Approaches to examination of Liquidity and Volatility Risk Pricing in Stock Markets—Implications for Indian Case

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Abstract. Liquidity and Volatility Risks is twin asset pricing issues that altogether affect the operational functioning and pricing in stock markets all over the globe. In developed countries as well in emerging markets, the researchers have put in large efforts to find the liquidity and volatility risk structures in individual stocks and well as market as a whole. There is also an ongoing research to explore whether there is a common uncertain factor across these risk classes. In this paper we provide a conceptual framework of the issue of liquidity and volatility and also the approaches used by researchers to measure the liquidity and volatility risk.

Key Words: Liquidity Risk, Volatility Risk, Commonality, Stock Market

1. Introduction

The financial systems throughout the globe is undergoing a tremendous change making the markets, particularly the financial markets fragile with large concerns of liquidity and volatility that create a devastating impact on the overall functioning of the economies. The markets in the developing world, especially the emerging markets are growing at a faster pace. Financial liquidity (which may be understood in terms of securities as high level of trading activity allowing buying and selling with minimum possible disturbance) is an elusive notion, yet of paramount importance for the well functioning of the financial institutions. In the recent years financial market tensions especially that of year 2008 has led the researchers to measure the liquidity variations and their impact on the market movements.

Along with liquidity risk the proposal focuses on Volatility risk which may be in simple words understood as the risk of fluctuation in the value of a financial asset due to change in its volatility. The prior literature work found on measuring liquidity risk premium is vast but more or less focused on comparing future realized volatility with current Black-Scholes implied volatilities in a regression framework. There has also been an extensive use of the GARCH family models. We are motivated to present the various evolving measures of liquidity and
volatility risk, the issue of joint pricing and the research gaps that need exploration in case of Indian stock markets.

2. **Evolving Measurement Measures**

   **Liquidity Measures**

   Various measures of liquidity have evolved globally by the researchers to measure the liquidity risk. We provide a brief overview in the following paragraphs. The first measure is based on the work of Amihud (2002). The Amihud measure for stock i in month t is defined as

   \[ A_{i,t} = \frac{1}{d_t} \sum_{j=1}^{d_t} \frac{|r_{i,j}|}{dvol_{i,j}} \]

   where \( r_{i,j} \) is the return on asset i on day j of month t, \( d_t \) is the number of trading days in the month, and \( dvol_{i,j} \) is the dollar volume for asset i on day j of month t. Acharya and Petersen (2005) and Korajczyk and Sadka (2008) have extended the measure scaling using the ratio of the market capitalization of the CRSP market index. The second liquidity measure commonly employed by researchers is the turnover defined as the ratio of monthly volume and shares outstanding. It is computed as-

   \[ TO_{i,t} = \frac{\sum_{j=1}^{d_t} vol_{i,j}}{SO_{i,t}} \]

   where \( SO_{i,t} \) is the number of shares outstanding at the end of month t. The third popular measure is relative spread. The relative spread is calculated as the difference between the bid and the ask divided by the midpoint price (average of the bid and ask). This is calculated at the daily frequency and then aggregated by taking the monthly average of the daily measures.

   \[ RS_{i,t} = \frac{1}{d_t} \sum_{j=1}^{d_t} \frac{Ask_{i,j} - Bid_{i,j}}{midpt_{i,j}} \]

   Roll (1984) has developed a measure based on covariance. Assuming the existence of a constant spread s, Roll shows that the spread can be estimated as
\[
\hat{s} = 2\sqrt{-\text{Scov}}
\]

where Scov is the covariance of adjacent daily returns.

Volatility measures

Conventional approach to examine volatility is the use of absolute measure of risk i.e. variances. An estimate formed from the daily realized variance measure simply defined as-

\[
RV_{i,t} = \sum_{j=1}^{dt} r_{i,j}^2
\]

where, \(r_{ij}\) is the return of asset \(i\) on day \(j\) of month \(t\) and \(dt\) is the number of trading days in month \(t\). Researchers engaged in forecasting time series, such as stock prices, inflation rates foreign exchange rates etc. have observed that their ability to forecast such variables varies considerably from one time period to another. This variability could very well be due to volatility in financial markets, sensitive as they are to rumors, political upheavals, changes in Government monetary fiscal policies, and the like. Stock Market Volatility increases during crisis, social unrest and with the effects of macroeconomic variables such as inflation, employment, GNP. For example, volatility is an important ingredient in the asset pricing model of Sharpe (1964) and the option pricing model of Black and Scholes (1973). This would suggest that the variance of forecast errors is not constant but varies from period to period, that is there is some kind of autocorrelation in the variance of forecast errors.

The autoregressive conditional heteroscedasticity (ARCH) model introduced by Engle (1982) allows the conditional variance to change over time and represent the stochastic process as a function of past errors. The strength of the ARCH techniques is that the conditional means and variances can be estimated jointly using traditional specified models for economic variables. Bollerslev (1986) extends the ARCH process to GARCH (generalized ARCH), which allows for a more flexible lag structure. Bollerslev point out the extension of the ARCH process is very much like the extension of the standard time series process to the general ARMA process. The key idea of ARCH is that the variance of \(u\) at time \(t\) (=\(\sigma_t^2\)) depends on the size of the squared error term at time \((t-1)\) i.e. on \(u_{t-1}^2\). The model is compatible with major stylized facts for asset
returns and uses efficient methods for estimating model parameters and calculating forecasts for future volatility.

GARCH models are defined by conditional density function that provides the Likelihood function of data set, which can be maximized to give optimal parameter estimates. For daily returns $r_t$ of a particular stock from time $t-1$ to time $t$, Let $I_{t-1}$ be the set of information up to time $t-1$ i.e. $I_{t-1} = \{ r_{t-1}, r_{t-2}, \ldots \}$. When investors make their investment decision at time $t-1$, they know the information in $I_{t-1}$. Given $I_{t-1}$, the expected stock return and volatility are the conditional expected value and conditional variance of $r_t$ denoted by $\mu_t$ and $h_t$ respectively. The unexpected stock return at time $t$ is $e_{t-1} = r_{t-1} - \mu_t$. (In the following empirical research, $r_t = \log (p_t) - \log (p_{t-1})$).

The conditional variance of the current error in the GARCH model is specified as a function of the past conditional variances and past errors. Thus, GARCH process of orders $p$ and $q$ ($p>0$, $q\geq 0$), denoted as GARCH $(p, q)$ can be described as follows.

$$r_t \mid I_{t-1} \sim F(\mu_t, h_t),$$

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i e_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j}.$$ 

where $h_t$ is a (measurable) function of $e_s$, $s < t$, and the (continuous) i.i.d. $(0,1)$ random variables $z_s = \frac{r_s - \mu_s}{\sqrt{h_s}}$ are independent of $\{ e_s, s < t \}$. There are four parameters $\mu$, $\alpha$, $\beta$, $\omega$ satisfy the conditions $\omega \geq 0$, $\alpha_i \geq 0$, $\beta_j \geq 0$, $i=1,2,\ldots,p$, $j=1,2,\ldots,q$. $F(\mu_t, h_t)$ is the conditional distribution of the variable, with conditional mean $\mu_t$ and variance $h_t$.

Garman-Klass in 1980 have developed a volatility estimator in 1980 mainly as an extension of the Parkinson measure that includes opening and closing prices. “The relative efficiency of an estimator is defined as the ratio of variance of the benchmark estimator to the variance of the estimator under consideration”. Garman and Klass estimator combined the traditional estimator and Parkinson’s estimator, thus incorporating more intraday information is

$$\sigma_{gk} = \sqrt{\frac{1}{T} \sum_{t=1}^{T} \left[ \frac{1}{2} \left( \frac{H_t}{L_t} \right)^2 - (2 \ln 2 - 1) \left( \frac{C_t}{O_t} \right)^2 \right]}$$
GK is believed to be 7.4 times as efficient as the close-to-close estimator but suffers from the limitation of discrete sampling that leads to a low estimate of the range. Yang and Zhang (2000) have offered an extension to the Garman and Klass historical volatility estimator by including logarithm of open and close prices.

\[ \sigma_{yz} = \sqrt{\frac{1}{T} \sum_{t=1}^{T} \left[ \left( \ln \frac{O_t}{C_{t-1}} \right)^2 + \frac{1}{2} \left( \ln \frac{H_t}{L_t} \right)^2 - (2 \ln 2 - 1) \left( \ln \frac{C_t}{O_t} \right)^2 \right]} \]

Where \( \sigma = \) volatility \( T = \) total number of trading days \( C_{t-1} = \) the closing price of previous day \( C_t = \) the closing price \( O_t = \) the opening price \( H_t = \) the high price \( L_t = \) the low price \( \ln = \) the natural log.

Researchers have also used the VAR regressions on the liquidity and volatility measures and their groups to examine the short term structures and VECM for the long term effects.

3. LIQUIDITY AND VOLATILITY RISK PRICING ISSUES

Many authors contributed in a way to measure and model liquidity adjusted pricing (Acharya and Pedersen, 2005; Liu, 2006; Wang and Chen, 2012; Kim and Lee, 2014) and incorporating liquidity risk using the value at Risk approach (Saout, 2002; Francois-Heude and Van Wynendaele, 2001; Roy, 2005; Johnson, 2008; Stange and Kaserer, 2010; Nagel, 2012). Value at risk (VAR) refers to a risk indicator of the maximum loss of a financial asset at a time horizon associated with a certain probability. This is a well-known risk management tool and one of the most popular currently used by market professionals and regulators for measuring market risk across financial institutions.

Some of the earlier works have found the existence of commonality in Liquidity: it refers to the co-movement in liquidity over time both for individual stocks and for the market as whole (Huberman and Halka, 1999; Chordiaet. al., 2000; Hasbrouck and Seppi, 2001; Kuntara and Nuttawat, 2009; Karolyiet. al. 2012) and that investors demand premium from illiquid market. There are continuous efforts in identifying the relative importance of market risk to liquidity risk (it is the risk associated to a asset or security that it cannot be quickly traded in the market to prevent loss). However, the conventional Value at Risk models based on normality assumption of the asset’s return is severely constrained while dealing with liquidity risk. This inevitably
leads to an underestimation of overall risk and consequently misapplication of capital for the safety of financial institutions. Standard Value at Risk (VaR) model assumes that any quantity of securities can be traded without influencing market prices. In reality, most markets are less than perfectly liquid and many securities cannot be traded with ease in markets. This is especially true for emerging market economies where the process of financial sector reform and deepening is currently taking place. Earlier research contribution by Harvey in 2012 advocated the advantages to invest in the emerging markets as they lead to higher expected yields and offer higher opportunities of growth. Indeed the emerging markets are more volatile and not only having the impact of market environment but also the conditions like political instability and governance problems. In this context, studies dealing with risk valuation are of great help for market professionals and regulators.

Despite episodic evidences of liquidity crisis in the Indian financial markets, risks associated with market illiquidity have not been effectively incorporated into the VaR models. In the face of sudden and persisting off-market prices of some of the securities in their portfolio, the Indian financial organizations often find it difficult to offload these securities without booking significant trading losses. As a consequence, several securities exhibit very low levels of turnover in the secondary segment of the debt market. Also, in most cases, measures of market risk fail to capture the costs of carrying illiquid assets in their portfolio. This becomes a constraining factor for market growth.

Mostly research studies used on an Inter-day basis, which takes only one observation to characterize the activity of the entire day. In present dynamic environment and the availability of information to the investors, the integration of the intraday information becomes then a necessity. Bangia et al. (1999) used the relative spread to measure the liquidity, which was later criticised by Saout in 2001. According to Le Saout, during periods of extreme variations large spreads are unobservable and thus leading to overestimation of risk with VAR approach. He also proposed to use value weighted spread to take into account the market resiliency. In continuation of the works initiated by Bangia et al. (1999) and Saout (2001), the integration of liquidity risk into a standard parametric VaR needs exploration. In Indian stock markets, there are no studies that have used liquidity-adjusted value at risk measure to examine the liquidity risk pricing structures.
4. COMMONALITY ISSUES

Various studies have considered both liquidity and volatility risk significant when considered separately. Liquidity risk is caused due to market trading frictions whereas volatility risk is caused due to fluctuation in the price of an asset. The studies focusing on importance of volatility and liquidity separately as a systematic risk factor have been done in the past not much efforts are made to link the two. Commonality in liquidity represents the impact of a common or market wide liquidity factor on an individual class of assets expressed in terms of spreads of bid-ask spreads and their depths. Commonality in liquidity and volatility has been studied by various researchers like Chordia et al. (2000), Brockman and Chung (2002), Fabre and Frino (2004) in developed markets. Bandi et al. (2008) examined liquidity risk and volatility risk jointly but at market level and for a small sample, it was concluded that liquidity risk and volatility risk are important factors when they are taken separately but when they are to be considered together, then volatility risk is more significant this may be due to underlying presence of uncertainty risk (which is risk associated with a situation where a person has no idea about future outcome) of which volatility is a better measure. There has been on-going research to examine that whether the individual firm's level effects are significantly influenced by changes in exchange-level parameters.

5. REMARKS

The studies on the emerging markets like India have been observed with high volatility and riskier and which is not only due to market environment but also to particular conditions such as political instability and companies governance problems. In this context, studies dealing with risk valuation are of great help especially for regulators since markets need structural and regulatory changes in order to improve trading environment (transparency and liquidity) and attract foreign investors. The risk related to international order flow migration makes market regulators more concerned about liquidity and risk valuation. Researchers have established that the across-measure liquidity and volatility factors may be orthogonalized to the common uncertainty factor to better isolate the risk specific to liquidity and volatility.

A research gap is quite evident on intraday liquidation of risk in Indian stock market. Examination of the cross-sectional pricing of liquidity and volatility risk and exploration of common uncertainty risk factors is a direction for research. We also argue that the measures of
liquidity and volatility risk that have been evolved by the researchers needs to be applied in the modified form when examining the Indian stock markets.

6. REFERENCES


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