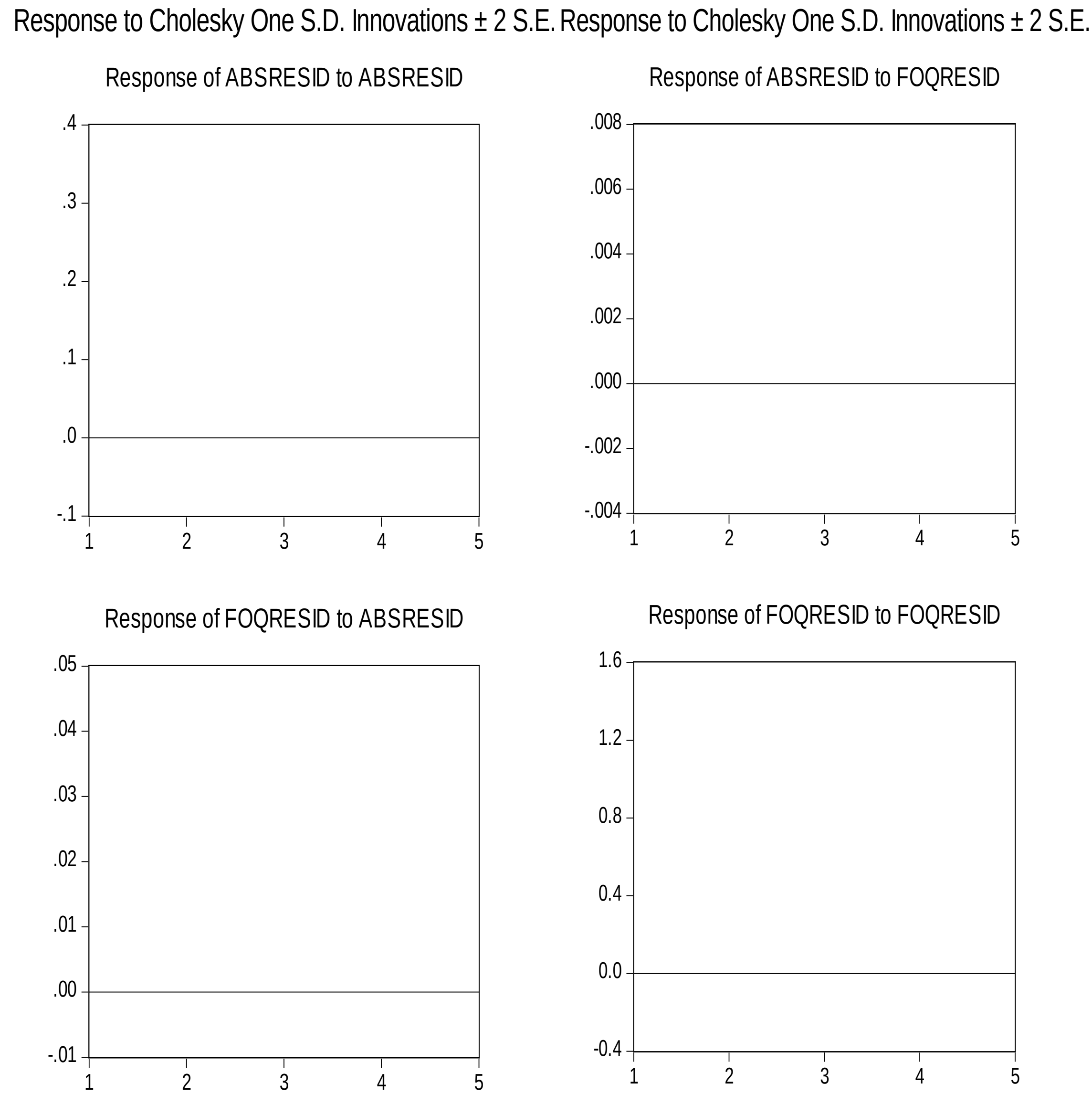


Figure 5
Impluse Response Function between Absolute Basis and Quoted Spreads of SSFs
The bivariate VAR pairs the adjusted series of absolute basis (ABSRESID) and quoted spread (FOQRESID) from stocks. Impulse response function is obtained using Monte Carlo two-standard-error bands (1000 replications for the pair.

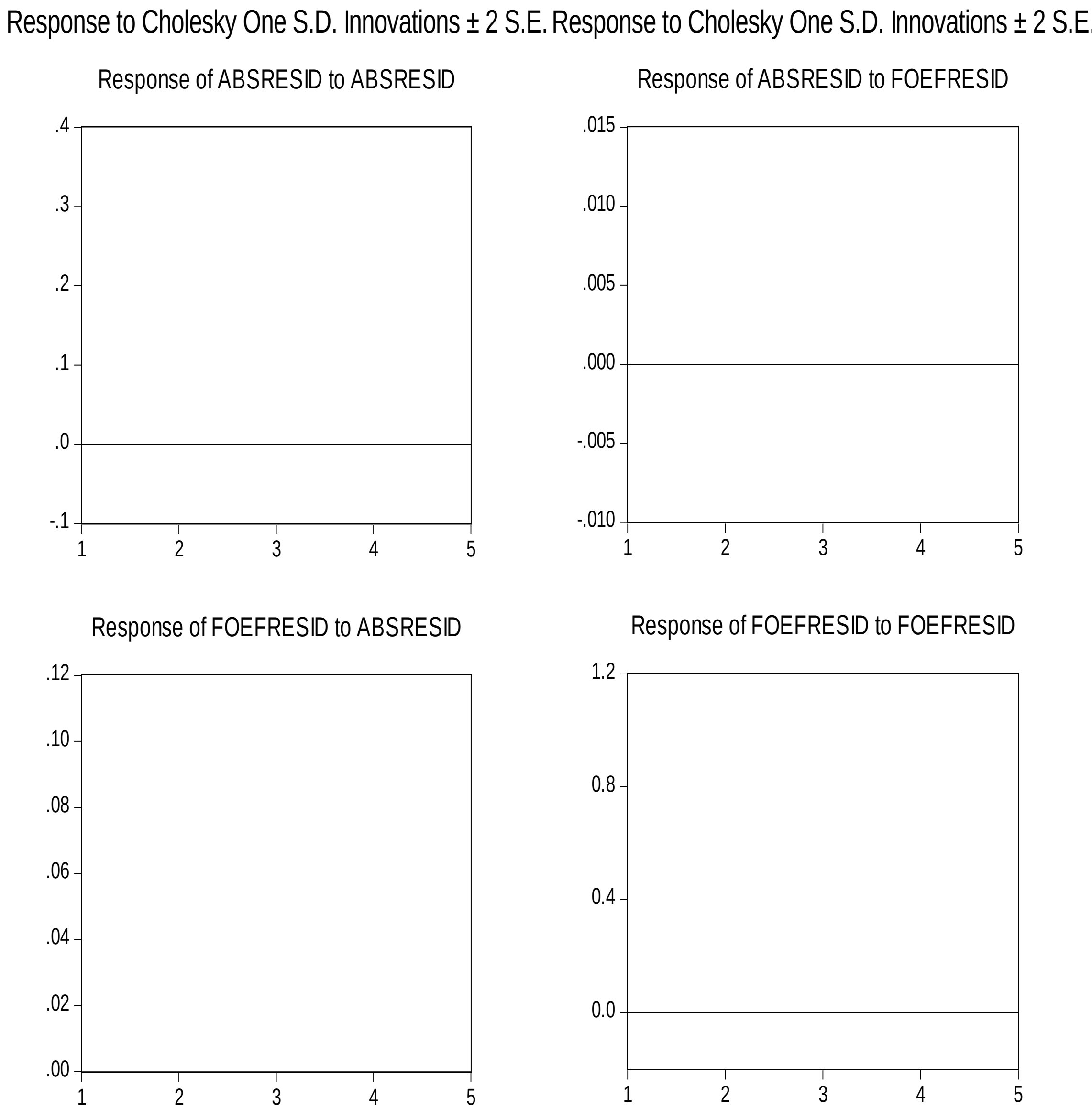


Figure 6

Impluse Response Function between Absolute Basis and Effective Spreads of SSFs

The bivariate VAR pairs the adjusted series of absolute basis (ABSRESID) and quoted spread (FOQRESID) from stocks. Impulse response function is obtained using Monte Carlo two-standard-error bands (1000 replications for the pair.