


MEAN REVERSION IN TURKISH STOCK MARKET AND TIME-VARYING EQUITY RISK PREMIUM

TÜRKİYE PAY PİYASALARINDA ORTALAMAYA DÖNME EĞİLİMİ VE ZAMANLA DEĞİŞEN PİYASA RİSK PRİMİ

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Abstract

Mean reversion in stock markets has been an open question for the decades it has been meticulously tested. This study first aims at shedding further light on this unsettled issue by assessing mean reversion in a broad Turkish stock data via a non-parametric and model-free methodology. Variance ratio computations and distribution-free statistical tests based on randomization are used on dollar and lira denominated nominal, real and excess returns of Borsa İstanbul equity market. As a strong mean reversion is apparent in the empirical tests, the study secondly tries to identify a possible cause of this apparent anomaly. CAPM-based equity risk premium estimations generated via two-pass cross-sectional regressions reveal that the mean reversion might be explained by the dynamic nature of equity risk-premium. The results indicate that the mean reversion in Turkish equity market is a result of time-varying behavior of rational investors rather than market inefficiency.

Keywords: Equity Risk Premium, Market Efficiency, Mean Reversion, Variance Ratio, Borsa İstanbul

JEL Classification: G1, G14, G15, C14

Özet

Pay piyasalarında ortalamaya dönme eğilimi, geçtiğimiz kırk yılda birçok çalışma tarafından sürekli olarak gözlemlendiği gibi birçok çalışma tarafından da varlığı reddedilmiş bir olgudur. Bu çalışmanın ilk amacı, güncel bir veri seti kullanarak Borsa İstanbul'da ortalamaya dönme eğilimini, parametrik olmayan ve modelden bağımsız bir metodoloji ile test ederek bu konunun aydınlatılmasına katkıda bulunmaktır. Bu doğrultuda, yerel pay piyasasının lira ve dolar bazındaki nominal, reel ve fazla getirileri üzerinde varyans oranı hesaplamaları yapılmış ve rasgeleleştirmeye dayanan, dağılımdan bağımsız bir istatistiksel test uygulanmıştır. Ampirik testlerde güçlü bir ortalamaya dönme eğilimi görüldüğünden, bu çalışma ikinci olarak bu anomalinin nedenlerini tespit etmeyi amaçlamaktadır. CAPM modeline dayalı iki geçişli

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kesitsel regresyonlarla üretilen sermaye risk primleri tahminleri, ortalamaya dönme eğiliminin, sermaye risk primlerinin dinamik doğasından ileri geldiğini ortaya koymaktadır. Sonuçlara göre Türkiye sermaye piyasasındaki ortalamaya dönme eğilimi pazarın etkin olmamasından değil, rasyonel yatırımcıların davranışlarının zamanla değişmesiyle açıklanabilir.

Anahtar Kelimeler: Piyasa Risk Primi; Etkin Piyasa Hipotezi; Ortalamaya Dönme; Varyans Oranı; Borsa İstanbul

JEL Sınıflandırması: G1, G14, G15, C14

1. Introduction

Understanding the dynamics of stock prices has been of particular interest for decades to academics and practitioners alike. The attraction is obvious for practitioners as it opens the door to endless profits if one can predict the future direction of stock prices. However, the most dominant theory established by academics claims the randomness and unpredictability of stock returns, striking a blow to many hoping for riches. Nonetheless, the diligent tries to establish a pattern in stock returns continue. The academic literature is rife with studies both claiming randomness and refuting it with statistical tests. This study is one aimed at contributing to this literature with its test of mean reversion pattern and a possible explanation for its existence in Turkish stock market, one of the major emerging markets.

The classical finance literature postulates that financial markets are efficient, in that prices reflect all available information and one cannot predict the future returns using that information (Fama, 1970). Although, not exactly the same, Efficient Market Hypothesis just described make a strong case for random walk theory (Malkiel, 1973). This theory suggests that returns in consecutive period are independently distributed with no serial correlations. If the opposite was true and autocorrelations between holding-period returns are different from zero, then it would imply there is a certain degree of predictability in stock prices.

Serial correlation patterns may take two distinct forms. If consistently positive, they point towards a unidirectional trend on stock prices, hence result in momentum in the markets. In contrast, if the serial correlations are consistently negative, they point towards a reversal in prices, implying mean reversion. In either case, an arbitrageur can exploit the knowledge for financial gains; employing either momentum or contrarian strategies. These observations promise to outperform the market by employing two completely opposite strategies. However, this seemingly contradictory finding is not entirely out of question, as serial correlations can display different properties for different holding periods.

Establishing mean reversion or aversion in a time series is an important step on its own in examining dynamics of a time series. A natural progression would be delving deeper to understand the underlying reasons behind the behavior of the time series. In understanding the dynamics of security prices, the question boils down to the fundamental issue of market efficiency. Do these results mean markets are inefficient or the prices actually reflect rational behavior of the investors? In other words,

is mean reversion/aversion an anomaly or not? This issue remains an open question in academic literature to this day with fervent supporters on both sides.

For example, Fama and French (1988) argue that observed serial correlations may be the result of “time varying equilibrium expected returns generated by rational investor behavior” (p.266). Moreover, Conrad and Kaul (1988) argue, while ex-post returns may display serial autocorrelations, expected return processes are stationary, which validates the earlier argument.

Mean reversion and aversion in stock returns are two of the major anomalies violating market efficiency arguments. However, their existence is not even indisputably established. Therefore, we aim to contribute to this literature in an important emerging market with a robust and novel methodology. We further aim to offer some insight to test if time-varying risk premium might be behind the observed mean reversion. As such, this study can be considered firstly as an empirical test of existence of mean reversion in Borsa Istanbul stock returns, and secondly if time-varying equity premia might be behind the observed mean reversion.

2. Literature Review

Mean reversion in stock returns have been first investigated by DeBondt and Thaler (1985), who labeled them as price reversals. They found that the portfolio of winner stocks underperforms the portfolio of loser stocks in the long run; an observation they attribute to investor overreaction, in one of the seminal contributions to behavioral finance. Chan (1988) challenged DeBondt and Thaler’s (1985) results by claiming that when risks are correctly readjusted, the price reversal lose economic and statistical significance. In a test relying on an asset pricing model like CAPM, the results were inconclusive, partly due to the fact that it was also a test of the model.

The tests developed in the subsequent years in testing serial correlations paved the way for a robust, model-free test of mean reversion. French and Roll (1986) reported negative serial correlations in daily returns. Cochrane (1988) computed variance ratios in his study with the methodology being adopted by subsequent studies in an effort to test random walk theory. The idea of variance ratios as test of randomness and mean reversion proved robust, as it is unencumbered with an asset-pricing model. Based on variance ratios, Lo and MacKinlay (1988) reported significant evidence of positive autocorrelations in the weekly data and therefore rejected the random walk hypothesis. Fama and French (1988) decomposed returns into two random processes and observed clear patterns of mean reversion. Both studies demonstrated that mean reversion weakens as the company size grows. In a comprehensive study, Poterba and Summers (1989) reported variance ratios separately for nominal, real and excess returns for international equity markets. Their results displayed mean aversion or momentum in horizons shorter than one year and mean reversion in horizons longer than one year.

Kim, Nelson and Startz (1991) contributed to the literature by improving the statistical tests of variance ratios. In their effort to do that, they created empirical distributions of variance ratios by randomization and tested observed variance ratios against this empirical distribution; thus creating a test statistic that is free of any distribution assumption. With their powerful tests at hand, Kim et

al. (1991) concluded that mean reversion was specific to a time-period in pre-war US stocks and not observed in more recent data.

The conflicting results of earlier studies have not been resolved in later studies. Richards (1997), Balvers, Wu and Gilliland (2000), Chaudhuri and Wu (2003), Gropp (2004) and Mukherji (2011) are among the studies that reported strong evidence of mean reversion in international stock returns. On the other hand, Spierdijk, Bikker and van den Hoek (2012) tested mean reversion across 18 OECD countries with an unusually large data set, covering the 1900-2009 period and were able to reject random walk in favor of mean reversion for only 8 countries out of 18. Eren and Karahan (2020) tested mean reversion in dollar denominated returns of international equity markets and concluded that the statistical significance of mean reversion is questionable. Jegadeesh (1990, 1991) studied seasonality in returns and found evidence that the month of January was responsible for the mean reversion in the U.S. stocks.

With the conflicting results, the attention returns to explaining the underlying reasons of the empirical findings. Fama and French (1986) assert that negative serial correlation in returns could be due to market inefficiency or it might be the result of time varying expected returns generated by rational investor behavior. They call this a “critical but unresolvable issue” (p.3). Lo and MacKinlay (1988) argue that rejection of the random walk hypothesis does not mean there is an inefficiency in stock-price formation. Poterba and Summers (1989) lean more towards the inefficiency argument by saying noise trading provides a plausible explanation for the predictability in stock prices.

Ball and Kothari (1989) stand on the opposite side of the argument by claiming that negative serial correlation in returns are mostly caused by changing relative risks and thus expected returns. Conrad and Kaul's (1988) assertion that variation in expected returns constitute a large portion of return variances also supports the proposition that return predictability of stocks does not contradict with market efficiency. Furthermore, Ferson and Harvey (1991) conclude that time variation in expected risk premiums is mostly responsible for the predictability of equity returns and their findings “strengthen the evidence that the predictability of returns is attributable to time-varying, rationally expected returns” (p.412).

Empirical evidence about return predictability and mean reversion in the Turkish equity market is awfully scarce. There are only a handful of papers that touch on this issue and none of them employ the techniques used in this paper, such as variance ratios. Sevim, Yıldız and Akkoç (2007) and Barak (2008) test the overreaction hypothesis in the Turkish market by comparing the returns of winner and loser portfolios for 3 and 5-year time periods respectively. Their findings suggest loser portfolios consistently outperform winner portfolios over the next period which suggests a strong tendency of mean reversion in stock returns. Muslumov, Aras and Kurtulus (2003) test the random-walk hypothesis in Turkey using a generalized auto-regressive conditional heteroscedastic (GARCH) model. They use individual stock returns and claim 65% of their sample space do not exhibit random walk behavior, which they interpret as evidence against weak-form efficiency. Assaf (2006) investigates long memory characteristics of stock returns in Egypt, Morocco, Jordan and Turkey by estimating

rescaled range statistics and rescaled variance statistics. He does not find significant persistence in Turkey but he claims volatility series demonstrate long memory in all markets. Cakici and Topyan (2013) explore the return predictability of Turkish stocks with cross-sectional regressions. Because they do not perform time series analysis, most of their results is irrelevant for our purpose. However, one of their independent variables is momentum which they found to possess no real predictive power.

In light of all of these conflicting arguments and lack of evidence for the local market, the goal of this study is exploring the mean reversion phenomenon in Turkish stock market. We first test the existence of mean reversion in returns using variance ratio and statistical tests based on randomization. We later investigate if predictable variation in stock returns can be linked to the variation in expected returns by testing the mean reversion on dynamic estimates of the equity risk premium, in effect testing the suggestion that time-varying expected returns might be responsible for the observed anomalies in stock returns.

3. Data and Methodology

The data used in this study comes from multiple sources. The preliminary tests are conducted on Borsa Istanbul stock index (BIST 100) denominated both in US Dollars and local currency Turkish Lira, with nominal, real and excess returns. BIST Index data is retrieved from Datastream database.¹ The consumer price index used in inflation computations for Turkey² and United States³ are compiled by OECD. US risk-free rates are provided by Ibbotson Associates⁴ based on one-month Treasury bill rate. Turkish risk-free rates are based on OECD's short-term interest rate data⁵ compiled for the country.

Individual stock data⁶ for Borsa Istanbul is provided by data vendor Finnet. The stock data are monthly returns of all common stocks that are traded on Borsa Istanbul during the 30-year period between January 1990 and December 2019. In beta calculations, we include at least 12 monthly observations, going back to January 1989. The list of stocks include all listed and delisted firms to avoid survivorship bias, but exclude funds, totaling 554 individual shares across 30 years. These returns are adjusted to reflect dividends, capital changes and any other corporate actions like splits, spin-offs, mergers, delistings and bankruptcies.

1 BIST 100 index data is retrieved from Refinitiv (formerly Thomson Reuters) Datastream database.

2 Organization for Economic Co-operation and Development, Consumer Price Index: All Items for Turkey, retrieved from Federal Reserve Bank of St. Louis; <https://fred.stlouisfed.org/series/TURCPIALLMINMEI>

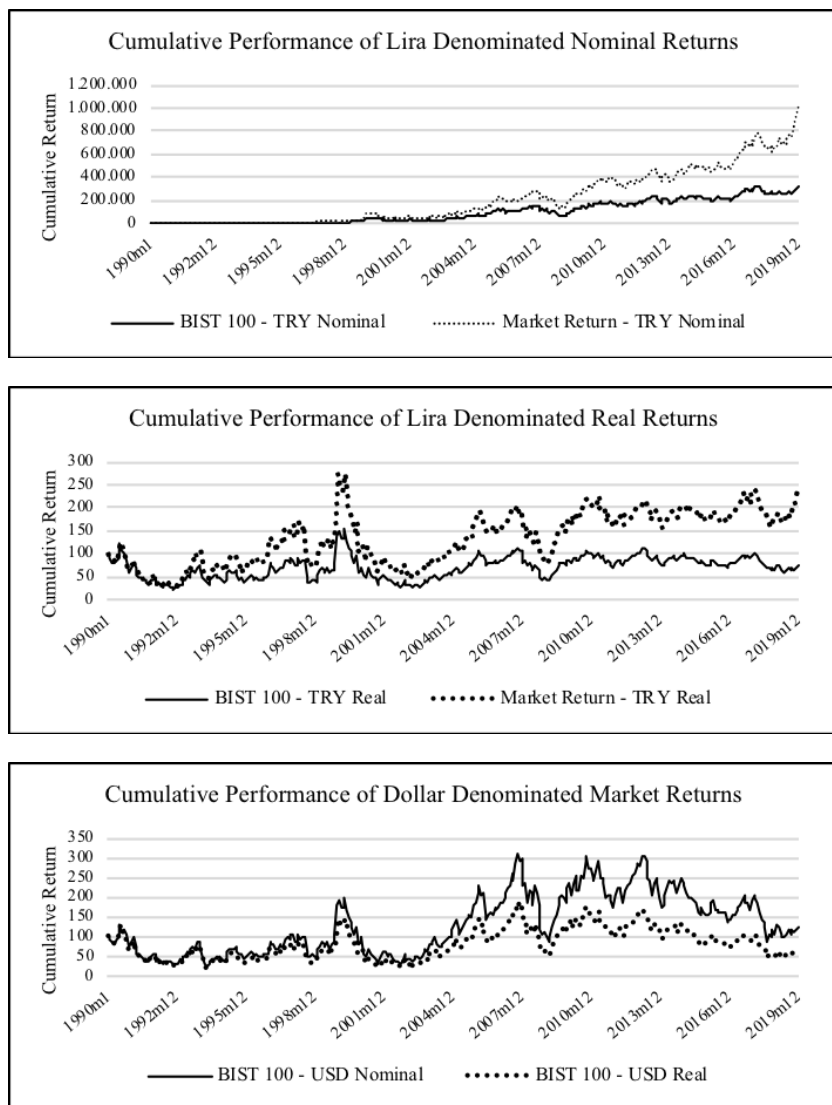
3 Organization for Economic Co-operation and Development, Consumer Price Index: All Items for the US, retrieved from Federal Reserve Bank of St. Louis; <https://fred.stlouisfed.org/series/CPALTT01USM657N>

4 Provided by Ibbotson Associates and retrieved from Prof. Ken French's Data Library; https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

5 Organization for Economic Co-operation and Development, Leading Indicators OECD: Component series: Short-term interest rate: Original series for Turkey, retrieved from Federal Reserve Bank of St. Louis; <https://fred.stlouisfed.org/series/TURLOCOSTORSTM>

6 The stock price and market capitalization data are retrieved from Finnet Analiz Expert platform.

Figure 1: Cumulative Returns for Various Market Return Measures



These figures display the cumulative value of 100⁺ or \$100 invested in the market in at the beginning of January 1990. BIST 100 data refers to Turkish Lira and US Dollar denominated headline index reported by Borsa Istanbul. Market return refers to the value-weighted lira denominated average returns of all stocks as computed by the authors. Real returns are computed using the monthly inflation in the respective currencies.

The market return used in regressions is the value-weighted average return of available stocks for each period as computed by the authors, which is a more appropriate measure of market return than the often used free-float weighted market indices. Market and portfolio return calculations are all based on discrete returns and rates. However, all returns, interest rates and inflation are converted

to continuously compounded logarithmic rates, in line with the assumptions of variance ratios as discussed below.

Table 1: Summary Statistics of Monthly Data

Index	Obs.	Average	Standard Deviation	Minimum	Maximum	Sharpe Ratio
BIST 100 – TRY NOMINAL	360	2.37%	12.75%	-49.49%	58.66%	-0.13
BIST 100 – TRY REAL	360	0.04%	12.74%	-53.36%	52.88%	-
BIST 100 – TRY EXCESS	360	-1.64%	12.77%	-56.89%	54.05%	-
BIST 100 – USD NOMINAL	360	0.19%	14.60%	-54.95%	54.07%	0.00
BIST 100 – USD REAL	360	0.00%	14.59%	-55.35%	54.07%	-
BIST 100 – USD EXCESS	360	-0.03%	14.60%	-55.33%	53.63%	-
MARKET – NOMINAL	360	2.71%	12.32%	-50.00%	59.35%	-0.11
MARKET – REAL	360	0.37%	12.29%	-53.88%	53.57%	-
MARKET – EXCESS	360	-1.31%	12.30%	-57.41%	54.74%	-
Risk-free rate – TRY	360	4.17%	4.05%	0.43%	27.05%	-
Risk-free rate – USD	360	0.22%	0.19%	0.00%	0.69%	-
Inflation – TR	360	2.40%	2.57%	-1.44%	23.38%	-
Inflation – USA	360	0.20%	0.33%	-1.92%	1.22%	-

This table reports summary statistics of the monthly data used in the study for the 30-year period between January 1990 and December 2019. BIST 100 data refers to Turkish Lira and US Dollar denominated headline index reported by Borsa Istanbul. Market return refers to the value-weighted lira denominated average returns of all stocks as computed by the authors. Real and excess returns are computed using the inflation and risk-free rates in the respective currencies.

3.1. Variance Ratios

Variance ratio computations follow the methodology offered by Poterba and Summers (1989). The statistical tests, however, are based on randomization with no distribution assumption. The underlying motivation in our selection is to make our nonparametric tests unencumbered by any assumption about asset pricing model and return distribution. Hence, we can claim the results are very intuitive to interpret and unbiased in their conclusions.

Under the assumption of continuously compounded log returns, k-period return is the sum of each 1-period return:

$$(1) \quad R_k = r_1 + r_2 + \dots + r_k$$

The variance of the compounded return would be:

$$(2) \quad Var(R_k) = \sum_{i=1}^k \sum_{j=1}^k Cov(r_i, r_j)$$

If random walk is assumed due to serial independence, the variance reduces to:

$$(3) \quad Var(R_k) = k \times \sigma^2$$

This leads to a natural definition of variance ratio as below, where r_t^k and r_t^1 are k-period and 1-period returns respectively. This ratios should be equal to 1 for random walk.

$$(4) \quad VR(k) = \frac{\text{var}(r_t^k)}{\text{var}(r_t^1) \times k}$$

As a variation of this statistic, we take the 12 month as basis in order to differentiate between the short term and long term variance ratios:

$$(5) \quad VR(k) = \frac{\text{var}(r_t^k)/k}{\text{var}(r_t^{12})/12}$$

Cochrane (1988) reinterprets variance ratios as linear combination of sample autocorrelations:

$$(6) \quad VR(k) \cong 1 + 2 \sum_{j=1}^{k-1} \frac{(k-j)}{k} \hat{\rho}(j)$$

where $\hat{\rho}(j)$ is sample autocorrelation at lag j . This representation allows us to make direct inferences about the time-series properties of the returns. If variance ratios are significantly smaller than 1, that will lead us to infer that the time-series in question is mean-reverting with negative autocorrelations. When this reinterpretation is applied to the measure with 12-month as basis, the variance ratio becomes:

$$(7) \quad VR(k) \cong 1 + 2 \sum_{j=1}^{11} j \left(\frac{k-12}{12k} \right) \hat{\rho}(j) + 2 \sum_{j=12}^{k-1} \frac{k-j}{k} \hat{\rho}(j)$$

Kendall and Stuart (1976) show that the sample autocorrelations would have downward bias under the null hypothesis of serial independence;

$$(8) \quad E[\hat{\rho}(j)] = -1/(T - j)$$

where $\hat{\rho}(j)$ is the sample autocorrelation at lag j and T is the sample size. With the appropriate bias correction, the variance ratio of equation 7 can be written as:

$$(9) \quad E[VR(k)] = \frac{12+5k}{6k} + \frac{2}{k} \sum_{j=1}^{k-1} \frac{T-k}{T-j} - \frac{1}{6} \sum_{j=1}^{11} \frac{T-12}{T-j}$$

The variance ratios in this study follow the methodology in equation 9 in a rolling window of overlapping time series, as is the standard in the literature. However, these numbers by themselves divulge little information. We have to test if they are significantly different from unity in order to reach conclusions with statistical clarity. For that purpose, we use a robust testing method proposed by Kim et al. (1991) based on randomization, which does not make any assumptions about the underlying distribution. This method relies on shuffling the time series of returns randomly for 1000 times to remove the effect of possible autocorrelations in the data. The collection of variance ratios computed for each random shuffle becomes the de-facto distribution, against which we test the variance ratio of the actual return series. If the variance ratio of the actual data lies below or above a certain percentile of the empirical distribution, the null hypothesis of random walk can be rejected.

3.2. Time-Varying Equity Risk Premium

We test the properties of time varying equity risk premium to explore the possible reasons behind the observed mean reversion in stock returns. In order to capture the time variation in equity risk premia, one has to use a dynamic asset pricing model. We employ the workhorse of the literature, Capital Asset Pricing Model (CAPM) by Sharpe (1964) and Lintner (1965) in a simple dynamic setting. We use a direct estimation of conditional betas and risk premia using rolling window regressions, a method similar to the one employed by Lewellen and Nagel (2006). The advantage of this method is its simplicity and the fact that one does not have to identify a set of state variables for conditioning information, which are usually unknown to the investors.

Beta values of individual stocks are calculated through a first-pass of standard time-series regression,

$$(10) \quad r_{i,t} - r_{f,t} = \alpha_{i,t} + \hat{\beta}_i \times (r_{m,t} - r_{f,t}) + \varepsilon_{i,t}$$

where $r_{i,t}$ is the return of stock i at time t , $\alpha_{i,t}$ is the abnormal returns of stock i at time t , $\hat{\beta}_i$ is the stock's estimated beta which indicates how closely it follows the market, $r_{m,t}$ is the return of the market portfolio, $r_{f,t}$ is the risk-free return at time t and $\varepsilon_{i,t}$ is the error term.

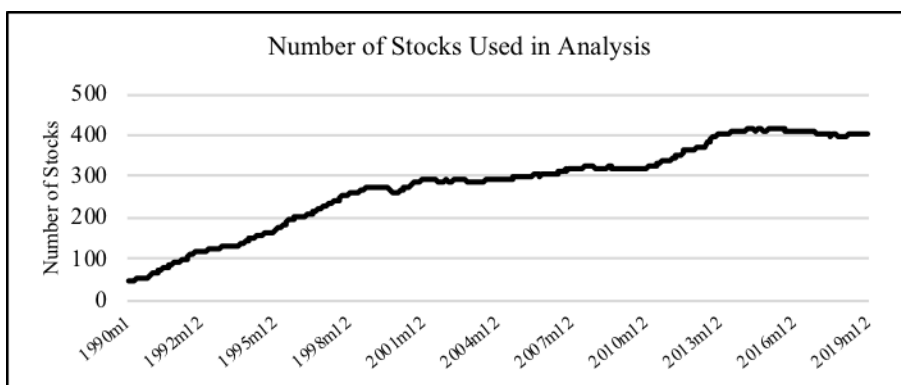
Each month from January 1990 through December 2019, betas of the individual stocks are estimated with the regression model above. We use the past 60 months' data, which is the standard in the literature, with at least 12 months of uninterrupted data prior to beta estimation, taking us back to January 1989 to initiate the analysis. Figure 2 tracks how many stocks meet this data requirement and are eventually used in the analysis each month. After estimating the betas of the stocks that meet the data requirement; in every month, a cross-sectional OLS regression is performed which regresses the monthly returns of the stocks against their estimated betas, where the second-pass regression yields the coefficient λ , an estimate for the equity risk premium in the stock market.

$$(11) \quad r_{i,t+1} = \gamma_{i,t+1} + \lambda_{t+1} \times \hat{\beta}_i + \zeta_{i,t+1}$$

One of the most important decisions when performing such an analysis is whether to use individual stocks or to form portfolios. While the likes of Black, Jensen and Scholes (1972), Fama and Macbeth (1973) and Ferson and Harvey (1991) form portfolios to perform cross sectional regressions; there are others such as Ang, Liu and Schwarz (2008) and Chordia, Goyal and Shanken (2015) who advocate the use of individual stocks. Fama and Macbeth (1973) say more precise beta estimates can be made when portfolios are used instead of individual stocks. On the other hand, Ang, et al. (2008) argue that more precise estimates of beta do not lead to better estimates of the risk premia. They claim that variance of the risk premia estimates decreases when individual stocks are used as opposed to portfolios. Nevertheless, both approaches have been adopted in our analysis for the sake of robustness.

Using the individual stocks as observations, a monthly equity risk premium estimation is obtained for each of the 360 months in our analysis period. This enables us to see the time variation in expected risk premia, priced by the classical CAPM model. In order to test the robustness of risk premia estimation to the selection between individual stocks and portfolios, a methodology very similar to that of Fama and Macbeth (1973) is also used. Each month, 20 value-weighted portfolios are formed using the already estimated betas of individual stocks. After ranking individual stocks based on their Beta values and classifying them into 20 Beta-ranked portfolios, portfolio betas are estimated to be the weighted average of stock betas following Blume (1970). We choose to compute portfolio betas as a simple average of stock betas for simplicity and not to limit the dataset further by performing additional regressions for portfolio betas like Fama and Macbeth (1973). As the results demonstrate, the equity risk premia are very similar across methods, with little difference in quantitative values.

Figure 2: Number of Stocks Used in Equity Risk Premium Estimations

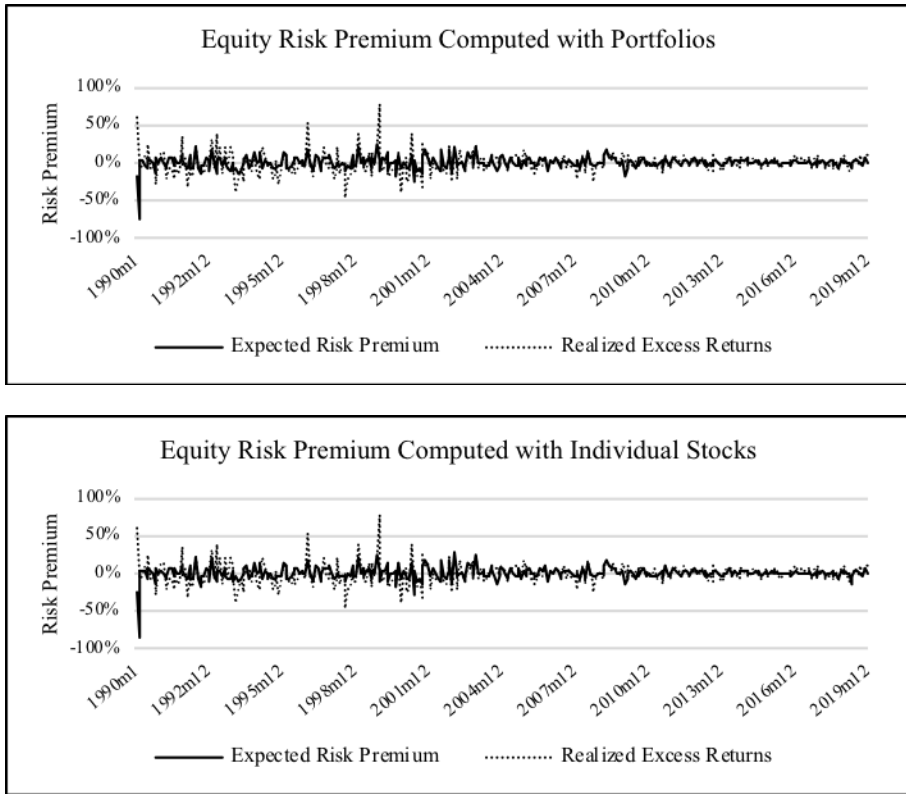


This figure tracks the number of stocks for each month that satisfy the data requirements to be included in time-varying equity risk premium calculations. Each stock should have a price history of at least 12 months to be included. Funds are excluded as they are redundant securities.

Table 2: Summary Statistics of Monthly Time-Varying Equity Risk Premia and Excess Market Returns

Method	Obs.	Average	Standard Deviation	Minimum	Maximum
ERP w/ Portfolios	360	-0.39%	8.00%	-76.57%	25.39%
ERP w/ Individual Stocks	360	-0.35%	8.31%	-85.51%	26.77%
Excess Market Return	360	-1.31%	12.30%	-57.41%	54.74%

This table reports the summary statistics of the time-varying equity risk premium and realized excess returns per month for the 30-year period between January 1990 and December 2019. The risk premia are computed via cross sectional regressions with either 20 Beta-based portfolios or individual stocks. Excess market return is the difference between the market return, the value-weighted lira denominated average returns of all stocks as computed by the authors, and the Turkish lira risk-free rate.

Figure 3: Time-Varying Equity Risk Premia and Excess Market Returns

These figures display the time-varying equity risk premium and realized excess returns per month for the 30-year period between January 1990 and December 2019. The risk premia are computed via cross sectional regressions with either 20 Beta-based portfolios (upper panel) or individual stocks (lower panel). The excess returns, which are akin to realized or ex-post market premiums, are based on value-weighted average return of all stocks and Turkish-lira risk-free rate.

4. Results

Upon inspection of the summary statistics of returns reported in Table 1 and visualized in Figure 1, the glaring differences in market return measures become very apparent. The upper graph reveals that a broader market measure might capture the realities of returns better than BIST 100 Index. BIST 100 is an index that is based on free-float market capitalization. The limited number of stocks and the free-float weights underestimate the market return. Our market return measure calculated as value-weighted average return of all available stocks outperform the BIST 100 index by 24 basis points on average each month. The cumulative effect of that difference over 30 years is more than three times in cumulative returns, both nominal and real, as shown in the graph.

The impact of inflation on stock returns can be seen in the visual representation of real returns as compared to nominal returns. The same effect can be surmised from comparison of USD denominated returns with those of comparable lira denominated ones. The nominal returns generate a very healthy cumulative return, yet when measured with inflation-adjustment, the returns seem to be moving in a lateral fashion. The difference between nominal and real returns are understandable as Turkey struggled with hyperinflation for most of the last three decades. However, considering the 30-year time period, this non-performance of stocks in real terms is a dramatic statement. The average real returns hovering slightly above zero makes the stock market an unattractive investment. In fact, risk-free interest rate in Turkey offers higher average returns than the stock market, making the equity excess returns negative on average.

Equity risk premia computed via cross sectional regressions provide a measure of expected excess returns. The cross-sectional regressions are conducted with either 20 Beta-based portfolios or individual stocks. In each cross sectional regression, Betas estimated with past data are regressed with next month's returns to yield the coefficient that estimates the expected equity risk premium. The results indicate a volatile equity risk premium as can be seen in Figure 3. The volatility of estimates with individual stocks are slightly higher than the estimates with portfolios, as expected. The average equity risk premium over 30 years is slightly below zero at -0.35% and -0.39% , verifying the observation above that the Turkish stock market does not offer a premium over risk-free return. The excess returns are reported in Table 3 again to offer a comparison to equity risk premium. As low and volatile as expectations are, the realized excess returns are even lower and more volatile. Overall picture reveals that time-varying equity risk premia behave very differently across time. The high volatility of earlier years in the analysis is replaced with a relatively more stable premium in the latter part of the analysis.

The difference in the currency base reveals the extent of inflation's and currency depreciations effect in a dramatic fashion. We next focus on the dynamics of each market return measure via variance ratio calculations before we look into equity risk premium dynamics.

4.1. Mean Reversion in Market Returns

As a starting point of our mean reversion analyses, we report below the variance ratios for three separate measures of market return in nominal, real and excess monthly log-returns, respectively. Table 3 reports the actual variance ratios for several holding periods, as well as the p-values obtained against the distribution of randomized ordering of returns for all return types and all three market return measures. Since the p-values are obtained from an empirical distribution via randomization, it is free from the shortcomings of assuming a standard distribution like normal.

According to Table 2 and associated Figures 3 and 5, the nominal lira-denominated market returns display an obvious and consistent trend of mean aversion. The variance ratios are significantly larger than unity at 5% level for BIST 100 and value-weighted market return in holding periods longer than 6 years and 4 years, respectively. These findings reveal a strong momentum in nominal markets returns,

which is expected in a market with high levels of inflation. Comparatively, variance ratios for dollar-denominated BIST 100 returns in Figure 4 reveal a mean reversion with statistical significance for most holding periods longer than 12 months. Since dollar inflation figures are low compared to lira inflation, it manifests itself in the currency base effect on stock market returns and variance ratios.

Table 3: Variance Ratios and Statistical Tests of Significance for Borsa Istanbul Market Returns

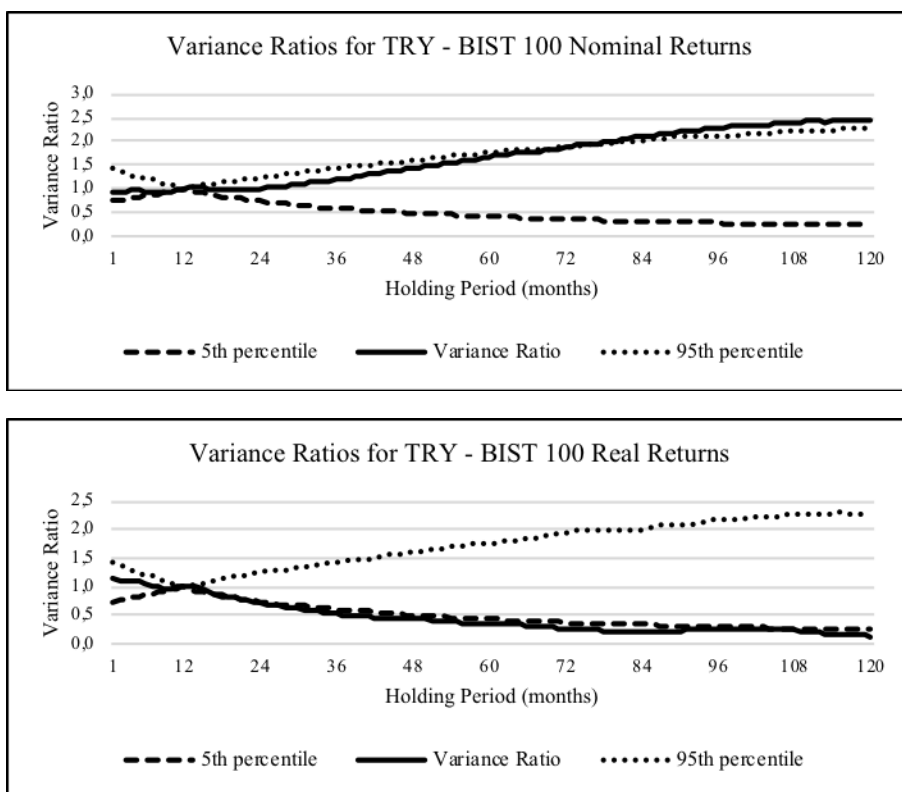
		1	6	24	36	48	72	96	120
		month	months	months	months	months	months	months	months
PANEL A: TURKISH LIRA DENOMINATED BIST 100									
Nominal	Variance Ratio	0.935	0.957	1.008	1.190	1.433	1.872	2.280	2.441
	<i>p</i> -value	0.356	0.313	0.546	0.799	0.898	0.948	0.964	0.956
Real	Variance Ratio	1.133	1.044	0.709	0.522	0.439	0.277	0.260	0.145
	<i>p</i> -value	0.713	0.652	0.023	0.018	0.016	0.008	0.017	0.002
Excess	Variance Ratio	0.873	0.933	0.902	0.920	1.044	1.357	1.785	2.060
	<i>p</i> -value	0.215	0.231	0.291	0.441	0.641	0.840	0.926	0.946
PANEL B: US DOLLAR DENOMINATED BIST 100									
Nominal	Variance Ratio	1.105	1.084	0.688	0.585	0.566	0.430	0.384	0.302
	<i>p</i> -value	0.655	0.744	0.017	0.026	0.073	0.077	0.116	0.100
Real	Variance Ratio	1.108	1.083	0.685	0.577	0.554	0.415	0.369	0.286
	<i>p</i> -value	0.659	0.731	0.018	0.042	0.073	0.068	0.098	0.062
Excess	Variance Ratio	1.094	1.077	0.690	0.577	0.550	0.406	0.367	0.294
	<i>p</i> -value	0.626	0.732	0.028	0.040	0.079	0.065	0.103	0.096
PANEL C: VALUE-WEIGHTED MARKET RETURNS									
Nominal	Variance Ratio	0.861	0.918	1.079	1.312	1.595	2.097	2.509	2.615
	<i>p</i> -value	0.205	0.189	0.703	0.890	0.959	0.980	0.980	0.972
Real	Variance Ratio	1.078	1.022	0.741	0.559	0.482	0.324	0.295	0.136
	<i>p</i> -value	0.622	0.561	0.046	0.030	0.041	0.034	0.055	0.003
Excess	Variance Ratio	0.852	0.928	0.894	0.894	1.001	1.296	1.732	2.018
	<i>p</i> -value	0.191	0.212	0.293	0.387	0.560	0.784	0.917	0.941

This table reports the variance ratios and their respective *p*-values obtained through randomization of monthly nominal, real and excess log-returns of various market return measures. Turkish Lira and US Dollar denominated headline indices are reported by Borsa Istanbul. Market return refers to the value-weighted lira denominated average returns of all stocks as computed by the authors. Real and excess returns are computed using the inflation and risk-free rates with the respective currencies.

In order to take the impact of inflation out, we test the variance ratios of real returns for each market return type by finding the inflation adjusted real returns. As expected, real returns display a strong mean reversion for all holding periods longer than 12 months even when the returns are lira denominated. The mean reversion in real market returns is independent from the currency base. In fact, lira denominated real returns display a statistically stronger mean reversion as can be seen in the *p*-values in Table 3.

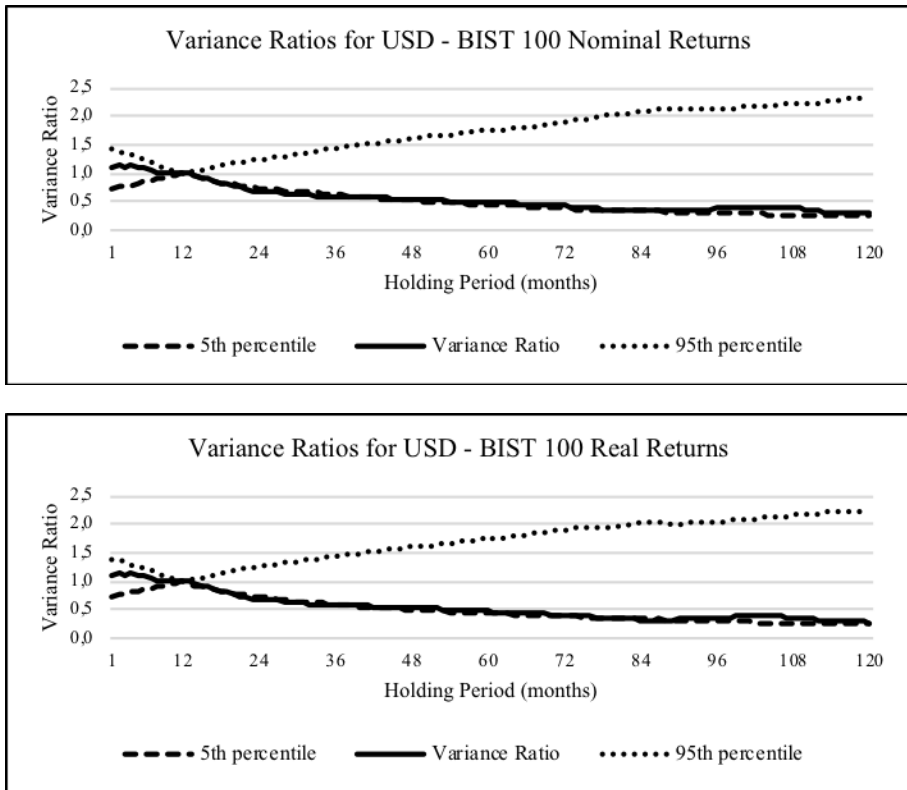
Excess market returns are measured as the difference between monthly market returns and the risk-free interest rate in the appropriate currency. Dollar denominated excess returns yield a variance ratio dynamic similar to real returns, which is not far off the nominal returns itself. Since dollar inflation and interest rates are relatively low, this result is expected. Excess market returns in lira denominated measures, however, yield surprising results. They do not display a discernible mean reversion or aversion pattern until longer holding periods. The mean aversion second comma is unnecessary or momentum, tendency in longer holding periods is not even statistically significant. The excess returns can be considered as realized risk premia that the equity market earns over the risk-free rate. As it shows significant difference with real return dynamics, we further analyze this phenomenon. Time-varying equity risk premia can be considered as the expected excess returns. Since this expectation drives the pricing in the market, next analysis documents the dynamics of equity risk premium.

Figure 3: Variance Ratios of Lira–Denominated BIST-100 Returns for Different Holding Periods



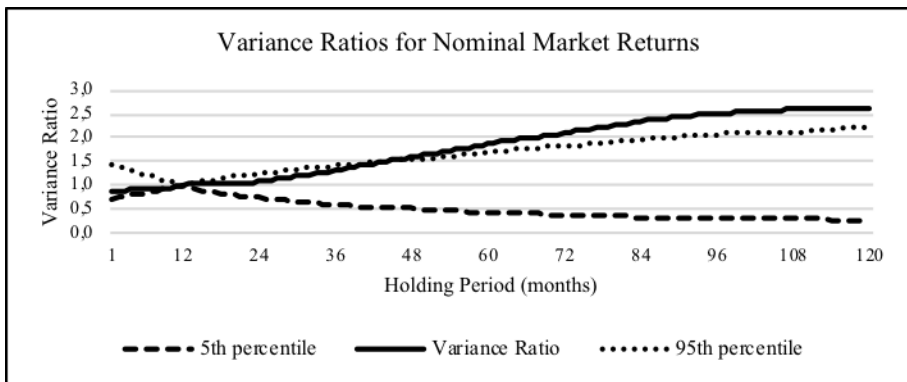
These figures display the variance ratios of monthly nominal and real log-returns for BIST 100 Turkish Lira denominated index from 1 month to 120 months holding periods. The confidence interval is based on the distribution of variance ratios in 1000 randomized shuffles of return time series.

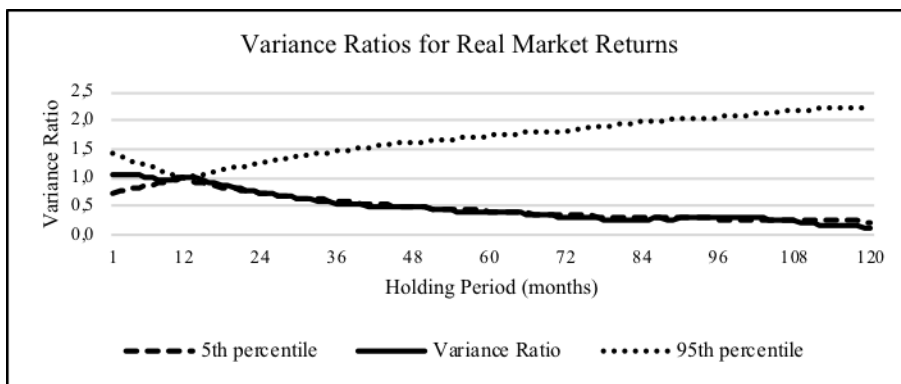
Figure 4: Variance Ratios of Dollar–Denominated BIST-100 Returns for Different Holding Periods



These figures display the variance ratios of monthly nominal and real log-returns for BIST 100 US Dollar denominated index from 1 month to 120 months holding periods. The confidence interval is based on the distribution of variance ratios in 1000 randomized shuffles of return time series.

Figure 5: Variance Ratios of Value–Weighted Market Returns for Different Holding Periods





These figures display the variance ratios of monthly nominal and real log-returns for the overall market from 1 month to 120 months holding periods. Market return refers to the value-weighted lira denominated average returns of all stocks as computed by the authors. The confidence interval is based on the distribution of variance ratios in 1000 randomized shuffles of return time series.

4.2. Mean Reversion in Time-Varying Equity Risk Premia

In order to assess the dynamics of the time series of estimated monthly equity risk premium, the same variance ratio test which was applied to market returns before has also been applied to the estimated equity risk premium series. The previous tests revealed that the Turkish equity market returns showed significant mean reversion in real returns. The current test would reveal if the mean reversion observed in market returns can be attributed to a similar property in the equity risk premium.

Table 3: Variance Ratios and Statistical Tests of Significance for Time-Varying Risk Premia and Excess Returns

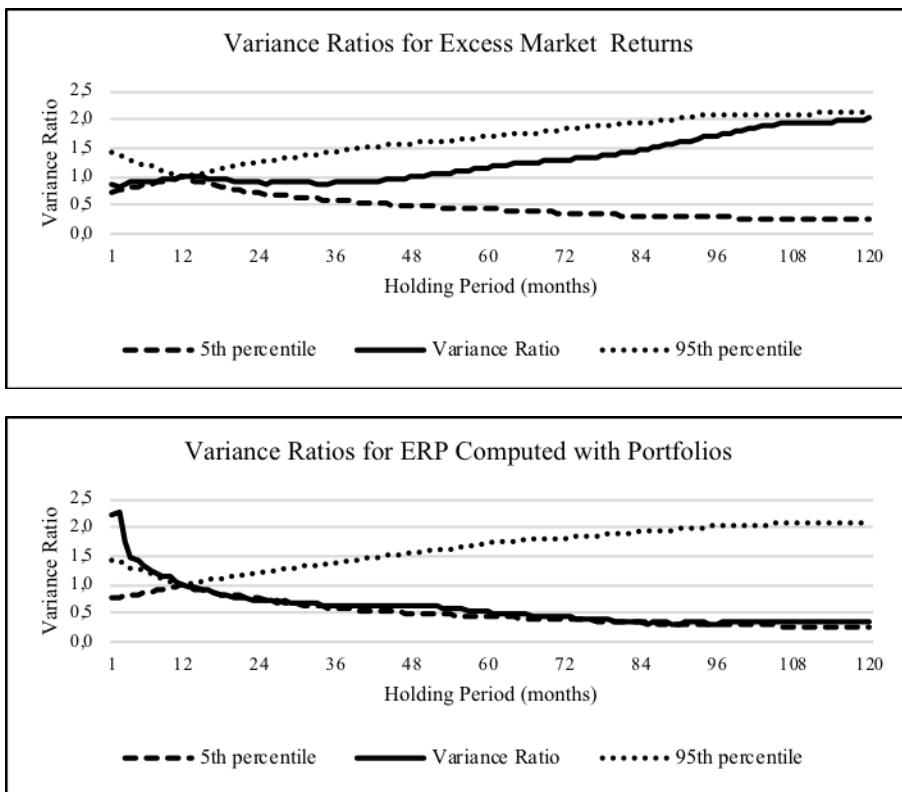
	1 month	6 months	24 months	36 months	48 months	72 months	96 months	120 months
PANEL A: TIME-VARYING EQUITY RISK PREMIA WITH PORTFOLIOS								
Variance Ratio	2.209	1.350	0.719	0.635	0.622	0.447	0.331	0.371
<i>p</i> -value	0.996	0.984	0.035	0.067	0.125	0.090	0.065	0.155
PANEL B: TIME-VARYING EQUITY RISK PREMIA WITH INDIVIDUAL STOCKS								
Variance Ratio	2.694	1.407	0.680	0.573	0.546	0.417	0.334	0.369
<i>p</i> -value	0.998	0.988	0.021	0.025	0.057	0.058	0.050	0.112
PANEL C: EXCESS MARKET RETURNS								
Variance Ratio	0.852	0.928	0.894	0.894	1.001	1.296	1.732	2.018
<i>p</i> -value	0.191	0.212	0.293	0.387	0.560	0.784	0.917	0.941

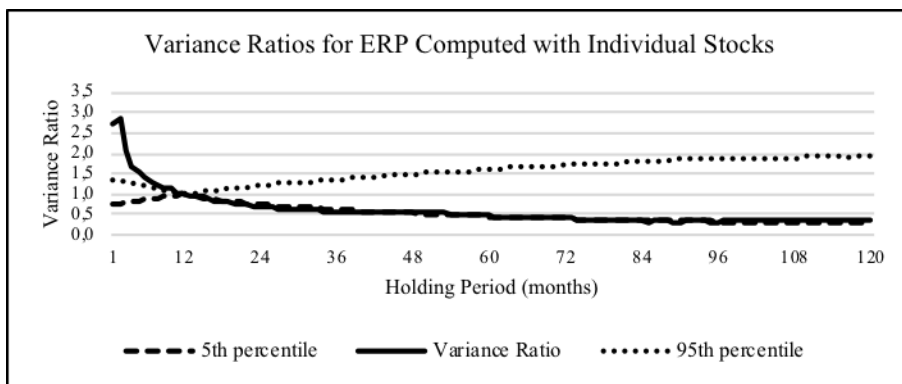
This table reports the variance ratios and their respective *p*-values obtained through randomization of the monthly time-varying equity risk premia and realized excess returns for the 30-year period between January 1990 and December 2019. The risk premia are computed via cross sectional regressions with either 20 Beta-based portfolios or individual stocks. Excess market return is the difference between the market return, the value-weighted lira denominated average returns of all stocks as computed by the authors, and the Turkish lira risk-free rate. All returns are converted to continuously compounded log returns for variance ratio calculations.

The variance ratios for equity risk premium yield very strong results in both the short term and the long term, in contrast with the excess market returns that does not exhibit any discernible time series anomalies. The variance ratio results are very similar for both methods of estimation of equity risk premium. The variance ratios for holding periods less than 12 months are very high and significantly more than unity with more than 95% confidence in all holding periods and moving up to 99.6% confidence in the 1-month horizon. Since this part is redundant and can be removed variance ratios used in this analysis take 12 months as basis, this actually implies mean reversion effect in equity risk premia.

More importantly, equity risk premia displays a very strong mean reversion for any holding period longer than 12 months with variance ratios declining rapidly and remaining well under 1 for all holding periods. The statistical significance is more pronounced for the equity premium estimated via individual stocks all holding periods. As Table 4 and Figure 7 reveal, equity risk premium is significantly mean reverting at 5% level up to 2.5 years and 4 years for portfolio-based and individual stock-based estimates, respectively. The statistical significance slightly goes below 5% for longer holding periods.

Figure 7: Variance Ratios of Excess Returns and Time-Varying Equity Risk Premia





These figures display the variance ratios of time-varying equity risk premium and realized excess returns from 1 month to 120 months holding periods. The risk premia are computed via cross sectional regressions with either 20 Beta-based portfolios or individual stocks. The excess returns, which are akin to realized or ex-post market premia, are based on value-weighted average return of all stocks and Turkish-lira risk-free rate. The confidence interval is based on the distribution of variance ratios in 1000 randomized shuffles of return time series.

5. Conclusion

This study was performed to analyze the times-series behavior of the Turkish equity market. In particular, we aim to test if Turkish equity market displays an anomaly like mean reversion. Our results indicate that Turkish market returns in liras cannot be entrusted to document anomalies like mean reversion or momentum. The nominal returns display a strong mean aversion, or momentum, effect. However, that momentum is not visible in dollar denominated returns. This result makes it clear that the momentum effect can be purely due to inflation or related currency depreciation in this volatile emerging market. In fact, when analyzed through inflation-adjusted real returns, the market displays mean reversion in holding periods longer than 1 year with statistical significance. This anomaly is not apparent in excess market returns with any significant pattern.

In order to explain the mean reversion in real returns or lack thereof in excess returns, we next look at the expectations formed in the marketplace, as they are the more important forces in price formation. We use CAPM model as basis to estimate time-varying equity risk premia, which represents the risk premium rational investors expect from an efficient equity market. Therefore; if the market return and the expected equity risk premium go hand in hand, in other words if the trends in the expected returns match the trends in the actual returns well enough, it points towards an efficient market. This is a case where an apparent anomaly can be rationally explained in a dynamic setting, where the market efficiency, in fact, is not violated.

According to these results, this is the case for the Turkish equity market. Time series of expected equity risk premia seems just as mean-reverting as the market itself. Hence, the empirically observed mean reversion in the Turkish equity market can be attributed to the time varying nature of equity

risk premium demanded by the investors. Taken to its natural conclusion, Turkish equity market can still be considered efficient when the parameters of our model are allowed to reflect the dynamic nature of the market itself.

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