Time varying estimate of beta (systematic risk): Evidence from Colombo stock exchange

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Abstract

This study investigates the time varying behavior of betas (Systematic risk) in Colombo Stock Exchange (CSE). The study used the trading data of 26 stocks listed in Bank Finance & Insurance, Hotels & Travel, and Manufacturing sectors for a period of 9 years for the analysis from 2005 to 2013. This study estimates time varying betas using two different approaches; Recursive regression and Rolling regression. These two different approaches are employed in order to estimate and analyze the time varying betas of 26 stocks under full period and three sub periods as 2005-2007, 2008-2010, and 2011-2013. The empirical finding of this study provides a clear evidence of time varying nature of 26 betas and indicates increasing and decreasing beta trends. It is also found that beta values varied across the techniques used to estimate the betas. Finally, finding suggests that, similar to some other evidences in developed and emerging markets, betas are not stable and demonstrate time varying nature in the CSE. The findings imply that the assumption of beta constancy is not valid in Capital Assets Pricing Model (CAPM) and the users of this model in estimating the systematic risk in CSE will not get the anticipated results.

Key words: *Beta, Capital Assets Pricing Model, Recursive regression, Rolling regression*

1. Introduction

In early 1960s the finance literature revolutionized with the advent of a model which can explain the cross sectional stock returns of securities. This model was originally evolved by the land mark paper of Shape (1964) and subsequently it was further shaped by Lintner (1965) and Black, Jensen & Scholes (1972) and became popular as Capital Asset pricing model (CAPM). The stem of this model is that it states the relationship between the required rate of return and systematic risk for individual securities as well as portfolios. The systematic risk is identified as the slope of the Ordinary Least Squared (OLS) regression of two return series which is known as CAPM beta among academic and practitioner community in finance. This model could fill the long standing vacuum in the asset pricing literature and it was well accepted by the finance community. However, empirical validation of this model requires the constant nature of CAPM beta throughout the observation of the OLS regression which is one of

the fundamental assumptions of the CAPM. For the time being , bad luck came to this model with study of Roll (1977)Titled as "A critique of the asset pricing theory's tests Part I: On past and potential testability of the theory." This discovery challenged the validity of the CAPM in determining the cross section of stock returns and started to explore the CAPM anomalies in several stock markets largely. Moreover, this model was heavily investigated both in developed markets and emerging since its emergence.

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Many scholars have concentrated on testing time varying beta because beta is an essential tool for measuring the systematic risk of securities. Financial economists and practitioners use beta to estimate stock's sensitivity to the overall market, to identify mispricing of shares and to apply evaluation models and performance evaluation. In Sri Lankan context, research on time varying is perhaps novel concept. Therefore, this study motives to fill this literature gap and used different techniques to model and estimate the time varying betas in important business sectors in CSE. Thus, the aim of this study is to examine the time varying nature of beta in Colombo Stock Exchange (CSE).

The remaining sections of this paper are organized as follows. The section 2 summarizes the previous empirical studies of time varying beta. The data and sample selection procedures and the Methodology adopted for the paper are stated under section 3. The results and the findings of the statistical tests are presented in section 4. Section 5 concludes the paper.

2. Empirical literature

Large number of empirical studies demonstrates that beta coefficient is stable over time. Importantly, Fama and French (1992, 1993, 1995 and 1996a) have examined the CAPM with constant beta and reported that model performs poorly. Baesel (1974) and Theobald (1981) also examined the stability of security betas over time. However, many researchers suggested that beta is not constant in various financial markets. Several studies documented that beta is time varying because of the influence of micro-economic and macro-economic factors. Blume (1971) first discovered the time varying nature of beta in New York Stock Exchange. Subsequently, many other researchers attempted to test the time

varying nature of beta in both developed and emerging markets. For example, Fama and Macbeth (1973), Fabozzi and Francis (1978), Sunder (1980), Bos and Newbold (1984), Collins et al. (1987), Brooks, Faff and Lee (1992), Gronewold and Fraser (1999),Faff , Hillier and Hillier (2000), Li (2003), Yeo (2004), Choudhry (2005) etc.

During the last five decades numerous studies have addressed the time varying nature of betas. In recent years, the general assumption of beta stationary, which is fundamental to security return models such as CAPM, has been argued. The previous evidence states that systematic risk varied across time.

Groenewold and Fraser (1999) studied time-varying estimates of CAPM betas in Australian stock exchange and documented that there is a considerable time variation in beta. Their work employed monthly data for 23 sectors for the period from 1979 to 1994 and used the recursive regression, rolling regression and Kalman filter methods for estimating time varying betas. Further they showed that the nature of time variation in the betas differed considerably depending on the method of estimation. Similarly, Yeo (2004) examined that time varying beta in Australia for the period 1980 to 2000 and study showed that there is significant variability in beta of eighteen industry portfolios rolling regression, recursive regression and Kalman filter method. The results revealed that the rolling and Kalman betas show more variation than recursive beta over sample.

Moreover, Adam, Jansky& Benecka (2012), in their study of time varying betas of banking industries in eight advanced countries (United States, United Kingdom, Germany, France, Switzerland, Japan, Hong Kong and Australia) found strong evidence that beta do not remain constant during January 1990 to February 2011 by using rolling regression, multivariate GARCH and Bayesian state space approaches. The results of time varying beta test showed both country specific and global events also affect to the beta coefficient.

Interestingly, Patton and Verardo (2009) investigated the time varying nature in beta of individual stock during firm specific information flow in London Stock Exchange over period of 1995-2006 which includes 22575 earnings announcements and found that beta increases by an economically and statistically significant amount on news announcement days and beta decline on post announcement days. Finally they suggested that variability in beta is substantially larger for companies which release strong news than for companies whose earnings announcement has smaller information content.

Furthermore, Faff, Hillier and Hillier (2000) explored the time variation beta in 32 UK industry sectors using daily data from 1969 to 1998. Results provided that considerable evidence for time variation in betas during sample period under three models which are used for the purpose and suggests that market model betas are unstable and systematically time varying. Another study of Eisenbei, Kauremann and Semmler's (2005) shows that time varying beta coefficient exists in German stock exchange and further reported that betas tend to be significantly larger in bear market than in bull market. Li (2003) added that on the NewZeland equity market by modeling the beta risk of NewZeland industry portfolios over the period from 1997 to 2002 and indicated that the betas of all the NewZeland industry portfolios are not stable and time varying.

The review of literature suggests that the time varying nature of the beta is highly debated topic both in emerging markets and developed markets. It is evidenced that most the previous studies has applied more or less similar methodology in different markets in different time periods. The methodology adopts in this study also very much similar to the previous researchers.

3. Methodology

For the purpose of this paper we usedaily data of listed stocks and All Share Price Index (ASPI) of Colombo Stock Exchange for the period from 2005 to 2013. The sectors included in this study are Bank Finance & Insurance Sector, Hotels& Travel sector and Manufacturing Sector and 26 securities areselected among above sectors. Security which is traded more than 200 trading per year, selected to sample and others are avoided.

We test the time varying beta for three sub periods covering the period 2005 to 2013. The method adopted in this paper is similar to several previous studies for example, Groenewold &

$$\Delta Y_t = aY_{t-1} + \delta X_t + e_t$$

Where,

a = Constant

X_t = Optional exogenous repressors

δ = Parameter to be estimated

e_t = Error term

The market model is applied to estimate the beta and it is assumed that beta is equal to 1 and beta behavior is time invariant. The Ordinary Least Squares (OLS) method is used as a proxy for the market model as shown in the below equation.

$$R_{it} = a_i + b_i R_{mi} + e_t$$

Where,

R_{it} = The rate of return of security i on day t,

a_i = The intercept term of security i,

b_i = The coefficient of security i,

R_{mi} = The rate of return of the market on day t,

e_t = The regression error term of security i on day t,

As similar to the previous studies we apply Rolling regression and Recursive

$$R_{it} = a_t + \beta_t R_{mt} + e_t$$

Where,

a_i = The intercept term of security i,

b_i = The coefficient of security i,

i = 1, 2 .....N securities

R_{it} = the return on security i

R_{mt} = the return on the market portfolio

e_t = The regression error term of security i on day t,

$t = \tau - 59, \ldots\ldots \tau$

$\tau = 60, \ldots\ldots T$

Recursive betas are estimating by application of ordinary Least squares (OLS) on the historical daily returns, the sample size increase by one observation at a time.in this study use following market model equation to estimate recursive beta;

$$R_{it} = a_t + \beta_t R_{mt} + e_t$$

Where,

a_i = The intercept term of security i,

b_i = The coefficient of security i,

i = 1, 2 ..... N securities

R_{it} = the return on security i

R_{mt} = the return on the market portfolio

e_t = The regression error term of Security i on day t,

t = 1…….. τ

τ = T_0…….. T

To test whether beta values change through time, regress rolling and recursive betas on a time trend equation. Gronewold and Fraser (1999) Celik (2013) used simple linear time series regression to test statistical significant of time varying beta estimations. Following equation used to test the time varying of beta.

$$\beta_t = \gamma_1 + \gamma_2 t + e_t$$

Where,

β_t= Beta value at time t

γ_1= Intercept

γ_2t= Slope coefficient at t

e_t= Error term

The null hypothesis and alternative hypothesis for this test statistic were set as follows:

$$H_0 : \gamma_2 = 0$$

$$H_1 : \gamma_2 \neq 0$$

If calculated t-value > critical (table) t-value then H_0 is rejected otherwise H_0 is accepted at 10% significant level. If the slope coefficient is significant, it can conclude that beta values are time varying or beta values not constant over the time.

4. Results

4.1. Unit Root Test

The study used Augmented Dickey Fuller (ADF) test on return series of all companies to examine the unit roots of the series. The results of the unit root tests are presented in Table 4. 1

The results indicate that each of stock return series and market return series (API) are stationary (no unit root) at significant level of 10%. This is because calculated t- value is greater than critical t- value and p - value is less than 0.05. It means that the null hypothesis of each stock return series and market return series (API) have a unit root is rejected and accept H_1 (no unit root). This result suggests that each return series is qualified to proceed with econometrics model to estimate time varying beta in the Sri Lanka.

Table 4.1: Unit Root Statistic of the Return Series

Return Series	ADF test	
	Null Hypothesis: Returns have a unit root	
	t-value	p-value
ACAP	-19.24896	0.000
ACL	-18.34430	0.000
AHPL	-21.54841	0.000
COMB	-19.89879	0.000
CSF	-22.67502	0.000
DPL	-18.18575	0.000
EDEN	-20.37998	0.000
GHLL	-19.26805	0.000
GLAS	-18.05093	0.000
GRAN	-21.74530	0.000
HASU	-20.55957	0.000
HNB	-20.68727	0.000
LLUB	-21.25624	0.000
LVEN	-18.96583	0.000
MARA	-19.57877	0.000
MBSL	-19.59129	0.000
NDB	-21.87384	0.000
NTB	-21.52233	0.000
RCL	-20.52917	0.000
REEF	-20.47641	0.000
RHTL	-21.20787	0.000
SAMP	-19.07254	0.000
SEMB	-20.61911	0.000
TAJ	-20.90909	0.000
TFC	-18.44841	0.000
TYRE	-23.03070	0.000

4.2 Constant beta estimation

As previously mentioned, CAPM betas of 26 stocks are calculated by using marketmodel. For this purpose all the return series of the companies are regressed with API returns (proxy for market risk). Table 4.2 demonstrates the beta values which obtained from the market model for the full sample series and other sub periods.

Table 4.2. Market model beta for full period & sub periods

Stock	Full Period	Sub Period 1	Sub Period 2	Sub Period 3
ACAP	0.42	0.60	0.11	0.65
ACL	0.52	0.82	0.26	0.53
AHPL	0.55	0.94	0.14	0.64
COMB	0.85	0.73	1.07	0.61
CSF	1.68	1.81	1.38	2.04
DPL	1.81	1.32	1.53	3.12
EDEN	1.43	1.49	1.45	1.27
GHLL	1.34	0.97	1.48	1.69
GLAS	1.17	1.30	1.09	1.12
GRAN	1.60	1.34	1.37	2.43
HASU	1.05	1.27	0.85	1.06
HNB	0.86	0.19	0.85	0.66
LLUB	0.57	0.73	0.49	0.45
LVEN	1.02	1.00	1.07	0.98
MARA	1.78	1.17	2.29	1.72
MBSL	1.62	1.61	1.48	1.88
NDB	0.52	0.73	0.28	0.61
NTB	1.07	1.16	0.99	1.08
RCL	1.31	1.61	1.27	0.86
REEF	1.61	1.45	1.43	2.13
RHTL	1.56	1.58	1.45	1.73
SAMP	0.83	0.73	0.97	0.73
SEMB	1.39	1.59	1.08	1.68
TAJ	1.45	1.53	1.40	1.36
TFC	1.41	1.69	0.97	1.79
TYRE	1.62	1.54	1.39	2.18

According to CAPM assumption, the calculated beta value for full period remains constant during 2005-2013 andthose are not varying with time. To identify beta variability, compared the estimated full sample betas with sub sample betas and sub sample betas with each other. Table 4.3 provides clear evidence against to CAPM assumption on the beta coefficient. It indicates that the estimated full period beta values differ between sub periods beta and beta is not constant. All securities included in the sample indicate, sub sample beta values different from the estimated beta for full sample period and each sub sample betas. One can argue that slope (beta) of the OLS regression model is subject to change when the number of observations varies in the regression.
The focus of this paper is to explore the validity issue of the CAPM due to time varying beta. However, this result invalids the assumption of beta constancy in the CAPM.

4.3 Rolling and recursive beta estimates

Time series properties of rolling beta and recursive beta indicate in the table 4.3. Most of securities in full period and sub periods supporting the beta are not constant over time because the coefficient of time trend is significant both in rolling regression and recursive regression.

The number of significant coefficient is 24 and 22 in full period for rolling and recursive regression respectively. The number of significant coefficient is 23, 23 and 22 for rolling regression in sub periods respectively. On other hand all coefficients are significant for recursive regression in sub periods respectively. In full period and sub periods beta values show both increases and decreases for rolling regression and recursive regression.

Table 4.3: Time series properties of Rolling beta & Recursive beta

Stock	Rolling Beta				Recursive Beta			
	γ_2 (2005/13)	γ_2 (2005/07)	γ_2 (2008/10)	γ_2 (2011/13)	γ_2 (2005/13)	γ_2 (2005/07)	γ_2 (2008/10)	γ_2 (2011/13)
ACAP	0.000180*	-0.001630*	0.000580*	0.00205*	-0.000233*	-0.00022*	0.000550*	0.00134*
	(7.90)	(-18.63)	(6.94)	(15.08)	(-59.85)	(-7.86)	(-23.83)	(43.04)
ACL	0.000060*	-0.001440*	0.000520*	0.00182*	-0.000362*	-0.00144*	0.000620	0.00093*
	(2.81)	(-21.21)	(4.19)	(14.52)	(-80.29)	(-21.21)	(26.69)*	(42.92)
AHPL	0.000191*	-0.002520*	0.000580*	0.00309*	-0.000472*	-0.00087*	0.000540*	0.00049*
	(7.78)	(-23.02)	(6.78)	(31.72)	(-98.62)	(-43.92)	(28.55)	(42.21)
COMB	0.000099*	-0.000060	0.000180*	-0.00017*	0.000212*	0.00116*	0.001160*	0.00004*
	(5.99)	(-0.49)	(2.57)	(-2.74)	(27.5)	(18.35)	(27.49)	(2.89)
CSF	0.000421*	-0.001520*	0.000430*	-0.00024	-0.000078*	0.00070*	0.000120*	0.00133*
	(15.54)	(-9.69)	(3.83)	(-1.73)	(-12.95)	(14.74)	(5.03)	(39.91)
DPL	0.001290*	-0.000500*	0.001140*	-0.00025	0.000263*	-0.00050*	0.000700*	0.00306*
	(33.74)	(-3.82)	(7.08)	(-1.02)	(58.86)	(-3.82)	(15.06)	(31.52)
EDEN	-0.000266*	-0.001050*	0.000070	-0.0035*	0.000002	0.00057*	0.000520*	0.00036*
	(-11.50)	(-10.33)	(0.72)	(-27.96)	(0.54)	(15.63)	(13.62)	(7.92)
GHLL	0.000419*	0.001980*	-0.001520*	-0.0009*	0.000459*	0.00152*	-0.000840*	0.00122*
	(9.84)	(13.04)	(-17.41)	(-8.3)	(73.13)	(47.54)	(-38.52)	(28.73)
GLAS	-0.000066*	-0.000040	-0.000260*	-0.00108*	0.000008	0.00073*	-0.000260*	0.00023*
	(-3.03)	(-0.23)	(-2.10)	(-12.33)	(-1.04)	(9.79)	(-2.1)	(15.07)
GRAN	0.000627*	-0.00115*	-0.000690*	-0.00176*	0.000090*	-0.00017*	-0.000400*	0.00064*
	(23.79)	(-14.20)	(-8.06)	(-10.64)	(31.16)	(-10.53)	(-26.37)	(10.9)
HASU	-0.000140*	-0.000690*	0.000870*	-0.00102*	-0.000093*	0.00053*	0.000430*	0.00032*
	(-7.99)	(-7.28)	(11.17)	(-10.25)	(-24.06)	(19.84)	(33.93)	(13.65)
HNB	-0.000164*	-0.000530*	0.000200*	-0.00041*	-0.000046*	0.00035*	0.001030*	0.00032*
	(15.99)	(-12.24)	(2.89)	(-8.41)	(-17.05)	(16.09)	(33.91)	(28.29)
LLUB	-0.000007	-0.000260*	-0.000150*	0.00142*	-0.000097*	0.00025*	-0.000110*	0.00034*
	(-0.57)	(-5.43)	(-2.20)	(26.05)	(-43.65)	(15.21)	(-5.55)	(63.64)
LVEN	-0.000157*	-0.001250*	-0.000660*	-0.00225*	-0.000006	-0.00009*	-0.000200*	0.00029*
	(-7.47)	(-13.95)	(-7.28)	(-24.55)	(-1.54)	(-2.42)	(-16.91)	(8.57)
MARA	-0.000663*	-0.000230*	-0.005930*	-0.00046*	0.000384*	0.00042*	-0.029290*	0.00154*
	(-2.84)	(-1.69)	(-5.50)	(-4.29)	(33.14)	(14.11)	(-29.78)	(32.75)
MBSL	0.000171*	-0.000910*	0.001150*	-0.00119*	0.000005	0.00018*	0.000360*	0.00099
	(7.79)	(-8.16)	(12.69)	(-9.01)	(1.25)	(4.79)	(19.52)	(24.85)

NDB	0.000074*	-0.000300*	-0.000010	0.00151*	-0.000100*	0.00057*	-0.000090*	0.00045*
	(4.35)	(-2.48)	(-0.24)	(26.9)	(-24.7)	(20.42)	(-18.29)	(37.66)
NTB	0.000099*	-0.000950*	0.000770*	-0.00022*	-0.000103*	-0.00010*	0.000500*	0.00048*
	(7.65)	(-13.13)	(13.36)	(-3.58)	(-35.11)	(-3.62)	(24.76)	(18.15)
RCL	-0.000572*	0.003850*	-0.000580*	0.00077*	0.000011*	0.00073*	-0.000320*	0.00142*
	(-11.14)	(8.26)	(-7.92)	(10.43)	(1.82)	(20.33)	(-18.88)	(38.36)
REEF	0.000947*	0.000720*	0.000660*	0.00344*	0.000359*	0.00308*	0.000140*	0.00115*
	(21.35)	(2.91)	(3.60)	(11.69)	(21.41)	(24.00)	(2.67)	(29.95)
RHTL	0.000359*	0.001290*	0.000550*	-0.00108*	0.000199*	0.00220*	0.000610*	0.00145*
	(12.56)	(6.95)	(4.13)	(-7.73)	(15.17)	(21.16)	(20.86)	(34.53)
SAMP	0.000094*	0.001320*	0.002430*	0.00007	-0.000026*	-0.00060*	0.001220*	0.00041*
	(5.18)	(-19.24)	(25.30)	(1.21)	(-6.27)	(-22.72)	(59.21)	(37.45)
SEMB	0.000244*	-0.000780*	-0.000820*	0.00211*	-0.000219*	0.00023*	0.000200*	0.00105*
	(6.97)	(-6.55)	(-3.99)	(11.38)	(-51.34)	(-6.33)	(9.61)	(29.62)
TAJ	0.000022	-0.000550*	-0.000030	-0.00184*	0.000070*	0.00126*	0.000120*	0.00053*
	(1.05)	(-4.04)	(-0.40)	(-17.08)	(10.55)	(26.58)	(10.4)	(16.02)
TFC	0.000659*	-0.000090	0.000950*	0.00255*	-0.000034*	0.00207*	0.000620*	0.00075*
	(23.94)	(-0.55)	(10.43)	(21.53)	(-2.78)	(24.18)	(26.1)	(51.86)
TYRE	0.000394*	0.000320*	-0.000870*	0.00006	0.000112*	0.00080*	0.001080*	0.00193*
	(13.40)	(3.21)	(-5.56)	(0.33)	(25.55)	(27.38)	(14.15)	(34.84)

Notes; * significant at 10% level, Figures in parentheses are t-ratio

5. Discussion

This study employed two techniques for modeling and estimate time varying beta. Findings of this study are summarized in to the Table 5.1 It indicates observed securities with constant beta betasunder different techniques for full sample period as well as sub sample periods.

Table 5.1: Summary of findings

Time Period	Method	No. of Securities	
		Constant Beta	Time varying beta
2005-2013	Rolling	02	24
	Recursive	04	22
2005-2007	Rolling	03	23
	Recursive	00	26
2008-2010	Rolling	03	23
	Recursive	00	26
2011-2013	Rolling	04	22
	Recursive	00	26

In the period from 2005 to 2013, out of 26 securities 24 very clearly demonstrate time varying nature of beta under rolling regression. Moreover, in the same period out of 26 securities 22show time varying nature of beta under recursive technique. Interestingly, Table 5.1 shows that for the full period only four (04) securities are constant under recursive technique in other sub periods almost all securities are time varying. All results show that more than 80% stocks demonstrate time varying betas for each estimating technique. Moreover, it can be concluded that all stocks which are in the sample show time varying. This is because the results do not indicate any stock which is constant nature under above eight estimation categories.

Further, estimated average beta values of rolling regression and recursive regression for Bank Finance & Insurance sector, Manufacturing sector and Hotels & travel Sector during the period from 2005 to 2013 are shown in Figure 4.1, Figure 4.2 and Figure 4.3 respectively.

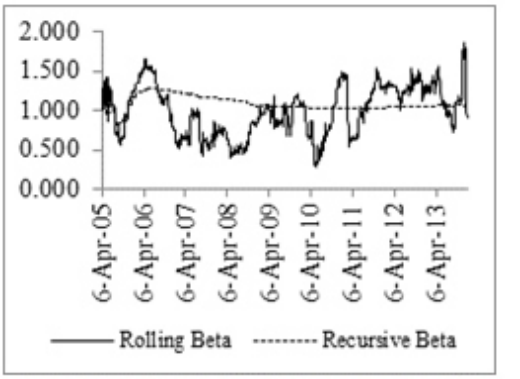

Figure 5.1: Time Varying Beta for Bank Finance & Insurance Sector (2005/13)

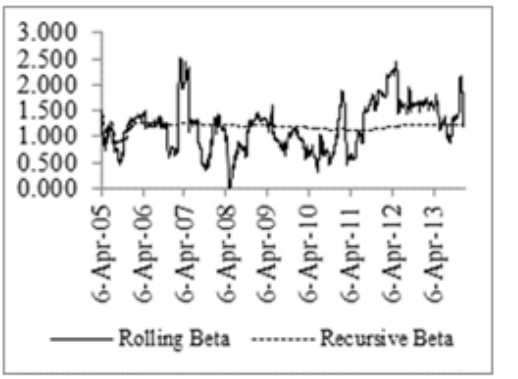

Figure 5.2: Time Varying Beta for Manufacturing Sector (2005/13)

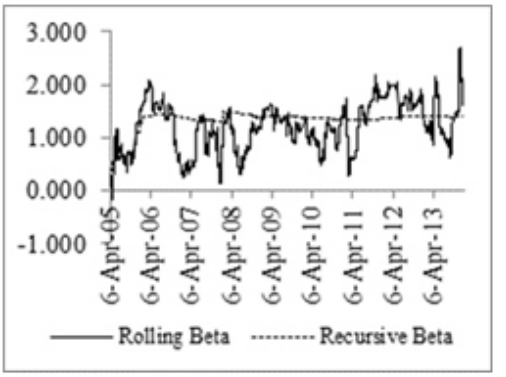

Figure 5.3: Time Varying Beta for Hotels & Travel Sector (2005/13)

Figure 5.1, 5.2 and 5.3clearly indicate that beta is not constant for all three sectors. Above figures display that, rolling betas indicate more variation than the recursive betas over time. All selected sectors demonstrate recursive beta tend to show grater variation earlier in the sample period then it decreases as the time goes on and becomes stable with lessvariations. On other hand rolling beta tend to show more variation over the estimatingperiod. This behavior appears because of the nature of rolling and recursive regression model. Rolling regression assigns equal weight to each observation in the rolling window. In this study we assign 60 days per each rolling window. Under recursive regression technique each successive observation carries less weight.

5. Conclusion

The main objective of this study is to examine the existence of time varying betas in three selected sectors in CSE. Two different approaches were employed to examine time varying betas: rolling regression, recursive regression. The results suggest a clear evidence of time varying nature of beta in the Colombo Stock Exchange and beta values varied across the estimation techniques which used for estimating the beta. In other words findings conclude that CAPM betas are not stable in Sri Lankan Market and show time varying nature over time. Therefore beta is not a good tool for measuring the risk of securities in the Bank Finance & Insurance, Manufacturing and Hotels & Travels sectors. Finally empirical results of this study conclude that assumption of beta constancy of CAPM is not valid in Sri Lankan market.

The finding implies that the investors and other practitioners should be cautious when they consider time varying beta in the investment decisions and portfolio management decisions.

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