Stability of Beta: An Empirical Investigation into Indian Stock Market

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The concept of risk management in case of investment decision assumes paramount importance in modern day financial management. Though risk cannot be completely eliminated, it can be reduced by taking precautionary measures. The risk involved in investment is categorized in two components: systematic risk and unsystematic risk. The comparison of the volatility to the market as a whole is termed as systematic risk. Beta is used to measure the systematic risk associated with the investment. Beta is a way of telling how volatile a stock is, compared with the rest of the market. The stability of beta is of great concern as it is a very important tool for almost all investment decisions and plays a significant role in risk measurement and risk management. This paper attempts to study the stability of beta for various stocks that formed a part of Bombay Stock Exchange Sensitivity Index (Sensex). Stability of beta is tested using Chow test and the result shows that betas are unstable over time.

Introduction

In the present competitive globalized business scenario, risk is attached with every dimension. The concept of risk management in case of investment decision assumes paramount importance in the modern day financial management. Though risk cannot be completely eliminated, it can be reduced by taking precautionary measures.

Risk is the measurable uncertainty (Knight, 1921) in predicting the future events that are affected by external and internal factors. Sharpe (1963) had categorized risks as systematic risk and unsystematic risk (Beja, 1972). The external factors are the sources of systematic risk. The elements of systematic risk are external to the firm. The examples are changes in economic conditions, interest rate changes, inflation, etc. On the other hand, internal factors are the sources of unsystematic risk. Unsystematic risks are classified as business risk or financial risk.

The systematic risk associated with the general market movement cannot be totally eliminated through diversification. Moreover, the degree of systematic risk is not constant but greatly varies from company to company.

The unsystematic risk, which is internal to a firm, cannot be eliminated. However, the systematic risk, which is external to the conditions of a firm, can be reduced to a certain

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extent. Beta, which is associated with systematic risk, helps the investor to measure the degree of risk associated with it. In portfolio management, beta has been regarded as the single most important aspect of risk of common stock. Rosenberg (1985) supported the importance of beta since it determines the systematic risk; and in a diversified portfolio, systematic risk is the bulk of investment risk.

Technically defined, beta is the systematic relationship between the return on the portfolio and the return on the market (Rosenberg and Marathe, 1979). Beta is a way of telling how volatile a stock is compared with the rest of the market. The comparison of the volatility to the market as a whole is also termed systematic risk. Beta is a measurement of a stock's volatility in relation to the market. When the return on the portfolio is more than the return on the market, beta measure is greater than one and those portfolios are referred to as aggressive. That means, in a booming market situation, aggressive portfolio will perform much better than the market performance. While in a bearish market condition the fall of aggressive portfolios will also be much prominent. On the other hand, when the return on portfolio is less than the return on market, beta measure is less than one and those portfolios are termed as defensive. In case of defensive portfolios, when the market is rising, the benefits associated with it will be less than the market portfolio. However, when the market moves down, the decline in the defensive portfolios would also be less than the market portfolio. In those situations where, the return of the portfolio exactly matches the return of the market, beta is equal to one that rarely occurs in real life situations. Aggressive stocks are supposed to be riskier but provide a potential for higher returns; defensive stocks pose less risk but also lower returns.

Importance of Beta

The measure of systematic risk, i.e., beta of a security, has been the most important tool for investment management among both academicians and practitioners. Beta has occupied center stage in both risk measurement and risk management. It is one of the most widely used measures of risk. Beta has wide ranging application in financial economics including:

- Capital Asset Pricing Model (CAPM),
- Estimation of cost of capital, and
- Evaluation of portfolio performance, etc.

CAPM dissects the risk of a portfolio into systematic risk and specific risk. Systematic risk is the risk of holding market portfolio at a given time. As the market is dynamic, each individual asset of the portfolio of an investor gets affected to a degree which varies from time to time. To the extent that any asset participates in such general market dynamics, is subjected to systematic risk.

Whereas, the risk, which is unique to an individual asset can be termed as the specific risk. Specific risk represents the component of an asset's return, which is uncorrelated with

the movement of the general market. Beta is used to measure the systematic risk. CAPM postulates that the expected return of a stock equals the risk-free rate plus the portfolio's beta multiplied by the expected excess return of the market portfolio (Sharpe, 1963; and Lintner, 1965). The CAPM equation suggests that the higher the beta, the higher the expected return.

The analysis of corporate investment decisions and for the assessment of the profitability a detail analysis of the cost of capital invested in an asset and its determinants is required. For the measurement of the performance of firms and the economic performance of individual investment decisions or portfolio decisions, the concepts of cost of capital have widely been used. Until and unless the profit of an organization or a unit is linked with the firm's equity investment and it exceed the cost of capital, one cannot say that the unit is profitable in economic sense even though the unit or the organization has positive accounting profit, net of interest on debt. There are various potential risk determinants which are playing a crucial role in determining cost of capital such as business risks, financial risks, inflation uncertainty, interest rate uncertainty and liquidity risk (Patterson, 1995).

Treynor (1965) has developed Portfolio Performance Measure (T), which is inversely proportional to β of a portfolio. Treynor argues that, using the characteristic line, one can determine the relationship between a security and the market. Deviations from the characteristic line (unique returns) should cancel out, if one is having a fully diversified portfolio. He was interested in a performance measure especially a Composite Performance Measure that would apply to all investors regardless of their risk preferences. Treynor's composite performance measure measures only the systematic risk. The higher the T value, the better the portfolio performance (Treynor and Black, 1973).

Hence, improvements in the measurement of beta would have useful ramification for all these areas. Beta used in financial decision-making models is a dynamic measure of the performance of the business that is referred to as the *ex ante* measure. Further, the stability of beta is of great concern as it is a very important tool for almost all investment decisions and plays a significant role in the modern portfolio theory.

Literature Review

Numerous studies are carried out to study the nature and the behavior of beta. Blume (1971) used the mean reversal technique to test the stationarity of the coefficients of the market. Levy (1971) and Levitz (1974) have shown that portfolio betas are very stable whereas individual security betas are highly unstable. Blume used monthly prices data and successive seven-year period; Levy (1971) used weekly data, 52 weeks base periods; and 52, 26 and 13 weeks subsequent periods whereas Levitz (1974) used three-base periods and one-year subsequent period.

Baesel (1974) studied the impact of the length of the estimation interval on stability of beta estimated. Using monthly beta, betas were estimated using estimation intervals of one year, two years, four years, six years and nine years. He concluded that the stability of beta increases substantially as the length of the estimation interval increases.

However, Theobald (1981) show that stationarity of beta is an increasing function of the time period used for the estimation of beta. An analytical expression is derived to show that beta stationarity would not increase indefinitely with estimation period length. An identical condition is required for beta stationarity to be an increasing function of the subsequent calendar period length.

Beta is linked to leverage, which changes owing to changes in the stock prices (Black, 1976); and Mandelkar and Rhee (1984) linked leverage to beta, owing to decisions by the firm.

Fabozzi and Francis (1978) showed that beta is a random coefficient. They suggest that many stocks beta coefficients are random through time rather than remain stable as the ordinary least square model presumes.

Allen *et al.* (1994) have considered the issue of comparative stability of beta coefficients for individual securities and portfolios. The usual perception regarding the investment in securities is that the portfolio betas are more stable than those for individual securities. Because of wide application of beta, the issue of stability of beta takes the center stage. The stability of beta estimates based on historical returns has found importance both in the investment industry as well as academia. They argue that if the portfolio betas are more stable than those for individual securities, the greater confidence can be placed in portfolio beta estimates over longer periods of time. But, their study concludes that greater confidence in portfolio betas is not justified.

Shan and Alles (2000) examined the stability of the Australian industry beta, in relation to, the variation of key macroeconomic factors. Betas of several industries were found to be sensitive to at least one macroeconomic factor and some industries, to two factors. The exchange rate factor was observed to be influential on the beta variability of most industries, while current account balance, trade balance, interest rates and unemployment were influential in the case of some industries.

Chawla (2001) examined the stability of beta using monthly data on returns for the period April 1996 to March 2000. The stability of beta was tested using two alternative econometric methods such as incorporating time variable in the regression and dummy variables for the slope coefficient. Both the methods reject the stability of beta in majority of cases.

Moonis and Shah (2002) tested the hypothesis of constant beta that was rejected for 26 of 50 stocks. They were trying to find the appropriate model for beta variation by using three models, such as:

1. Mean Reverting Model;
2. Random Coefficient Model; and
3. Random Walk Model.

The results show that the Indian stock market exhibits symptoms of time-varying betas and the tendency of beta to be mean reverting, and show little evidence of beta as a random walk process.

Odabasi (2003) studied the beta instability in the Istanbul Stock Market, where it has been found that betas are time varying. Secondly, the incidence of beta instability at about 80% for the full eight-year interval is a high score compared to the scores for similar length periods in the studies made earlier. Similar statement can be put forward for the score of about 65% in the case of four-year sub-periods. Third, the incidence of instability gets lower as the estimation sub-period shortens.

Haddad (2007) investigate the degree of return volatility persistence and time-varying behavior of systematic risk of two Egyptian stock portfolios. He used the Schwert and Seguin (1990) market model to examine the relationship between market capitalization and time varying beta for a sample of investable Egyptian portfolios during the period January, 2001 to June, 2004. According to the findings of Haddad, the small stocks portfolio exhibits difference in volatility persistence and time variability. The study also suggests that there are evidences that the volatility persistence of each portfolio and its systematic risk are significantly positively related. Because of that, the systematic risks of different portfolios tend to move in a different direction during the periods of increasing market volatility.

This paper attempts to test the stability of beta for various stocks of Bombay Stock Exchange Sensitivity Index (Sensex). The most common estimation strategy that is used by researchers for estimating the market model is a straight ordinary least square of regression of stock returns on market returns.

Data and Methodology

The data of this study is taken from five stocks that formed a part of the BSE Index (Sensex), such as, Wipro Ltd., ICICI Bank, ACC Ltd., Dr. Reddy's Laboratories and TATA Motors Ltd. These stocks are taken from five different sectors and were the part of BSE Index during the year of study. Ordinary Least Square betas of these stocks were estimated for five years. The data is collected for the period from December 2001 to November 2006.

The daily closing price for each day is taken and daily rate of return on each of the stock is computed by using the formula:

$$r_{jt} = \frac{P_{j,t} - P_{j,t-1}}{P_{j,t-1}} \times 100$$

where $P_{j,\,t}$ = Daily closing price of stock j in the time period t,

$P_{j,\,t-1}$ = Daily closing price of stock j in the time period t–1, and

r_{jt} = Daily rate of return of stock j in the time period t

The daily market rate of return is computed using the following formula.

$$m_t = \frac{B_t - B_{t-1}}{B_t} \times 100$$

where B_t = Sensex value at time period *t*,

B_{t-1} = Sensex value at time period *t–1, and*

m_t = Market return at the time period *t*

The following regression is used to compute beta values for three stocks.

$$r_{jt} = \alpha + \beta m_t + u \qquad ...(1)$$

where r_{jt} = Daily rate of return of stock *j* in the time period *t*,

m_t = Market return at the time period *t*,

u = Random error or the normally distributed disturbance term distributed normally with mean 0 and variance σ^2, and

α, β = Parameters to be estimated

Applying the regression method of estimation, 60 monthly beta values were generated for each of the five stocks. Since, beta is a parameter, the interest is to estimate beta in terms of the observed values. The estimate of beta is given by:

$$\hat{\beta} = \frac{Cov(r_{jt}, m_t)}{Var(m_t)}$$

The stability of beta values is tested by *F*-test suggested by Chow (Koutsoyiannis, 1973).

For this estimation of the relationship between r_{jt} and m_t is obtained for five different periods, *viz*., December, 2001-November, 2002; December, 2002-November, 2003; December, 2003-November, 2004; December, 2004-November, 2005; and December, 2005-November, 2006.

The steps for Chow test are:

Step 1: Calculation of pooled function of r_{jt} on m_t which is given by

$$\hat{r}_{jt} = \hat{\alpha} + \hat{\beta}_{mt}$$

then the unexplained variation

$$\sum e_p^2 = \sum r_{jt}^2 - \hat{r}_{jt}^2$$

with ($n_1 + n_2 + n_3 + n_4 + n_5 - k$) d.f. (*p* stands for 'pooled' and k is the total number of parameters, i.e., $k = 2$.)

Step 2: Regression analysis for each sample separately, which are given by two samples.

From the first sample:

$$\hat{r}_{1t} = \hat{\alpha} + \hat{\beta}_{m_t}$$

$$\sum e_1^2 = \sum r_{1t}^2 - \hat{r}_{1t}^2$$

with $(n_1 - 2)$ d.f.

From the second sample:

$$\hat{r}_{2t} = \hat{\alpha} + \beta \hat{m}_t$$

with $(n_2 - 2)$ d.f. and so on.

Step 3: The test statistic

$$F^* = \frac{[\sum e_p^2 - (\sum e_1^2 + \sum e_2^2 + \sum e_3^2 + \sum e_4^2 + \sum e_5^2)]/k}{[\sum e_1^2 + \sum e_2^2 + \sum e_3^2 + \sum e_4^2 + \sum e_5^2)]/(\sum n_i - 2k)} \quad ...(2)$$

follows F distribution with $v_1 = 2$ and $v_1 = (\Sigma n_i - 2k)$ is used to test the hypothesis of stability of beta over time.

Estimation of Beta

Along with the test for stability of beta, the estimates of beta play a vital role in financial decision-making. Estimators and their properties are to be studied to understand the behavior and nature of the parameter which have paramount importance in financial management. To estimate the beta for different stocks, the regression Equation 1 is used. The estimation of beta was carried out by using monthly return data for five years, 2001-2002, 2002-2003, 2003-2004, 2004-2005 and 2005-2006 for each of the five stocks. The values of beta which measure the systematic risk for different stocks are given in Table 1. Stock market performance is usually measured by the percentage change in the stock price or index value, that is, the returns over a period of time.

The regression model used to estimate beta as given in Equation 1 is

$$r_{jt} = \alpha + \beta m_t + u$$

Therefore, $r_{jt} - (\alpha + \beta m_t)$ is distributed normally with mean 0 and variance σ^2. Hence, it is apparent that the estimate of beta, which can also be termed as the least square estimator, coincides with the Maximum Likelihood Estimator (MLE) for the model given by Equation 1. Consequently, it inherits desirable asymptotic properties of maximum likelihood estimator, namely, consistency, efficiency, invariants and the estimator is asymptotically normally distributed (Greene, 2002).

Again since the normal distribution belongs to the exponential family of distribution, beta estimate, i.e., $\hat{\beta}$ is a sufficient estimator. And since $\hat{\beta}$ is also a least square estimator, it is an unbiased estimator and a function of sufficient statistics. Therefore, according to Rao-Blackwell theorem in the classical regression model with normally distributed disturbance, the estimator $\hat{\beta}$ of β is Uniformly Minimum Variance Unbiased Estimator (UMVUE) (Rao, 1989).

The estimate of beta values exhibit no systematic pattern which is observed in the beta values of different stocks given in Table 1. It can be said that Table 1 indicates that beta values are varying over time. To validate it statistically, Chow test has been used. For this we need to estimate model (1) and infer the results thereupon.

For all the five stocks, the values of the test static F referred to above as Equation 2 are significant. Thus, from the Chow test we can infer that the function has only changed and this change may be due to changes in either of the parameter *a* or *b* or both. To investigate the stability of the coefficient *b* for varying sample size modified, Chow test is used. The aim of this test is to investigate the stability of the coefficient estimates as the sample size increases. We want to find out whether the estimates will be different in enlarged samples and whether they will remain stable over time. In other words, whether the estimates will remain stable over time for varying sample size or not.

The modified test statistic:

$$F^* = \frac{(\sum e^2 - \sum e_1^2)/n_2}{\sum e_1^2/(n_1 - k)} \qquad ...(3)$$

The above test follows *F* distribution with $v_1 = n_2$ and $v_2 = (n_1 - k)$ d.f., where Σe^2 is the residual sum of squares from the augmented sample with n_2 being the additional sample size and Σe_1^2 is the residual sum of squares from the original sample with n_1 samples.

Conclusion

In making the inference on beta, we have seen that betas are UMVUE and the stability of beta has been examined using monthly data on returns of five stocks for the period December 2001 to November 2006 and using the Chow test stability of beta for a period of five years has been rejected (Appendix 1, Table 2).

However, another significant study showed that the test gave consistent result of beta for a period of eighteen months from December 2001, for four stocks except Wipro. The study further revealed that for the period of two years from December 2001 to November 2003 except ICICI Bank and ACC Ltd. the other three stocks, namely Wipro, TATA Motors and Dr. Reddy's Laboratories exhibit instability of beta (Appendix 1, Table 3).

In case of a period of three years from December 2001 to November 2004, all the stocks show instability except the ICICI Bank stock. In other words, ICICI Bank stock shows stable behavior up to three years compared to other stocks (Appendix 1, Table 3). The study of stability or instability of beta has its implications for taking any kind of long or short range sound corporate financial decisions.

As discussed in earlier section, beta which can also be termed as the maximum likelihood estimator, the inference can also be made that they are UMVUE (Greene, 2002).

The findings of this study are sample specific, due to the short period covered and smaller number of companies included in the sample. This study does not claim the generalization of the results. It tries to give an approach for testing the stability of beta by the method of Chow test besides the usual process of testing the stability by time as a variable and dummy variable method. Further, it may be conceded that the study proposes to research and delve into the study on the effect of time for determination of stability of beta. In relation to the behavior of beta, there is also a scope of application of the stochastic process in discrete time and study the probabilistic structure of beta. Moreover, the Markovian properties on beta may be exploited to a great extent. By observing sample values of the stock price along with the exact time of observation a Bayesian approach for estimation of beta may be considered for further future research. ❖

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Appendix

Table 1: Beta Values of Different Stocks

Sl. No.	Year/Month	Estimates of Beta Values				
		ICICI	TATA Motors	Wipro	ACC	Dr. Reddy
1	December 2001	0.395	0.935	2.403	1.292	–0.077
	January 2002	0.890	0.595	2.613	1.565	0.484
	February 2002	–0.151	0.340	2.473	1.288	0.373
	March 2002	1.264	0.969	1.294	1.655	0.467
	April 2002	1.008	1.207	0.648	0.471	–0.365
	May 2002	0.780	–0.041	2.658	0.651	0.130
	June 2002	0.788	0.420	0.513	0.378	0.777
	July 2002	1.669	0.234	0.823	1.026	0.620
	August 2002	0.818	1.575	0.255	0.635	1.534
	September 2002	0.599	2.019	–0.038	1.266	0.207
	October 2002	0.479	1.044	1.909	1.000	1.011
	November 2002	0.316	1.781	–0.118	0.866	0.458
2	December 2002	2.792	2.397	0.430	1.189	0.898
	January 2003	0.513	1.161	1.788	1.277	0.590
	February 2003	0.507	1.655	1.602	1.982	0.848
	March 2003	0.421	1.528	1.718	0.333	–0.056
	April 2003	0.666	0.838	0.995	0.361	0.014
	May 2003	0.324	0.719	3.166	0.930	0.086
	June 2003	0.997	0.186	2.111	1.382	0.740
	July 2003	0.886	1.096	1.340	1.692	0.891
	August 2003	1.158	1.117	1.592	1.347	0.628
	September 2003	1.349	1.221	1.300	1.226	0.637
	October 2003	0.732	1.400	1.963	1.226	0.272
	November 2003	0.664	1.727	1.977	1.545	0.451
3	December 2003	1.308	1.062	1.478	1.155	1.455
	January 2004	1.610	0.949	1.740	1.601	1.093
	February 2004	0.701	1.970	0.949	1.722	0.524
	March 2004	0.742	1.704	0.758	1.451	–0.108
	April 2004	1.388	1.562	0.792	1.241	–1.501
	May 2004	0.182	1.623	1.332	0.700	0.292
	June 2004	0.961	1.015	1.669	1.103	0.629
	July 2004	1.028	1.583	–0.571	1.059	0.076

(*Contd...*)

Appendix

(...contd)

Table 1: Beta Values of Different Stocks

Sl. No.	Year/Month	Estimates of Beta Values				
		ICICI	TATA Motors	Wipro	ACC	Dr. Reddy
	August 2004	0.900	1.991	1.121	0.884	0.870
	September 2004	1.035	1.287	1.367	0.569	0.367
	October 2004	0.619	1.742	1.626	0.860	0.946
	November 2004	1.946	1.469	1.268	0.210	–0.058
4	December 2004	1.073	1.290	0.731	0.785	0.428
	January 2005	1.067	1.108	2.313	0.720	0.743
	February 2005	1.174	1.005	1.065	1.060	0.185
	March 2005	1.391	1.333	1.434	0.434	0.198
	April 2005	–0.045	0.113	0.084	0.019	–0.013
	May 2005	0.708	1.434	1.789	0.450	0.293
	June 2005	1.081	1.047	1.170	–0.067	0.298
	July 2005	1.916	0.637	0.889	0.606	0.566
	August 2005	1.129	1.376	2.424	0.523	0.853
	September 2005	0.337	0.745	1.169	0.813	–0.120
	October 2005	0.903	1.085	1.053	0.644	2.054
	November 2005	0.208	0.188	0.094	–0.032	0.048
5	December 2005	1.202	1.234	0.910	1.684	0.175
	January 2006	1.041	1.074	0.874	0.683	0.377
	February 2006	2.045	1.468	0.557	0.874	0.114
	March 2006	0.906	1.076	1.247	1.363	0.027
	April 2006	0.963	1.435	1.245	0.980	0.219
	May 2006	0.877	1.155	1.157	1.073	0.707
	June 2006	0.735	1.064	1.070	0.955	0.181
	July 2006	0.798	1.252	1.189	0.885	0.704
	August 2006	0.642	1.551	1.024	0.792	0.532
	September 2006	0.939	1.483	0.849	1.038	0.347
	October 2006	1.000	0.394	1.398	0.630	0.665
	November 2006	1.556	1.601	1.407	1.001	1.907

Source: http://www.bseindia.com

(Contd...)

Appendix

(*...contd*)

Table 2: *F*(Chow Test) Statistic Values of Different Stock

Stock	*F*(Cal)	*F*(Tab)
Wipro	20.583*	Lying between 3.15 and 3.23
ICICI Bank	28.929*	
TATA Motors	51.602*	
ACC	93.687*	
Dr. Reddy's Lab	23.553*	

Note: * indicates the test statistic *F* is significant at 5% level of significance with $v_1 = 2$ and $v_2 = (\Sigma n_i - 2k)$ degrees of freedom (df).

Source: http://www.bseindia.com

Table 3: Calculated *F* Values of Different Stock for Varying Sample Sizes

	n = 18		n = 24		n = 36		n = 60	
Stock	*F*(Cal)	*F*(Tab)	*F*(Cal)	*F*(Tab)	*F*(Cal)	*F*(Tab)	*F*(Cal)	*F*(Tab)
Wipro	3.433*	3.32	7.639*	2.91	10.994*	2.74	20.583*	Lying between 3.15 and 3.23
ICICI Bank	0.703	–	2.192	–	1.832	–	28.929*	
TATA Motors	1.00	–	5.304*	–	4.584*	–	51.602*	
ACC	1.136	–	2.232	–	4.348*	–	93.687*	
Dr. Reddy's Lab	1.748	–	3.257*	–	26.441*	–	23.553*	

Note: * indicates the test statistic F is significant at 5% level of significance with $1 = n_2$ and $2 = (n_1 - k)$ degrees of freedom (df).

Source: http://www.bseindia.com

Reference # 37J-2008-09-01-01