DO TIME-VARYING BETAS HELP IN ASSET PRICING? EVIDENCE FROM THE BORSA ISTANBUL STOCK EXCHANGE

A Master's Thesis

by
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Management
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Ankara
August 2013

To my family and Melike

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Graduate School of Economics and Social Sciences
of
İhsan Doğramacı Bilkent University

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August 2013

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science in Management.

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Supervisor

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ABSTRACT

DO TIME-VARYING BETAS HELP IN ASSET PRICING?
EVIDENCE FROM THE BORSA ISTANBUL STOCK EXCHANGE

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Supervisor: Assoc. Prof. Levent Akdeniz

August 2013

The purpose of this thesis is to investigate the time variation in betas of nonfinancial firms traded in the Borsa Istanbul Stock Exchange over the period from January, 1998 to December, 2011 by utilizing the threshold CAPM of Akdeniz, Altay-Salih & Caner (2003). The threshold CAPM defines beta as a function of an underlying economic variable, namely the threshold variable, to allow beta to change among two different regimes when the threshold variable hits a certain threshold level. For empirical analysis, monthly observations of interest rates, currency basket, real effective currency index, and market volatility are selected as candidates for the threshold variable. The empirical findings indicate significant time variation in betas during the sample period due to rate of changes in the currency basket level. The findings of this study also suggest that dynamics of time variation in betas differ across industry specifications, market capitalizations and book-to-market ratios. Furthermore, comparing the pricing performance of the model with the traditional CAPM via time-series regressions, the threshold CAPM performs better in pricing.

Keywords: Time variation in beta, Threshold CAPM, the Borsa Istanbul Stock Exchange

ÖZET

ZAMANLA DEĞİŞEN BETALAR VARLIK FIYATLANDIRMASINDA FAYDA SAĞLIYOR MU?
BORSA İSTANBUL'DAN KANIT

Yayvak, Berk

Yüksek Lisans, İşletme Bölümü

Tez Yöneticisi: Doç. Dr. Levent Akdeniz

Ağustos 2013

Bu tezin amacı Ocak 1998 ve Aralık 2011 tarihleri arasında Borsa İstanbul'da işlem görmüş hisse senedi betalarının zamana bağlı değişimini Akdeniz, Altay-Salih ve Caner (2003) tarafından önerilen Eşik Sermaye Varlıkları Fiyatlama Modeli'nden (Eşik SVFM) faydalanarak incelemektir. Eşik SVFM, betayı bir dayanak ekonomik değişkenin, yani eşik değişkenin bir fonksiyonu olarak tanımlayarak; betaların, eşik değişken belirli bir eşik değere ulaştığı zaman, iki rejim arasında değişmesini sağlamaktadır. Ampirik inceleme için faiz oranları, döviz sepeti, reel effektif döviz endeksi ve piyasa volatilitesi eşik değişkene aday olarak seçilmişlerdir. Bulgular betaların örneklem periyodu süresince döviz sepeti seviyesindeki oransal değişime ilişkin zamana bağlı önemli bir değişim sergilediğini ortaya koymaktadır. Çalışmanın bulguları ek olarak betalardaki değişim dinamiklerinin endüstri tanımlamalarına, piyasa değerine ve piyasa değeri-defter değeri oranına bağlı farklılaştığını göstermektedir. Ayrıca, Eşik SVFM'nin fiyatlandırma randımanının geleneksel SVFM modelininki ile karşılaştırılması ile Eşik SVFM fiyatlandırma açısından daha etkin bulunmuştur.

Anahtar Kelimeler: Betada zamana bağlı değişim, eşik SVFM, Borsa İstanbul

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CHAPTER I

INTRODUCTION

A fundamental question in finance is how investors assess the risk of future cash flows of an asset and how much premium they demand for that risk. Over last decades, along with this question, the valuation of risky assets has attracted the attention of the academia and the business world for its practical applications. Several models have been proposed to describe how investors measure an asset's risk and associate its expected return with that risk. Among these models, The Capital Asset Pricing Model (CAPM) of Sharpe (1964), Lintner (1965) and Black (1972) has been considered as a cornerstone of theoretical and empirical finance; which postulates a stable and linear relationship between an asset's expected return and risk. In the context of the CAPM, the concerned risk measure in holding an asset is beta, which is the sensitivity of asset return to the return on a comprehensive market portfolio.

The early empirical tests of the model generally supported its predictions, but later studies; especially Ball (1978), Banz (1981), Reinganum (1981), Basu (1983), Statman (1980), Rosenberg et al. (1985), Bhandari (1988) and Fama & French (1992) have examined empirical implementations of the model and reported that much of the variation in expected return is unrelated to beta. One of the explanations for the failure of the model is the assumption that beta and market risk premium are constant over time. Since the CAPM is a single-period theory assuming that all investors have the same expectations of mean, variance and covariance of returns; in the empirical examination of this unconditional model with real-world data, it is necessary to assume that risk measures of investors remain constant over time. However, as stated by Jaganathan & Wang (1996), this is not a reasonable assumption because changes in overall economic conditions might conduce the alteration of the tradeoff between risk and expected return. Many other studies, notably Ferson (1989), Ferson & Harvey (1991, 1993), and Ferson & Korajczyk (1995) also argue that beta and market risk premium vary over time rather than being constant.

Early empirical investigations on time-varying betas (e.g. Blume, 1971; Fabozzi & Francis, 1978; and Sunder (1980)) show that beta appear to be time-varying. In addition to these studies, more recent studies also find evidence for time variation in betas for both developed and emerging countries; e.g., Australia (Faff et al., 1992; Brooks et al., 1998), Canada (Episcopos, 1996), Hong Kong (Chang, 1996), Korea (Bos & Fetherston, 1992), Singapore (Brooks et al., 1998), United Kingdom (Reyes, 1999) and United States (Bollerslev et al., 1988; Ferson 1989; Ferson & Harvey, 1991, 1993, Ferson & Korajczyk, 1995; and Jaganathan & Wang, 1996).

Despite the considerable number of empirical studies presenting evidence on time variation in betas, there is no consensus on a framework to capture this variation. There are two common approaches to explicitly model time-varying beta with continuous approximations; one approach utilizes autoregressive conditional heteroscedasticity (ARCH) based techniques to estimate conditional beta, and the other uses instrumental variables to proxy time-variation in betas and market risk premium. However, Ghysels (1998) shows that continuous approximation fails to capture the dynamics of beta risk due to the structural breaks in parameter estimates. He argues that time-variation in betas stated by linear models such as the conditional CAPM is higher than the true time-variation. Thus the conditional approximation yields large pricing errors. He suggests the use of the static CAPM until researchers propose a new model that captures time variation accurately.

Empirically documented large pricing errors of conditional CAPMs has prompted researchers to investigate alternative approaches to model time variation in beta, many of which have assumed that beta changes discretely over time. As stated by Akdeniz, Altay-Salih & Caner (2003), this assumption yields a non-linear relationship between risk and expected return, and treating a possible non-linear relationship as a linear one may lead to serious problems in estimation. Since non-linear models are inherently more difficult than linear models to interpret, there are only a few non-linear asset pricing models in the literature. Basically, two non-linear approaches stand out in empirical studies that capture the slow variation in betas: discrete Markov-switching specifications and threshold regression frameworks. These two closely related approaches allow betas to switch between different regimes due to changes in an underlying variable such as volatility, interest rates, default premium, or dividend yield.

Among these non-linear approaches, this thesis concentrates on a threshold estimation framework that is the two-regime homoscedastic threshold non-linear model: the threshold CAPM of Akdeniz et al. (2003). In order to propose this non-linear version of the conditional CAPM, they benefit form Hansen's (2000) threshold estimation framework. This is a simple and intuitive version of the conditional CAPM, which captures the slow variation by allowing beta to respond to changes in the economic environment. Unlike the traditional CAPM, the market risk is modeled as a function of an underlying economic variable, which is called threshold variable in order to procure beta to change among two different regimes when the threshold variable reaches a certain threshold level.

The use of non-linear asset pricing models in the developed markets generally provides supportive evidence for the existence of discrete changes in betas. For instance, empirical findings of Perez-Quiros & Timmermann (1999), Huang (2000), Akdeniz et al. (2003), Guidolin & Timmermann (2008), Abdymomunov & Morley (2011), and Akdeniz et al. (2011) provide strong evidence of discrete variation in betas for developed markets, and report the superiority of non-linear asset pricing models over both unconditional and conditional CAPM.

On the other hand, the evidence of time-varying beta in the emerging markets remains ambiguous because of limited number of studies. Although there are numerous emprical papers that apply several conditional CAPM versions in emerging markets, none of them accounts for the non-linear relationship between risk and expected return. Only a limited number of empirical papers (e.g. Assoe, 1998; and Kenourgios & Samitas, 2009) investigate the emerging markets utilizing Markov-switching specifications or threshold regression frameworks, but just through tails of the market return distributions and market volatility regimes.

The investigations of time-varying betas in Turkey are also inadequate and most of these studies either suffer from unavailability of data or short sample periods. First of all, most of the empirical works simply concentrate on the evidence of time variation in betas, solely very little effort is made to model the attitude of time-varying betas. All the papers performing tests in the Borsa Istanbul Stock Exchange (BIST), notably Odabasi (2000, 2002, 2003a, 2003b), Aygoren & Saritas (2007), Oran & Soytas (2008), and Tuncel (2009) confirm that beta coefficients are not stable, but there is no consensus about effects of estimation period, return interval, and portfolio size. In addition, these studies consider shorter investigation periods than the period considered in this thesis, and examine limited number of stocks, ranging from 90 to 189, due to unavailability of data. Beside these investigations, Altınsoy et al. (2010) and Köseoglu & Gökbulut (2012) utilize continuous approximations to model time varying betas in the BIST, but their studies are limited to specific sectors only. As in other emerging markets, there is a lack of studies regarding non-linear relationship between risk and expected return.

The ambiguous results from the studies mentioned above, as well as the lack of studies assuming discrete changes in beta reveal a gap in the literature. There is a significant need for testing non-linearity in the time series relationship of asset returns with market returns in an emerging market setting. The Borsa Istanbul is a good candidate for analyzing the non-linear relationship since it reflects the basic characteristics of the emerging markets as discussed in Section 2. This thesis tries to fill the gap by investigating whether the threshold CAPM of Akdeniz et al. (2003) is successful in capturing time variation in beta of stocks trading in the BIST.

The main hypothesis of this thesis is that the threshold CAPM should be able to capture slowly changing nature of beta in the BIST. To verify this point, I examine the superiority of the threshold CAPM over the unconditional CAPM and the three-factor model of Fama & French (1993). As a secondary research question, I investigate the existence of time variation in beta due to the threshold variable. In addition, it is also investigated that, whether dynamics of time variation of beta differ across industries, market capitalizations or book-to-market ratios.

This study benefits from the methodology of Akdeniz et al. (2003). Similar to their empirical work, four economic variables are selected as candidates for the threshold variable. These are risk-free interest rate, rate of change in the currency basket level, rate of change in the real effective currency index, and historical volatility of the market index. There are several reasons why it is assumed that asset betas should change with respect any of these variables. As in Akdeniz et al. (2003); I use interest rate as candidate, but I do not consider detrended stock price level, dividend yield of the market index, measure of the slope of the term structure and quality related yield spread in the corporate bond market as candidates since it is not possible to obtain a reliable data for these variables in the early years of the sample period. Moreover, these candidates are not found to be significant underlying variables of time variation by Akdeniz et al. (2003). In order to investigate whether currency risk is relevant in explaining returns in an emerging market, rate of change in the currency basket level and rate of change in the real effective currency index are considered as candidate variables. Finally, volatility is selected as a candidate by following Akdeniz et al. (2011).

This study considers a sample of 150 to 227 stocks trading in the BIST between January 1998 and December 2011. First, it examines the existence of time-variation in market risk due to each candidate variable by utilizing series for candidate variables and excess returns on several assets which are thirteen portfolios sorted with respect to industries, ten portfolios formed with respect to market capitalizations, ten portfolios with respect to book-to-market ratios, and further twenty-five portfolios sorted with respect to both market capitalizations and book-to-market ratios. The modified sup-LM test suggested by Hansen (1996) reports significant time variation due to the rate of changes in currency basket level. None of the other candidates of threshold variables signals regime shifts as significant as rate of changes in the currency basket level. Therefore, investors update betas depending on the currency risk. Next, beta coefficients are estimated to test whether portfolios exhibit different beta sensitivities with respect to their industry, market capitalization or book-to-market ratio, and evidence for size and book-to-market effects are reported. To test the power of the threshold CAPM, in sample root mean squared pricing errors of the threshold CAPM are compared with those of the unconditional CAPM and three-factor model. The root-mean squared pricing errors for the threshold CAPM are better than those of the static CAPM for all portfolios, but not always better than those of the three-factor model.

In order to check robustness of the results, different measures for the currency risk are introduced as candidates for the threshold variable, and results of the sup-LM test indicate that none of these signals a regime shift statistically stronger than the currency basket. The robustness tests also include subperiod examinations since the literature includes a large number studies that apply empirical tests on the CAPM by splitting their study periods into several subperiods to allow for breaks in beta; but threshold CAPM yields lower pricing errors than the unconditional CAPM even two or four sub-periods are considered.

The remainder of the thesis is organized as follows: Chapter 2 describes the Borsa Istanbul and provides information about the financial crises experienced in Turkey during the sample period utilized in this study. Chapter 3 reviews the literature on asset pricing with an emphasis on the time-varying betas. Chapter 4 presents the research methodology and data used in the study. Chapter 5 reports the empirical results from both sup-LM test and time-series regressions. Finally, Chapter 6 presents the concluding remarks.

CHAPTER II

A REVIEW ON THE BORSA ISTANBUL STOCK EXCHANGE

2.1 The Borsa Istanbul Stock Exchange

The Borsa Istanbul (BIST) is the main organized securities exchange in Turkey offering opportunity to invest in various products in an organized, transparent and reliable trading floor to local and international investors. It was established as an incorporated company on April 3, 2013, and commenced to operate on April 5, 2013. It combines the former Istanbul Stock Exchange (ISE), the Istanbul Gold Exchange, and the Derivatives Exchange of Turkey (TURKDEX) under one umbrella.

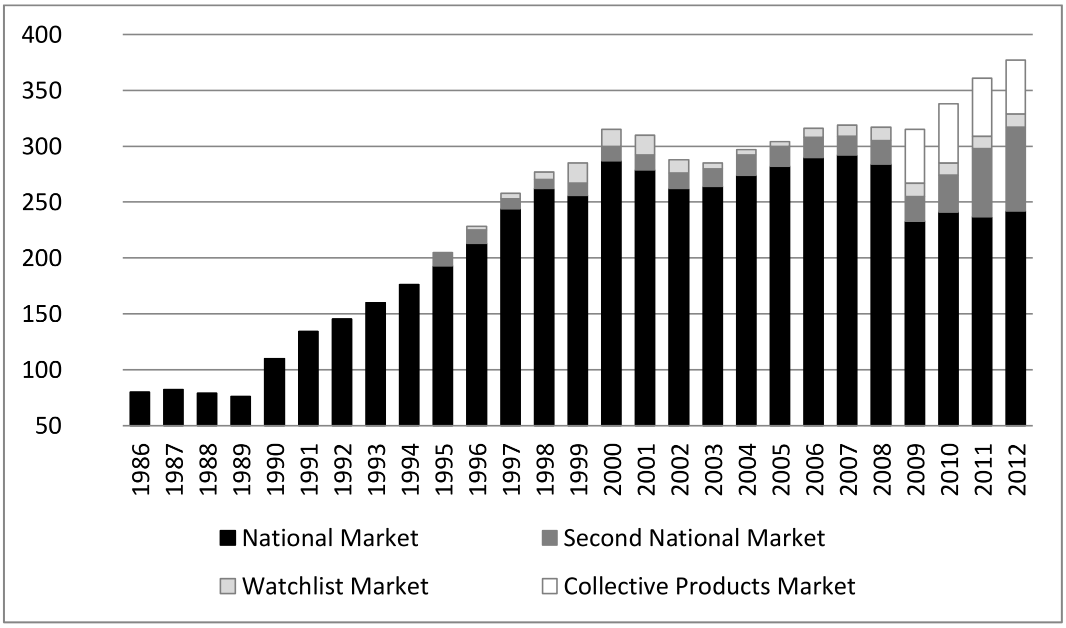
All of the equities market, emerging companies market, debt securities market and foreign securities market instruments are traded electronically. The equity market securities include equity and rights coupons of companies, exchange traded funds and warrants. The secondary market transactions of fixed income securities such as treasury bills, government bonds, corporate bonds and repos are conducted in the debt securities market. The foreign debt securities which have been issued by

Turkish Treasury (Eurobonds) are traded in the foreign securities market. The emerging companies market gives the opportunity to companies with growth and development potential to be traded.

The negative outlook of the global economy in 2011 exposed itself in BIST as well, but the effect of the negative outlook remained impotent on its trade volume. The BIST was the top 20th among the members of the World Federation of Exchange (WFE) in terms of its equities market trade volume of around 423 billion US dollars in 2011. The BIST ranked 32th in terms of total market capitalization with 201 billion US dollars, and 34th in number of companies traded in 2011. On the other hand, the BIST was the top 7th among WFE- member emerging markets in terms of its trade volume, 15th in terms of market capitalization and 16th in terms of number of companies traded in 2011. There were 361 companies traded on BIST in 2011. With new listings, the number of companies traded on BIST has reached to 377 as of January 2012. There are 242 companies on the national market, 48 on the collective products market, 75 on the second national market and 12 on the watch list companies market.

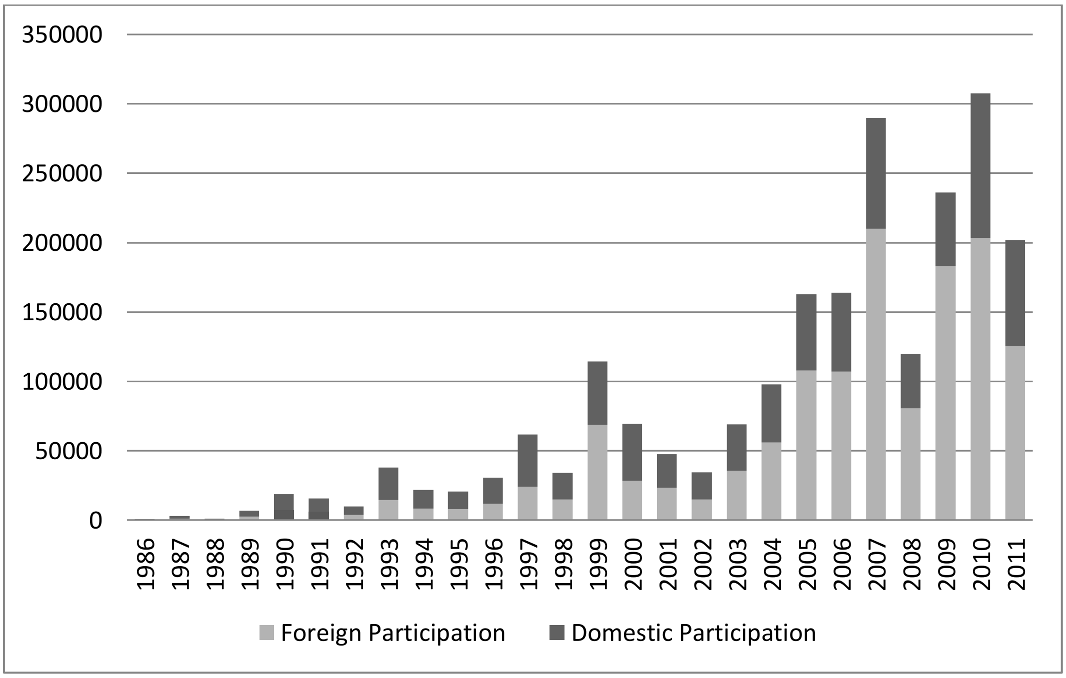
The Borsa Istanbul was recognized as a Designated Offshore Securities Market by the US Securities and Exchange Commission (SEC) in 1993. Since then there has been growing interest by both the foreign and domestic investors in the BIST. Since the Turkish government gives great importance to the promotion of the Turkish capital markets to the institutional and individual foreign investors, there is strong foreign participation in the BIST. The share of foreign participation in total market capitalization was 62.1% in 2011. On the other hand, the share of foreign participation in total trade volume was around 30% in the same year.

Figure 1: Number of Companies in the BIST



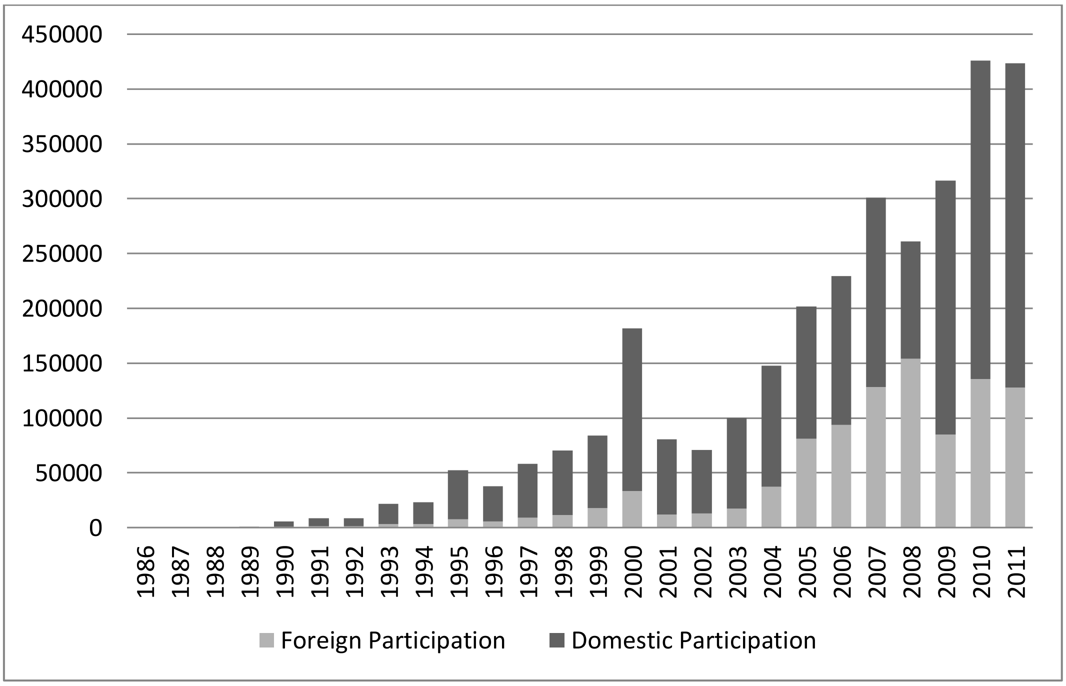
Source: Equities Market Database of the BIST

Figure 2: Total Market Capitalization (million USD)



Source: Equities Market Database of the BIST

Figure 3: Total Trade Volume (million USD)



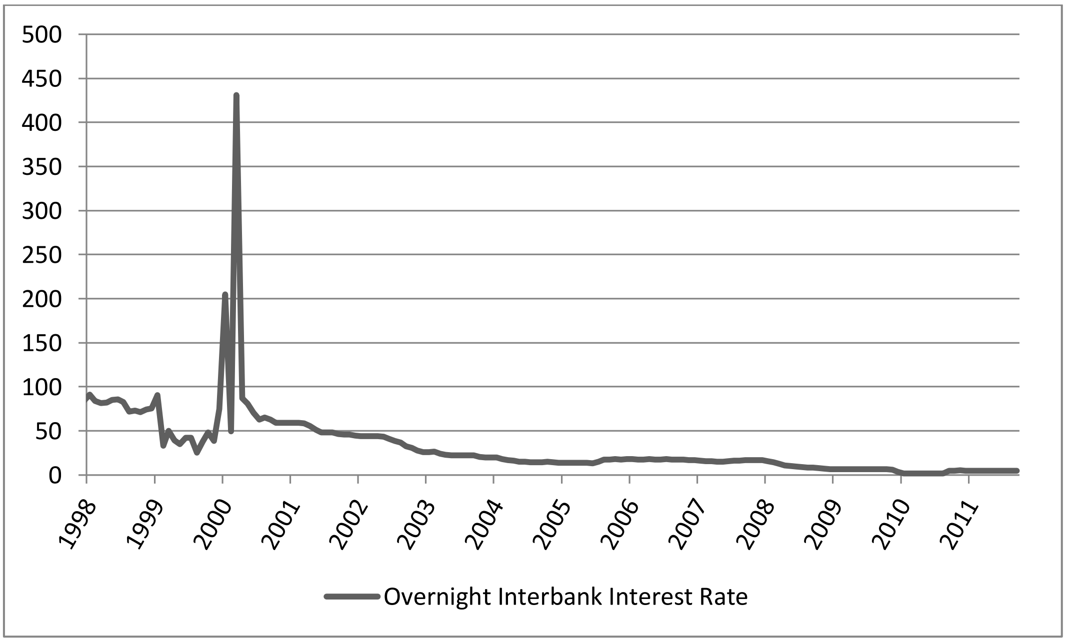
Source: Equities Market Database of the BIST

2.2 Financial Crises in Turkey

Turkey has suffered from three financial crises during the examination period between 1998 and 2011. The first two crises, the one in November 2000 and the other one in February 2001, were mainly resulted from the poor economic and financial structure of Turkey. On the other hand, the third crisis which affected Turkey during 2007-2008 was a global crisis originated in the US.

Prior to 2000s, the economic and financial system in Turkey was unstable and fragile. The annual inflation level was above 60% and there was a large budget deficit in the country. The annual GDP growth rate was experiencing a boom-and-bust episode fluctuating among positive and negative levels. Due to these poor performing indicators, the government introduced an economic stabilization program with the support of the International Monetary Fund (IMF) in December 1999. The program was relied on a crawling peg exchange-rate based disinflation system aimed to decrease the inflation rate to single figures at the end of 2002. Foreign financial capital inflows were the primary resource for maintaining the liquidity needs under the program (Yeldan, 2002). At first the program seemed to be prospering due to decline in inflation and real inflation rates relative to 1999, but a severe liquidity shortage occurred in November 2000 with a sharp increase in exchange rates. During the last week of November 2000, an outflow of $5.3 billion occurred and overnight interbank interest rates reached to 210% (Boratav, 2001).

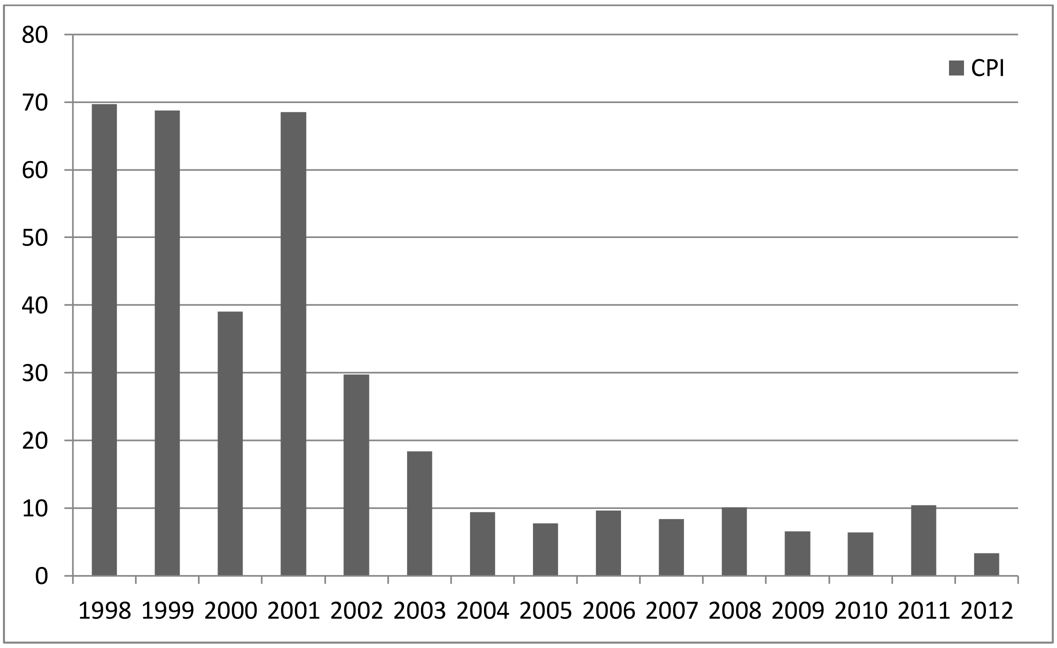
Figure 4: Overnight Interbank Interest Rate Levels



Source : Global Financial Data

Right after the November 2000 crisis, a severe wave of capital outflows was once again occurred. On February 19th alone, an outflow of $5 billion was led by foreign investors. The overnight interest rate reached to several hundreds percent and the stock market fell by 18% within a day. The US dollar reserves of the central bank dropped below $20 billion while defending the exchange rate of Turkish Lira (Dufour & Orhangazi, 2009). Immediately after the announcement that the disinflation program had been left, the value of Turkish Lira depreciated by almost 35% against US dollar. At the end of 2001 the inflation rate was increased above 60% again and the annual GDP growth rate was -6.95%.

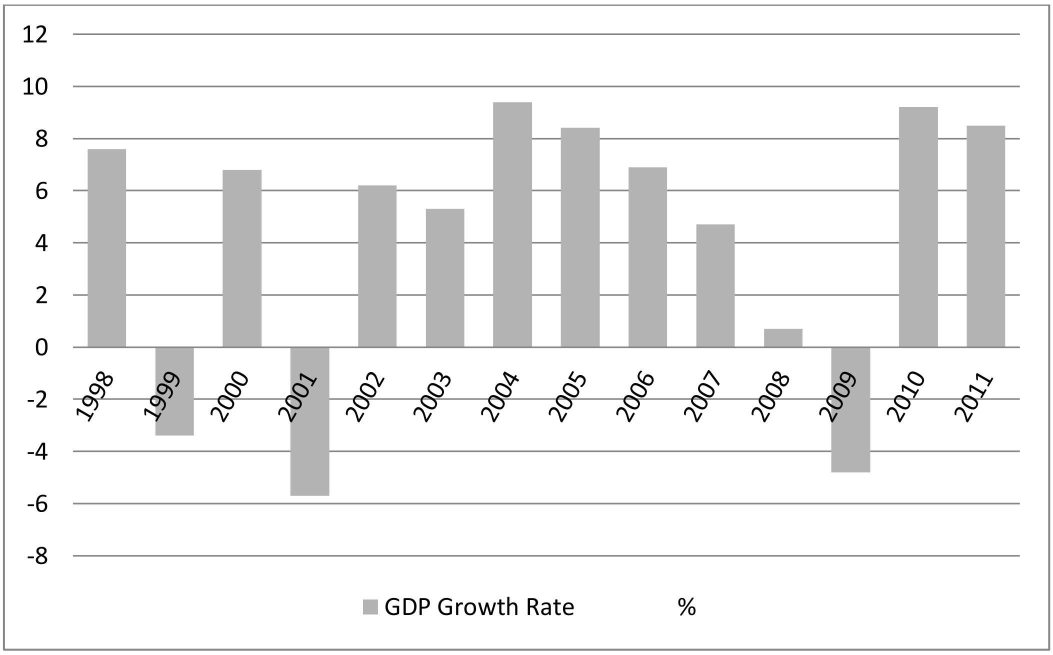
Figure 5: Year-end Inflation Rates in Turkey



Source: Central Bank of Republic of Turkey

Since both crises are stemmed from the own fragile financial system in Turkey, there was a chance to find foreign assistance to put the economy back on its track. During the crises period between 1999 and 2002, the IMF was involved in the macro management of the economy and provided financial assistance of about $20 billion (Yeldan, 2004). However, the one experienced in 2007/2008 was a global financial crisis characterized in the mortgage market of the US and it has affected Turkey as in almost all countries. Also known as the mortgage crisis, it has been considered as the most destructive crisis for the world since 1929 Great Depression. The factors that triggered the crisis reached back to the early 2000s. Throughout the 2000s, a large increase was observed in real estate prices in the US due to the increasing demand for it. The reasons for the increasing demand were low interest rates and easily obtainable mortgage loans. That situation created an air of excessive optimism for the future of financial markets in the US and banks provided sub-prime mortgages for borrowers with lower credit ratings. Unfortunately when the real estate prices fell short of estimates, the borrowers of the sub-prime mortgages were unable to repay their loans. The collapse in the sub-prime mortgage market affected the high leveraged financial system in the US since these mortgages were wrapped into financial products that were sold to the investment banks and commercial banks. The banks holding many risky mortgagees bankrupted one after the other in 2008. In order to avoid defaults, the US Congress has approved a rescue package. The mortgage crisis has affected Turkey as well as the European countries. After the crisis the foreign fund inflows sharply declined in Turkey as a result of the credit crunch. The decline has been reflected in the real sector and the productivity, the capacity utilization and unemployment rates were decreased. The inflation rate rose to double digits and the GDP growth rate fell to 0.7% in 2008 and -4.8% in 2009. Consequently, the BIST-100 index level fell from its peak closing level 57615 in 2007 to 20923 in 2009.

Figure 6: The GDP Growth Rate (%)



Source: Turkish Statistical Institute

Figure 7: BIST-100 Index Levels

Source: Equities Market Database of the BIST

CHAPTER III

LITERATURE REVIEW

3.1 The CAPM

The Capital Asset Pricing Model (CAPM) of Sharpe (1964), Lintner (1965) and Black (1972) has been considered as the milestone of theoretical and empirical finance. The attractiveness of the CAPM comes from its powerful and pleasing predictions about how to measure risk and relation between expected return and risk (Fama & French, 2004). The CAPM measures the sensitivity of an assets' return against the market return by the beta of returns, and posits a stable linear relationship between beta and expected return. It also implies that beta is the only explanatory variable for the prediction of excess returns.

The model developed by Sharpe (1964) and Lintner (1965), known as Sharpe-Lintner model, is an extension of the mean-variance portfolio choice model of Markowitz (1959). In Markowitz's model, the portfolio selection is reduced to balancing the mean and the variance of the portfolio return. The model assumes all investors are risk averse and one period utility maximizers. Investors choose portfolios that minimize the variance of portfolio return, given expected return, and maximize expected return given variance of portfolio return. Such portfolios are called mean-variance efficient.

The Sharpe-Lintner model uses the characteristics of mean-variance model to derive a linear relation between an asset's systematic risk and expected return. In order to accomplish this relation following assumptions are made on investors and market conditions: (a) investors are risk-averse individuals who maximize their expected end-of-period utility of wealth, (b) investors are price takers and form the same belief on securities' expected returns that have a joint normal distribution, (c) there is a common risk free asset such that all investors are able to borrow or lend at a risk free rate, which does not depend on the proportion borrowed or lent, (d) there are fixed number of assets, and all assets are marketable and perfectly divisible, (e) asset markets are frictionless, and information is costless and simultaneously available to all investors, (f) there are no market imperfections such as taxes, regulations, or restrictions on shortsales. Under these assumptions the Sharpe-Lintner model reports that one period expected return of any security will satisfy:

$$E(R_i) = R_f + \beta_i \left[E\left(R_M\right) - R_f \right],$$

$$\beta_i = \frac{\operatorname{cov}\left(R_i, R_M\right)}{\sigma^2\left(R_M\right)}.$$

where $E(R_i)$ is the expected return on asset i, R_f is risk free rate, $E(R_M)$ is market return and the parameter β_i represents the market sensitivity of asset i. The second term on the right-hand side of equation (1) is defined as risk premium, which is the expected return of the asset i in excess of the risk-free rate of return and calculated by multiplying the beta of asset i by premium of market.

However, Black (1972) argues that the assumption that risk-free borrowing and lending does not hold for many investors and develops a version of the CAPM without risk-free borrowing and lending. In Black's version of the CAPM, the assumption of unrestricted short selling of risky assets is introduced and a zero beta portfolio is used as a proxy for the risk-free asset, therefore it is referred as the Zero-Beta CAPM.

The central argument of the CAPM is the presence of the simple linear relation between expected return and systematic risk of an asset. Its simplicity makes it the most widely used model in asset pricing. However, the validity of the model has always been criticized because of its restrictive and rigid assumptions.

3.2 Early Empirical Tests

Tests of the CAPM are based on three implications of the relation between expected return and the beta: (a) expected returns on all assets are linearly related to their betas, and there is no other explanatory variable, (b) expected return on the market portfolio is higher than the expected return on the zero beta portfolio, (c) expected return on zero beta portfolio is the risk-free rate of return in Sharpe-Lintner model. The early empirical tests of these three predictions use either cross-sectional or time series regressions.

The central prediction of the Sharpe-Lintner model that existence of linear relation between expected return and beta is targeted in the early cross-sectional regression tests that apply the methodology for cross-section of average asset returns on betas that are estimated by time series regressions. In these regressions, the intercept is the risk-free rate and the coefficient of beta is the market premium. The first tests on individual assets, such as Lintner (1965b) and Douglas (1969), have found that the intercept is greater than the risk-free rate, the coefficient of beta has a lower value than the market premium, and the nonsystematic risk has effect on asset returns. The first regression tests seem to be a contradiction to the Sharpe-Lintner model, but each includes various statistical problems: there exist measurement errors in estimates of asset betas, and regression residuals have positive correlation that generates downward bias.

The statistical weakness of the early regression tests have directed researchers to work with portfolios instead of individual assets. Using diversified portfolios in regression tests provides more precise estimates of beta and less measurement errors in variables. The standard technique used in regression tests to form portfolios is that assets are initially sorted on beta; the first portfolio is formed from assets with the lowest betas, and so on, up to the last one containing assets with highest betas.

As Jensen (1968) has pointed out that the linear relation between a portfolio's expected return and beta also indicates time-series regressions, Blume (1970), Friend & Blume (1970), Black et al. (1972) and Stambauh (1982) have worked with portfolios to test the CAPM using time-series regressions and have all verified a significant linear relation between average returns and betas. Jensen (1968) extends the Sharpe-Lintner model into a multi-period model in which investors are allowed to have heterogeneous horizon periods. Since Sharpe-Lintner model predicts that risk premium of an asset is explained only by its beta times the premium on the market, the intercept term in time-series regressions, called Jensen's alpha, must be zero for each asset. The result of the Jensen's empirical test shows that the relation between average return and beta is positive but too flat, hence it fails to verify the validity of the CAPM. Black, Jensen & Scholes (1972) perform time-series regressions on portfolios and deduce that the intercept term, Jensen's alpha, is different from zero and time varying. Fama & MacBeth (1973) propose a new methodology to overcome statistical problems caused in the time series tests. They use a three-step approach which is considered as one of the standards in the literature. The tests do not provide a significant statistical evidence to reject the hypothesis that the relation between expected return and beta is linear. In contrast to Lintner (1965), their results also support that residual risk does not affect the expected return. Furthermore, the results indicate that there is a positive tradeoff between average return and beta on average. However, they show that the intercept is higher than the risk-free rate that is proxied by 1-month T-bill rate.

The early empirical analysis reject the validity of the Sharpe-Lintner model, since the intercept of regressions is found to be greater than the average risk-free rate, and the coefficient on beta is less than the market premium. Nevertheless, Roll (1977) propounds that these early empirical tests cannot be considered as evidence for the validity of the CAPM, and rejects its empirical testability. In the paper, known as Roll's critique, he demonstrates that it is not possible to accomplish a correct and unambiguous test of the CAPM since market portfolio is not observable. The model defines the market portfolio as the portfolio of all assets in the economy that should include all risky assets such as marketable and nonmarketable, commodities, human capital as well as stocks and bonds. Roll's critique states that an empirical test performed by using any portfolio instead of true market portfolio is the test of whether chosen proxy is efficient or not.

Stambaugh (1982) finds the Roll's critique exaggerated and claims that empirical tests of the CAPM are not sensitive to the proxy for the real market portfolio. He forms a market portfolio composed of durable goods, real estates, corporate and governmental bonds as well as stocks listed on NYSE. He performs Lagrange multiplier test and results support the validity of the Zero-Beta CAPM, but rejects the validity of Sharpe-Lintner model. The Zero-Beta CAPM is also supported by Gibbons (1982).

3.3 Recent Empirical Studies

The success of the Zero-Beta CAPM in early tests created a consensus that the CAPM was superior at describing expected returns. However, starting in late 1970s, a large number of studies have been identified several variables other than beta that were found to have relations with expected returns. These variables, which are called anomalies, include earnings-to-price ratio (E/P), size (ME), book-to-market ratio (BE/ME) and leverage.

Basu (1977) and Ball (1978) first documents the evidence that E/P has explanatory power on variation of expected returns, where expected returns increase with increasing E/P. In his seminal paper, Banz (1981) introduces the size effect as an additional factor besides beta, where stocks with lower market capitalizations have higher returns than those predicted by the CAPM. Statman (1980) and Rosenberg et al. (1985) discover the BE/ME effect: higher the ratio of a firms' book value over market value, higher average returns that are not captured by beta. Finally, the leverage effect is documented by Bhandari (1988) where leverage is positively related to expected returns.

Recent studies have found weak or no statistical evidence in support of the simple linear relationship between market risk and asset returns, thus two strands of research have come into stage to find alternative explanations for the risk and return trade off. The one strand of research explores for additional risk factors in the cross-section of expected returns to overcome the failure of the CAPM. The other strand of research argue that beta and market risk premium vary over time.

Several empirical works have investigated a number of macroeconomic and firm-specific variables as candidates in explaining cross-section of returns, but only the seminal work on cross-section of returns, Fama & French (1992), and the three-factor model of Fama & French (1993), which explains most of the anomalies, will be introduced in here since this side of the literature is beyond the scope of this thesis.

This thesis also replicates the Fama & French portfolio design to form the size-BE/ME portfolios that will be used in testing in order to see interaction between effects of size and BE/ME effects on the relationship between risk and return. In addition, the pricing errors of the three-factor model are compared with those of the threshold CAPM.

Fama & French (1992) investigate the evidence on the empirical failures of the CAPM for the US market over the period between 1963 and 1990. They examine the cross-sectional relations between the average returns and the four factors (size, E/P, leverage and BE/ME) together with the beta in order to update the evidence on the empirical failures of the CAPM. They create portfolios formed on beta, size, E/P, leverage and BE/ME to observe effects of different factors separately, and they also construct two-pass portfolios to investigate interaction between size and BE/ME effects. Fama & MacBeth (1973) methodology is used to perform cross-sectional regressions, and regression results indicate that the CAPM is not correctly specified and there is no significant relation between average returns and beta. Their findings also confirm that size, BE/ME, E/P and leverage add to the explanation of expected stock returns, but the size and BE/ME effects have strong explanatory power on returns absorbing leverage and E/P effects.

Fama & French (1993) propose a three-factor model with excess market return, SMB (small minus big), and HML (high minus low) as factors to explain expected returns. The SMB, the difference between the returns on diversified portfolios of small and big stocks, and HML, the difference between the return on diversified portfolios of high and low B/M stocks, are mimicking factors which are proxies for size and BE/ME effects respectively. They use the time-series regression method of Black, Jensen & Scholes (1972) to examine twenty five portfolios formed on size and BE/ME ratio. The R^2 values are utilized to investigate the explanatory power of models constructed with market return alone, SMB and HML together, all three factors together, and addition of bond factors. Jensen's alpha values are also observed for cross-sectional effects of the factors. According to the findings, the three-factor model is satisfactory in explaining the cross-section of returns.

3.4 Time Variation in Betas

The CAPM, which posits a linear and stable relationship between an asset's return and systematic risk, assumes that all investors have the same expectations of means, variances and covariances of future returns; therefore beta and market risk premium are assumed to be constant over time. The early time-series tests of the CAPM such as Friend & Blume (1970), Black et al. (1972), and Stambaugh (1982); and cross-sectional tests such as Fama & MacBeth (1973) assume stationary betas over a fixed period. However, one of the explanations for the failure of the main argument of the CAPM is the same assumption. Many papers including Bollerslev et al. (1988), Ferson (1989), Ferson & Harvey (1991, 1993, 1999), Ferson & Korajczyk (1995) and Jaganathan & Wang (1996) argue that beta and market risk are time varying. In addition to the evidence of time variation, Ferson & Harvey (1991) and Chen (1991) also indicate that time variation in assets' betas are associated with economic variables.

A considerable amount of attention has been paid to the instability of beta coefficients. Blume (1971), in a pioneering effort, find the evidence of beta variation in US markets. Black et al. (1972) and Fama & Macbeth (1973) also notify on the time variation in beta. Fabozzi and Francis (1978) suggest that many stocks' beta coefficients move randomly through time rather than remain stable using ordinary Least Squares (OLS) to estimate betas for 700 stocks traded in NYSE during the period 1965-1971, and tests the significance of the variance of the difference in the beta estimates and the mean beta coefficient which is estimated by the restricted Generalized Least Squares (GLS). According to the results, betas of 103 out of 700 stocks are statistically random. For a larger sample period, between 1926 and 1975, Sunder (1980) finds that 88% of the stocks traded in NYSE have instable betas. Bos & Newbold (1984) investigate the period from 1970 to 1979 and find that 58% of stocks have time-varying betas. Collins, Ledolter & Rayburn (1987) analyze various subperiods between 1962 and 1981 on weekly data; and find 34% of stocks have time varying beta for five-year subperiods and 65% of stocks for ten-year subperiods. The evidence is also confirmed for both stocks and bonds in many papers such as Rayner (1986), Ferson (1985, 1989), Fama & Frech (1989) and Harvey (1989).

As reported by Bollerslev et al. (1988), the evidence implies that investors' expectations of the moments of future returns are conditional on the information at a specific time. Therefore, the conditional version of the CAPM implies:

$$E\left(r_{it} \middle| Z_{t-1}\right) = \beta_{it}\left[E\left(r_{mt} \middle| Z_{t-1}\right)\right],$$

where r_{it} is excess return on asset i at time t, R_{mt} is excess return on the market portfolio, Z_{t-1} represents the observed set of information on the true information set, and β_{it} captures the time variation in beta which is defined as:

$$\beta_{it} = \frac{\operatorname{cov}\left(r_{it}, r_{mt} \middle| Z_{t-1}\right)}{\operatorname{var}\left(r_{mt} \middle| r_{t-1}\right)}.$$

In order to formulate a test of the conditional CAPM, several papers involving Gibbons & Ferson (1985), Rayner (1986), and Bollerslev et al. (1988) assume the market price of risk to be constant since covariance between the true conditional means are unobservable. On the other hand, Harvey (1989) argues that assuming a constant ratio of conditionally expected return on the market portfolio divided by the conditional variance of the market is inappropriate.

Regarding on shortcomings of the conditional CAPM, several techniques have appeared in the recent literature to estimate time variation in beta. These techniques can be distinguished into two conceptual approaches: (i) time-series models providing estimates of beta series through time which allow examining the time-varying betas, and (ii) econometric models using instrumental variables to proxy time-variation in beta.

3.4.1 Time – Series Approaches

Many different time-series methods have introduced to estimate time-variation in betas. One of the major methods is the autoregressive conditional heteroscedasticity (ARCH) based approaches. Engle et al. (1987) propose the autoregressive conditional heteroscedasticity in the mean model (ARCH-M) by extending Engle's (1982) ARCH model to allow the conditional variance to affect the expected return on a portfolio.[1] The ARCH-M model is proposed to examine the time varying term premia in the term structure of interest rates. However, a disadvantage of the model to examine portfolio betas is that ARCH process is not aggregate, as a result a portfolio of assets does not necessarily follow the ARCH process even the assets individually follow a particular ARCH process.

Bollerslev (1986) specifies a generalization of Engle's ARCH model, which is referred as GARCH model. The GARCH model assumes that conditional variance is a function of past errors and past variances. Various GARCH based approaches in modeling time-varying betas have been applied in many conditional beta studies including Harvey (1989), Ng (1991), Bodurtha & Mark (1991), Braun et al. (1995) and Giannopoulus (1995). For instance, Ng (1991) uses a multivariate GARCH

[1] See Engle, Lilien & Robins (1987) for a detailed description of ARCH-M model.

(MGARCH) approach to assess the conditional CAPM with the estimates performed by maximum likelihood estimation. On the other hand, Harvey (1989) and Bodurtha & Mark (1991) perform method of generalized moments (GMM) as the estimation technique on ARCH-M model. Braun, Nelson & Sunier (1995) investigate the conditional covariances of a set of size and industry portfolios using bivariate exponential ARCH (EGARCH) models. Furthermore, Giannopoulos (1995) assumes that time varying covariance follows a bivariate GARCH-M model.[2]

As a major alternative to GARCH based models to estimate conditional beta, Schwert & Seguin (1990) propose and estimate a single factor model of heteroskedasticity for portfolio returns which implies time-varying betas. It is assumed that stocks respond differently to variations of the market volatility according to their size. In the study, only excess returns of size ranked portfolios are tested over the sample period from 1927 to 1986. Portfolio volatilities predicted by this model is similar to those predicted by GARCH procedures. Their findings also suggest that while testing the conditional CAPM, failure to account for predictable heteroskedasticity may lead to the misleading results that conditional distribution of returns on assets is much more fat-tailed than a normal distribution. The Schwert & Seguin approach is wildly used in time-varying beta tests, especially to compare its performance with alternative approaches such as GARCH and Kalman filter.

The Kalman filter approach, developed by Kalman (1960) within the framework of state-space model, is an algorithm proposed to predict variances for time series applications. Instead of calculating conditional variances first, the Kalman-filter

[2] There are also many other GARCH approaches which are used in testing the conditional CAPM. Bollerslev (2008) provides an encyclopedic reference glossary to a long list of ARCH (GARCH) models.

method estimates directly time-varying betas with a conditional market model, referred as the measurement equation. The next step, which is called the transition equation, is to describe the stochastic process followed by beta according to its lags and innovations. As a result two series of beta estimates, first one is filtered and second one is smoothed, are gathered. The method provides two benefits: (i) the calculation is recursive, and (ii) it converges quickly regardless of the underlying model.

Since several models exist in the literature to estimate time-varying betas, their performances are compared in many studies to find which one is superior to others. Faff et al. (2000) investigate the performance of three major approaches to modeling time variation in conditional betas: GARCH models, Schwert and Sequin (1990) model and the Kalman filter model. The performed analyses on UK stocks suggest that the Kalman filter is more powerful than remaining models in modeling time variation in conditional betas. With a similar comparison performed on Australian stocks, Brooks et al. (1998) find Kalman filter superior to others. However, Brooks et al. (2002) indicate that GARCH-based estimates of risk generate the lowest forecast error for Morgan Stanley country index data. In addition to these studies, Faff (2002), Hillier (2002), Marti (2006) suggest that the Kalman filter is more efficient in forecasting when compared to other models.

3.4.2 Econometric Approaches

Although GARCH, Schwert & Sequin and Kalman filter approaches have the ability to estimate the time variation in conditional betas, none of them accounts for the potential drivers of time-varying betas. There are several papers in asset pricing literature that explore a set of economic variables as systematic influences on asset returns; Lucas (1978), Cox et al. (1985) and Chen et al. (1985) model the relation between expected returns and characteristics of the economy. Following their findings, several researchers including Harvey (1989), Ferson & Harvey (1991), and Chen (1991) show that time variation in betas occur as a result of changes in the economic variables with using these variables to proxy time-variation in the CAPM betas and market risk premium.

Harvey (1989) follows the instrumental variables approach of Campbell (1987), in which Campbell has found that uncertainty in nominal interest rates is important in time-variation, to test the CAPM and a multifactor asset pricing model that allow for time varying expected returns and conditional covariances. The paper approximates the conditional covariances by the product of the innovations from projections of the asset returns and factors onto the information set which includes the first lag of the excess return on market index, the junk bond premium, the dividend yield of market index, the spread between long-term and short-term government bonds, and a dummy variable for January. The results of the paper indicate that conditional covariances are time-varying.

Following Chen et al. (1986), Chen (1991) presents evidence to the ability of economic variables to forecast the market premiums by using industrial production, term structure, 1-month T-bill rate, spread between low and high grade bonds, and dividend yield as state variables which are indeed related to the changes in the macroeconomic conditions. In addition, Ferson & Harvey (1991) use a cross sectional regression approach to assess the time varying beta on ten size and twelve industry portfolios over the period between 1959 to 1986, and indicate that variation is associated with the sensitivity to economic variables which can be listed as excess market returns, interest rates, expected and unexpected inflation, the spread between high and low grade bonds, and the slope of the term structure. They also use lagged excess market returns, lagged bond spread, lagged slope of term structure, the dividend yield of market index and nominal T-bill rate as information variables to define the information set.

On the other hand, Ferson & Korajczyk (1995) argues that Ferson & Harvey (1991) do not study the ability of cross-sectional approach to capture variation in long horizons. The authors also note that empirical estimates of the CAPM depend on the investment horizon, and they provide tests of beta pricing models for conditional expected returns using investment horizons 1 month to 2 years. As suggested by the previous studies, the information set consists of six variables which are 1-month T-bill rate, the dividend yield of the market index, a detrended stock index price level, the slope of the term structure, a quality-related yield spread in bond market, and a dummy variable for January. In order to avoid multistep procedure used by Ferson & Harvey (1991), the GMM is used to estimate the fraction of predictability in returns. In addition, the data is extended to the period from 1926 to 1989. Tests are performed on ten size and twelve industry portfolios, and the findings indicate that models with constant betas and one to five factors[3] do not explain the predictability.

In contrast to the previous studies, Jagannathan & Wang (1996) restrict their attention to a small number of variables to predict economic conditions. Following

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[3] The economic risk factors is similar to Chen et al. (1986). These factors can be listed as: (i) SP500 Stock Index returns, (ii) real interest rate, (iii) unexpected inflation, (iv) corporate default factor which is the spread between low and high grade bonds, and (v) term structure risk factor.

the general agreement that stock prices vary over the business cycle, they argue that the market risk premium can be forecasted by the variables that help to predict the business cycle. They use the yield spread between BAA- and AAA-rated bonds as a proxy for market risk premium, value-weighted stock index portfolio as a proxy for wealth portfolio, and growth rate in per capita labor income as a proxy for the return on human capital. The models for the moments are estimated by GMM, and test the conditional CAPM with and without human capital. The results of the tests indicate that their conditional CAPM specification with proxies for market risk premium and aggregate wealth portfolio is strong, and including the proxy for return on human capital makes better. Jaganathan and Wang also find that the conditional version of the CAPM explains the cross-section of returns as well.

However, Harvey (2001) shows that results of the econometric studies can be highly sensitive to the choice of economic variables. In addition, Lewellen & Nagel (2006) argue the difficulty in knowing the right state variables, and also provide that the variation in betas and market risk premium have to be preposterously large to explain asset-pricing anomalies.

3.4.3 Discrete Time Variation in Betas

There is now considerable evidence that suggest that estimated betas of unconditional CAPM display time variation. Many of the previous studies either use time-series approaches to estimate time variation in betas, or use economic variables to proxy time variation in betas and market risk premium. These studies model the time variation in betas using continuous approximation and the theoretical framework of the conditional CAPM, but Ghysels (1998) indicates that continuous approximation fails to capture the dynamics of the beta risk due to the structural breaks in parameter estimates. The author argues that the proposed conditional CAPMs overestimate the actual time variation in betas; as a result they produce highly volatile variation in beta which yields large pricing errors. He also finds that constant beta models in many cases still yield better predictions, and suggests the use of unconditional models in pricing since none of the conditional models estimate time variation in betas correctly.[4]

As stated by Akdeniz et al. (2003), empirically documented large pricing errors could be resulted from linear approximations. Past findings on the conditional CAPM has prompted researchers to investigate alternative approaches to model time variation in beta, many of which have assumed that betas change discretely over time to capture slowly changing nature of market risk. This assumption yields a nonlinear relationship between assets' returns and market returns in which betas change discretely between different regimes. To model this intuitive nonlinear relationship, two major approaches have emerged in the literature: (i) discrete Markov-switching specifications which allow coefficients to vary between states generated by a Markov process, and (ii) threshold regression frameworks which use an observed variable to split sample into groups.

The literature has witnessed a substantial increase in the number of studies that have applied Markov switching methods to model nonstationary time series after the contributions of Hamilton (1989), Schwert (1989), and Turner et al. (1989). A discrete Markov switching model, also known as the regime-switching model, uses

[4] Ghysels (1998) performs tests on several conditional CAPM and conditional APT models using the same data with Ferson & Korajczyk (1995).

multiple states to represent different patterns in time series, but most of the studies prefer to estimate time variation in betas using only two states. In a simple two-state Markov switching method, the structure is modeled with a state variable that allows to structure to vary according to states. The common assumption at this point is that the state transition probabilities follow a first order Markov chain. In addition, the standard specification of the model uses constant probabilities, but several studies such as Durland & McCurdy (1994), and Gray (1996) argue to let the probability of staying in a state depend on the duration of the state or some other conditioning information. In the literature, the Markov switching model is commonly used to jointly model conditional CAPM with monthly stock return volatility (low-volatility and high-volatility states) as well as interest rates, default premium, dividend yield and illiquidity by several studies; e.g. Perez-Quiros & Timmermann (1999), Huang (2000), Guidolin & Timmermann (2008), and Abdymomunov & Morley (2011).

Another major way to allow important non-linearity in time-varying betas is using threshold regression frameworks which have emerged as special cases of switching models. The threshold autoregressive (TAR) model developed by Howell Tong has been enormously influential in time-series, and as a result there has been a substantial number of papers suggesting a threshold regression framework such as Cao & Tsay (1992), Rabemananjara & Zakoian (1993), Li & Li (1996), Domian & Louton (1997), and Hansen (2000).

To describe slowly changing betas, Akdeniz et al. (2003) benefit from Hansen's (2000) threshold estimation framework and propose a two-regime homoscedastic threshold nonlinear model called the threshold CAPM. Utilizing an 0-1 indicator function, the market risk is modeled as a function of an underlying economic variable which is called threshold variable in order to procure beta to change among two different beta regimes when the threshold variable reaches a certain threshold level.

Akdeniz et al. (2003) use the same data used in Ferson & Korajczk (1995) covering monthly returns of twelve industry portfolios of NYSE firms over the period between January 1972 and January 1988. The authors first utilize Hansen (1996)'s sup-LM test to find a significant evidence of non-linearity in the relationship between market returns with industry returns. One-month real T-bill rate, dividend yield of NYSE stock index, detrended stock price level, the slope of term structure and bond spread are used as candidates for the threshold variable. Test results indicate the existence of statistically significant non-linearity in industry returns and market risk relationship with respect to real interest rates. The authors then estimate betas over time for two regimes, and perform a forecasting exercise same as in Ghysels (1998) to compare pricing errors of the proposed threshold CAPM with unconditional CAPM, conditional CAPM and conditional APT. They find that the threshold CAPM yields much lower pricing errors than those of conditional models.

Following a similar methodology to Akdeniz et al. (2003), Akdeniz et al. (2011) propose a volatility based threshold CAPM in which aggregate volatility is used as a threshold variable. In this study tests are performed on several portfolios sorted according to their size and BE/ME ratios: ten size portfolios, ten BE/ME portfolios, ten portfolios sorted according to dividend yield-to-price ratios, twenty five size-BE/ME portfolios and six size-BE/ME portfolios. Returns on at-the-money straddles written on the S&P 500 index and range of the VIX index are used as proxies for changes in the aggregate volatility, and tests reach the conclusion that portfolios betas change significantly with recpect to aggregate market volatility.

In their working paper, Chen et al. (2011) further extend the two-regime homoscedastic threshold nonlinear CAPM to a multi-regime threshold CAPM-GARCH model that allows asymmetric response in both the conditional mean and volatility equations. The performed tests on sixteen stocks show that there are three regimes in average returns: bear markets, bull markets and stable markets. Another extension on two-regime threshold CAPM is proposed by Chen et al. (2012). The sharp indicator function is replaced by a continuous function in the mean and volatility equations, which changes smoothly among 0 and 1. These two nonlinear studies are just introduced in the literature and verified only with a very scant sample data. We will not cover these two models in this paper, since they are still pending for verification from a complete analysis on a high quality data.

3.4.4 Evidence from Turkish Market

Starting in 1970s, an extensive number of empirical work has intended to identify and model time variation in betas for many countries such as Australia (Faff et al., 1992; Brooks et al., 1998; Groenewold & Fraser, 1999), Canada (Episcopos, 1996), United Kingdom (Reyes, 1999; Faff et al., 2000) and the United States (Blume, 1971; Fabozzi & Francis, 1978; Bollerslev et al., 1988; Ferson & Harvey, 1991; Ferson & Korajczyk, 1995, Jaganathan & Wang, 1996). Beta instability has also identified for emerging markets such as Brazil (Grieb & Reyes, 2001), Hong Kong (Li & Li, 1996; Cheng, 1997), India (Moonish & Shah, 2002), Korea (Bos &

Fetherston, 1992), Malaysia (Kok, 1992; Brooks & Faff, 1997), Mexico (Domanech et al., 2011), Singapore (Brooks et al.,1998), and South Africa (Brooks et al., 1997).

Besides these international empirical studies, the asset pricing literature includes only a few paper that concentrate on time varying-betas in Turkey. The evidence for beta instability in the BIST can be found in studies provided by Odabasi (2000, 2002, 2003a, 2003b), Aygoren & Saritas (2007), Oran & Soytas (2008), Tuncel (2009), Altinsoy et al. (2010), and Koseoglu & Gokbulut (2012).

Odabasi (2000) investigates time variation in betas of 100 firms traded in the BIST for the period from 1992 to 1997. He utilizes both weekly and monthly rate of returns of individual stocks and portfolios. His results imply that betas get more stable with longer estimation periods. In addition, portfolios with five or more stocks tend to have more stable betas. With an extended sample period, between 1992 and 1999, Odabasi (2002) conducts tests on 100 stock traded in the BIST and finds that betas are highly time-varying over four- and eight-year estimation periods. On the other hand, his results also imply that variation gets lower as the estimation period gets shorter. He also concludes that time variation in beta can be diversified away since it reduces with the size of the portfolio. Odabasi (2003a) again utilizes a sample of weekly returns on 100 stocks over the period from 1992 to 1999. He tests the stability of betas for both individual stocks and portfolios of different sizes. He observes a significant difference between betas gathered from weekly and monthly returns. He concludes that an estimation period of two years yields stable betas for weekly returns, and similarly an estimation period of four years yields stable betas for monthly returns; therefore estimation period seems to affect the variation in betas.

In a much related study, Odabasi (2003b) observes that both the estimation period and return period have punch on stability of beta.

Aygoren & Saritas (2007) suggests correction methods to provide accurate beta estimates, using monthly returns of 90 stocks traded in the BIST for the period from 1994 to 2004. They conclude that more accurate beta estimations can be made as the estimation period is increased to 8-9 years.

In their working research paper, Oran & Soytas (2008) examine the time-varying betas of individual stock and 500 portfolios over the period from January, 2006 to June, 2007. To check the instability of betas, they extend the market model by adding dummy variables for randomly chosen event dates. Their findings are in line with Odabasi (2000, 2002, 2003a, 2003b), the relationship between market returns and asset returns are not stable, but they do not find evidence showing that portfolio betas are more stable than individual betas.

Tuncel (2009) studies the evidence of return interval effect in Turkey for the sample period from 2000 to 2007. He utilizes daily, weekly and monthly returns to estimate betas for 189 stocks for the sample period and two sub-periods. He observes the existence of beta instability in the BIST, but his findings contradict with findings of Odabasi (2000, 2002, 2003a, 2003b) and Aygoren & Saritas (2007) since estimation period is not found to be influential on the stability.

Although the above studies observe the evidence of time variation in betas, none of them attempts to model the behavior of time-varying betas for the BIST. In an attempt to fill this gap, Altinsoy et al. (2010) employ a GARCH model, the Schwert & Seguin model and the Kalman Filter approach to estimate and examine the time-varying betas in the BIST, but the study is limited to real estate investment trusts. They use both daily and weekly data ranging from February, 2002 to April, 2009, and empirical results suggest that betas are not stable for the real estate investment trusts. With an extended sample data, Koseoglu & Gokbulut (2012) utilize a bivariate GARCH approach to empirically investigate the stochastic structure of time-varying betas of three main sectors indices of the BIST. They compare the unconditional and time-varying betas of industrial, service and financial sector indices of the BIST using daily observations over the period from January, 2001 to March, 2011. In their study, the unconditional betas of these three sectors are estimated by OLS, and time-varying betas are estimated by capturing the conditional volatility of returns with a bivariate GARCH model. Their findings indicate that time-varying betas are remarkably similar to the OLS estimates for all sectors. Consistent with the previous studies, they find that beta estimations for sub-periods are not stable over time. They also observe a statistically significant decline in the systematic risk of industrial and service sectors, as well as a dramatic increase in financial sector during the sample period.

The studies mentioned above investigate the time variation in beta both for individual firms and portfolios of different sizes; and all find the evidence that beta-coefficients are far from being stable for the BIST. These studies also examine the effects of several factors, such as estimation period, return interval and portfolio size on the variation in beta, but there is a contradiction in terms of their inferences. For instance, one study observes that both the sample period and return interval have an impact on stability of beta, while other one finds that these factors have no effect on stability. Similarly, while one reports evidence for the effect of portfolio size, others find no evidence for it. Despite all these contradicting inferences, these studies give a broad picture of time-varying betas in the Borsa Istanbul Stock Exchange.

The empirical investigations on the BIST are also inadequate and most of the studies suffer from their own shortcomings. First of all, most of them have relatively short time periods and poor dataset for investigation, which makes it necessary to conduct an extended analysis on the market. Furthermore, almost all include the financial firms in their sample, which may not be appropriate since the high leverage of the former might distort the results. In addition, many of these studies utilize daily observations on the market, but daily observations are considered to involve too much noise and are affected by the day of the week effect (Worthington and Higgs, 2006). Finally, the existing literature on the time-varying betas for Turkey lacks evidence on modeling and estimation of time variation. In our knowledge, only two empirical papers performed by Altınsoy ei al. (2010) and Koseoglu & Gokbulut (2012) employ linear time-series models to estimate time varying-betas for the BIST, but these papers concentrate on specific sectors. On the other hand, these two empirical papers assume that beta changes continuously over time to capture time-variation. As Ghysels (1998) argues, the continuous approximation fails to capture the dynamic of the market risk and overestimate the actual time variation in betas. Many of recent researches in the literature assume that betas change discretely over time, which yields a non-linear relationship between assets' returns and market returns. As far as I know, there is no empirical study employed in Turkey which assumes that betas change discretely over time. As in other emerging markets, there is a significant need for testing non-linearity in the time series relationship of asset returns with market returns in the BIST.

CHAPTER IV

METHODOLOGY & DATA

4.1. Introduction

To capture the impact of time variation in beta, many researchers, notably Ferson (1985), Bollerslev et al. (1988), Harvey (1989), Ferson & Harvey (1991, 1993) and Ferson & Korajczyk (1995), have assumed that investors' expectations of the moments of future returns are conditional on the information at a specific time. This assumption yields the following basic version of conditional CAPM:

$$E\left[r_{i,t+1} \mid Z_t\right] = \alpha_i + \beta_t E\left[r_{m,t+1} \mid Z_t\right] + \varepsilon_{i,t+1}, \tag{1}$$

where $r_{i,t+1}$ is the excess return on asset *i* at time *t+1*, $r_{m,t+1}$ represents the excess return on the market portfolio, β_t is the parameterized time varying beta, and Z_t stands for the information set available at time *t*.

However, Ghysels (1998) argue that this assumption fails to capture the true dynamics of betas since actual time variation in betas is slower than assumed by linear factor models. Following Ghysel's argument, Akdeniz et al. (2003) model an asset's beta neither as static nor as a continuous approximation, rather they assume that assets betas change slowly and discretely over time.

This study follows the methodology of Akdeniz et al. (2003) by assuming betas change discretely over time in the Borsa Istanbul Stock Exchange. Their two-regime homoscedastic threshold non-linear model, called the threshold CAPM, is adopted to examine whether it performs better than the static CAPM and the three-factor model in pricing stocks traded the BIST.

4.2 The Threshold CAPM

Akdeniz et al. (2003) formulate time-varying beta as a function of an underlying variable by using a characteristic function to allow beta to change discretely between two regimes;

$$r_{i,t+1} = \left(\alpha_1 1_{\{Zt \leq \lambda\}} + \alpha_2 1_{\{Zt > \lambda\}}\right) + \left(\beta_1 1_{\{Zt \leq \lambda\}} + \beta_2 1_{\{Zt > \lambda\}}\right) r_{m,t+1} + \varepsilon_{i,t+1}, \tag{2}$$

where $1_{\{\}}$ is the characteristic function and λ, is the parameter for the underlying economic variable, which is called threshold parameter, and Z_t stands for the threshold variable.

Following econometric conditions are necessary for defining the econometric model. The observed sample for the econometric model is $\{r_{t+1}, r_{m,t+1}, Z_t\}$, t=1,…,T-1. The random variables r_t, $r_{m,t}$ and Z_t are real valued; and information set Z_t is assumed to have a continuous distribution. Thus, the econometric model follows;

$$r_{t+1} = \theta' x_{t+1} + \delta' x_{t+1}(\lambda) + e_{t+1}, \tag{3}$$

where λ is in a bounded subset of the real line Γ; and $x_{t+1} = r_{m,t+1}$, $x_{t+1}(\lambda) = x_{t+1} 1_{\{Zt \le \lambda\}}$, $\theta = \beta_2$, and $\delta = \beta_1 - \beta_2$.

The assumptions of the model (Equation 3) are followed by Hansen's (2000) Assumption 1:

1. The random variables $r_{m,t}$, Z_t and e_t are assumed to be strictly stationary ergodic and p-mixing, with p-mixing coefficients satisfying $\sum_{m=1}^{\infty} \sqrt{p}_{m}$.
2. $E[e_t \mid Z_{t-1}] = 0$.
3. $E|r_{m,t}|^4 < \infty$ and $E|r_{m,t} e_t|^4 < \infty$.
4. Let $f(.)$ denote the density function of Z_t. For all λ ϵ Γ, $E\left(r_{m,t}{}^4 e_t{}^4 \middle| Z_t = \lambda\right) \le C$ and $E\left(r_{m,t}{}^4 \middle| Z_t = \lambda\right) \le C$ for some $C < \infty$ and $f(\lambda) \le \bar{f} < \infty$.
5. Let λ_0 is the true value of the threshold. Then, the moment functionals $E\left[r_{m,t} r_{m,t}{}' \middle| Z_t = \lambda\right]$ and $E\left[r_{m,t} r_{m,t}{}' e_t 2 \middle| Z_t = \lambda\right]$ are continuous at $\lambda = \lambda_0$.
6. $\delta_T = cT^{-\alpha}$ with $c \ne 0$ and $0 < \alpha < 1/2$.
7. $c' E\left[r_{m,t} r_{m,t}{}' \middle| Z_t = \lambda\right] c > 0$, $c' E\left[r_{m,t} r_{m,t}{}' e_t 2 \middle| Z_t = \lambda\right] c > 0$ and $f(\lambda_0) > 0$.
8. $E\left[r_{m,t} r_{m,t}{}'\right] > E\left[r_{m,t} r_{m,t}{}' 1_{[Z_t \le \lambda]}\right] > 0$ for all $\lambda \in \Gamma$.

The first assumption is related with time series applications: the stationarity excludes time trends and integrated processes, and the p-mixing[5] controls the degree of time series dependence which allows the processes to be autocorrelated and heteroscedastic. It is flexible to embrace threshold autoregressions. The second assumption provides the correct specification of the conditional mean. The third assumption shows unconditional moment bounds and the next one shows conditional moment bounds. The fifth assumption requires continuous distribution for the threshold variable and excludes regime dependent heteroskedasticity. The sixth assumption states that the difference in regression slopes decreases as the sample size increase, and this situation provides assistance to get a nuisance parameter free distribution. The seventh assumption is a full rank condition that is needed to have nondegenerate asymptotic distributions. The last assumption excludes multicolinearity.[6]

4.3 Methodology

4.3.1 Testing for a Threshold

Before performing estimations for test portfolios, the existence of time variation in the relationship between market risk and expected return is investigated by testing for a threshold effect. Following the steps outlined in Akdeniz et al. (2003), the heteroscedasticity-consistent Lagrange Multiplier (LM) test of Hansen (1996) is used for a threshold.

The null hypothesis of no significant regime shifts in portfolio betas due to changes in the level of threshold parameter, H_0: $\delta = 0$, is tested against H_1: $\delta \neq 0$.

[5] See Ibragimov (1975) for a definition of p-mixing.
[6] See Hansen (2000) for more detailed explanations of the assumptions.

For all $\lambda \in \Gamma$, there exist the following LM statistics for the null hypothesis of no threshold effect:

$$LM_t(\lambda) = T\left[R\hat{\gamma}(\lambda)\right]'\left[R\hat{V}_T^*(\lambda)R'\right]^{-1}\left[R\hat{\gamma}(\lambda)\right],$$

$$\text{where } R = [0, I], \hat{\gamma}(\lambda) = \left[\hat{\theta}(\lambda)', \hat{\delta}(\lambda)'\right]',$$

$$\hat{\gamma}(\lambda) = \left[\sum_{t=1}^{T} x_{t+1}^*(\lambda) x_{t+1}^*(\lambda)'\right]^{-1}\left[\sum_{t=1}^{T} x_{t+1}^*(\lambda) r_{t+1}\right],$$

$$x_{t+1}^*(\lambda) = \left[xt+1, xt+1(\lambda)\right],$$

$$\hat{V}_T^*(\lambda) = M_T(\lambda)^{-1}\tilde{V}_T(\lambda)M_T(\lambda)^{-1},$$

$$M_T(\lambda) = \frac{1}{T}\sum_{t=1}^{T} x_{t+1}^*(\lambda) x_{t+1}^*(\lambda)',$$

$$\tilde{V}_T(\lambda) = \frac{1}{T}\sum_{t=1}^{T} x_{t+1}^*(\lambda) x_{t+1}^*(\lambda)' \tilde{e}_{t+1}^2,$$

where $\tilde{e}_t$ is procured from restricted least squares regression. Since the threshold λ is not identified under the null hypothesis, Hansen (1996) proposes a bootstrap analog to compute the p-values and shows that the process generates asymptotically correct p-values. In this paper, the following steps of the bootstrap analog are used:

1. $LM_t(\lambda)$ is formed for each $\lambda \in \Gamma$ and the maximum one is defined as LM_t^*.
2. To generate the dependent variable r_b, a standard random vector of T observations are multiplied with the residuals from restricted least squares.
3. Lagrange multiplier is formed again with fixed regressors and r_b, which is called $LM_t^b(\lambda)$. The maximum Lagrange multiplier is defined as LM_t^{b*}.
4. Steps 2 and 3 are repeated to generate 1000 replications of LM_t^{b*}.
5. The percentage of LM_t^{b*} exceeding LM_t^* is the p-value.

4.3.2 Estimation

For the portfolios exhibiting significant regime shifts due to the certain threshold variable, the threshold level is estimated by following Akdeniz et al. (2003).

First, it is convenient to rewrite the Equation (3) by transforming the threshold parameter δ to the threshold effect δ_T:

$$r_{t+1} = \theta' x_{t+1} + \delta_T ' x_{t+1}(\lambda) + e_{t+1}, \quad t = 1,...,T-1, \tag{5}$$

where $\delta_T \to 0$ as $T \to \infty$ to have a nuisance parameter free asymptotic distribution, and it is an upper bound on the asymptotic distribution for the case that the threshold effect does not decrease with the sample size. This condition allows building confidence intervals for λ even when the threshold effect does not decrease as sample size increases (Hansen, 2000).

The matrix expression of Equation (5) can be written as;

$$R = X\theta + X_\lambda \delta_T + e, \tag{6}$$

where X and X_λ are defined as T x 2 matrices and R is a T x 1 vector. Least Squares Estimation is used in accordance with the same methodology:

$$S_T(\theta, \delta_T, \lambda) = (R - X\theta - X_\lambda \delta_T)'(R - X\theta - X_\lambda \delta_T), \tag{7}$$

where $(\theta, \delta_T, \lambda)$ are regression parameters and S_T is the sum of squared errors function. In order to obtain least squares estimates, at first, Hansen (2000) observes that conditional on λ, the equation (7) is linear in θ and δ_T. This linear relation yields the conditional least squares estimates $\hat{\theta}(\lambda)$ and $\hat{\delta}(\lambda)$ by regressing R on $[X\ X_\lambda]$. Thus, the estimate $\hat{\lambda}$, the value that minimizes the sum of squared errors, can be defined as;

$$\hat{\lambda} = \arg\min S_T(\lambda), \tag{8}$$

where $\lambda \in \Gamma_T = \Gamma \cap \{Z_1, \ldots Z_T\}$. As a result of that, it requires less than T function evaluations to derive the estimate of threshold parameter. The asymptotic distribution for the estimate is identified in Hansen's (2000) Theorem 1.

4.3.3 Benchmark Models

In order to evaluate the pricing performance of the threshold CAPM, two asset pricing models are considered as benchmarks. The first benchmark model used in the tests is the traditional specification of the static CAPM (Sharpe, 1964; Lintner, 1965; and Black, 1972):

$$r_{it} = \alpha_t + \beta_i r_{mt} + \varepsilon_t, \tag{9}$$

where r_{it} is the excess return on asset i in period t, r_{mt} is excess market return in period t and the parameter β_i represents the market sensitivity of asset i.

Excess returns on different asset classes are regressed only on the excess market returns for empirical tests. The least squares estimate of β_i, and sum of squared errors are reported in order to make a comparison with those of the threshold CAPM.

In addition to the static CAPM, the three-factor model of Fama & French (1993) is used as a benchmark for the threshold CAPM. Including mimicking factors of size and book-to-market with the market factor, the-three factor model of Fama & French (1993) is produced;

$$r_{it} = \alpha_t + \beta_i r_{mt} + s_i \left(SMB_t \right) + h_i \left(HML_t \right) + \varepsilon_t, \tag{10}$$

where SMB_t the difference between the returns on diversified portfolios of small and big stocks, HML_t is the difference between the return on diversified portfolios of high and low B/M stocks, s_i is the coefficient for size factor, and h_i is the coefficient for the book-to-market factor. By following the methodology of Fama & French (1993), in sample sum of squared errors of the regressions are produced for all test portfolios.

4.4 The Data Description

The data in this study includes only the non-financial firms that were traded in the Borsa Istanbul Stock Exchange during the period between January 1998 and December 2011, with a total of 168 months. This was a period during which local and global financial crises were occurred, enabling us to see the response of betas to the changes in the economic environment. The earlier years are not covered in the sample due to the poor quality of data for many publicly traded firms. Consistent with the literature, the study focuses on only the non-financial firms since highly-leveraged capital structure of financial institutions such as banks, holding companies and insurance companies would be able to distort the results of the empirical tests. To be included in the sample data, for each year *t*, a firm must be trading in BIST both for June of year *t* and for December of year *t*-1. This hinders a possible survivorship bias by allowing us to also include the suspended and delisted firms. A fiscal year ending in December for each firm is also required. The number of firms that meet these requirements ranges from a minimum of 150 in 1998 to a maximum of 227 in 2011.

The adjusted[7] monthly closing prices of each stock are obtained from Datastream. The proxy for the market portfolio is the National 100-market index (BIST-100) and its levels are also obtained from Datastream. Since all the prices are adjusted to stocks splits and dividends, the percentage monthly returns, simply referred as monthly returns, are calculated as the change in the stock price between consecutive time periods.

Finding a proxy for the risk-free rate is very problematic for studies focusing on the BIST. The one-month T-bill rate is mainly used in the asset pricing literature, but it is not possible to find a valid series for Turkey, especially for early years of the sample period of this study. As a result of that, most of the studies use the overnight interbank rates that are listed by the Central Bank of Turkey. Instead of overnight interbank rates, this study uses the series for the monthly interest rates of treasury auctions from the database of Ministry of Development since overnight rate is not a good proxy for the crisis periods. As in 2001 crisis, the overnight rates shoot up in tight liquidity conditions.

4.5 Candidates for the Threshold Variable

As stated by Harvey (2001), the evidence of time variation in betas can be highly sensitive to the choice of instrumental variables. Considering the variables suggested in the literature as predicting stock returns, four instrumental variables are selected as candidates for the threshold variable of the model. These variables are risk-free

[7] To remove the effects of stock splits, cash dividends and stock dividends.

interest rate, rate of change in the currency basket level, rate of change in the real effective currency index, and historical volatility of the BIST-100 index. There are several reasons why it is assumed that asset betas should change with respect to any of these variables.

As in Akdeniz et al. (2003), the risk free interest rate is used as a candidate for the threshold variable in this study. They show that interest rate signals a regime shift in betas in the strongest manner when compared to other threshold variables. Therefore, investors update portfolio betas in the NYSE with respect to a threshold level of interest rates. Bansal & Viswanathan (1993) and Perez-Quiros & Timmermann (1999) also document a similar evidence for non-linearity of returns due to market risk and interest rates. Considering the high volatility of interest rates during the crisis periods in Turkey, one may suspect the interest rates as the provoker of the variation in market betas.

Second candidate for the threshold variable is the foreign currency basket which is a portfolio of selected currencies with different weightings. It functions as a benchmark for regional currency movements, and it is commonly used for minimizing the risk of currency fluctuations. Thus, it is considered as a good proxy for the currency risk. Since emerging markets are not fully integrated with the developed markets, they present valuable opportunities for diversification. As a result of that foreign currency risk becomes an important factor, and several studies have shown that fluctuations in the foreign exchange impose stock markets, especially during the crisis periods (Chkili et al., 2011). Considering the major financial crisis during the sample period, it is necessary to investigate whether foreign currency basket is relevant in explaining returns on the BIST. Therefore, rate of change in the foreign currency basket consisting of US Dollar to TL and EURO to TL exchange rates with equal weights is selected as the candidate for the threshold variable.

Foreign currency basket takes the inflation differentials among Turkey and foreign countries into account, and it is not adjusted for the full effect of compounding. In order to examine the currency risk without the effects of inflation and compounding, I select the real effective currency index, which is calculated by the Central Bank of Turkey, as the third candidate for the threshold variable. The index is generated by deflating a portfolio of thirty six countries' effective currency ratios with weights specified by Turkey's foreign trade volume.[8] It also allows investigating whether industries or portfolios are exposed to a large number of currencies rather than USD and EURO.

Many studies including Ang et al. (2006), Moise (2007), and Adrien and Rosenberg (2008), and Abdymomunov & Morley (2011) suggest volatility in predicting stock returns. In addition, Akdeniz et al. (2011) propose a volatility-based threshold CAPM in which an asset's beta changes discretely with respect to changes in volatility. They find that portfolio betas in NYSE change significantly when market volatility is beyond a certain threshold. In order to analyze whether betas of stocks trading in the BIST change discretely due to the volatility of the market portfolio, which is proxied by the historical volatility of the BIST-100 index, it is considered as the fourth candidate for the threshold variable.

The following formula is used to calculate the historical volatility for time *t*;

[8] For a more detailed description, see Saygili, Saygili & Yilmaz (2010)

$$Vol_{t,n} = \sqrt{\frac{N}{n}\sum_{i=1}^{n}\left(R_{t-i+1} - \bar{R}_{t,n}\right)^2}, \tag{4}$$

where n is number of datum points, R_t is the return on index level, $\bar{R}_{t,n}$ is the moving average of returns for n datum points, and N is the total number of points in a year.

Table 1 provides a list for four candidates of the threshold variable. Different database sources are used to form series for these variables. Risk-free interest rates are proxied by series for the monthly interest rates of treasury auctions from the database of Ministry of Development. The exchange rate series for USD to TL and EURO to TL are downloaded from the Electronic Data Delivery System (EDDS) of the Central Bank of Turkey. These are used to calculate the rate of change in the currency basket level. For the period from January 1998 to January 1999, German Mark to TL series is obtained and converted into EURO to TL by dividing the fixed ratio of 1.955830.

Table 1

List of candidates for the threshold variable

#	Code	Variable	Data Source
1	RF	Risk-Free Interest Rate	Min. of Development
2	CB	Rate of Change in Currency Basket	CBRT Database
3	CI	Rate of Change in Real Effective Currency Index	CBRT Database
4	HV	Historical Volatility of BIST-100	BIST Database

Note: This table reports the instrumental variables that are considered to be candidates for the threshold variable. The risk-free interest rate is proxied by the average monthly interest rate of treasury auctions. The currency basket is the portfolio of foreign currencies USD and Euro, and its level is calculated in Turkish Lira. The real effective currency index is the value of Turkish Lira in exchange for a portfolio formed with 36 foreign currencies. Weight of each currency is determined by Turkey’s bilateral trade flows with each country.

4.6 Portfolio Formation

4.6.1 The Industry Portfolios

The industry portfolios are formed for each month from January 1998 until December 2011 in order to examine the relationship between economic variables that are empirical proxies for changing economic environment, and market beta for each industry. These portfolios are value-weighted within each industry. Table 2 provides definition for industry portfolios.

In each month, stocks satisfying the data requirements are allocated into groups according to industry index codes of the Borsa Istanbul. The groups having a few numbers of stocks over the whole sample period are removed to ensure that each industry group contains a large number of stocks for diversification. There are thirteen industry groups satisfying this condition. In order to form value-weighted portfolios with these industry groups, portfolio weights are determined on the basis of market capitalizations. For each month, monthly returns on all stocks in an industry group are multiplied by their associated weights, and the sum of this operation in all months gives the monthly returns on that industry group which is simply called the industry returns. The operation is repeated for all groups to from 13 value-weighted industry portfolios.

Table 2

List of Industry Portfolios

#	Industry
Portfolio 1	Non-Metalic Mineral Products
Portfolio 2	Basic Metal Industry
Portfolio 3	Fabricated Metal Products,Machinery & Equipment
Portfolio 4	Food, Beverage & Tobacco
Portfolio 5	Textile
Portfolio 6	Paper & Paper Products, Printing & Publishing
Portfolio 7	Chemicals, Petroleum Rubber & Plastic Products
Portfolio 8	Tourism
Portfolio 9	Wholesale & Retail Trade
Portfolio 10	Transportation, Telecommunication & Storage
Portfolio 11	Electricity, Gas & Water
Portfolio 12	Construction
Portfolio 13	Technology

Note: This table reports the names of the industries in accordance with the industry indices of the Borsa Istanbul Stock Exchange. The study covers stocks trading in the BIST over the period from January 1998 to December 2011. The sector of education, health, sports and other social services is excluded from the sample since there are only a few companies traded over a small period.

4.6.2 10 Size and 10 BE/ME Portfolios

Concentrations of big (or small) size firms and high (or low) BE/ME firms are unknown for an industry portfolio. Therefore, it is not possible to see how these factors are affecting the results. In order to observe the individual effects of size and BE/ME on the relationship between the threshold variable and market beta, ten size and ten BE/ME portfolios are formed. For each year, stocks are sorted with respect to their market capitalization at the end of June and these sorted stocks are divided into deciles. The stocks in each size decile form a size portfolio, and returns for twelve months beginning in July of each year are calculated for these portfolios.

The BE/ME portfolios are created using a similar procedure. For each year, stocks are sorted with respect to their book-to-market ratios at the end of December in the previous year, and these sorted stocks are divided into deciles. The reason for imposing six months of lag is that effects of the financial statement announcements are not immediate. The stocks in each decile form a BE/ME portfolio, and returns for twelve months beginning in July of each year are calculated for these portfolios.

4.6.3 25 Size-BE/ME Portfolios

A possible BE/ME effect can distract the results of tests performed on size portfolios, or similarly a possible size effect can distract the results of tests performed on BE/ME portfolios. It is not possible to observe such a case on theses portfolios since concentrations of high (or low) BE/ME firms in size portfolios, or concentrations of big (or small) size firms in BE/ME portfolios are unknown. In order to eliminate a possible BE/ME effect on size portfolios, and a size effect on BE/ME portfolios, their interaction must be unraveled. For this purpose, twenty five size-BE/ME portfolios are formed and the effects of these variables are distinguished from each other.

The stocks are first sorted with respect to their market capitalization at the end of June for each year. These sorted stocks are grouped into five size quintiles. The stocks in each size quintile are sorted with respect to their book-to-market ratios at the end of December of the previous year, and five BE/ME quintiles are formed for each size quintile. As a result of the process, 5x5 portfolios are formed each of which belongs to one size and one BE/ME quintile. The returns for twelve months beginning in July of each year are calculated for these portfolios.

These twenty five size-BE/ME portfolios are used to test the static CAPM, the threshold CAPM and the three-factor model of Fama & French (1993). To examine the three-factor model, the second and third factors of it which are SMB (small minus big) and HML (high minus low) are also needed. In order to construct these variables, six portfolios are formed using two-pass sorts again. The stocks are first sorted on size for each year and divided into two groups called small (S) and big (B). Then each group is sub-divided into three BE/ME groups where the stocks within the first 30% lowest BE/ME ratio are called low (L), the stocks within the last 30% highest BE/ME ratio are called high (H), and the remaining stocks are called medium (M). As a result, six portfolios (S/L, S/M, S/H, B/L, B/M, B/H) are formed with respect to size and BE/ME. The SMB factor is constructed by taking the difference between average return on three small portfolios and the average return on three big portfolios for each year. Similarly, the HML factor is constructed by taking the difference between average return on two high and average returns on two low portfolios.

CHAPTER V

EMPIRICAL RESULTS

5.1 Descriptive Statistics

This thesis considers different portfolio formations in order to examine whether dynamics of time variation of beta differ across industries, market capitalization or book-to-market ratio. More precisely, there are 13 portfolios formed according to industry codes, 10 portfolios sorted with respect to size, 10 portfolios sorted with respect to book-to-market ratio, and 25 portfolios (5x5) sorted with respect to both market capitalizations and book-to-market ratios. Before moving on to tests of the threshold CAPM, this section presents descriptive statistics for portfolio returns, market returns and economic variables to demonstrate the nature of these variables.

First, the portfolios formed with respect to industries for the period from 1998 to 2011 are examined in the formal tests. Table 3 presents descriptive statistics for monthly industry and market returns. The monthly mean returns have a wide range across industries. For instance, the lowest mean is 0.50% and the highest mean is

4.05%, while the market mean return is 2.54%. The standard deviations of the returns on the portfolios are quite high reaching up to 20.26%, while the standard deviation of the market returns is 14.22%. More precisely, industries of tourism; transportation, telecommunication and storage; and technology have highest standard deviations. On the other hand, six portfolios have lower standard deviations than the standard deviation of the market. The market portfolio seems to be more risky than these portfolios, and this is because the BIST-100 index contains many financial firms. The correlation coefficients of returns on industry portfolios with the market returns have a range from 67% to 94%. The lowest coefficient is for the industry of electricity, gas and water, therefore the relationship of this industry with the market portfolio is slightly low when compared to other industry portfolios.

Table 3

Descriptive statistics for monthly returns on industry portfolios

	Mean	Median	Max.	Min.	Std.Dev.	Correl.
Market P.	2.54	2.35	79.78	-39.03	14.22	
Portfolio 1	2.45	3.35	65.89	-39.65	11.97	86.93
Portfolio 2	2.94	2.68	62.34	-41.01	15.13	83.55
Portfolio 3	2.67	1.22	84.46	-42.04	15.59	93.71
Portfolio 4	2.96	2.10	69.64	-34.76	12.69	81.83
Portfolio 5	2.05	1.10	67.99	-43.17	13.45	82.75
Portfolio 6	2.32	2.45	71.70	-41.37	15.00	83.60
Portfolio 7	2.41	2.32	72.83	-42.91	13.38	90.13
Portfolio 8	2.26	-0.24	93.97	-56.04	20.26	72.95
Portfolio 9	2.66	2.67	62.94	-34.74	12.17	85.46
Portfolio 10	3.21	0.29	127.03	-37.71	19.11	79.96
Portfolio 11	0.50	0.01	73.82	-45.08	13.96	66.85
Portfolio 12	4.05	3.20	66.04	-47.61	15.46	73.19
Portfolio 13	3.01	1.48	111.53	-43.83	19.56	87.22

Note: This table reports descriptive statistics for adjusted monthly returns on the market portfolio and industry portfolios. The sample covers the period between January 1998 and December 2011, and all values are given in percentages. To be included in the sample, for each year t, a firm must be trading in BIST both for June of year t and for December of year t-1. The market portfolio is proxied by the National 100 Market Index (BIST-100).

Since it is not possible to observe whether these portfolios exhibit effects of size or BE/ME, 10 portfolios sorted with respect to size and 10 portfolios sorted with respect to book-to-market ratio are also used in the tests. Table 4 shows that mean returns are negatively related with market capitalization, but they do not monotonically decrease with increasing size. The mean return on the biggest portfolio is higher than the expected. In addition, it is observable that correlation coefficients of the returns on size portfolios with market returns are increasing with increasing size. According to the second panel of Table 4, portfolios exhibit the individual effect of BE/ME for the sample period. The mean returns have a tendency to increase with increasing BE/ME across portfolios.

In order to unravel the interaction of size and BE/ME effects, 25 size-BE/ME portfolios are also used in the tests. Descriptive statistics for 25 portfolios are presented in Table 5. The monthly mean returns for these portfolios have a range between 1.47% to 5.18%. Except for the lowest BE/ME quintile, the average monthly returns decrease with increasing size for the sample period; which is consistent with the literature (Fama & French, 1992; Akdeniz, Altay-Salih & Aydogan, 2000; and Yuksel, Yuksel & Doganay, 2010). In addition, average monthly returns increase with increasing BE/ME for each size quintile. Both range of mean and the standard deviations of the returns for 25 size-BE/ME portfolios more than doubles the findings of Fama & French (1993). The range between the correlation coefficients of these portfolios with the market portfolio is also quite high, and they have a tendency to increase with increasing size for each quintile. According to the above descriptive statistics, dynamics of time variation of beta might change across industries, and effects of size and BE/ME factors.

Table 4

Descriptive statistics for monthly returns on 10 size and 10 BE/ME portfolios

Panel A: 10 Size Portfolios						
	Mean	Median	Max.	Min.	Std. Dev.	Correl.
Small	4.66	4.02	87.40	-40.86	15.55	74.65
2	3.09	2.71	46.83	-42.17	13.13	79.38
3	3.69	1.45	97.41	-37.55	15.79	82.38
4	3.00	1.89	85.35	-43.55	14.96	87.66
5	3.69	2.91	69.48	-38.14	14.22	81.61
6	3.25	2.81	68.50	-38.69	13.95	85.11
7	2.62	2.29	76.33	-34.01	13.33	90.44
8	2.55	2.42	85.81	-45.45	14.34	90.11
9	2.40	2.03	72.71	-43.29	13.95	94.46
Big	3.09	2.17	87.30	-38.42	15.09	94.57
Panel B: 10 BE/ME Portfolios						
	Mean	Median	Max.	Min.	Std. Dev.	Correl.
Low	2.72	1.20	87.40	-39.09	14.70	85.27
2	3.04	2.64	46.83	-37.57	12.52	85.44
3	3.06	2.21	97.41	-43.11	14.76	85.09
4	3.15	2.18	85.35	-39.65	14.86	87.55
5	2.76	2.98	69.48	-40.84	13.78	89.67
6	2.97	2.95	68.50	-30.71	13.74	84.52
7	3.27	3.02	76.33	-39.24	14.52	88.23
8	3.97	3.64	85.81	-41.17	14.62	90.64
9	3.60	2.78	72.71	-37.04	14.17	86.15
High	4.00	2.50	87.30	-39.31	15.39	83.76

Note: This table reports descriptive statistics for monthly returns on 10 size and 10 BE/ME portfolios. The sample covers the period between January 1998 and December 2011, with a total of 168 months. To be included in the sample, for each year t, a firm must be trading in BIST both for June of year t and for December of year t-1. This hinders a possible survivorship bias by allowing us to also include the suspended and delisted firms. A fiscal year ending in December for each firm is also required. All values are given in percentages. The last column presents the correlation coefficients of portfolio returns with the market returns.

Table 5

Descriptive statistics for monthly returns on 25 size-BE/ME portfolios

Size	B/M	Mean	Median	Max	Min	Std.Dev	Correl
S	L	2.60	1.73	48.77	-47.27	13.66	62.89
S	2	3.66	2.51	88.65	-41.40	14.69	77.50
S	3	4.78	3.90	74.69	-34.35	15.08	67.23
S	4	3.46	2.42	85.51	-41.44	15.05	74.43
S	H	5.18	3.71	84.21	-40.04	18.24	57.96
2	L	2.69	1.49	54.10	-44.01	14.89	74.62
2	2	3.03	1.87	58.14	-41.94	14.40	78.76
2	3	2.65	3.72	82.17	-53.02	14.58	75.12
2	4	3.62	2.32	99.85	-41.61	15.69	77.55
2	H	2.92	1.07	76.64	-38.36	14.68	82.84
3	L	3.65	2.85	118.91	-41.61	17.47	63.67
3	2	4.04	1.99	95.33	-46.16	16.40	81.84
3	3	3.17	2.11	76.81	-32.37	14.28	86.70
3	4	3.32	2.22	85.58	-38.63	14.16	84.63
3	H	3.66	3.14	79.87	-43.07	15.67	80.45
4	L	1.47	1.46	75.92	-47.38	14.54	82.91
4	2	2.96	1.85	72.52	-35.12	13.42	80.20
4	3	3.09	2.54	66.78	-38.67	13.28	84.61
4	4	2.93	1.69	68.56	-36.64	14.07	85.33
4	H	3.28	2.68	60.56	-41.26	13.89	86.14
B	L	2.81	1.71	76.40	-39.33	13.85	75.21
B	2	2.44	2.06	68.95	-39.26	13.66	90.16
B	3	2.28	2.05	76.22	-41.14	14.69	91.75
B	4	2.40	2.10	97.67	-38.26	14.91	90.46
B	H	2.87	2.37	76.66	-43.22	14.20	91.90

Note: This table reports the descriptive statistics for monthly returns on 25 (5x5) portfolios sorted with respect to both market capitalizations and book-to-market ratios. All values are given in percentages. The sample covers the period between January 1998 and December 2011, with a total of 168 months. To be included in the sample, for each year t, a firm must be trading in BIST both for June of year t and for December of year t-1. This hinders a possible survivorship bias by allowing us to also include the suspended and delisted firms. A fiscal year ending in December for each firm is also required. The last column presents the correlation coefficients of portfolio returns with the market returns.

Table 6 presents descriptive statistics for five candidates for the threshold variable of the threshold CAPM. These are risk-free interest rate, rate of change in the currency basket level, rate of change in the real effective currency index level, and historical volatility of the market index. According to the presented statistics, the average monthly rate for the interest rates is 2.74% for the period between January 1998 and December 2011, this seems to be high when compared to the developed markets. The average historical volatility of the BIST-100 index is also quite high with 44.19% compared to developed markets.

The candidates of the threshold variable are plotted against time for the study period 1998-2011 and presented in figures 8-11. Each figure also contains a time series plot of market returns in order to see market movements at different levels of the economic variables. First, looking at Figure 8, one can observe that the variability of the market is high when the market experiences high interest rate levels. Second, looking at Figure 9, one can see that market experiences huge drops when currency basket level experiences increases and vice versa. Third, Figure 10 presents a similar attitude on the market for the real effective currency index level. Figure 11 also presents a similar relationship between market returns and historical volatility.

Table 6

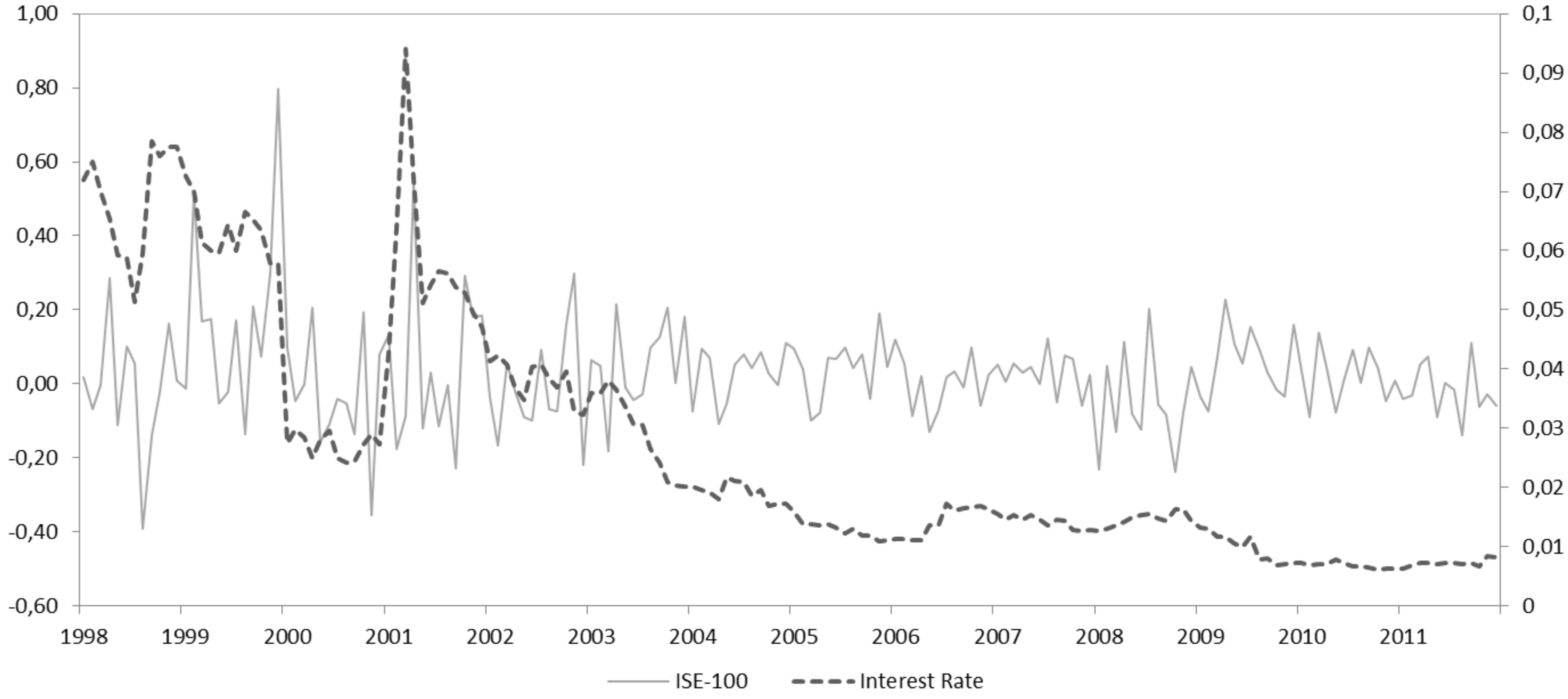
Descriptive statistics for chosen candidates of the threshold variable

	Mean	Median	Maximum	Minimum	Std.Dev.
RF	2.74%	1.70%	9.40%	0.62%	2.12%
CB	1.91%	0.91%	22.75%	-7.27%	4.91%
CI	0.23%	0.45%	14.50%	-14.68%	3.60%
HV	44.19%	36.75%	100.88%	18.84%	20.93%

Note: This table reports descriptive statistics for five economic variable that are considered to be proxies of the economic environment. All values are given in percentages and the sample data covers the period between January 1998 and December 2011, with a total of 168 months. RF is the monthly risk free rate, CB is the monthly percentage change in the Currency Basket, CI is the monthly percentage change in the Real Effective Currency Index, and HV is the historical volatility of the BIST-100.

Figure 8

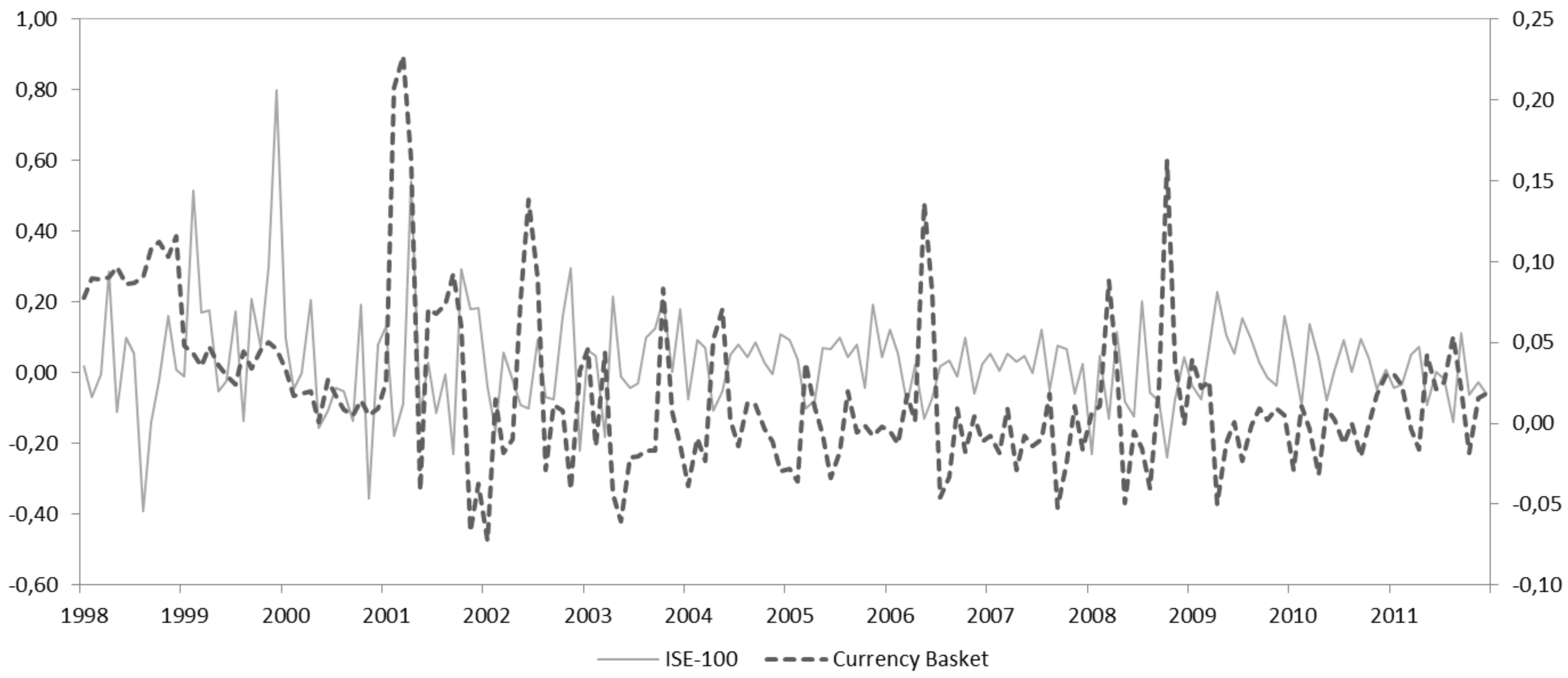
Time series of BIST-100 returns and risk free interest rate levels



Note: This figure plots the monthly time series of market returns and the risk free interest rate. The market portfolio is proxied by the National 100 Market Index (BIST-100). The left axis corresponds to the monthly returns of the market portfolio, and the right axis corresponds to the monthly risk free interest levels.

Figure 9

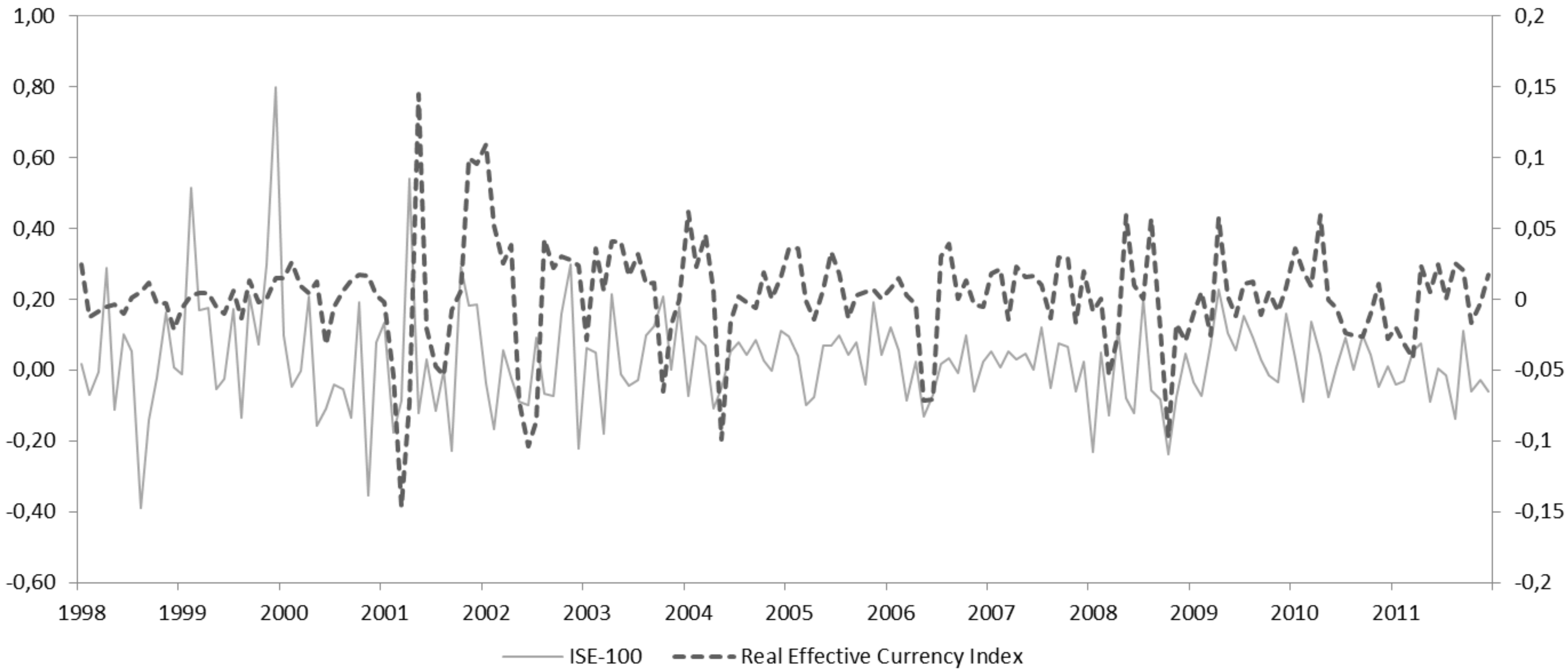
Time series of BIST-100 returns and rate of changes in currency basket level



Note: This figure plots the monthly time series of market returns and rate of changes in currency basket level. The market portfolio is proxied by the National 100 Market Index (BIST-100). The left axis corresponds to the monthly returns of the market portfolio and the right axis corresponds to the rate of changes in currency basket level.

Figure 10

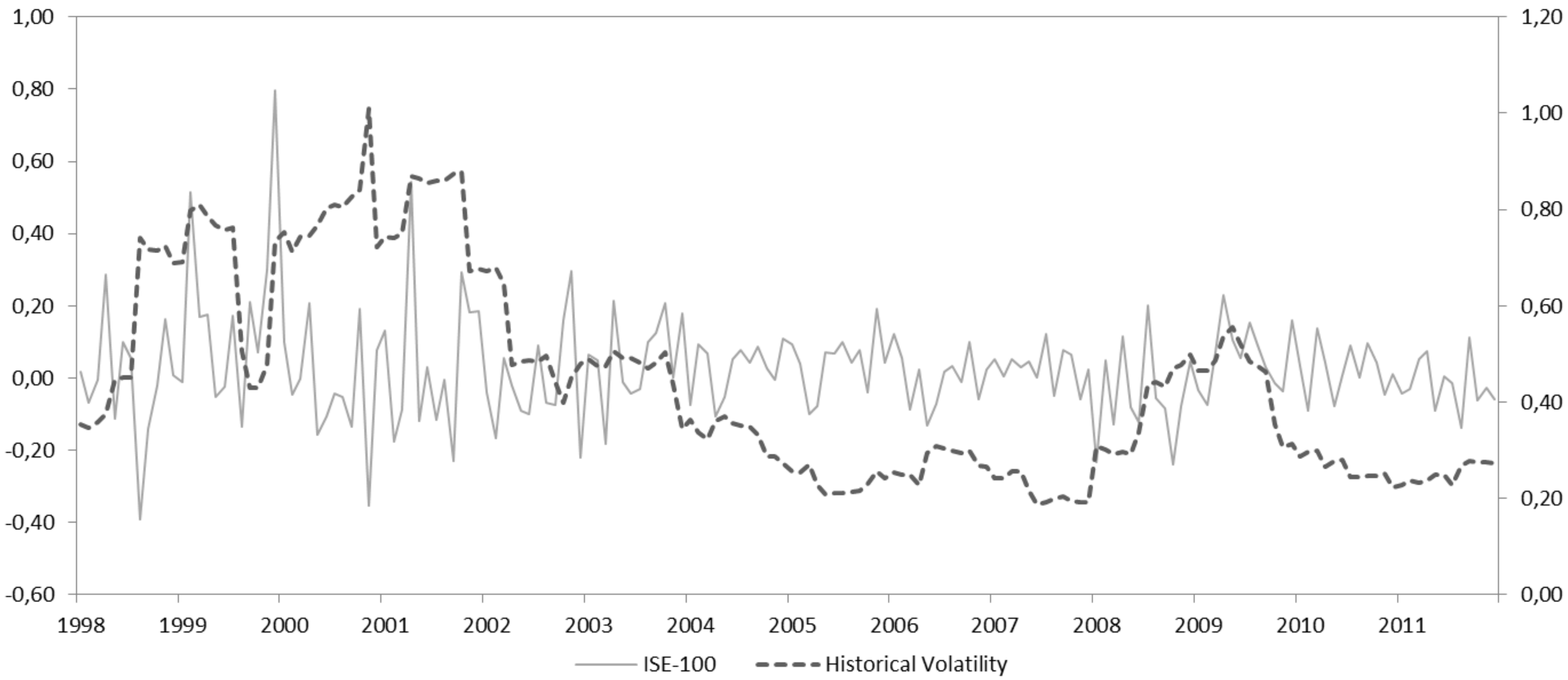
Time series of BIST-100 returns and rate of changes in real effective currency index level



Note: This figure plots the monthly time series of market returns and rate of changes in real effective currency index level. The market portfolio is proxied by the National 100 Market Index (BIST-100). The left axis corresponds to the monthly returns of the market portfolio and the right axis corresponds to the rate of changes in real effective currency index level.

Figure 11

Time series of BIST-100 returns and historical volatility levels



Note: This figure plots the monthly time series of market returns and historical volatility levels. The market portfolio is proxied by the National 100 Market Index (BIST-100). The left axis corresponds to the monthly returns of the market portfolio and the right axis corresponds to historical volatility levels of the BIST-100.

5.2 Testing for a Threshold

In this section, empirical tests are applied to examine whether there are statistically significant discrete regime shifts in market betas due to changes in the level of certain candidates for the threshold variable. Several portfolio formations are utilized in tests in order to observe whether significance of shifts are affected from industry specifications, market capitalizations and book-to-market ratios of firms. The null hypothesis of no significant regime shifts in portfolio betas, namely no threshold effect, is tested against the alternative hypothesis. The significance of null hypothesis is measured by following the steps of Hansen's (1996) bootstrap analog outlined in Section 4.3.1.

5.2.1 Industry Portfolios

The sup-LM test suggested by Hansen (1996) is first performed for industry portfolios to determine whether there are statistically significant discrete regime shifts in betas due to certain instrumental variables. Table 7 reports the bootstrap p-values for the test which describes the likelihood of no regime shift. These values are reported for thirteen industry portfolios over the period from January 1998 to December 2011. According to the reported results, eight out of thirteen industry portfolios exhibit statistically significant regime shifts in betas due to interest rates at ten percent or below significance levels. On the other hand, only four industry portfolios exhibit regime shifts in betas due to interest rates at five percent significance level, and three of those results are significant at one percent significance level.

When rate of change in the currency basket level is considered as the threshold variable, the evidence indicates a statistically significant regime shift in betas of twelve out of thirteen portfolios at ten percent or below significance levels. The one that does not display significant variation in betas due to rate of change in the currency basket level is the portfolio consisting of firms in the industry of paper and paper products, printing and publishing. In addition, regime shifts in betas of eleven out of those twelve portfolios are also significant at five percent significance level, and seven of those are significant at one percent significance level. Therefore, currency basket signals a regime shift in a stronger manner than interest rates.

As it can be seen from the third column, eight out of thirteen experience significant changes in betas due to rate of change in the real effective currency index level at ten percent significance level, but p-values are not statistically significant at one percent significance level. On the other hand, the bootstrap p-value for Portfolio 6, the only portfolio that does not exhibit statistically significant time variation in its beta due to the currency basket, is 0.016. Therefore, sixth portfolio exhibits significant regime shift in its beta due to real effective currency index. This is probably because influence of associated industry of Portfolio 6 on overall inflation index is very limited.

The evidence is mixed for historical volatility; six out of thirteen experience significant changes in betas due to the historical volatility level at ten percent or lower significance levels. However, none of these industry portfolios experiences significant regime shifts at one percent significance level.

Table 7

Bootstrap p-values for Industry Portfolios

	RF	CB	CI	HV
Portfolio 1	0.057*	0.012**	0.091*	0.013**
Portfolio 2	0.041**	0.008***	0.016**	0.056*
Portfolio 3	0.005***	0.031**	0.493	0.124
Portfolio 4	0.779	0.000***	0.494	0.254
Portfolio 5	0.072*	0.006***	0.455	0.037**
Portfolio 6	0.062*	0.278	0.016**	0.188
Portfolio 7	0.083*	0.016**	0.030**	0.026**
Portfolio 8	0.568	0.008***	0.231	0.217
Portfolio 9	0.009***	0.001***	0.049**	0.075*
Portfolio 10	0.206	0.000***	0.059*	0.356
Portfolio 11	0.184	0.028**	0.036**	0.338
Portfolio 12	0.007***	0.000***	0.099*	0.069*
Portfolio 13	0.623	0.075*	0.739	0.115

Note: The bootstrap p-values are calculated from modified sup-LM test by following the steps outlined by Hansen (1996). The null hypothesis of no significant regime shifts in industry portfolio betas due to changes in the level of economic variables, H_0: $\delta = 0$, is tested with monthly data from January 1998 to December 2011. The bootstrap p-values are listed for each economic variable and industry portfolio in the above table. Candidate economic variables for the threshold variable are the monthly risk free rate (RF), the monthly rate of change in the Currency Basket (CB), the monthly rate of change in the Real Effective Currency Index (CI), and the historical volatility of the BIST-100 (HV). *, **, and *** denote significance levels at 10%, 5% and 1%, respectively.

The above findings indicate that the evidence of time variation is highly dependent on the underlying variable. This is in line with Harvey (2001), who argues that the results of tests on time-varying betas are highly sensitive to the choice of the instrumental variable. The econometric theory behind the threshold CAPM of Akdeniz et al. (2003) requires only one threshold variable. On the other hand, it is also possible to proxy the information set with a combination of instrumental variables, but combining variables that signal significant regime shift does not guarantee a significant regime shift in a stronger manner. Therefore, currency basket, which is the variable that produces the lowest bootstrap p-values across all portfolios except Portfolio 6, is chosen as the threshold variable for the threshold CAPM. In addition, the bootstrap p-values also indicate that rate of change in the currency basket level is good empirical proxy for changing economic environment.

5.2.2 10 Size and 10 BE/ME Portfolios

Since industry portfolios are formed with respect to industry of firms only, concentration of high (or low) market capitalization firms and high (or low) book-to-market firms are not known. The above findings could be affected from a possible size or BE/ME effect. In order to have a clear understanding of the effects of size and BE/ME factors, the sup-LM test is next performed for ten size and ten BE/ME portfolios. The associated bootstrap p-values for the test are presented in Table 8. According to Panel A, the evidence for a significant threshold effect due to interest rates is not clear, five out of ten size portfolios experience significant regime shifts in betas at ten percent significance level. Both the smallest and the biggest size portfolios exhibit statistically significant discrete variation in betas. On the other hand, seven out of size portfolios exhibit significant changes in betas due to the changes in currency basket level. Again both the smallest and the biggest size portfolios exhibit significant discrete variation in betas, but second, third and fourth biggest size portfolios does not have time-varying betas. Considering this evidence, one can argue that big stocks are not affected from the changes in the economic conditions. The significant p-value for the biggest size portfolio could be due to the concentration of high (or low) book-to-market firms in the portfolio. On the other hand, only the biggest size portfolio exhibits a significant regime shift in its beta due to rate of changes in real effective currency index level. Finally, four out of ten size portfolios, the smallest four size portfolios, exhibit significant shifts in their betas due to volatility of the market portfolio.

For portfolios sorted with respect to book-to-market ratios, the results are quite similar to those of size portfolios. According to Panel B of Table 8, again rate of change in the currency basket level is the one that signals a regime shift in betas in the strongest manner. Both value and growth portfolios exhibit significant shifts in their betas due to rate of change in the currency basket; but third, fifth and sixth highest BE/ME portfolios do not exhibit significant time variation. The sup-LM test provides conflicting evidence for the effect of book-to-market ratio. It would be better to disentangle the size and book-to-market factors, they may distort effects of each other.

5.2.3 25 Size-BE/ME Portfolios

In order to eliminate a possible BE/ME effect on size portfolios, and a size effect on BE/ME portfolios, the sup-LM test is next performed for twenty five size-BE/ME portfolios sorted with respect to their market capitalizations and book-to-market ratios.

Table 9 reports the associated bootstrap p-values for size-BE/ME portfolios. According to the first panel, the evidence for a threshold effect due to interest rate is not evident, nine out of twenty five portfolios experience significant regime shifts in betas at ten percent significance level. None of the portfolios displays statistically significant p-values for the highest BE/ME quintile. According to the second panel, twenty out of twenty five portfolios exhibit regime shifts in portfolio betas due to rate of change in the currency basket level at ten percent or lower significance levels. Presented p-values of ten of those portfolios are also significant at one percent significance level. Therefore, consistent with the above findings; the null hypothesis of no threshold effect is rejected for most of the size-BE/ME portfolios when rate of change in the currency basket level is considered as the threshold variable.

Table 8

Bootstrap p-values for 10 size and 10 BE/ME portfolios

Panel A: 10 Size Portfolios				
	RF	CB	CI	HV
Small	0.013**	0.000***	0.406	0.037**
2	0.087*	0.097*	0.458	0.063*
3	0.161	0.035**	0.126	0.088*
4	0.355	0.027**	0.180	0.023**
5	0.095*	0.012**	0.238	0.162
6	0.205	0.026**	0.338	0.104
7	0.145	0.663	0.342	0.301
8	0.275	0.169	0.165	0.271
9	0.580	0.740	0.711	0.728
Big	0.067*	0.001***	0.020**	0.144
Panel B: 10 BE/ME Portfolios				
	RF	CB	CI	HV
Low	0.364	0.065*	0.289	0.097*
2	0.027**	0.065*	0.216	0.050**
3	0.371	0.045**	0.034**	0.077*
4	0.594	0.023**	0.160	0.057*
5	0.024**	0.170	0.105	0.109
6	0.239	0.281	0.246	0.088*
7	0.454	0.047**	0.117	0.136
8	0.706	0.323	0.135	0.294
9	0.027**	0.017**	0.074*	0.054*
High	0.432	0.010***	0.188	0.064*

Note: The bootstrap p-values are calculated from modified sup-LM test by following the steps outlined by Hansen (1996). The null hypothesis of no significant regime shifts in portfolio betas due to changes in the level of economic variables, H_0: $\delta = 0$, is tested with monthly data from 1998 to 2011. The bootstrap p-values are listed for each variable in the above table. Candidates for the threshold variable are the monthly risk free rate (RF), the monthly rate of change in the Currency Basket (CB), the monthly rate of change in the Real Effective Currency Index (CI), and the volatility of the BIST-100 (HV). *, **, and *** denote significance levels at 10%, 5% and 1%, respectively.

Looking at the third panel of Table 9, one can conclude that the threshold effect due to real effective currency index is weaker for the size-BE/ME portfolios compared to industry portfolios. Only six out of twenty five exhibit significant shifts in betas at ten percent significance level.

The final panel indicates that the results are still mixing for historical volatility; thirteen out of twenty five size-BE/ME portfolios display significant changes in their betas due to the volatility at ten percent or lower significance levels. None of the value portfolios exhibits statistically significant p-values, although three out of five growth portfolios experience statistically significant shifts in their betas. This finding might indicate an evidence for the book-to-market effect, and provide an explanation for value vs. growth anomalies.

Similar to the findings for industry portfolios, size and BE/ME portfolios; the above findings suggest that investors seem to update their beta estimates for size-BE/ME portfolios due to the changes in the currency basket level.

As reported by Jagannathan and Wang (1996), the beta of an asset does not remain constant over time since relative risk of a firm's cash flow is likely to vary over time. Many other studies including Keim & Stanbough (1986), Fama & French (1989), Ferson & Harvey (1991, 1993) and Ferson and Korajczyk (1995) argue that market beta is continuously varying over time rather than being constant. On the other hand, Ghysels (1998) shows betas change through time very slowly. His findings indicate that using continuous approximation and conditional models like the conditional CAPM have a tendency to overstate the time variation. This is also confirmed with the evidence of Braun, Nelson & Sunier (1995). The findings of the bootstrap sup-LM test are consistent with these studies. Therefore, modeling the market risk as a function of an underlying variable which allows betas to respond to the movements in the economic activity may be a good approximation to capture the slow variation in betas. More specifically, this paper assumes that portfolio betas change significantly when the rate of change in the currency basket level exceeds a certain threshold level.

Table 9

Bootstrap p-values for 25 (5x5) size-BE/ME portfolios

Size\BM	Low	2	3	4	High
Panel A: RF, Risk Free Interest Rate					
Small	0.024**	0.022**	0.272	0.349	0.147
2	0.096*	0.257	0.703	0.483	0.436
3	0.327	0.566	0.117	0.007***	0.707
4	0.198	0.063*	0.007***	0.069**	0.715
Big	0.098*	0.890	0.689	0.134	0.119
Panel B: CB, Rate of Change in the Currency Basket					
Small	0.000***	0.000***	0.002***	0.025**	0.001***
2	0.007***	0.077*	0.688	0.010***	0.556
3	0.422	0.000***	0.551	0.000***	0.097*
4	0.074*	0.032**	0.043**	0.002***	0.065*
Big	0.000***	0.000***	0.552	0.082*	0.088*
Panel C: CI, Rate of Change in the Real Effective Currency Index					
Small	0.274	0.252	0.490	0.346	0.181
2	0.219	0.184	0.334	0.074*	0.318
3	0.314	0.462	0.093*	0.086*	0.065*
4	0.813	0.492	0.463	0.183	0.043**
Big	0.006***	0.281	0.228	0.992	0.122
Panel D: HV, Historical Volatility					
Small	0.004	0.021	0.048	0.149	0.341
2	0.023	0.043	0.343	0.041	0.160
3	0.191	0.016	0.089	0.006	0.288
4	0.241	0.430	0.008	0.027	0.245
Big	0.042	0.095	0.541	0.166	0.322

Note: The bootstrap p-values are calculated from modified sup-LM test by following the steps outlined by Hansen (1996). The null hypothesis of no significant regime shifts in portfolio betas due to changes in the level of economic variables, H_0: $\delta = 0$, is tested with monthly data from January 1998 to December 2011. The bootstrap p-values are listed for each economic variable in the above table. *, **, and *** denote significance levels at 10%, 5% and 1%, respectively.

5.3 Estimation

The previous section reveals significant regime shifts in betas for most of the portfolios. Since the threshold CAPM is a two-regime threshold model; beta of an asset shifts to Regime 1 when the rate of change in the currency basket level is below or equal to the threshold estimate, or Regime 2 when the rate of change in the currency basket is above the threshold estimate. In order to analyze the magnitude of the shifts, this section makes necessary estimations on portfolios.

Table 10 reports the static CAPM betas, the threshold CAPM betas in two regimes (below and above the threshold level), and the threshold estimate of the currency basket for the industry portfolios. Threshold betas and associated threshold estimates are not reported for portfolios that do not possess a threshold effect. First column shows the values for the static CAPM betas which are below one for most of the portfolios. This is probably because firms with higher beta values are mostly financial firms in the BIST, due to their highly leveraged capital structure, which are excluded from the sample. It is not surprising for portfolios 8, 10 and 13 to have high market betas since their standard deviations are too high as reported in Table 3. Looking at second and third columns in Table 10, one can observe considerable shifts in the betas of the industry portfolios. Betas of the most of the industry portfolios increase considerably from Regime 1 to Regime 2.

Therefore, investors re-assess the riskiness of the industry portfolios when rate of change in the currency basket level is above (or below) the threshold estimate. For example, the portfolio of basic metal industry (Portfolio 2) holds a less risky structure with the beta of 0.6501 when the rate of change in the currency basket level is below -0.23%. On the other hand, it becomes riskier with the beta value of 0.9171 when rate of change in the currency basket level exceeds 0.23%. If one ignores the time variation and estimates a constant beta using the static CAPM at 0.8922, serious pricing errors might occur.

Table 10

Unconditional CAPM betas. threshold CAPM betas and threshold estimates of rate of change in the currency basket level for industry portfolios

	β_{CAPM}	$\beta_{Regime\ 1}$	$\beta_{Regime\ 2}$	Threshold Estimate
Portfolio 1	0.7276	0.9221	0.7174	-0.0411
Portfolio 2	0.8922	0.6501	0.9171	-0.0023
Portfolio 3	1.0247	0.9759	1.0494	-0.0050
Portfolio 4	0.7257	0.6909	1.0743	0.1359
Portfolio 5	0.7910	0.6478	0.8958	0.0429
Portfolio 6	0.8782	-	-	-
Portfolio 7	0.8445	0.5110	0.8543	-0.0499
Portfolio 8	1.0421	1.0762	0.8464	0.1383
Portfolio 9	0.7310	0.5681	0.7692	-0.0050
Portfolio 10	1.0676	0.8849	1.2817	0.0449
Portfolio 11	0.6611	0.6013	1.2295	0.1119
Portfolio 12	0.7891	0.5896	0.9130	0.0358
Portfolio 13	1.2047	1.0069	1.3917	0.0449

Note: Unconditional CAPM betas, threshold CAPM beta estimates for two regimes, and associated threshold estimates are reported for industry portfolios when rate of change in the currency basket is used as the threshold variable.. Regime 1 (2) corresponds to lower (higher) rate of changes in currency basket than the threshold estimate. The BIST-100 index is used as a market portfolio, and the sample includes the adjusted monthly returns on industry portfolios over the period from January 1998 to December 2011. Threshold betas and associated threshold estimates are not reported for portfolios that do not possess a threshold effect.

The last column in the Table 10 also indicates that each industry portfolio responds to the fluctuations in currency basket level at different levels. Therefore, investors' response reaction threshold to fluctuations in currency basket level changes across industries. For instance, the associated threshold estimate for the portfolio of tourism (Portfolio 8) is 13.83%, hence investors have a high tolerance to increases in currency basket level. The riskiness of that portfolio is reassessed at that level, but unlike the others, beta is lower when rate of changes in the currency basket level is above the threshold. Actually, this situation is normal for tourism since rise of the foreign exchange increases the profitability of the sector. A similar case also exists for Portfolio 1. Therefore, by covarying less with the market when rate of changes in the currency basket level is higher than the estimated threshold levels, these two industries offer a hedging opportunity to investors who are averse to depreciation of the TL.

To investigate whether magnitude of changes in market betas vary across factors of size and BE/ME factors, coefficients are estimated for also the size and BE/ME portfolios. Table 11 reports the static CAPM betas, the threshold CAPM betas in Regime 1 and Regime 2, and associated threshold estimate for ten size portfolios sorted with respect to market capitalizations and ten BE/ME portfolios sorted with respect to book-to-market ratios. According to the first panel, the static CAPM betas have a tendency to increase with increasing size. The second and third columns indicate that all except one of the beta estimates for Regime 2 are higher than those for Regime 1. This implies that investors reassess the riskiness of the size portfolios when the rate of change in the currency basket level is above (or below) the threshold estimate. In addition, the beta differential between two regimes decreases from 0.61 for the smallest portfolio to 0.09 for the largest portfolio. Therefore, investors require a premium for holding stocks in small portfolios since they lose more when the currency risk is high. Figure 9 reveals that increase in the currency basket level generally results with loss in the market.

According to the Panel B of Table 11, the CAPM betas do not possess a strong BE/ME effect; actually estimated betas of the growth and value portfolios are very close. All except one of the beta estimates for Regime 2 are higher than those for

Regime 1. Beta differential in two regimes is higher for the first value portfolio than those for the second growth portfolio, but it is higher for the second growth portfolio than those for the second value portfolio.

Table 11

Unconditional CAPM betas, threshold CAPM betas and threshold estimates of rate of change in the currency basket level for size and BE/ME portfolios

Panel A: 10 Size Portfolios				
	β_{CAPM}	$\beta_{Regime\ 1}$	$\beta_{Regime\ 2}$	Threshold Estimate
Small	0.8046	0.2703	0.8787	-0.0128
2	0.7363	0.0765	0.7516	-0.0499
3	0.9046	0.8428	0.9592	0.0258
4	0.9221	0.5850	0.9681	-0.0143
5	0.8162	0.7447	0.8149	-0.0289
6	0.8301	0.9457	0.7584	0.0338
7	0.8508	-	-	-
8	0.9069	-	-	-
9	0.9279	-	-	-
Big	0.9917	0.9424	1.0379	0.0263
Panel B: 10 BE/ME Portfolios				
	β_{CAPM}	$\beta_{Regime\ 1}$	$\beta_{Regime\ 2}$	Threshold Estimate
Low	0.8818	0.5788	0.9475	0.0022
2	0.7528	0.7158	0.7918	0.0886
3	0.8823	0.7845	0.9385	0.0195
4	0.9184	0.5854	0.9581	-0.0143
5	0.8642	-	-	-
6	0.8139	-	-	-
7	0.8985	0.9299	0.6931	0.0922
8	0.9218	-	-	-
9	0.8484	0.6013	0.8809	-0.0153
High	0.8983	0.8814	1.0307	0.0835

Note: Unconditional CAPM betas, threshold CAPM beta estimates for two regimes, and associated threshold estimates are reported for size portfolios (Panel A) and BE/ME portfolios (Panel B) when rate of change in the currency basket is used as the threshold variable. Regime 1 (2) corresponds to lower (higher) rate of changes in currency basket than the threshold estimate. The BIST-100 index is used as a market portfolio, and the sample includes the adjusted monthly returns on industry portfolios over the period from January 1998 to December 2011. Threshold betas and associated threshold estimates are not reported for portfolios that do not possess a threshold effect.

To better understand the sensitivity of portfolio returns to the changes in the currency basket level, size and book-to-market effects should be disentangled from each other. Table 12 reports the static CAPM betas, the threshold CAPM betas in two regimes, and associated threshold estimate for size-BE/ME portfolios sorted with respect to size and book-to-market. Looking at the first column, one can observe that the values for the static CAPM betas are always below 1 similar to ones in Table 11. This is again probably due to the exclusion of financial firms with higher static beta values. According to second and third columns, investors' response to change in the currency basket level varies depending on the associated size and BE/ME quintiles. For example, the beta of value portfolio in the smallest size quintile holds a less risky nature when the rate of change in the currency basket level is above the threshold estimate, whereas the beta of value portfolio in the remaining size quintiles holds a less risky nature when the rate of change in the currency basket level is below the threshold estimate. This is not an expected result because Table 11 shows that small size portfolios and low book-to-market portfolios have higher betas when rate of change in the currency basket level is above the threshold estimate. The results might possibly be affected from industry of the firms. On the other hand, the first and second growth portfolios in all except one of the size quintiles exhibit lower betas in Regime 2. Therefore, growth stocks seem to offer a hedge against to the depreciation of the Turkish Lira by having a lower covariance with the market at times of high rises in the currency basket levels. The findings indicate that the demand for growth stocks in the BIST increases during those times which results with lower returns for growth stocks.

The above findings[9], which suggest that fluctuations on the currency basket impose the relationship between risk and expected return, are consistent with the literature on emerging markets. The investors care not only about market returns but also about the changes in the currency basket levels. Adler and Dumas (1984), in a pioneering effort, measure foreign currency exposure on stock returns. Jorion (1991) develops a two factor APT model by implying a linear relation between expected returns and the sensitivity to market and exchange rate movements, but the model is tested in U.S. stock markets and as a result pricing of exchange rate exposure is found to be insignificant. On the other hand, empirical studies on emerging markets, such as De Santis & Gerard (1998) and De Santis, Gerard & Hillion (2003), find that currency risk is priced in several emerging markets and its impact is time-varying. In addition, Phylaktis & Ravazzolo (2004) show that currency risk varies significantly over time in Asian emerging markets. Carrieri, Errunza & Majeberi (2006) proxy the currency risk by foreign exchange rate and claim that the impact of currency risk is high during crisis periods. On the other hand, none of the empirical studies in the literature has measured the currency exposure by regime shifting; therefore this paper is the first to apply regime shifting and threshold estimation by using the currency basket as a threshold variable.

[9] 95% confidence intervals for threshold estimates are presented in Appendix A.

Table 12

Unconditional CAPM betas, threshold CAPM betas and threshold estimates of rate of change in the currency basket level for size-BE/ME portfolios

Size	B/M	β_{CAPM}	$\beta_{Regime\ 1}$	$\beta_{Regime\ 2}$	Threshold Estimate
S	L	0.6082	0.7347	0.4941	0.0422
S	2	0.7960	0.6005	0.9856	0.0443
S	3	0.7062	0.0852	0.7570	-0.0404
S	4	0.7888	0.5869	0.7959	-0.0375
S	H	0.7500	0.8220	0.6776	0.0371
2	L	0.7796	0.7291	1.0805	0.1032
2	2	0.8021	0.8411	0.7934	-0.0386
2	3	0.7721	-	-	-
2	4	0.8672	0.9146	0.5167	0.0922
2	H	0.8612	-	-	-
3	L	0.8003	-	-	-
3	2	0.9324	0.9207	1.0926	0.1383
3	3	0.8708	-	-	-
3	4	0.8447	0.7779	0.8506	0.0089
3	H	0.8847	0.9277	0.5421	0.0922
4	L	0.8497	0.4275	0.9214	-0.0059
4	2	0.7570	0.7716	0.5911	0.1383
4	3	0.7871	0.7604	0.9289	0.0861
4	4	0.8402	1.1449	0.8076	-0.029
4	H	0.8365	0.8711	0.6199	0.0907
B	L	0.7371	0.5657	0.7475	-0.0499
B	2	0.8600	0.8161	1.0228	0.0866
B	3	0.9482	-	-	-
B	4	0.9439	0.9797	0.8031	0.0775
B	H	0.9143	0.9481	0.6732	0.1359

Note: Unconditional CAPM betas, threshold CAPM beta estimates for two regimes, and associated threshold estimates are reported for size-BE/ME portfolios when rate of change in the currency basket is used as the threshold variable. Regime 1 (2) corresponds to lower (higher) rate of changes in currency basket than the threshold estimate. The BIST-100 index is used as a market portfolio, and the sample includes the adjusted monthly returns on industry portfolios over the period from January 1998 to December 2011. Threshold betas and associated threshold estimates are not reported for portfolios that do not possess a threshold effect.

5.4 Pricing Errors

The documented evidence indicates that portfolio betas shift significantly between two regimes when rate of change in the currency basket is used as the threshold variable. Investors reassess riskiness of an asset depending on the asset class when rate of change in the currency basket level is above (or below) the threshold. In order to measure the economic value of the improvement gained over the static CAPM, pricing errors are calculated for the threshold CAPM, and compared with pricing errors of the static CAPM for which the excess returns on the portfolios are regressed only on the excess market returns. In addition, the three-factor CAPM is used as a benchmark, and pricing errors of the threshold CAPM are also compared with those of the three-factor model for which the excess returns on the portfolios are regressed on the excess market returns and returns on the size and BE/ME factors.

5.4.1 Root Mean Squared Errors

The following root mean square error formula (RMSE) is used to calculate the in sample pricing errors of the threshold CAPM, the static CAPM and the three-factor model:

$$RMSE = \sqrt{\frac{1}{T}\sum_{t}^{T}\left(r_{i,t} - \widehat{r}_{i,t}\right)^2}, \qquad (11)$$

where $r_{i,t}$ is the return on a portfolio at time *t*, and $\widehat{r}_{i,t}$ is the estimate for that return.

Table 13 reports associated pricing errors for the industry portfolios. As it is discussed in Section 5.2, portfolio 6 does not exhibit a significant threshold effect due to rate of change in the currency basket level. Hence, pricing error of the threshold CAPM is not documented for it. The pricing errors of the static CAPM ranges from a minimum of 0.0543 to a maximum of 0.1381. One can observe that the threshold CAPM produces lower pricing errors in all industries when compared to the static CAPM. The improvement in pricing errors goes up to 3.8%. Therefore, the threshold CAPM outperforms the static CAPM. However, the three-factor model yields lower pricing errors compared to the threshold CAPM in some portfolios; more precisely, seven out of twelve portfolios exhibit lower pricing errors for the three-factor model.

Table 13

Pricing errors for the unconditional CAPM, the threshold CAPM and the three-factor model on industry portfolios

	Unconditional CAPM	Threshold CAPM	3-factor Model
Portfolio 1	0.0588	0.0586*	0.0587
Portfolio 2	0.0830	0.0829	0.0828*
Portfolio 3	0.0543	0.0541	0.0534*
Portfolio 4	0.0725	0.0716	0.0706*
Portfolio 5	0.0758	0.0738	0.0651*
Portfolio 6	0.0820	-	0.0791*
Portfolio 7	0.0577	0.0570	0.0567*
Portfolio 8	0.1381	0.1375	0.1322*
Portfolio 9	0.0632	0.0623	0.0622*
Portfolio 10	0.1145	0.1120*	0.1136
Portfolio 11	0.1040	0.1036*	0.1039
Portfolio 12	0.1049	0.1039*	0.1043
Portfolio 13	0.0952	0.0916*	0.0949

Note: This table reports root mean squared pricing errors for the unconditional CAPM, the threshold CAPM, and the three-factor model. The pricing errors are calculated according to Equation 11 in Chapter 5. The sample covers the period from January 1998 to December 2011. Pricing errors for the threshold CAPM are not reported for portfolios that do not exhibit a significant threshold effect. * denotes the smallest pricing error listed in each column.

The pricing errors for the size and BE/ME portfolios are presented in Table 14. For the threshold CAPM, pricing errors are documented only for portfolios where a significant regime shift was found. According to Panel A, pricing errors of the static CAPM decreases with size. One possible explanation could be that the static CAPM might be able to price the high market capitalization firms more accurately due to the high professional trading activity of foreign instutional investors on these firms in the BIST. On the other hand, one can observe that the threshold CAPM outperforms the static CAPM in producing lower pricing errors in all size portfolios. The improvement in pricing goes up to 4.5%. However, the threshold CAPM outperforms the benchmark three-factor model for only two portfolios which are the biggest and second smallest size portfolios. As for the size portfolios, according to Panel B, the threshold CAPM performs better than the static CAPM in producing lower pricing errors in all BE/ME portfolios. The decrease in pricing errors goes up to 3.1%. However, the three-factor model again performs better than the threshold CAPM for most of the portfolios. The threshold CAPM yields lower pricing errors than those of the three-factor model for only two BE/ME portfolios.

Table 15 reports the associated root mean squared pricing errors for the size-BE/ME portfolios. Pricing errors for the threshold CAPM are not reported for portfolios that do not exhibit a significant threshold effect. According to the reported results in the first column, which are pricing errors when excess returns on the portfolios formed on size and book-to-market ratio are regressed only on the excess market returns, pricing errors are decreasing with increasing size. Therefore, the static CAPM performs better for big firms rather than small firms. Comparing these values with pricing erros of the threshold CAPM one can see that the threshold CAPM again produces lower pricing errors for all portfolios. For this time, the improvement in the pricing errors goes up to 4.3%. On the other hand, the three-factor model yields much smaller pricing errors in most of the portfolios when compared to the static CAPM and the threshold CAPM. Only four portfolios, mostly big size portfolios, have exhibit smaller pricing errors for the threshold CAPM.

Table 14

Pricing errors for the unconditional CAPM, the threshold CAPM and the three-factor model on size and BE/ME portfolios

Panel A: 10 Size Portfolios			
	Unconditional CAPM	Threshold CAPM	3-Factor Model
Small	0.1028	0.0992	0.0917*
2	0.0800	0.0784*	0.0796
3	0.0891	0.0874	0.0668*
4	0.0718	0.0697	0.0581*
5	0.0820	0.0811	0.0642*
6	0.0729	0.0717	0.0705*
7	0.0569	-	0.0528*
8	0.0620	-	0.0609*
9	0.0457	-	0.0456*
Big	0.0489	0.0467*	0.0478
Panel B: 10 BE/ME Portfolios			
	Unconditional CAPM	Threshold CAPM	3-Factor Model
Low	0.0766	0.0742	0.0725*
2	0.0651	0.0638*	0.0781
3	0.0773	0.0760	0.0676*
4	0.0717	0.0699*	0.0717
5	0.0607	-	0.0680
6	0.0732	-	0.0886
7	0.0681	0.0672	0.0578*
8	0.0613	-	0.0576*
9	0.0714	0.0703	0.0628*
High	0.0836	0.0824	0.0556*

Note: This table reports root mean squared pricing errors for the unconditional CAPM, the threshold CAPM, and the three-factor model. The pricing errors are calculated according to Equation 11 in Chapter 5. The sample covers the period from January 1998 to December 2011. Panels A and B present results for portfolios sorted with respect to market capitalizations and book-to-market ratios, respectively. Pricing errors for the threshold CAPM are not reported for portfolios that do not exhibit a significant threshold effect. * denotes the smallest pricing error listed in each column.

Table 15

Pricing errors for the unconditional CAPM, the threshold CAPM and the three-factor model on size-BE/ME portfolios

Size	B/M	Unconditional CAPM	Threshold CAPM	3-Factor Model
S	L	0.1064	0.1023	0.0917*
S	2	0.0924	0.0884	0.0796*
S	3	0.1111	0.1072	0.0931*
S	4	0.1003	0.0989	0.0789*
S	H	0.1485	0.1471	0.1276*
2	L	0.0989	0.0973	0.0791*
2	2	0.0887	0.0875	0.0754*
2	3	0.0961	-	0.0815*
2	4	0.0991	0.0972	0.0859*
2	H	0.0822	-	0.0714*
3	L	0.1350	-	0.1163*
3	2	0.0938	0.0917	0.0865*
3	3	0.0710	-	0.0659*
3	4	0.0754	0.0744	0.0716*
3	H	0.0928	0.0907	0.0828*
4	L	0.0812	0.0778	0.0725*
4	2	0.0800	0.0785	0.0781*
4	3	0.0705	0.0694	0.0676*
4	4	0.0730	0.0710*	0.0717
4	H	0.0702	0.0691	0.0680*
B	L	0.0914	0.0903	0.0886*
B	2	0.0587	0.0574*	0.0578
B	3	0.0583	-	0.0576*
B	4	0.0633	0.0621*	0.0628
B	H	0.0558	0.0542*	0.0556

Note: The root mean squared pricing errors (RMSE) for unconditional CAPM, the Fama-French (1992) three-factor model and the threshold CAPM on size-BE/ME portfolios with rate of change in the currency basket as the threshold variable are reported in this table. The sample covers the period between January 1998 and December 2011. The pricing errors are calculated according to the Equation 11 in Chapter 5. Pricing errors are not reported for the portfolios that do not possess a threshold effect. * denotes the smallest pricing error listed in each column.

5.5 Robustness Checks

The performed tests indicate that there is significant time variation in market betas with respect to changes in the currency basket level. To observe whether this finding is sensitive to alternative proxies for the currency risk, several portfolio combinations of foreign currency basket is used as additional candidates for the threshold variable. These portfolios can be listed as; USD to TL exchange rate, EURO to TL exchange rate, and currency basket with 77 % EURO per 1 USD. In addition these, real returns on the official currency basket level is also considered as a candidate. The bootstrap p-values of the sup-LM test are presented in tables 1-3 in Appendix B for different equity portfolios. According to presented p-values, rate of change in the currency basket level is still the only one that produces the lowest p-values across all portfolios relative to other proxies for the currency risk. Regarding this finding, it may be proper to conclude that neither change in the USD to TL exchange rate nor change in the EURO to TL exchange rate are not a sufficient underlying variable for time-varying beta on their own.

The robustness tests also include subperiod examinations since the literature includes a large number studies applying empirical tests on the CAPM by splitting their study periods into several subperiods to allow for breaks in market beta. As stated by Muradoglu & Aydogan (1999), market reactions may change for sub-periods that display different phases of the market. Following this argument, first, we divide our sample period into two sub-periods for deeper analysis on the BIST. The intervals for these sub-periods are: January 1998 - December 2003; and January 2004 – December 2011. These intervals provide the opportunity of comparing local and effects of global crises on the market. The first sub-period is decided to end in December 2003 because market index level increased above the pre-crisis levels in that month. In order to get pre- and post-crisis periods, each sub-period is further divided into two more sub-periods by assuming beginning dates of the crises as the breakpoints. As a result, there are four sub-periods with intervals: January 1998 – January 2001; February 2001 – December 2003; January 2004 – December 2007; and January 2008 – December 2011. The associated bootstrap p-values of the sup-LM test are presented in the Appendix. According to Table 4, only two out of thirteen industry portfolios exhibit statistically significant regime shifts in betas due to rate of changes in the currency basket level during the sub-period between January 1998 – December 2003. On the other hand, twelve out of thirteen industry portfolios exhibit significant changes in betas for the sub-period January 2004 – December 2011, on top of that eleven of those are significant at one percent significance level. Considering the pre- and post-crisis sub-periods, one can observe that all except one of industry portfolios do not indicate a significant regime shift in betas during the sub-period of pre-2001 crisis, and only five industry portfolios exhibit a significant shift during the sub-period of post-2001 crisis. On the contrary, the sub-period including the global crisis in 2007/2008 presents significant evidence for discrete time variation in betas. Twelve out of thirteen industry portfolios exhibit shifts in betas in pre-crisis sub-period, and seven portfolios exhibit significant shifts in betas for post-crisis sub-period at ten percent or below significance levels. Similar findings are also observable on size and BE/ME portfolios; according to Table 5, all except one of the size portfolios and all of the BE/ME portfolios do not exhibit any significant evidence for discrete time variation during January 1998 – December 2003. Only two out of then size portfolios exhibit significant shifts in betas in the post-crisis sub-period. On the other hand, we observe significant discrete time variation on most of the portfolios, except big size deciles, during the sub-period between January 2004 and December 2011, especially in the pre-crisis sub-period. By looking at Table 6, one can observe similar findings on twenty five size-BE/ME portfolios; and portfolios that do not exhibit significant variation in betas are only in biggest size deciles for the second sub-period, the remaining portfolios exhibit at ten percent or below significance levels. On the other hand, most of the portfolios do not have time-varying betas due to changes in currency basket for the first sub-period. By considering these findings, one can conclude that there are still significant time variation in most of the betas even the whole period is divided into two or four sub-periods. The pricing errors are also supportive for the threshold CAPM; according to tables 7-9, threshold CAPM still yields lower pricing errors than the unconditional CAPM for most of the portfolios even two or four sub-periods are considered. Table 8 shows that only the biggest size and growth portfolios have pricing errors for the static CAPM with 4-subperiods than those for the threshold CAPM. Similarly, Table 9 shows that only the growth portfolios in the biggest size quintile exhibit lower pricing errors for static CAPM with two or four sub-periods. These findings indicate that dynamics of time variation in betas changes across market capitalizations and book-to-market ratios.

The above findings indicate that there is no significant time-variation in betas for most of the portfolios due to the changes in currency basket during the sub-periods January 1998 – January 2001 and February 2001 – December 2003. Since the crisis in 2001 is a local crisis and there were high fluctuations on interest rates during those intervals, there might be a variation due to interest rates. Therefore, as a further analysis, we also consider interest rate as a threshold variable to observe whether results are changing for the chosen threshold variable or not. The bootstrap p-values are reported in tables 10-12 for industry portfolios, size and BE/ME portfolios and twenty five size-BE/ME portfolios. Number of portfolios that exhibit time variation in betas increases for sub-periods January 1998 – January 2001 and February 2001 – December 2003, when interest rate is the threshold parameter, but same number decreases for the sub-periods January 2004 – December 2007 and January 2008 – December 2011. One possible explanation for this finding could be that interest rate risk was high during first two sub-periods, and low for last two sub-periods. This is in line with the literature that market reactions may change for different sub-periods. Investors reassess an asset's riskiness during January 2004 – December 2011 when changes in currency basket reaches a certain threshold level, but they do not reassess during January 1998 – December 2003 with respect to changes in currency basket.

CHAPTER VI

CONCLUSION

This thesis investigates the time variation in beta of stocks trading in the Borsa Istanbul Stock Exchange by following non-linear time series approach of Akdeniz et al. (2003). The data for 150 to 227 nonfinancial firms are used in the study covering the period from 1998 to 2011. Main argument of the study is that the relationship between risk and expected return changes significantly at different points in time in relation with changes in the economic environment, and the threshold CAPM should be able to capture the discrete changes.

First, results show that there is significant time variation in betas with respect to rate of changes in the currency basket level. Second, the results also indicate that evidence of time variation is highly dependent on the choice of the instrumental variable; in this particular, currency risk proxied by currency basket is found to be one of the most significant instrumental variables to stand in for changes in the economic conditions of Turkey. Moreover, dynamics of time variation differ across industry specifications, market capitalizations and book-to-market ratios. In particular, industries whose profitability is positively related with the foreign exchange rate are less risky during times of rises in the currency basket level. In addition, small market capitalization portfolios have more risk premium compared to large market capitalization portfolios when rate of changes in the currency basket is high. Moreover, the growth portfolios exhibit lower betas when rate of change in the currency basket level is high, but higher betas when rate of change in the currency basket level is low. Therefore, growth stocks seem to offer a hedge against to the depreciation of the Turkish Lira by having a lower covariance with the market.

When compared with alternative asset pricing models, the threshold CAPM outperforms the static CAPM since it produces lower pricing errors. On the other hand, the threshold CAPM still yields higher pricing errors than those of the three-factor model for most of the portfolios; but big market capitalization firms and big-growth firms display smaller pricing errors for the threshold CAPM. Finally, the sub-period investigations reveal that sample splitting technique is not able to capture time variation in betas since most of the portfolios still exhibit variation in betas over several subperiods.

The findings of this study have important implications for both portfolio managers and investors who are performing asset allocation, portfolio selection and hedging decisions in Turkish markets. This study empirically presents that the threshold CAPM performs better than the static CAPM. Therefore, it is better to use the threshold CAPM instead of the static CAPM in analysis. In addition, the knowledge of dynamics of time-varying betas could contribute to dynamic strategies for hedging.

As a conclusion, this study contributes to the asset pricing literature in several ways. Since the literature does not provide any evidence for slowly and discretely changing nature of betas in the Borsa Istanbul Stock Exchange, this thesis seems to be the first in modeling time-varying betas with a regime shifting model. In addition, it is discovered that investors of the BIST care not only about market returns but also about the exchange rates, and further changes in the exchange rates of major world currencies directly reflect the changes in the economic conditions.

There is still more to do to discover about the dynamics of time-varying betas on the Borsa Istanbul Stock Exchange. For the future research, alternative non-linear approaches, notably multi-regime threshold models and Markow-switching frameworks should be utilized to model time-varying betas in order to examine whether the threshold CAPM accurately captures the variation. Furthermore, the possibility of additional regimes for betas should be analyzed. Finally, I plan to include other emerging markets in tests to investigate whether findings of this study are specific to Turkey or also hold for other emerging markets.

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APPENDICES

APPENDIX A: 95% Confidence Intervals for Estimations

Table A.1

95 % confidence intervals for threshold beta estimates

	$\beta_{Regime\ 1}$		$\beta_{Regime\ 2}$		Threshold Estimates	
Portfolio 1	0.3726	1.2849	0.4999	1.2849	-0.0727	0.2275
Portfolio 2	0.3511	0.9490	0.8205	1.0138	-0.0023	-0.0023
Portfolio 3	0.8145	1.1393	0.7744	1.1430	-0.0404	0.1359
Portfolio 4	0.7844	0.9378	0.9378	1.2108	0.1161	0.1363
Portfolio 5	0.3892	1.0623	0.6241	1.0876	-0.0727	0.2275
Portfolio 6						
Portfolio 7	0.4020	0.6278	0.7874	0.9209	-0.0499	-0.0497
Portfolio 8	0.9014	1.2590	0.4775	1.2152	0.0119	0.1383
Portfolio 9	0.3445	1.3434	0.5805	0.8389	-0.0524	0.1383
Portfolio 10	0.7873	0.9824	0.9385	1.6250	0.0449	0.0449
Portfolio 11	0.2198	0.8795	0.7208	1.3576	0.0141	0.1383
Portfolio 12	0.8793	1.1612	0.5742	1.8711	-0.0727	0.2275
Portfolio 13	0.8487	1.1294	1.1589	1.6115	0.0381	0.0449

Note: This table reports the 95% confidence intervals of threshold betas, and their associated threshold estimates when rate of change in the currency basket is used as the threshold parameter except for sixth portfolio. For the sixth portfolio, rate of change in the real effective currency index is used as the threshold parameter since there is no significant regime shifts due to changes in currency basket. The BIST-100 index is used as a market portfolio. The sample includes the adjusted monthly returns of industry portfolios during the period from January 1998 to December 2011. For the threshold beta estimates, regime 1 (2) corresponds to lower (higher) rate of changes in currency basket than the associated threshold estimate. The * denotes the 95% confidence interval when rate of change in the real effective currency index is used as the threshold parameter.

Table A.2

95 % confidence intervals for threshold beta estimates

Panel A: 10 Size Portfolios						
	$\beta_{Regime\ 1}$		$\beta_{Regime\ 2}$		Threshold Estimates	
Small	-0.1508	0.6574	0.7280	1.0277	-0.0153	-0.0128
2	-0.3554	0.1833	0.6426	0.8605	-0.0499	-0.0499
3	0.6950	0.9905	0.7698	1.1487	0.0258	0.0258
4	0.3816	0.8434	0.8772	1.0713	-0.0153	-0.0045
5	0.5351	0.9615	0.7247	0.9031	-0.0290	-0.0284
6	0.8272	1.0641	0.6432	0.8737	0.0338	0.0338
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	-	-	-
Big	0.7087	1.0299	0.9794	1.1007	-0.0045	0.0332
Panel B: 10 BE/ME Portfolios						
	$\beta_{Regime\ 1}$		$\beta_{Regime\ 2}$		Threshold Estimates	
Low	0.5788	0.9475	0.8185	1.0626	-0.0162	0.0322
2	0.7158	0.7918	0.6799	0.9038	0.0886	0.0886
3	0.7845	0.9385	0.7357	1.1386	-0.0166	0.0449
4	0.5854	0.9581	0.8800	1.0363	-0.0143	-0.0143
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	0.9299	0.6931	0.5114	1.0252	-0.0727	0.2275
8	-	-	-	-	-	-
9	0.6013	0.8809	0.7429	1.1292	-0.0413	0.1383
High	0.8814	1.0307	0.5185	1.5440	-0.0404	0.0968

Note: This table reports the 95% confidence intervals of threshold betas, and their associated threshold estimates for 10 size and 10 BE/ME portfolios when rate of change in the currency basket is used as the threshold parameter The BIST-100 index is used as a market portfolio. The sample includes the adjusted monthly returns of 5x5 portfolios during the period from January 1998 to December 2010. For the threshold beta estimates, regime 1 (2) corresponds to lower (higher) rate of changes in currency basket than the associated threshold estimate. Confidence interevals are not reported for portfolios that do not possess a statistically significant threshold effect.

Table A.3

95 % Confidence intervals for threshold beta estimates of size-BE/ME portfolios

Size	B/M	$\beta_{\text{Regime 1}}$		$\beta_{\text{Regime 2}}$		Threshold Estimate	
S	L	0.5245	0.9450	0.3575	0.6307	0.0393	0.0422
S	2	0.3990	0.8086	0.8475	1.1031	0.0429	0.0449
S	3	-0.6793	0.4684	0.6079	0.9046	-0.0411	-0.0404
S	4	0.0370	1.1473	0.6310	0.9607	-0.0386	-0.0375
S	H	-0.1154	1.2189	0.5356	0.9101	-0.0404	0.0703
2	L	0.0329	1.3735	0.5307	6.3451	-0.0727	0.2275
2	2	0.6966	0.9855	0.6747	0.9121	-0.0386	-0.0386
2	3	-	-	-	-	-	-
2	4	0.6898	1.1055	0.3115	0.8520	0.0866	0.0968
2	H	-	-	-	-	-	-
3	L	-	-	-	-	-	-
3	2	0.7737	1.0717	0.8188	1.3664	0.1119	0.1383
3	3	-	-	-	-	-	-
3	4	0.1851	1.2943	0.4597	3.8759	-0.0727	0.2275
3	H	-0.3783	1.2067	0.2341	5.9552	-0.0727	0.2275
4	L	0.2083	0.6466	0.7893	1.0535	-0.0059	-0.0059
4	2	0.6849	0.8808	0.3309	0.8455	-0.0524	0.1383
4	3	0.5305	1.3831	0.5871	1.1222	-0.0727	0.2275
4	4	0.4754	1.6666	0.5367	3.9906	-0.0727	0.2275
4	H	0.2681	2.1990	0.3166	6.2206	-0.0727	0.2275
B	L	0.3466	0.7849	0.6735	0.8215	-0.0499	-0.0499
B	2	0.7394	0.8865	0.8333	1.2111	-0.0045	0.0898
B	3	-	-	-	-	-	-
B	4	0.8367	1.1264	0.6695	0.9336	0.0598	0.0810
B	H	0.8847	1.0116	0.5347	0.8116	0.1359	0.1359

Note: This table reports the 95% confidence intervals of threshold betas, and their associated threshold estimates for size-BE/ME portfolios when rate of change in the currency basket is used as the threshold parameter The BIST-100 index is used as a market portfolio. The sample includes the adjusted monthly returns of 5x5 portfolios during the period from January 1998 to December 2010. For the threshold beta estimates, regime 1 (2) corresponds to lower (higher) rate of changes in currency basket than the associated threshold estimate. Confidence interevals are not reported for portfolios that do not possess a statistically significant threshold effect.

APPENDIX B: Robustness Check Results

Table B.1

Robustness check with alternative measures of threshold variables on industry portfolios

	Original Weights	1 US Dollar 0.77 EURO	US Dollar	EURO
Portfolio 1	0.012**	0.017**	0.124	0.071
Portfolio 2	0.008***	0.010***	0.058*	0.039**
Portfolio 3	0.031**	0.271	0.417	0.530
Portfolio 4	0.000***	0.027**	0.008***	0.605
Portfolio 5	0.006***	0.127	0.038**	0.123
Portfolio 6	0.278	0.690	0.486	0.162
Portfolio 7	0.016**	0.033**	0.027**	0.069*
Portfolio 8	0.008***	0.035**	0.129	0.118
Portfolio 9	0.001***	0.003***	0.001***	0.001***
Portfolio 10	0.000***	0.002***	0.006***	0.002***
Portfolio 11	0.028**	0.035**	0.238	0.015**
Portfolio 12	0.000***	0.011**	0.028**	0.039**
Portfolio 13	0.075*	0.187	0.191	0.789

Note: This table reports the bootstrap p-values that are calculated by modified sup-LM test in Hansen (1996). The null hypothesis of no significant regime shifts in industry betas due to changes in the level of threshold variable, H_0: $\delta = 0$ is tested with montly data from January 1998 to December 2011. *, **, and *** denote significance levels at 10%, 5% and 1%, respectively.

Table B.2

Robustness check with alternative measures of threshold variables on size and BE/ME portfolios

Panel A: 10 Size Portfolios				
Size	S1	S2	S1.1	S1.2
Small	0.000***	0.000***	0.000***	0.019**
2	0.097	0.702	0.405	0.271
3	0.035**	0.261	0.322	0.141
4	0.027**	0.228	0.179	0.323
5	0.012**	0.224	0.405	0.114
6	0.026**	0.040**	0.021**	0.121
7	0.663	0.841	0.760	0.682
8	0.169	0.233	0.165	0.341
9	0.740	0.435	0.439	0.786
Big	0.001***	0.001***	0.000***	0.019**
Panel B: 10 BE/ME Portfolios				
BE/ME	S1	S2	S1.1	S1.2
Low	0.065*	0.262	0.127	0.332
2	0.065*	0.015**	0.017**	0.648
3	0.045**	0.086*	0.161	0.017**
4	0.023**	0.092*	0.060*	0.270
5	0.170	0.738	0.640	0.496
6	0.281	0.557	0.604	0.620
7	0.047**	0.114	0.269	0.196
8	0.323	0.208	0.253	0.256
9	0.017**	0.050**	0.075*	0.013**
High	0.010***	0.135	0.179	0.167

Note: This table reports the bootstrap p-values that are calculated by modified sup-LM test in Hansen (1996). The null hypothesis of no significant regime shifts in betas of size-BE/ME portfolios due to changes in the level of currency portfolios, H_0: $\delta = 0$ is tested with montly data from January 1998 to December 2011. *, **, and *** denote significance levels at 10%, 5% and 1%, respectively.

Table B.3

Robustness check with alternative measures of threshold variables on size-BE/ME portfolios

Size	B/M	Currency Basket	US Dollar	EURO	1 US Dollar 0.77 Euro
S	L	0.001***	0.016**	0.087*	0.022**
S	2	0.001***	0.044**	0.044**	0.032**
S	3	0.001***	0.005***	0.254	0.009***
S	4	0.030**	0.351	0.129	0.124
S	H	0.001***	0.068*	0.106	0.134
2	L	0.005***	0.115	0.212	0.085*
2	2	0.043**	0.236	0.026**	0.229
2	3	0.608	0.843	0.654	0.844
2	4	0.013**	0.148	0.146	0.048**
2	H	0.616	0.898	0.720	0.557
3	L	0.325	0.639	0.302	0.660
3	2	0.001***	0.050**	0.040**	0.055*
3	3	0.407	0.672	0.466	0.229
3	4	0.002***	0.019**	0.018**	0.008***
3	H	0.077*	0.265	0.124	0.283
4	L	0.079*	0.346	0.921	0.365
4	2	0.040**	0.218	0.451	0.554
4	3	0.090*	0.502	0.283	0.649
4	4	0.002***	0.034**	0.020**	0.025**
4	H	0.041**	0.019**	0.062	0.081*
B	L	0.001***	0.025**	0.014**	0.019**
B	2	0.001***	0.015**	0.232	0.051*
B	3	0.540	0.105	0.112	0.140
B	4	0.069*	0.062*	0.480	0.145
B	H	0.032**	0.135	0.073*	0.030**

Note: This table reports the bootstrap p-values that are calculated by modified sup-LM test in Hansen (1996). The null hypothesis of no significant regime shifts in betas of size-BE/ME portfolios due to changes in the level of threshold variable, H_0: $\delta = 0$ is tested with montly data from January 1998 to December 2011. *, **, and *** denote significance levels at 10%, 5% and 1%, respectively.

Table B.4

The bootstrap p-values for industry portfolios during several subperiods

	S1	S2	S1.1	S1.2	S2.1	S2.2
Portfolio 1	0.096*	0.186	0.957	0.012**	0.114	0.322
Portfolio 2	0.404	0.000***	0.756	0.116	0.000***	0.441
Portfolio 3	0.432	0.006***	0.139	0.158	0.020**	0.096*
Portfolio 4	0.331	0.000***	0.810	0.070*	0.000***	0.074*
Portfolio 5	0.678	0.000***	0.292	0.336	0.011**	0.035**
Portfolio 6	0.289	0.063*	0.665	0.126	0.003***	0.203
Portfolio 7	0.455	0.003***	0.285	0.000***	0.001***	0.026**
Portfolio 8	0.714	0.000***	0.953	0.729	0.000***	0.003***
Portfolio 9	0.001***	0.000***	0.008***	0.150	0.000***	0.416
Portfolio 10	0.247	0.000***	0.554	0.136	0.001***	0.006***
Portfolio 11	0.185	0.003***	0.336	0.067*	0.000***	0.169
Portfolio 12	0.391	0.000***	0.166	0.061*	0.000***	0.331
Portfolio 13	0.998	0.000***	0.654	0.956	0.032**	0.017**

Note: The bootstrap p-values are calculated from modified sup-LM test by following the steps outlined by Hansen (1996). The null hypothesis of no significant regime shifts in industry portfolio betas due to rate of change in the level of currency basket., H_0: $\delta = 0$, is tested with montly data from January 1998 to December 2011.The bootstrap p-values are listed for each subperiod in the table. Periods are defined as following; S1 is January 1998 - December 2003, S2 is January 2004 – December 2011, S1.1 is January 1998 – January 2001, S1.2 is February 2001 – December 2003, S2.1 is January 2004 – December 2007, and S2.2 is January 2008 – December 2001. *, **, and *** denote significance levels at 10%, 5% and 1%, respectively.

Table B.5

The bootstrap p-values for size portfolios during several subperiods

Panel A: 10 Size Portfolios						
Size	S1	S2	S1.1	S1.2	S2.1	S2.2
Small	0.206	0.000***	0.277	0.204	0.000***	0.002***
2	0.985	0.000***	0.665	0.951	0.000***	0.234
3	0.722	0.001***	0.457	0.773	0.002***	0.042**
4	0.765	0.005***	0.465	0.257	0.000***	0.210
5	0.445	0.003***	0.161	0.701	0.003***	0.265
6	0.104	0.001***	0.653	0.070*	0.000***	0.581
7	0.988	0.046	0.953	0.980	0.003***	0.047**
8	0.577	0.023**	0.305	0.193	0.150	0.035**
9	0.680	0.774	0.797	0.147	0.481	0.819
Big	0.010***	0.378	0.779	0.001***	0.075*	0.424
Panel B: 10 BE/ME Portfolios						
BE/ME	S1	S2	S1.1	S1.2	S2.1	S2.2
Low	0.532	0.001***	0.627	0.730	0.000***	0.720
2	0.654	0.001***	0.364	0.378	0.000***	0.519
3	0.588	0.004***	0.588	0.178	0.015**	0.066*
4	0.698	0.000***	0.442	0.704	0.013**	0.092*
5	0.736	0.048**	0.332	0.744	0.024**	0.048**
6	0.700	0.039**	0.836	0.819	0.033**	0.574
7	0.360	0.032**	0.626	0.531	0.012**	0.295
8	0.808	0.056*	0.823	0.807	0.014**	0.609
9	0.368	0.000***	0.349	0.529	0.000***	0.090*
High	0.872	0.001***	0.404	0.135	0.004***	0.108

Note: The bootstrap p-values are calculated from modified sup-LM test by following the steps outlined by Hansen (1996). The null hypothesis of no significant regime shifts in size portfolio betas (Panel A) and BE/ME portfolio betas (Panel B) due to rate of change in the level of currency basket., H_0: $\delta = 0$, is tested with montly data from January 1998 to December 2011.The bootstrap p-values are listed for each subperiod in the table. Periods are defined as following; S1 is January 1998 - December 2003, S2 is January 2004 – December 2011, S1.1 is January 1998 – January 2001, S1.2 is February 2001 – December 2003, S2.1 is January 2004 – December 2007, and S2.2 is January 2008 – December 2001. *, **, and *** denote significance levels at 10%, 5% and 1%, respectively.

Table B.6

The bootstrap p-values for 5x5 size-BE/ME portfolios during several subperiods

Size	B/M	S1	S2	S1.1	S1.2	S2.1	S2.2
S	L	0.604	0.000***	0.768	0.400	0.000***	0.014**
S	2	0.227	0.000***	0.790	0.362	0.000***	0.031**
S	3	0.504	0.000***	0.632	0.069*	0.000***	0.167
S	4	0.387	0.000***	0.463	0.209	0.001***	0.273
S	H	0.527	0.000***	0.496	0.277	0.001***	0.002***
2	L	0.741	0.000***	0.841	0.504	0.000***	0.145
2	2	0.334	0.003***	0.428	0.835	0.000***	0.045**
2	3	0.331	0.001***	0.835	0.268	0.025**	0.310
2	4	0.843	0.000***	0.414	0.064*	0.000***	0.338
2	H	0.730	0.004***	0.533	0.287	0.000***	0.244
3	L	0.581	0.000***	0.369	0.015**	0.000***	0.032**
3	2	0.757	0.000***	0.892	0.036**	0.003***	0.003***
3	3	0.745	0.018**	0.856	0.609	0.005***	0.129
3	4	0.258	0.003***	0.150	0.368	0.002***	0.493
3	H	0.308	0.000***	0.857	0.996	0.000***	0.438
4	L	0.581	0.000***	0.924	0.481	0.000***	0.064*
4	2	0.021**	0.001***	0.129	0.258	0.003***	0.184
4	3	0.140	0.019**	0.249	0.408	0.002***	0.173
4	4	0.051*	0.006***	0.758	0.017**	0.015**	0.234
4	H	0.481	0.000***	0.516	0.070*	0.000***	0.024**
5	L	0.056*	0.000***	0.325	0.000***	0.000***	0.068*
5	2	0.744	0.001***	0.632	0.000***	0.004***	0.048**
5	3	0.171	0.316	0.750	0.714	0.103	0.997
5	4	0.632	0.511	0.882	0.006***	0.473	0.458
5	H	0.489	0.025**	0.796	0.057*	0.009***	0.111

Note: The bootstrap p-values are calculated from modified sup-LM test by following the steps outlined by Hansen (1996). The null hypothesis of no significant regime shifts in size –BE/ME portfolio betas due to rate of change in the level of currency basket., H_0: $\delta = 0$, is tested with montly data from January 1998 to December 2011.The bootstrap p-values are listed for each subperiod in the table. Periods are defined as following; S1 is January 1998 - December 2003, S2 is January 2004 – December 2011, S1.1 is January 1998 – January 2001, S1.2 is February 2001 – December 2003, S2.1 is January 2004 – December 2007, and S2.2 is January 2008 – December 2001. *, **, and *** denote significance levels at 10%, 5% and 1%, respectively.

Table B.7

Comparison of pricing errors for unconditional CAPMs and the threshold CAPM on industry portfolios

Industry	Unconditional CAPM	2 Subperiods	4 Subperiods	Threshold CAPM
Portfolio 1	0.0588	0.0587	0.0586*	0.0586*
Portfolio 2	0.0830	0.0829	0.0822*	0.0829
Portfolio 3	0.0543	0.0538	0.0525*	0.0541
Portfolio 4	0.0725	0.0722	0.0721	0.0716*
Portfolio 5	0.0758	0.0752	0.0747	0.0738*
Portfolio 6	0.0820	0.0818	0.0805*	-
Portfolio 7	0.0577	0.0574	0.0572	0.0570*
Portfolio 8	0.1381	0.1367	0.1363*	0.1375
Portfolio 9	0.0632	0.0619	0.0616*	0.0623
Portfolio 10	0.1145	0.1132	0.1126	0.1120*
Portfolio 11	0.1040	0.1024	0.0980*	0.1036
Portfolio 12	0.1049	0.1042	0.1040	0.1039*
Portfolio 13	0.0952	0.0933	0.0925	0.0916*

Note: This table presents root mean squared pricing errors for the unconditional CAPM over several periods and for the threshold CAPM over the whole sample period. The pricing errors are calculated for industry portfolios according to Equation 11 in Section 5. First, second and third columns report the results when the whole sample period, two sub-periods, and four sub-periods are considered in time-series regressions. Periods are described in Section 5.5. The BIST-100 index is used as a proxy for the market portfolio. The sample includes the adjusted monthly returns on portfolios over the period from January 1998 to December 2011. Pricing errors for the threshold CAPM are not reported for portfolios that do not exhibit a significant threshold effect. * denotes the smallest pricing error listed in each column.

Table B.8

Comparison of pricing errors for unconditional CAPMs and the threshold CAPM

on 10 size and 10 BE/ME portfolios

Panel A: 10 Size Portfolios				
Size	Unconditional CAPM	2 Subperiods	4 Subperiods	Threshold CAPM
Small	0.1028	0.1026	0.1012	0.0992*
2	0.0800	0.0797	0.0788	0.0784*
3	0.0891	0.0888	0.0877	0.0874*
4	0.0718	0.0715	0.0705	0.0697*
5	0.0820	0.0818	0.0813	0.0811*
6	0.0729	0.0728	0.0723	0.0717*
7	0.0569	0.0567	0.0565*	-
8	0.0620	0.0618	0.0607*	-
9	0.0457	0.0454	0.0453*	-
Big	0.0489	0.0469	0.0456*	0.0467

Panel B: 10 BE/ME Portfolios				
BE/ME	Unconditional CAPM	2 Subperiods	4 Subperiods	Threshold CAPM
Low	0.0766	0.0764	0.0752	0.0742*
2	0.0651	0.0650	0.0648	0.0638*
3	0.0773	0.0768	0.0763	0.0760*
4	0.0717	0.0715	0.0700	0.0699*
5	0.0607	0.0607	0.0605*	-
6	0.0732	0.0727	0.0727*	-
7	0.0681	0.0680	0.0677	0.0672*
8	0.0613	0.0608	0.0602*	-
9	0.0714	0.0713	0.0708	0.0703*
High	0.0836	0.0829	0.0819*	0.0824

Note: This table presents root mean squared pricing errors for the unconditional CAPM over several periods and for the threshold CAPM over the whole sample period. The pricing errors are calculated according to Equation 11 in Section 5. Panel A and B stand for portfolios sorted with respect to market capitalizations and book-to-market ratios.First, second and third columns report the results when the whole sample period, two sub-periods, and four sub-periods are considered in time-series regressions. Periods are described in Section 5.5. The BIST-100 index is used as a proxy for the market portfolio. The sample includes the adjusted monthly returns on portfolios over the period from January 1998 to December 2011. Pricing errors for the threshold CAPM are not reported for portfolios that do not exhibit a significant threshold effect. * denotes the smallest pricing error listed in each column.

Table B.9

Comparison of pricing errors for unconditional CAPMs and the threshold CAPM

on 5x5 size-BE/ME portfolios

Size	B/M	Unconditional CAPM	2 Subperiods	4 Subperiods	Threshold CAPM
S	L	0.1064	0.1049	0.1041	0.0917*
S	2	0.0924	0.0920	0.0916	0.0796*
S	3	0.1111	0.1095	0.1081	0.0931*
S	4	0.1003	0.1002	0.1000	0.0789*
S	H	0.1485	0.1481	0.1475	0.1276*
2	L	0.0989	0.0986	0.0980	0.0791*
2	2	0.0887	0.0885	0.0866	0.0754*
2	3	0.0961	0.0959	0.0953*	-
2	4	0.0991	0.0986	0.0980	0.0859*
2	H	0.0822	0.0821	0.0806*	-
3	L	0.1350	0.1335	0.1322*	-
3	2	0.0938	0.0936	0.0930	0.0865*
3	3	0.0710	0.0710	0.0708*	-
3	4	0.0754	0.0752	0.0750	0.0716*
3	H	0.0928	0.0923	0.0916	0.0828*
4	L	0.0812	0.0809	0.0793	0.0725*
4	2	0.0800	0.0799	0.0797	0.0781*
4	3	0.0705	0.0705	0.0698	0.0676*
4	4	0.0730	0.0730	0.0720	0.0717*
4	H	0.0702	0.0701	0.0694	0.0680*
B	L	0.0914	0.0910	0.0904	0.0886*
B	2	0.0587	0.0580	0.0575*	0.0578
B	3	0.0583	0.0580	0.0572*	-
B	4	0.0633	0.0629	0.0620*	0.0628
B	H	0.0558	0.0557	0.0537*	0.0556

Note: This table presents root mean squared pricing errors for the unconditional CAPM over several periods and for the threshold CAPM over the whole sample period. The pricing errors are calculated for size-BE/ME portfolios according to Equation 11 in Section 5. First, second and third columns report the results when the whole sample period, two sub-periods, and four sub-periods are considered in time-series regressions. Periods are described in Section 5.5. The BIST-100 index is used as a proxy for the market portfolio. The sample includes the adjusted monthly returns on portfolios over the period from January 1998 to December 2011. Pricing errors for the threshold CAPM are not reported for portfolios that do not exhibit a significant threshold effect. * denotes the smallest pricing error listed in each column.

Table B.10

The bootstrap p-values for industry portfolios when interest rate is considered as a threshold variable

	S1.1	S1.2	S2.1	S2.2
Portfolio 1	0.779	0.001***	0.510	0.192
Portfolio 2	0.234	0.302	0.140	0.662
Portfolio 3	0.267	0.322	0.907	0.734
Portfolio 4	0.377	0.310	0.464	0.448
Portfolio 5	0.159	0.028**	0.979	0.124
Portfolio 6	0.033**	0.216	0.555	0.052*
Portfolio 7	0.048**	0.016**	0.116	0.509
Portfolio 8	0.075*	0.244	0.856	0.163
Portfolio 9	0.015**	0.034**	0.352	0.840
Portfolio 10	0.878	0.707	0.537	0.577
Portfolio 11	0.157	0.024**	0.320	0.174
Portfolio 12	0.357	0.072*	0.610	0.335
Portfolio 13	0.847	0.236	0.993	0.853

Note: The bootstrap p-values are calculated from modified sup-LM test by following the steps outlined by Hansen (1996). The null hypothesis of no significant regime shifts in industry portfolio betas due to interest rates, H_0: $\delta = 0$, is tested with montly data over the period from January 1998 to December 2011.The bootstrap p-values are listed for each subperiod in the table. Periods are defined as following; S1 is January 1998 - December 2003, S2 is January 2004 – December 2011, S1.1 is January 1998 – January 2001, S1.2 is February 2001 – December 2003, S2.1 is January 2004 – December 2007, and S2.2 is January 2008 – December 2001. *, **, and *** denote significance levels at 10%, 5% and 1%, respectively.

Table B.11

The bootstrap p-values for 10 size and 10 BE/ME portfolios when interest rate is considered as a threshold variable

Panel A: 10 Size Portfolios				
Size	S1.1	S1.2	S2.1	S2.2
Small	0.297	0.157	0.704	0.989
2	0.365	0.216	0.640	0.190
3	0.668	0.096*	0.439	0.579
4	0.852	0.032**	0.988	0.432
5	0.431	0.345	0.659	0.631
6	0.122	0.000***	0.961	0.575
7	0.594	0.007***	0.820	0.306
8	0.392	0.037**	0.855	0.997
9	0.850	0.006***	0.685	0.344
Big	0.063*	0.079*	0.678	0.240
Panel B: 10 BE/ME Portfolios				
BE/ME	S1.1	S1.2	S2.1	S2.2
Low	0.627	0.237	0.413	0.099*
2	0.364	0.131	0.732	0.002***
3	0.588	0.092*	0.875	0.429
4	0.442	0.077*	0.916	0.777
5	0.332	0.156	0.679	0.687
6	0.836	0.023**	0.770	0.680
7	0.626	0.091*	0.971	0.622
8	0.823	0.150	0.993	0.701
9	0.349	0.043**	0.460	0.772
High	0.404	0.084*	0.946	0.720

Note: The bootstrap p-values are calculated from modified sup-LM test by following the steps outlined by Hansen (1996). The null hypothesis of no significant regime shifts in size portfolio betas (Panel A) and BE/ME portfolio betas (Panel B) due to interest rates, H_0: $\delta = 0$, is tested with montly data from January 1998 to December 2011.The bootstrap p-values are listed for each subperiod in the table. Periods are defined as following; S1 is January 1998 - December 2003, S2 is January 2004 – December 2011, S1.1 is January 1998 – January 2001, S1.2 is February 2001 – December 2003, S2.1 is January 2004 – December 2007, and S2.2 is January 2008 – December 2001. *, **, and *** denote significance levels at 10%, 5% and 1%, respectively.

Table B.12

The bootstrap p-values for 5x5 size-BE/ME portfolios when interest rate is considered as a threshold variable

Size	B/M	S1.1	S1.2	S2.1	S2.2
S	L	0.437	0.437	0.623	0.378
S	2	0.063*	0.063*	0.852	0.324
S	3	0.181	0.181	0.288	0.118
S	4	0.808	0.808	0.770	0.249
S	H	0.359	0.359	0.209	0.664
2	L	0.045**	0.045**	0.917	0.338
2	2	0.147	0.147	0.571	0.404
2	3	0.481	0.481	0.879	0.998
2	4	0.030**	0.030**	0.930	0.180
2	H	0.197	0.197	0.994	0.173
3	L	0.108	0.098*	0.174	0.114
3	2	0.183	0.183	0.573	0.217
3	3	0.498	0.498	0.706	0.674
3	4	0.037**	0.037**	0.963	0.340
3	H	0.118	0.098*	0.941	0.455
4	L	0.208	0.208	0.875	0.521
4	2	0.052*	0.052*	0.935	0.079*
4	3	0.373	0.373	0.942	0.643
4	4	0.001***	0.001***	0.008***	0.165
4	H	0.094*	0.094*	0.864	0.467
5	L	0.010***	0.010***	0.193	0.006***
5	2	0.152	0.152	0.528	0.376
5	3	0.445	0.445	0.466	0.145
5	4	0.038**	0.038**	0.185	0.235
5	H	0.048**	0.048**	0.240	0.467

Note: The bootstrap p-values are calculated from modified sup-LM test by following the steps outlined by Hansen (1996). The null hypothesis of no significant regime shifts in size-BE/ME portfolio due to interest rates,H_0: $\delta = 0$, is tested with montly data from January 1998 to December 2011.The bootstrap p-values are listed for each subperiod in the table. Periods are defined as following; S1 is January 1998 - December 2003, S2 is January 2004 – December 2011, S1.1 is January 1998 – January 2001, S1.2 is February 2001 – December 2003, S2.1 is January 2004 – December 2007, and S2.2 is January 2008 – December 2001.