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ARTICLE

Beta Stationarity and Estimation Period: Evidence from Pakistan's Equity Market

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Abstract

This study examines the stability of individual stock beta coefficients over time and its link with the length of estimation periods. Using data for 325 stocks from Pakistan for the period 1999 to 2012, I show that beta coefficients are not stable on average but become more stable as the estimation period increases. This suggests that longer estimation periods should be used for predicting future beta coefficients.

Key Words: Beta, stocks, Karachi Stock Exchange.

JEL Classification: G12, G23.

Introduction

Risk and return are two most important factors which common stock investors include in their investment analysis. Risk is defined as the uncertainty of the return and is categorized in two components: firm-specific risk and the market risk. When the stocks are combined in a portfolio, the risk caused by the firm-specific factors is diversified. For well-diversified portfolios, the firm-specific risk is completely eliminated and the remaining risk is the market risk only. Thus, the market-related portion of a stock's total risk determines the stock's impact on the risk of the portfolio. Investors demand and receive a higher return from investments which involve higher market risk, implying that the expected returns for equity holders are a positive function of the market risk. The market risk is represented by the beta coefficient in the market model developed by Sharpe (1963). While making the investment decision, an investor assesses the future market risk of an investment based on the historical beta figure. The accurate estimation of beta is, therefore, important for investment decision making.

This paper investigates the stability of individual stock's beta coefficient across time and the impact of the length of estimation interval on the stability of estimated beta coefficients in Pakistan's equity market. Consistent with the findings in existing literature, the beta coefficients for Pakistan's stocks do not show stability across time. Moreover, the beta coefficients estimated using long time intervals exhibit less instability than the beta coefficients estimated using short time intervals.

The paper is organized in the following way: section 2 reviews the relevant literature, sample and methodology are presented in section 3, section 4 presents the findings of the study and section 5 concludes the paper.

Literature Review

Stability of beta has been tested empirically in a number of studies. These studies have concluded that the individual security beta is instable and it varies depending on various factors including the estimation period used for beta calculation, time interval between the data points, market conditions, trading volume and liquidity, industry group, size of portfolio examined, extremity of the beta, firm size and differential information.

Many studies have found evidence of beta instability when the estimation period is changed (Levy, 1971; Baesel,1974; Singh, 2008 and Deb & Mishra, 2011). These studies found evidence of beta instability, particularly over shorter time horizon, at both individual security as well as portfolio levels. This instability is reported to decline as the length of beta estimation period increases.

Beta coefficients are also found to be dependent on the intervals between data points over the estimation period. Singh (2008) reported that the variability of beta is higher with longer interval periods.

Studies relating the stability of beta with the extremity of beta have found the extreme betas (both very low and very high) to be marginally more stable than the intermediate beta values (Baesel, 1974 and Deb & Mishra, 2011). Stability of beta has also been examined over different market phases. Celik (2013) found evidence of varying beta under different market conditions (bull and bear). However, Levy (1971) reported the stability of beta to be independent of the market direction.

Studies including Levy (1071), Blume (1971) and Alexander and Chervany (1980) concluded that individual security betas are unstable and the time stability of portfolio beta coefficients is directly related to the number of securities in the portfolio. As the number of securities in the portfolio rises, the magnitude of inter-temporal changes in portfolio beta coefficients decreases. Contrary to this, Gregory-Allen, Impson and Karafiath (1994) concluded that portfolio betas are no more stable than individual securities' betas. Singh (2008) concluded that portfolio formation contributes to the beta stationarity only when monthly returns are used.

De Jong and Collins (1985) related the instability of equity beta to the unexpected changes in the risk-free rates and the level of leverage employed by the firm. The firms with relatively higher level of debt were found to exhibit greater beta instability as compared to the firms with relatively lesser debt levels. Moreover, the equity betas were more instable during the periods of relatively large unexpected changes in the risk-free rates.

The issue of beta instability has been explored thoroughly in the developed markets but considerably less evidence is available from developing markets. This paper contributes to the existing literature by presenting the evidence of beta instability from a developing market and it is the first attempt to explore the issue of beta instability in the context of Pakistan's equity market.

Data and Methodology

The sample of the study consists of the price data on 325 stocks listed on the Karachi Stock Exchange (KSE), for the period of January 1999 to December 2012. The total number of listed companies on KSE in December 2012 was 573. The companies which did not exist throughout the study period and which reported zero returns for a continuous period of 12 months or more are excluded from the sample. KSE-100 index is used as a proxy for the

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market. The adjusted prices for 325 stocks and the KSE-100 indices are extracted from Bloomberg data base.

Using monthly returns, the following basic Market Model is used to calculate the beta values of individual stocks over different time periods:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t} \qquad (1)$$

where,

$R_{i,t}$ = Return on stock *i* for month *t*

$R_{m,t}$ = Return on the market for month *t*

α and ß = Parameters to be estimated

The beta coefficients are calculated over various estimation periods (one year, two years, three years, etc, up to fourteen years). Table 1 shows the descriptive statistics of these beta coefficients. The mean beta coefficient reduces as the estimation period is increased. This is in contrast to the statistics reported by Deb and Misra (2011) for the Indian equity. The standard deviation of beta coefficients and the range of beta coefficients are smaller for longer estimation periods.

Table 1
Descriptive Statistics for Beta Values Calculated Using Various Estimation Periods

Beta Calculated Over:	Mean	Standard Deviation	Minimum	Maximum
1 year	0.646	1.832	-40.029	44.646
2 years	0.626	1.166	-27.969	15.143
3 years	0.603	1.018	-20.148	9.167
4 years	0.577	0.938	-18.698	6.011
5 years	0.575	0.857	-17.798	4.297
6 years	0.572	0.803	-15.800	3.955
7 years	0.574	0.749	-13.957	3.143
8 years	0.580	0.700	-12.594	2.558
9 years	0.589	0.631	-11.394	2.456
10 years	0.593	0.579	-7.148	2.462
11 years	0.582	0.592	-6.911	2.454
12 years	0.572	0.618	-6.578	2.172
13 years	0.563	0.659	-6.471	1.791
14 years	0.561	0.637	-6.163	1.777

The following approaches are used to measure the stability of beta coefficients across various time periods:

1. A regression model with 13 dummy variables, is used to measure the change in beta coefficients across single calendar year periods, as listed below:

$$R_{i,t} = \alpha_i + \beta_1 R_{m,t} + \beta_2 D_2 R_{m,t} + \ldots \beta_{14} D_{14} R_{m,t} + \varepsilon_{i,t} \qquad (2)$$

where,

$R_{i,t}$ = Return on stock *i*for month *t*

$D_2 R_{m,t} = R_{m,t}$, if data is for the second year (2000)

= 0, otherwise

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$D_{14}R_{m,t} = R_{m,t}$, if data is for the fourteenth year (2012)

= 0, otherwise

α and β= Parameters to be estimated

If one or more of the slope coefficients (β_1 to β_{14}) are significant, the hypothesis of beta stability across time will be rejected.

2. Mean difference test is used to test if the mean beta coefficients calculated using different estimation periods (1-year, 2-years till 7-years) are statistically different. If the t-statistics corresponding to the differences of mean beta coefficients are significant, the hypothesis of beta stability will be rejected.

3. Transition matrices are estimated for two sub-periods of 12-months and 84 months with 14 and 2 observations available respectively. For each sub-period, betas are grouped into percentiles (risk classes) on the basis of magnitude, with the first risk class containing 20% of the stocks with lowest beta values and the fifth risk class containing 20% of the stocks with highest beta values. The stocks are then cross classified by their risk class in period t and the risk class in period t+1 to identify the proportion of stocks switching from one risk class in period t to some other risk class in period t+1. For each transition matrix, chi-square statistic is calculated. If the chi-square statistic is significant, the hypothesis that the distribution is a result of pure randomness will be rejected.

4. Product moment correlations and rank order correlations are calculated among the beta coefficients estimated across different time periods and with different estimation intervals. Significance tests of correlation coefficients are used to assess whether the relationships between the beta coefficients are the result of chance. If these correlations are significant, the hypothesis of no relationship between the beta coefficients estimated across different time periods will be rejected.

Empirical Results

Using the regression model with dummy variables, 248 companies out of 325 companies reported at least one significant slope coefficient. Table 2 presents the total number of companies with positive significant slope coefficients and total number of companies with negative significant slope coefficients. These results show that the beta coefficients are not stable and fluctuate across time.

Table 3 reports the mean differences of the beta coefficients estimated using different estimation periods. Differences of mean beta coefficients are calculated from one year to seven-year estimation period. Most of the mean differences are significant; however, as the estimation period increases the mean differences become less significant suggesting an increase in beta stability for longer estimation periods as compared to shorter estimation periods.

Table 4A represents the transition matrix using 14 sequential twelve month sub-periods (a total of 4225 observations) and table 4B represents the transition matrix using 2 sequential eighty-four month sub-periods (a total of 325 observations). For each sub-period, betas are grouped into percentiles (risk classes) on the basis of magnitude, with the first risk class containing 20% of the stocks with lowest beta values and the fifth risk class containing 20% of the stocks with highest beta values. Each entry in the transition matrix shows the proportion of the stocks falling in risk class r in period t and risk class r in period t+1. For example, the first element (1,1) in table 4A has a value 0.31 which means 31% of stocks which were in the lowest risk class in period t.

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Table 2
Results for the Regression Model

Coefficient	Number of Companies with significant coefficient	Number of Companies with positive significant coefficient	Number of Companies with negative significant coefficient
A	43	37	6
β_1	71	65	6
β_2	44	32	12
β_3	31	16	15
β_4	38	23	15
β_5	51	42	9
β_6	42	37	5
β_7	36	20	16
β_8	23	10	13
β_9	39	30	9
β_{10}	52	32	20
β_{11}	65	34	31
β_{12}	35	28	7
β_{13}	23	15	8
β_{14}	61	56	5

Table 3
Mean Differences of Beta Coefficients Estimated Using Different Estimation Periods

Estimation Period	1 year	1999 & 2000	2000 & 2001	2001 & 2002	2002 & 2003	2003 & 2004	2004 & 2005	2005 & 2006
Mean Difference		0.0036	-0.0581	-0.0486	-0.2861*	-0.3837**	0.6173***	0.1490***
Estimation Period	2 years	1999-2000 & 2000-01	2000-01 & 2002-03	2001-02 & 2003-04	2002-03 & 2004-05	2003-04 & 2005-06	2004-05 & 2006-07	2005-06 & 2007-08
Mean Difference		-0.0331	-0.2051*	-0.4578***	-0.0372	0.3627***	0.0985**	-0.0785**
Estimation Period	3 years	1999-2001 & 2002-04	2000-02 & 2003-04	2001-03 & 2004-06	2002-04 & 2005-07	2003-05 & 2006-08	2004-06 & 2007-09	2005-07 & 2008-10
Mean Difference		-0.2921***	-0.3330***	-0.0985	0.1237**	0.1910	0.0749*	-0.0094
Estimation Period	4 years	1999-2002 & 2003-06	2000-03 & 2004-07	2001-04 & 2005-08	2002-05 & 2006-09	2003-06 & 2007-10	2004-07 & 2008-11	2005-08 & 2009-12
Mean Difference		-0.3029***	-0.1583*	0.0184	0.1395***	0.1135**	0.0561	-0.1786***
Estimation Period	5 years	1999-2003 & 2004-08	2000-04 & 2005-09	2001-05 & 2006-10	2002-06 & 2007-11	2003-07 & 2008-12		
Mean Difference		-0.1373*	-0.0206	-0.0140	0.0851**	0.0526		
Estimation Period	6 years	1999-2004 & 2005-10	2000-05 & 2006-11	2001-06 & 2007-12				
Mean Difference		-0.0396	-0.0736	-0.0795				
Estimation Period	7 years	1999-2005 & 2006-12						
Mean Difference		-0.1345*						

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Table 3 (continued…)

Estimation Period	2006 & 2007	2007 & 2008	2008 & 2009	2009 & 2010	2010 & 2011	2011 & 2012
Mean Difference	-0.2503***	0.1435***	0.1487*	-0.7159***	0.4618***	-0.4120*
Estimation Period	2006-07 & 2008-09	2007-08 & 2009-10	2008-09 & 2010-11	2009-10 & 2011-12		
Mean Difference	0.0694	-0.0370	-0.3965***	-0.4403***		
Estimation Period	2006-08 & 2009-11	2007-09 & 2010-12				
Mean Difference	-0.0899*	-0.5170***				

***,** and * indicate that the difference is positive and significant at 1%, 5% and 10% level of significance.

Table 4A
Transition Matrix Using 12-month Estimation Interval

	Risk Class in Period t+1					
		1	2	3	4	5
Risk Class in Period t	1	0.31	0.23	0.17	0.13	0.16
	2	0.23	0.24	0.22	0.20	0.11
	3	0.19	0.22	0.21	0.20	0.18
	4	0.13	0.18	0.22	0.27	0.20
	5	0.15	0.13	0.17	0.20	0.34

Chi-square statistic is 299.7 which is significant at 1% level.

Table 4B
Transition Matrix Using 84-month Estimation Interval

	Risk Class in Period t+1					
		1	2	3	4	5
Risk Class in Period t	1	0.39	0.27	0.11	0.14	0.09
	2	0.20	0.38	0.25	0.11	0.06
	3	0.25	0.12	0.22	0.30	0.11
	4	0.06	0.11	0.08	0.29	0.47
	5	0.09	0.12	0.35	0.17	0.27

Chi-square statistic is 105 which is significant at 1% level remained in the lowest risk class in period t+1.From table 4A, we find that using the one-year estimation period 27% of the stocks on average remain in the same risk class; Whereas, 73% of the stocks moved from one risk class to the other exhibiting signs of beta instability. The percentage of stocks remaining in the same risk class is marginally higher for the highest beta values (34%) and lowest beta values (31%). As the estimation period is increased, the percentage of stocks sticking to the same risk class increases (31% on average for seven-year estimation period in table 4B). However, for a longer estimation period only the lowest beta values show more stability. The chi-square statistic is used to test the hypothesis that the proportions of securities moving from one risk class to the other over the sub-periods used are same. In both

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tables, the chi-square statistic is significant showing that the observed results do not occur by chance.

Table 5 shows the mean product moment correlation coefficients and rank order correlation coefficients among the beta coefficients for different estimation intervals. Tables 6A and 6B show the product moment correlation coefficients and rank order correlation coefficients, respectively; Among them the beta coefficients are estimated across different time periods and with different estimation intervals. Most of the correlation coefficients are positive and significant which shows that the relationships between the beta coefficients across time are not the result of chance. Moreover, the mean correlation increases as the estimation period increases which shows that the historical beta coefficients calculated using longer estimation period are better in predicting the future beta coefficients.

Table 5
Product Moment Correlation Coefficients and Rank Order Correlation Coefficients

Estimation Period Length	Mean Product Moment Correlation Coefficient	Mean Rank Order Correlation Coefficient
1	-0.007	0.220
2	0.196	0.317
3	0.190	0.351
4	0.200	0.383
5	0.206	0.422
6	0.149	0.404
7	0.173	0.414

Table 6A
Product Moment Correlation Coefficients Among Beta Coefficients Estimated Across Different Time Periods and with Different Estimation Intervals

Estimation Period	1 year	1999 & 2000	2000 & 2001	2001 & 2002	2002 & 2003	2003 & 2004	2004 & 2005	2005 & 2006
MD		-0.375	-0.353	0.135***	-0.094	-0.072	0.131***	0.028
Estimation Period	2 years	1999-2000 & 2000-01	2000-01 & 2002-03	2001-02 & 2003-04	2002-03 & 2004-05	2003-04 & 2005-06	2004-05 & 2006-07	2005-06 & 2007-08
MD		0.715***	0.213***	-0.065	0.077*	0.150***	0.0378	0.216***
Estimation Period	3 years	1999-2001 & 2002-04	2000-02 & 2003-04	2001-03 & 2004-06	2002-04 & 2005-07	2003-05 & 2006-08	2004-06 & 2007-09	2005-07 & 2008-10
MD		0.214***	0.028	0.126**	0.209***	0.182***	0.190***	0.248***
Estimation Period	4 years	1999-2002 & 2003-06	2000-03 & 2004-07	2001-04 & 2005-08	2002-05 & 2006-09	2003-06 & 2007-10	2004-07 & 2008-11	2005-08 & 2009-12
MD		0.083*	0.153***	0.208***	0.231***	0.178***	0.236***	0.313***
Estimation Period	5 years	1999-2003 & 2004-08	2000-04 & 2005-09	2001-05 & 2006-10	2002-06 & 2007-11	2003-07 & 2008-12		
MD		0.218***	0.150***	0.147***	0.279***	0.239***		
Estimation Period	6 years	1999-2004 & 2005-10	2000-05 & 2006-11	2001-06 & 2007-12				
MD		0.184***	0.114**	0.149***				
Estimation Period	7 years	1999-2005 & 2006-12						
MD		0.173***						

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Table 6A (Continued…)

Estimation Period	1 year	2006 & 2007	2007 & 2008	2008 & 2009	2009 & 2010	2010 & 2011	2011 & 2012
MD		0.031	0.190***	0.203***	0.115**	-0.055	0.019
Estimation Period	2 years	2006-07 & 2008-09	2007-08 & 2009-10	2008-09 & 2010-11	2009-10 & 2011-12		
MD		0.187***	0.243***	0.166***	0.220***		
Estimation Period	3 years	2006-08 & 2009-11	2007-09 & 2010-12				
MD		0.254***	0.256***				

***,** and * indicate that the difference is positive and significant at 1%, 5% and 10% level of significance. MD is the mean difference.

Table 6B
Rank Order Correlation Coefficients Among Beta Coefficients Estimated Across Different Time Periods and with Different Estimation Intervals

Estimation Period	1 year	1999 & 2000	2000 & 2001	2001 & 2002	2002 & 2003	2003 & 2004	2004 & 2005	2005 & 2006
MD		0.320***	0.369***	0.382***	0.306***	0.175***	0.107**	0.158***
Estimation Period	2 years	1999-2000 & 2000-01	2000-01 & 2002-03	2001-02 & 2003-04	2002-03 & 2004-05	2003-04 & 2005-06	2004-05 & 2006-07	2005-06 & 2007-08
MD		0.391***	0.483***	0.338***	0.281***	0.268***	0.198***	0.294***
Estimation Period	3 years	1999-2001 & 2002-04	2000-02 & 2003-04	2001-03 & 2004-06	2002-04 & 2005-07	2003-05 & 2006-08	2004-06 & 2007-09	2005-07 & 2008-10
MD		0.459***	0.438***	0.321***	0.329***	0.362***	0.258***	0.337***
Estimation Period	4 years	1999-2002 & 2003-06	2000-03 & 2004-07	2001-04 & 2005-08	2002-05 & 2006-09	2003-06 & 2007-10	2004-07 & 2008-11	2005-08 & 2009-12
MD		0.401***	0.408***	0.402***	0.364***	0.344***	0.346***	0.418***
Estimation Period	5 years	1999-2003 & 2004-08	2000-04 & 2005-09	2001-05 & 2006-10	2002-06 & 2007-11	2003-07 & 2008-12		
MD		0.461***	0.437***	0.370***	0.391***	0.452***		
Estimation Period	6 years	1999-2004 & 2005-10	2000-05 & 2006-11	2001-06 & 2007-12				
MD		0.411***	0.421***	0.381***				
Estimation Period	7 years	1999-2005 & 2006-12						
MD		0.4143						

Table 6B (Continued…)

Estimation Period	1 year	2006 & 2007	2007 & 2008	2008 & 2009	2009 & 2010	2010 & 2011	2011 & 2012
MD		0.147***	0.266***	0.324***	0.111***	0.096**	0.093**
Estimation Period	2 years	2006-07 & 2008-09	2007-08 & 2009-10	2008-09 & 2010-11	2009-10 & 2011-12		
MD		0.275***	0.375***	0.188***	0.393***		
Estimation Period	3 years	2006-08 & 2009-11	2007-09 & 2010-12				
MD		0.359***	0.298***				

***,** and * indicate that the difference is positive and significant at 1%, 5% and 10% level of significance. MD is the mean difference.

Conclusion

This paper examines the stability of individual stock's beta coefficient across time and the impact of the length of estimation interval on the stability of estimated beta coefficients using the price data of 325 stocks listed on the Karachi Stock Exchange (KSE), for the period from January 1999 to December 2012. Empirical results show that the beta coefficients are not stable and they fluctuate across time. Moreover, the beta instability decreases as the estimation period increases suggesting that the historical beta coefficients calculated using longer estimation period are better in predicting the future beta coefficients.

This study uses the monthly returns for estimation of beta coefficients of individual stocks. The issue of beta stability can be explored using daily or weekly returns. Further, research can also be done to investigate the stability of beta coefficients for portfolios.

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