Liquidity-adjusted Capital Asset Pricing Model In Indian Stock Market

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Abstract

Liquidity and asset pricing have a strong relationship as per the available literature from developed stock markets. Capital Asset Pricing Model propounded by Sharpe considers only market risk as the predictor of expected return and significantly excludes all other risks including liquidity risk. This paper aims at constructing liquidity – adjusted CAPM for Indian stock market by considering five-minute quotation data. Employing Fama – MacBeth cross-sectional regression, it is proved that the liquidity risk and expected liquidity are priced in the Indian stock market. It provides that the liquidity shocks can have significant inferences on portfolio diversification strategies to be adopted by the investors.

Keywords: High frequency data, Liquidity-adjusted CAPM, Liquidity Beta, Liquidity risk

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Liquidity of stock market is a vital element as refers to the extent to which a market allows assets to be bought and sold at stable prices. It is an essential pre-requisite for the growth and development of financial markets. It holds direct linkage with the returns required by the investors out of their investments (Amihud and Mendelson, 1986) and thus has implications for the investment performance as well as portfolio diversification strategies. Liquidity is regarded as a characteristic of asset returns (Brennan and Subrahmanyam, 1996) as well as a risk factor (Acharya and Pedersen, 2005). It is an important component affecting the efficiency of asset pricing (Chordia et al., 2008). Liquidity risk refers to the risk arising out of the inability to buy or sell assets at a given point of time at the price prevailing in the market. It is the possibility of liquidity being disappear from the market when the investor needs it (Acharya and Pedersen, 2005).

Liquidity affects the price of an asset in the market. Whenever an asset is traded in market, the parties involved in

the transaction incur a cost in form of brokerage fees, transaction taxes, or order processing costs. In addition, the buyer of the asset is expected to have some future cost while selling the asset at a future point of time. These expected transaction costs infer lower prices for the asset and thus higher rates of discount. The market maker who is holding the stock after purchasing it from agents, who did not find any buyer, faces the risk of change in prices and therefore expects to be compensated; which also imposes a transaction cost while selling the asset. All these factors affect the price an investor is willing to pay for an asset. Assuming all other factors to be constant, higher transaction costs result in lower prices for the assets, and thus increases the expected returns. This price discount owing illiquidity is the present value of the transaction costs being expected to incur in future. Transforming such costs into required return, the required return would be the sum of return required on a similar, but perfectly liquid security and the expected trading cost per period. It is proven that liquidity and asset pricing have relationship (Pastor and Stambaugh, 2003). The lower the liquidity of an asset (due to higher transaction costs), higher will be the return expected out of the asset. The more liquid asset will have a higher price for which it can be sold. This liquidity consideration is a must as it affects the financial policies.

Investors wish to have rate of return that compensates for taking risks including liquidity risk because irrespective of diversification opportunities, it is not possible to avoid all the risks associated with an asset. Capital Asset Pricing Model helps to determine the expected return on investment in relation to such an unavoidable risk which is regarded as systematic or market risk, though it is not the only risk affecting the price of an asset as propounded by Sharpe in CAPM. Thus, the model was improvised by Fama and French (1992) by introducing a three factor model. Further, there are studies which have considered liquidity and liquidity risk as a factor in asset pricing model (Acharya and Pedersen, 2005; Pastor and Stambaugh, 2003). Most of these studies belong to developed stock markets with a particular focus on US stock market. It is rare to find a study establishing liquidity adjusted CAPM in emerging stock markets. Therefore, this study makes an attempt to construct a liquidity adjusted CAPM for the Indian stock market.

Using high frequency dataset, this study attempts to estimate model-free liquidity betas. It employs a non-parametric estimator viz. integrated variance to measure variability in ex-post returns. It examines whether there is any cross sectional association among the high frequency stock returns and the betas estimated using various liquidity factors. The study employs individual stock returns in estimating liquidity risk unlike the previous studies that uses portfolios.

The remainder of this paper is structures as follows: Section 2 discusses the methodology specifications along with a description of data. The empirical findings are discussed in Section 3 and Section 4 provide concluding remarks.

1. Data and Methodology

BSE is Asia's first and a leading stock exchange in India with more than 5500 companies listed on it. The S&P BSE SENSEX is a market-weighted index of 30 financially sound and highly active companies listed on BSE. The present study employs quotation data of ten most active stocks of S&P BSE SENSEX, for the period extending from January 15, 2016 to July 15, 2016, sourced from Bloomberg database based on market capitalization. The stocks selected for the study includes: Coal India Ltd., HDFC Ltd., HDFC Bank Ltd., Hindustan Unilever Ltd., Infosys Ltd., ITC Ltd., ONGC Ltd, Reliance Industries Ltd., Sun Pharmaceutical Industries Ltd., and TCS Ltd.

The data obtained from Bloomberg are cleaned for errors and missing values. Sampling at 5-minute intervals, the unbalanced time series dataset is converted into equally spaced, balanced data series. The selection of 5-minute returns is the most popular choice which is extensively used in realized volatility literature (Andersen et. al., 2001; Andersen and Bollerslev, 1998). The missing values generated in the sampling process were interpolated aiding Cubic splines. There were 123 trading days on BSE during the study period after the elimination of the weekends and other public holidays, with a total of 9,898 data points.

As a measure of true prices, the study uses mid values of bid-ask quotes. Log values of quote-midpoints are used to compute continuously compounded 5-minute returns. A daily realized variance measure is then calculated by summing up the intraday squared 5-min returns. The square root of variance series provided with the daily realized volatility. The study uses absolute quoted spread as a

measure of liquidity proxy. The absolute quoted spread is constructed for all the ten stocks in the dataset. Further, the absolute quoted spreads of individual stocks were aggregated to obtain an aggregate measure of market liquidity, i.e., an equally weighted measure of market spread, as follows:

$$LIQUID_{mpt} = \frac{1}{N_{mpt}} \sum_{i=1}^{N_{mip}} LIQUID_{ipt} \qquad (1)$$

$LIQUID_{ipt}$ is the liquidity measure of stock *i* on the interval of *p* in the trading day of *t* and N_{mip} indicates the number of stocks in the market on interval of *p* in the trading day of *t*. Next, the liquidity innovations are computed for each interval at market level as well as individual stock level.

Chordia et al. (2000) and Huberman and Halka (2001) pointed out the time varying and persistent characteristic of liquidity implying that it can predict future returns. Thus, it is essential to pay attention of liquidity innovations while calculating liquidity betas. In order to account for serial correlation, the literature provides for the extensive use of fitting data into an autoregressive model employing information criteria. The liquidity innovations thus generated will takes into account the autocorrelation problem. It will further enable to have better forecast and lower forecasting errors and thus reduces the measurement errors (Bollerslev and Zhang, 2003). Following this line, the data is fitted into an autoregressive model employing Schwarz Information Criteria (SC) for the whole sample period. The residuals acquired from the autoregressive model are used as liquidity innovations as recommended by Acharya and Pedersen (2005) and are used as a proxy of liquidity. Using these liquidity innovation series, the study constructed three different liquidity betas viz. the beta arising out of covariance between liquidity of individual security and the market liquidity, the beta due to covariance between return of individual security and the liquidity of market, and a third one arising out of covariance between market return and the liquidity of individual security as given below:

$$\beta 1_{it} = \frac{\sum_{p=1}^{N_t} LIQUID_{ipt} LIQUID_{mpt}}{\sum_{p=1}^{N_t} R_{mpt}^2} \qquad (2)$$

$$\beta 2_{it} = \frac{\sum_{p=1}^{N_t} R_{ipt} LIQUID_{mpt}}{\sum_{p=1}^{N_t} R_{mpt}^2} \qquad (3)$$

$$\beta 3_{it} = \frac{\sum_{p=1}^{N_t} LIQUID_{ipt} R_{mpt}}{\sum_{p=1}^{N_t} R_{mpt}^2} \qquad (4)$$

Where, $LIQUID_{ipt}$ refers to the liquidity innovation of individual stock *i* during the interval *p* of trading day *t*, $LIQUID_{mpt}$ is the liquidity innovation of market during the interval *p* of trading day *t*, R_{pt} is the return of individual stock *i* during the interval *p* of trading day *t*, and R_{mpt} indicates the return of SENSEX at the interval *p* of trading day *t*. The liquidity adjusted Capital Asset Pricing Model advocated by Acharya and Pedersen (2005) postulates that β1 ought to be related positively to the expected stock returns. It implies that if the liquidity of stocks is negatively commoved with the liquidity of market, such stocks would trade at a premium in the market. Contrarily, $\beta 2_{it}$ and $\beta 3_{it}$ are suggested to be negatively correlated to the returns expected by the investor.

The three betas explained above follows the realized beta logic as expressed by Andersen et al. (2006) as follows:

$$\hat{\beta}_{it} = \frac{\sum_{p=1}^{N_t} R_{ipt} R_{mpt}}{\sum_{p=1}^{N_t} R_{mpt}^2} \qquad (5)$$

Where, the numerator indicates the covariance between the return of market and that of individual stock, and the denominator explains the realized volatility of the market.

Further, the study measures two additional betas, similar to Acharya and Pedersen (2005) as follows:

$$\beta 4_{it} = \beta 1_{it} - \beta 2_{it} - \beta 3_{it} \qquad (6)$$

$$\beta 5_{it} = \beta_{it} + \beta 1_{it} - \beta 2_{it} - \beta 3_{it} \qquad (7)$$

Where, $\beta 4_{it}$ refers to a liquidity net beta that brings out a linear combination of the three liquidity betas excluding market beta. It enables to differentiate the impact of liquidity risks on the pricing of stocks from that of market risk. $\beta 5_{it}$ provides a net beta that comprises all the four covariance terms, where $\beta 3_{it}$ refers to the market beta as posits by CAPM constructed using equation (5).

3. Empirical Results

Table 1 summarizes the distribution of daily volatility series of ten most actively traded stocks of BSE SENSEX index. It provides the statistical properties of three volatility measure viz. realized daily variances, realized daily standard deviations, and realized logarithmic standard deviations.

The table shows that the distribution of realized daily variances is right-skewed and leptokurtic, and the Jarque - Bera statistics rejects the normality assumption.

The distributional properties of realized volatility (realized daily standard deviation) show that skewness and kurtosis values are relatively small. It indicates the movement of distribution towards symmetry while converting the realized variance sequence to standard deviation sequence. Finally, the table also shows the statistical properties of logarithmic standard deviations series. The kurtosis is around the standard value of 3 for all the stocks considered and thus gives a better normality assumption compared to the other two measures. It indicates that the distribution is approximately Gaussian in the case of realized logarithmic standard deviations.

Table 2 displays the conditional distribution of realized logarithmic standard deviations calculated for all the ten stocks considered in the study. Ljung-Box portmanteau test shows that there is autocorrelation up to the order of 24. The white noise hypothesis is rejected as the Q statistics are highly significant for all the stocks considered. Further the Augmented Dickey Fuller test employed to identify the presence of unit root reject the null hypothesis of unit root at 1% level of significance and thus indicates that the series fulfills stationary properties.

Geweke and Porter-Hudak (GPH) semi-parametric procedure is adopted to estimate the fractional or memory parameter d. The GPH estimator tests the null hypothesis that the realized logarithmic standard deviation series are stationary as against the alternative hypothesis that there is long range dependence among these series. The parameter *d* is estimated at two different frequencies viz. $m = [N^{0.5}]$ and $m = [N^{0.8}]$ The results presented in Table 3 indicates that there exists fractional dynamics with features of long range dependence for all the 10 series considered in the study as their *d* estimates are lower than a value of 0.5 which is regarded as the stationary boundary with statistical significance.

Table 3 depicts the statistical properties of the daily realized betas. It exhibits the mean, standard deviation, ADF unit root test, Q statistics and GPH estimates for the degree of fractional integration where the $m = [N^{0.5}]$. The daily realized standard betas constructed from the 5-minutes data using (5) is analyzed here. The ADF test suggests the stationarity of data and Q statistics exhibit slight serial dependence.

Table 4 exhibits the daily liquidity beta statistics. It provides mean values of three liquidity betas estimated from 5-minute individual stock as well as market returns along with their liquidity innovations. It also reports the stationary properties of the beta estimates using ADF. The table gives a clear picture of the nature of three different liquidity risk measures established in the study. It shows that all the mean $\beta 1_{it}$ values are positive whereas all $\beta 3_{it}$values are negative. Employing these betas into a CAPM framework is expected to generate better insights towards asset pricing.

A liquidity-adjusted CAPM model is estimated using the methodology proposed by Fama and MacBeth (1973). The Fama-MacBeth cross sectional regression estimates parameters for the liquidity adjusted CAPM model used in the study. It estimates beta values as well as risk premia for the risk factors that are expected to determine the prices of assets. This method assumes that the cross sectional stock return variability is significantly influenced by the variability in standard market betas.

By employing the returns of individual stocks along with the betas estimated, the cross sectional regressions are executed for the study period on a monthly basis. Table 5 presents the average of risk premium estimated for the time series out of Fama – MacBeth regressions on liquidity-adjusted CAPM. The Newey and West (1987) methodology is employed using 4 lags to estimate the standard errors. Panel A displays the results of regression carried out by considering a single regressor viz. net beta. It proves that the net beta consisting of the market risk component as represented by standard market beta is significantly priced in Indian stock market (t-value 2.38). However the risk premium is negligible. Panel B depicts the risk premium estimated taking a sole regressor, namely, liquidity net beta. The regression results indicate that the liquidity net beta comprising all the three liquidity betas is also found significant in determining the price of a stock in the Indian stock market but with a very low premium. Panel C exhibits the result of regression estimated detaching the effect of standard beta (market beta) on the stock returns from that of net beta. It measures the distinct contribution of net beta to the pricing of the most active stocks in Indian stock market. The results vindicate that the market beta got an expected sign as per the predictions of

CAPM, but is insignificantly priced in Indian stock market. This result coincides with the result of Fama and French (1992) and Papavassiliou (2013) that proved that the market risk fails in explaining the cross sectional differences in asset returns.

Panel D provides the coefficients of each of the liquidity risk measures separately along with average R^2. Panel D proves that the liquidity net beta is priced only because of $\beta 1_{it}$. The other two liquidity risk measures viz. $\beta 2_{it}$ and $\beta 3_{it}$ fail to influence the pricing of assets. It is found from the table that $\beta 1_{it}$ premia is positive and significant at 1% level indicating the presence of liquidity commonality in the Indian stock market. It goes with the findings of Dunne et al. and proves that the investor expects a premium for the assets that are illiquid when the whole market is illiquid. However these results are contradictory to that of developed markets as evident from Lee (2011).

In line with the expectations of liquidity adjusted CAPM, $\beta 2_{it}$ as well as $\beta 3_{it}$ hold a negative, but insignificant sign and thus are not priced in the Indian stock market. These results are consistent with that of Acharya and Pedersen (2005); but, inconsistent with the results of Papavassiliou (2013) which provided an insignificantly positive $\beta 3_{it}$as against the assumptions of liquidity adjusted CAPM in the Greek market. Further, the results provide that the average adjusted R^2 values are consistent with earlier studies and are considerably small. It can be concluded that the Indian investors expect to be compensated for holding stocks that are sensitive to the liquidity fluctuations in the Indian stock market.

Table 6 provides the results of an extended Fama and MacBeth regression model. The *E(L)* denotes the liquidity expected which is computed from the average liquidity of each stock over the whole sample period. This model exhibits more statistically significant results than that of earlier model. Panel A and Panel B provide that $\beta 4_{it}$ and $\beta 5_{it}$ shows positive coefficients which are significant at 1% level and thus supports the expectations of liquidity adjusted CAPM. The positive risk premiums indicate that the stocks which are highly sensitive to the liquidity shocks in market provides a higher expected return to the investors. Panel C provides the same result as in the Table 5. Panel D confirms once again that the liquidity net beta being found significant in Panel B is priced exclusively because of $\beta 1_{it}$. Further all the coefficients maintain expected signs as per the expectations of liquidity adjusted CAPM. Table 6 also presents a higher average value of R^2 as compared to the previous model. It is also found that the expected liquidity is priced in all the four cases and carries a positive sign. This finding is inconsistent with that of Papavassiliou (2013) and Brennan and Subrahmanyam (1996), and rejects the indication that the return on the assets is a decreasing function of liquidity. On the other hand, it affirms the findings of Amihud and Mendelson (1989), proving that there exists a significant and positive relationship between expected liquidity and asset returns, and thus endorses the validity of liquidity adjusted CAPM. It further emphasizes that the asset pricing and liquidity are significantly linked and cannot be analyzed in isolation with each other.

4. Conclusion

The study, using high frequency data to estimate liquidity betas in a non-parametric platform, emphasizes the validity of a liquidity adjusted CAPM model in the Indian stock market. The study provides evidences that liquidity risk is significantly priced in Indian stock market. It further emphasizes that the liquidity risk priced in the Indian stock market is arising out of liquidity commonality existing in the market. It proves that the expected liquidity also plays a vital role in determining the asset prices. The study provides important insights towards portfolio diversification strategies as liquidity is a significant factor affecting the value of the assets.

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