An Empirical Investigation of the Determinants of Market Efficiency in Borsa Istanbul

Yusuf VARLI[1] (Corresponding Author), Ebubekir S. SAHIN[2]

Abstract

Following the last global financial crisis, efficiencies of stock markets have come to sight as a novel area of research. The question of what factors shape the efficiency of the stock market is naturally always of a curiosity in theory and practice. In line with the framework of this curiosity, this study examines the main determinants that play a crucial role in the efficiency of a certain stock market, Borsa Istanbul. Our study contributes to the literature by using five years and daily data belonging to both individual and institutional investors. We here aim to specify the ten determinants of market efficiency which are categorized under investor-based, market-based and country-based determinants. According to the three different regressions and VAR analysis, the results indicate the strong relationship between the market efficiency and the specified determinants such as turnover, market volatility, the share of foreign investors and interest rate.

Keywords: Market Efficiency, Borsa Istanbul, Individual Investors, Institutional Investors

JEL Classification: G1, G11, G14, G23

Borsa İstanbul'da Piyasa Verimliliğinin Belirleyicileri Üzerine Ampirik Bir İnceleme

Özet

Yaşanılan son küresel finansal krizin ardından borsaların etkinlikleri öncelikli bir araştırma alanı olarak öne çıkmaya başlamıştır. Borsa etkinliğini hangi faktörlerin şekillendirdiği sorusu, doğal olarak teori ve pratikte her zaman bir merak uyandırmaktadır. Bu merak çerçevesinde, bu çalışma Borsa İstanbul'un piyasa etkinliğinde önemli rol oynayan temel belirleyicileri incelemektedir. Çalışmamız hem bireysel hem de kurumsal yatırımcılara ait günlük bazda ve beş yıllık verileri kullanarak literatüre katkıda bulunmaktadır. Bu çalışmada yatırımcı, piyasa ve ülke bazlı ayrı kategorilerde elde edilen toplam 10 piyasa etkinliği belirleyicisinin ortaya konması amaçlanmıştır. Üç farklı regresyon ve VAR analizinden elde edilen sonuçlara göre, piyasa etkinliği ile devir hızı, piyasa oynaklığı, yabancı yatırımcıların payı ve faiz oranı gibi belirleyiciler arasında güçlü bir ilişkiselliğin olduğu gösterilmektedir.

Anahtar Kelimeler: Piyasa Etkinliği, Borsa, Borsa Istanbul, Bireysel Yatırımcılar, Kurumsal Yatırımcılar

JEL Sınıflandırması: G1, G11, G14, G23

[1] Assistant Professor. Department of Economics, School Of The Humanities And Social Sciences, Ibn Haldun University, Istanbul, Turkey. Email: yusuf.varli@ihu.edu.tr

[2] PhD Student. Department of Economics, School Of The Humanities And Social Sciences, Ibn Haldun University, Istanbul, Turkey. Email: ebubekir.sahin@ibnhaldun.edu.tr

1 Introduction

Market efficiency has always been one of the most appealing and curious topics in finance theory. Answer for the question of what determines the market efficiency is sought by not only academics but also people from the industry. For screening and evaluating the quality of financial markets, the efficient market hypothesis (EMH) has recently become a broad approach (Malkiel and Fama, 1970). The role of efficiency for stock markets and what factors determines the efficiency are widely questioned in literature. Numerous studies (Basu, 1977; Fama, 1991) aim to investigate the relevance of the EMH hypothesis. With the introduction of EMH in 1970 (Malkiel and Fama, 1970), the weak form efficiency and semi-strong form efficiency are described. Afterwards, Fama (1991) mounts the stronger form of efficiency, which is the main form that we take into account for this article, to his model. In strong from, all private information is assumed to be reflected by the price. This form explores if the investors' profits can climb up to exceptional levels by trading with private information. Strong form is tested by examining the group of insiders if any abnormal returns can be generated by utilizing any private information. (Chaudhuri, 1991; Del Brio et al., 2002; Tahaoglu and Guner, 2010).

There are many studies which links efficiency with the market beating[1], i.e. getting abnormal returns higher than the market. In the simplest terms, if any given market is able to provide smooth return rates for investors and not beaten consistently, it can be considered as efficient. Damodaran (2003) defines market-beaters as that the investors who are be able to have 'higher' returns than others by doing better valuation, thanks to their capability to detect under-valued and over-valued firms.

Especially, emerging and developing markets are investigated to reveal the factors having an impact on efficiency or the historical progression of the efficiency. Rizvi et al. (2014) examines the status of the efficiency of the stock markets in Islamic countries and compared them with the developed countries by using EMH approach. In another study, Jamaani and Rocca (2015) investigates whether the stock markets of Gulf countries are weak-form efficient and demonstrated that those markets are not weak-form efficient, hence inefficient. In another study

[1] "Market beating" is defined as being able to attain higher returns than adjusted returns while the definition of "market beaten" is vice versa, as attaining lower returns than adjusted returns.

using EMH, Rizvi and Arshad (2014) studies the progress of the efficiency in east Asian stock markets and illustrated that the overall efficiency has improved the past two decades.

As well as stock markets of developing countries, stock markets of developed countries have become an area of study by the researchers. Urquhart and McGroarty (2016) questions the common belief about the efficiency of stock markets in the developed world by examining stock markets in US, Japan, England and EU and resulted that the predictability for return in stock markets indeed varies over time and each market adjust itself separately to specific market conditions. Anagnostidis et al. (2016) studies the impact of 2008 crises over the Eurozone stock market efficiency and concluded that the efficiency is adversely affected by 2008 crisis.

From the view of the variables affecting the efficiency, there is great lack of researches in literature. Numerous researchers study the link between stock market prices and other variables while little attention is given to determinants of market efficiency. In their work, Muradoglu et al. (2000) investigates the causality between stock market prices and macro-level variables; stock turnover, interest rate, exchange rates, inflation in nineteen emerging markets with twenty years of data. Gay (2008) investigates the time-series relationship between the market and macroeconomics variables such as interest rate and for emerging countries, BRIC. Studies on market efficiency is densified in recent years. Beltratti et al. (2016) figures out the impacts of stock returns and trading volumes on the stock market efficiency in China. Ito et al. (2016) aim to find whether the market efficiency in US evolve over time by employing time-varying autoregressive (TV-AR) model. As observed in the literature, the variables of efficiency are barely studied.

As it can be seen the examples from the recent literature, although some studies contribute to the revealing the development of the efficiency in specific markets or try to find the relationship between efficiency and a specific factor, best to our knowledge, there is significant gap in literature aiming to specify the most of the determinants behind the efficiency. The existing studies mostly use common approaches or regressed the price predictability over time to measure the efficiency.

In this study, we aim to cast light upon this area by determining the factors effecting the efficiency of stock markets. By revealing the variables which have a significant effect on the

efficiency would help policymakers to enhance the market efficiency which also related with the economic outlook of the country.

In order to find the factors behind the market efficiency, we add various determinants obtained from literature review along with efficiency itself by using 5-year daily based investor data from Borsa Istanbul. Firstly, the variables are regressed by various types of estimators to overcome any statistical complications. Then, multiple tests are employed to increase robustness. Tests specifically related with time-series VAR models such as unit root or Jarque-Bera are run to detect or eliminate statistical issues, unique to that kind of models. Lastly, causality, impulse response and variance decomposition analyses are made. According to the results, there is significance relationship between efficiency and other variables such as turnover, market volatility, the share of foreigners, interest rate. Furthermore, it is found that, during the study time, 2008-2012, the efficiency is increasing in Borsa Istanbul.

This paper is organized as follows; section 2 provides the data descriptions and data-sets as methodology of the study is provided in section 3. Empirical results are illustrated in section 4 and some concluding remarks are highlighted in section 5.

2 Data

Central Securities Depositaries (MKK) where all the stocks listed on Borsa Istanbul are available online for account of investors is used for data collection of this study. We categorized the total stock investors (#1,091,950) into two groups as individuals (#1,086,400) and institutions (#5,550) and build the regression analysis for both group in order to provide better insight. First, investors are sorted by their portfolio size and then the data of investors who have portfolios valued below USD 500 are eliminated. Thereafter, the data of all institution investors and 25,000 individuals which are selected among the individual investors by using the method of stratified random sampling are employed.

The data has 1259 days since it is daily and is consisted of non-holiday regular weekdays between the years 2008-2012. We have the advantage of high frequency to have better view for the performance of the investors thanks to our daily data that is uncommon in literature in which annual data is mostly used.

The efficiency is defined by the situation of market beating. Then, we determine nine different variables linked with efficiency [**Error! Reference source not found.**]. The variables are categorized under three group as investor based, market based and country based. The data is evaluated separately for individual and institutional investors.

Table 1. Data Descriptions and Sources

	Abbreviation	Data	Description	Frequency	Source
Investor Based	eff	Efficiency	Market efficiency based on market beating conditions	Daily	BİST
	divers	Portfolio diversification	Number of stocks in a given portfolio	Daily	BİST
	turnover	Turnover	Average turnover rate	Daily	BİST
	size	Portfolio size	Average value of portfolio holdings of investors (USD)	Daily	BİST
Market Based	mcap	Market cap	Market cap value (USD)	Daily	BİST
	volume	Trade volume	Total amount of trade volume (USD)	Daily	BİST
	volatility	Market volatility	Historical volatility of the market	Daily	Bloomberg
	foreigners	Share of foreigners	Share of foreign investors in the market	Daily	CRA
	ticksize	Tick size change	Dummy variable for the change of price ticks	Daily	BİST
Country Based	interest	Interest rate	2-year generic government bond interest rate of Turkey	Daily	Bloomberg

3 Methodology

3.1 Definitions of Basics

We define efficiency as a function of adjusted return which is a calculation depended on daily raw returns of portfolios of the investors. Defining the basics, we benefit from the study of Varli (2018).

3.1.1 Adjusted Return

For the definition of daily raw returns of portfolios, we use the equations follows:

$$r_{jt}^{raw} = \sum_{i=1}^{s_{jt}} p_{ijt} r_{it} \quad (1)$$

where for the stock *i* in day *t*, r_{it} represents daily return, p_{ijt} is the weight computed by dividing the market value for stock *i* at the end-of-day (*t);* to the end-of-day (*t*) market value of portfolio of investor *j*. Finally, the number of stocks held by investor *j* at day *t is represented by* s_{jt}.

To calculate the daily market adjusted returns of individual j:

$$r_{jt} = r_{jt}^{raw} - r_t^m \tag{2}$$

Here, r_{tm} is the corresponding daily rate of return of the market.

After having the market adjusted daily returns in Equation (2) for each day *t* which is $\in$ [1,2,…,1259], the daily average return $\bar{r}_t$ for investors are calculated as:

$$\bar{r}_t = \frac{1}{J}\sum_{j=1}^{J} r_{jt} \tag{3}$$

where *J* denotes the total number of investors. It can be observed from the Equation (2), the "average return" is market adjusted.

3.2 Turnover

From Barber and Odean (2000), the turnover is defined as follows:

$$Turnover_{jt} = \frac{1}{2}\left(\frac{TradedValue_{jt}}{\overline{PSize}_j}\right) \tag{4}$$

where in regard to market value for each investor *j*, $TradedValue_{jt}$ is the total trade at day *t*. and, $\overline{PSize}_j$ is the monthly average of end-of-day portfolio holdings.

Having computed market adjusted daily turnover in Equation (4) for each day $t \in [1,2,\ldots,1259]$, the daily average turnover $\overline{Turnover}_t$ over investors is calculated as follows:

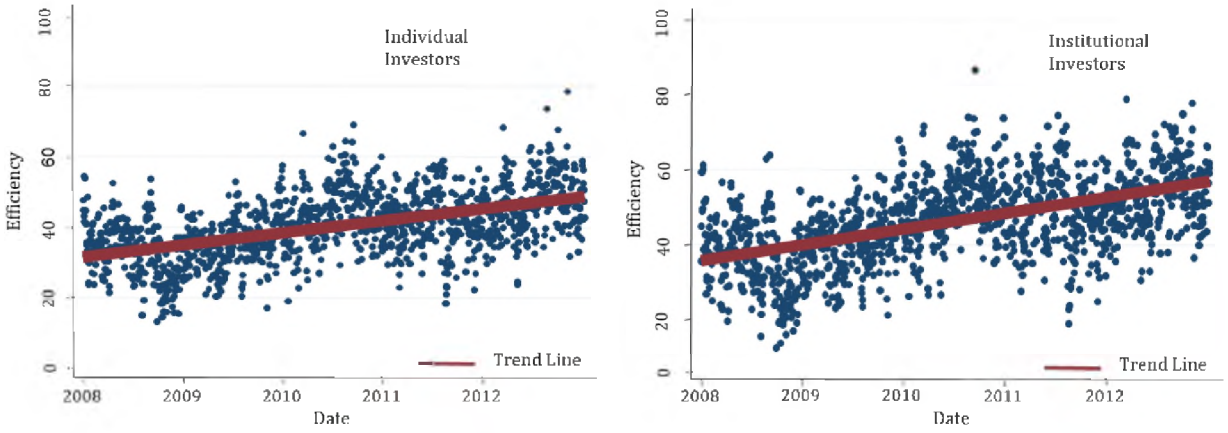
$$\overline{Turnover}_t = \left(\sum_{j=1}^{J} Turnover_{jt}/J\right) \tag{5}$$

3.3 Characterization of Efficiency

One of the most common and accurate inferences of Efficient Market Hypothesis is that both the daily returns of market beaters and daily returns of market beatens are near zero (Damodaran, 2003). When the group of investors over-perform (under-perform) the market, which can also be translated as investors with positive (negative) adjusted return they are called as market beaters (market beatens). Here, we want to test whether the difference between the returns of market beaters and returns of market beatens are zero or not. The purpose of this test is to see the evaluation of the market efficiency. Therefore, we use standard t test for each day. The null hypothesis of the test is that the average of adjusted returns of market beaters equal to the average of adjusted returns of market beatens. The direction of the daily t test values indicates the evaluation of efficiency in the market.

$$Efficiency_t = [(Average\ Adjusted\ Return\ of\ Beaters)_t - (Average\ Adjusted\ Return\ of\ Beatens)_t]_{-1}$$

Figure 1: The Efficiency Performance of Borsa Istanbul



There are also some alternative definitions for market efficiency (Varli, 2018): Due to the randomness in stock prices, the Efficient Market Hypothesis remarks that half of all investors should beat the market in a given period (Damodaran, 2003). According to the results of (Barber & Odean, 2000), 49.3% of investors beat the market. Moreover, other half of investors is expected to underperform the market. In order to observe whether the market is efficient or not as a robustness check, we prefer to conduct a test for the null hypothesis of "Number of Market Beaters" equals to "Number of Market Beatens". In other words, we want to examine that the

proportion of the number of market beaters and beatens is 1 or not. As a result, we cannot reject H_0 hypothesis.

3.4 Descriptions and Casual Identification of Variables

We classify the variables as potential variables of market efficiency into three categories; investor-based variables which are shaped based on the investors' decisions as the diversification and size of their portfolios, and average turnover rates; market-based variables which differ based on the market conditions as the maximum cap value and volatility of the market, total trading volume, the share of foreigners and the change in the tick sizes of prices (dummy); and additional one country-based variable which is completely exogenous, interest rate.

Investor-Based

- *Portfolio diversification:* Since the efficiency is defined as the difference between market beaters and market beatens, how the investors diversify their portfolios likely to have a significant impact on efficiency. This data denotes the number of stocks in the investor's portfolio, which is computed daily.

- *Portfolio size:* The size of the given portfolio for each investor is calculated as the portfolio holdings at the end of the day. It is a variable that should be considered in the same path as the diversification since it is a crucial indicator for investor behaviors.

- *Turnover:* Finally, the last variable for the investor-based side is turnover which is widely used in the literature to describe the efficiency. The calculation is provided with detailed explanations in the previous section.

Market-Based

- *Market cap:* We also add the market capitalization that we believe that it might an impact on efficiency based on market beating. It basically means what the company priced at the given time in the market. It is calculated for each stock with the multiplication of the number of shares of the company and the price of a stock, and all calculations summed up to find the whole market cap.

- *Trade volume:* The impact of trade volume over efficiency is almost as old as the introduction of market efficiency (Easley & O'Hara, 1992). It is demonstrated as the volume get larger, the efficiency increases.

- *Market volatility:* Volatility is translated as the fluctuations of the asset prices over time, which is one of the important indicators that demonstrates the performance and foreseeability of the market. Since the foreseeability of the market is closely linked with the efficiency, we put into the model as efficiency determinants. The researchers have also study which way the volatility have an impact on market efficiency (Hameed, Ashraf, & Siddiqui, 2006). For the study, the historical volatility data for BIST is obtained from Bloomberg, which is calculated by using close-close volatility method.

- *Share of foreigners*: We also insert the variable of share of foreigners to the model in order to see whether it has an impact on market efficiency. Since the presence of the foreign stocks occupies 65% of all stocks in Borsa Istanbul, which is our case study, the efficiency of Borsa Istanbul likely to have close connection with the variable.

- *Tick size change:* Since the model is based on daily data, minimum price variations of instrument likely to have an impact on efficiency. We insert the variable because BIST recently changed this minimum value.

Country-Based

- *Interest rate:* The country conditions have also crucial role over stock markets, naturally. Many variables related with the country are considered such as FX Rate or the prices of precious metals, but only interest rate is taken amongst them due to high correlation between the considered variables. The change in interest rates is expected to have some impact on the efficiency.

4 Results

In order to see the evaluation of market efficiency, we analyze how the market is efficient by using several test and statistics. First, traditional OLS estimation method is employed along with Newey-West and Prais-Winston estimators to test and eliminate potential statistical issues with the

model. Secondly, stationary status, auto-correlation and heteroscedasticity of our time-series VAR model are tested through unit root test and others. Thirdly, granger causality is applied to the model in order to deeply analyze the relationship between each variable with themselves. Lastly, impulse response and variance decomposition analyses is made to see the responses of each variable during a shock rise in other variables and the amount of information each variable contributes to the other variables, respectively.

4.1 Regression Analysis

In order to see the evaluation of market efficiency, we analyze parameters of market efficiency by employing several test and statistics. Firstly, we use Regression Analysis (OLS) to test whether there are significant impacts of selected variables on the efficiency. The results generated using Stata software for both individual and institutional investors are illustrated in Table 2.

As it can be seen from the OLS section in Table 2, turnover rate, market cap, trade value, market volatility and interest rate are statistically significant for both agents; individual and institutional investors. In addition, portfolio diversification is statistically significant for only individual investors whereas share of foreigners and tick size change are statistically significant for only institutional investors. Portfolio size, on the other hand, fail to have a significant effect on efficiency for both investor types. With 0.57 R_2 for the model of individual investors and 0.60 R_2 for the model of institutional investors show that both models have sufficiently specified what variables have affect the efficiency while. However, Durbin-Watson d-statistic value which falls outside of the secure area (1.93 – 2.06) for both investor types demonstrates that the disturbances are serially correlated as we initially suspected. Thus, we use different estimations to overcome the serial-correlation problem such as Newey-West and Prais-Winsten.

Table 2. Regression Analysis for Individual and Institutional Investors

	OLS		**Newey-West Est.**		**Prais-Winsten Est.**	
	Individuals	Institutions	Individuals	Institutions	Individuals	Institutions
$divers_1$	-14.7527***	29.1849	-14.7527***	29.1849	-14.5551***	11.4021
	(-6.99)	(1.03)	(-5.61)	(0.83)	(-5.50)	(0.33)
turnover	-60.5644***	-25.5372**	-60.5644***	-25.5372*	-49.4254***	-9.9412
	(-4.68)	(-2.06)	(-3.61)	(-1.73)	(-3.26)	(-0.75)
$size_1$	0.8547	9.7280	0.8547	9.7280	4.8188	13.6168
	(0.09)	(0.92)	(0.10)	(0.92)	(0.51)	(1.23)
$mcap_1$	-17.0449**	-29.5013***	-17.0449**	-29.5013***	-17.6263**	-26.2016***
	(-2.31)	(-3.49)	(-2.34)	(-3.23)	(-2.52)	(-3.05)
volume	-1.6500***	-1.8400***	-1.6500***	-1.8400***	-1.7700***	-2.0108***

	(-9.84)	(-10.78)	(-7.61)	(-8.28)	(-8.79)	(-9.51)
volatility	-0.2576***	-0.3954***	-0.2576***	-0.3954***	-0.2269***	-0.3488***
	(-14.13)	(-18.59)	(-12.32)	(-14.60)	(-11.93)	(-15.02)
foreigners	-	58.0487***	-	58.0487***	-	59.7812***
	-	(5.47)	-	(4.50)	-	(4.32)
ticksize	0.9118	1.5807***	0.9118	1.5807**	1.1558	1.8360**
	(1.51)	(2.68)	(1.08)	(2.01)	(1.49)	(2.42)
interest	-1.0444***	-1.2142***	-1.0444***	-1.2142***	-1.0773***	-1.2595***
	(-18.49)	(-18.44)	(-14.22)	(-13.85)	(-15.72)	(-14.84)
_cons	137.0719***	40.0011***	137.0719***	40.0011***	133.7695***	37.5785***
	(15.28)	(5.83)	(11.83)	(4.75)	(12.06)	(4.20)
R_2	0.57	0.60	0.57	0.60	0.48	0.50
Durbin-Watson	1.57	1.59	-	-	1.57-2.06	1.50-2.09

Note: Estimation results for different regression analysis. The t statistics are in parentheses.
*** indicates significance at 1% level.
** indicates significance at 5% level.
* indicates significance at 10% level.
1 The change (first difference) is evaluated for some cases (institution etc.).

4.2 Newey–West Estimation

In the time of common statistical complications such as autocorrelation -the situation occurring during the error terms are correlated over time- and heteroscedasticity, common inferences from OLS model could not directly be performed due to the inefficient estimators and inconsistent standard errors. The interpretations would be biased and invalid. In such cases, two alternatives arise: (1) applying different methods rather than OLS, such as GLS (Prais-Winston i.e.) to achieve more efficient estimations; or (2) accepting the inefficiency and correcting the standard errors by mounting specific techniques such as Newey-West estimator (1987).

Newey-West is defined as the estimator which is used to tackle some statistical problems such as autocorrelation and heteroscedasticity in the error terms in the models. It is usually applied to time series data specifically when the dependent variable is lagged. The coefficients typically remain same while the t-values are changed after the estimator is applied. This common technique is employed to correct the standard errors, and in order to that, valid interpretation can be performed. Therefore, robustness of the tests can be enhanced and the inefficient and biased standard errors can be eliminated. One of the special strengths about Newey-West Estimator (aka Robust Standard Errors) is its power to eliminate both problems (autocorrelation and heteroscedasticity) at the same time.

In our results, Durbin Watson test value of OLS estimation illustrated the obvious existence of autocorrelation problem. Thus, Newey-West estimators are employed to overcome the existing

problem. After the Newey-West estimation is performed, as it can be observed from the table 2, the significance of the variables mostly remains same except for some tiny differences that would not affect the analysis. Therefore, we can say the serial-correlation problem successfully eliminated.

4.3 Prais–Winsten Estimation

In order to increase the robustness of the model, along with others, we also apply Prais-Winsten estimator which is defined as one of the three feasible and common estimators using the generalized least-squares (GLS) method to estimate the variables in a linear regression model in which the errors are serially correlated. The Prais-Winsten is an updated version of Cochrane-Orcutt estimator (1949). Unlike Newey-West, the coefficients are expected to be different from OLS estimations as well as the standard errors, since Prais-Winsten works fundamentally different from OLS. Even though it is considered as good estimators when there is no lagged which we have in our model, we apply it to increase the robustness.

As demonstrated in Table 2, after the estimation, the significance of the variables mostly remains same except for some tiny differences that would not affect the analysis, which illustrates that we manage to tackle serial-correlation problem for the model. As observed from the table, after Prais-Winston Test, specifically t-values which are on the edge of being significant switch to insignificant such as turnover for institutional investors.

4.4 Vector Auto Regression (VAR) Analysis

After the demonstrating OLS estimators along with Newey-West estimators and Prais-Winsten estimators to eliminate the serial correlation problem and to enhance robustness, we move on to the diagnostics for VAR (vector auto regression) model. VAR (vector auto regression) is a model used to capture the linear interdependencies among time-series. Since our model is a time-series model, several analyses are conducted to check whether the variables are integrated of order one or not.

4.4.1 Unit Root Test Results

Before moving the deep analyses, we check for possible statistical issues such as that model being stationary and having stability. So, first, we examine the variables if they are stationary. In this line, we test the null-hypothesis of an existence of a unit root. According to the results of ADF (Augmented Dickey-Fuller) Unit Root Test, which is commonly used for detecting the unit roots, in Table 3 below, for both investor types, almost all of the test values of the variables fall within critical levels for 1% significance level (divers 5%). Therefore, we can conclude that the most of the variables are stationary.

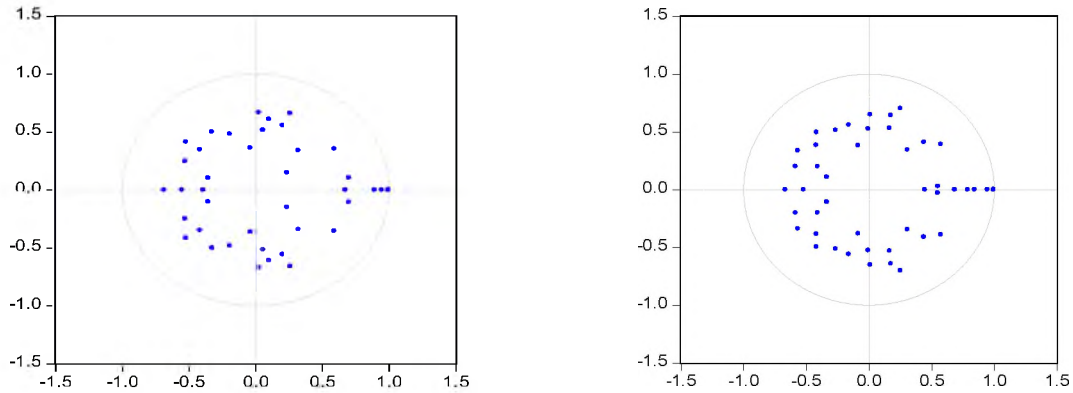
Table 3. Unit Root Test Results (Augmented Dickey-Fuller - ADF) for Individual and Institutional Investors (H0: Non-stationary)

Variable	Deterministic Terms	Lags	Test Value for Individuals	Test Value for Institutions	Critical Levels		
					1%	5%	10%
eff	Intercept	5	-6.42	-6.26	-3.44	-2.86	-2.57
divers[1]	Intercept	5	-2.99	-15.98	-3.44	-2.86	-2.57
turnover	Intercept	5	-4.82	-7.66	-3.44	-2.86	-2.57
size[1]	Intercept	5	-15.33	-13.94	-3.44	-2.86	-2.57
mcap[1]	Intercept	5	-15.45		-3.44	-2.86	-2.57
volume	Intercept	5	-5.66		-3.44	-2.86	-2.57
volatility	Intercept	5	-8.32		-3.44	-2.86	-2.57
foreigners	Intercept	5	-2.2*		-3.44	-2.86	-2.57
interest	Intercept	5	0.92		-3.44	-2.86	-2.57

[1] The change (first difference) is evaluated for some cases (institution etc.)
* Since the correlation between divers and foreigners for individual investors is -0.9551, we dropped out those variables.
We select "Domestic Funds" as a representative institutional type due to the restrictions on portfolio data.

Furthermore, as it can be observed from the Figure 2, no root lies outside the unit circle and no roots modulus are more than 1. Thus, we can conclude that VAR model also satisfies the stability condition. So, long-run relationship between the variables is stable. The results of ADF unit root tests indicate that there is no problem about stability of the model with individual or institutional investors. As a result, we can move on to impulse response and variance decomposition tests which can be considered valid since the unit root test satisfies the validity.

Figure 2. Inverse roots of AR Characteristics Polynomial for Individual Investors (left) and Institutional Investors (right)



4.4.2 Other Tests

Additional diagnostic tests are performed to have more robust results from the model are summarized in Table 4. LM (Langrage Multiplier; H0:no autocorrelation) test, also called "Score Test", is employed to test if there is possible auto-correlation, while ARCH-LM Autoregressive Conditional Heteroscedasticity concerns the auto-correlation of the heteroscedasticity (H0: there is no ARCH effect present) and Jarque-Bera Test is simply kind of fitness-of-fit which checks the sample have normal distribution regarding its skewness and kurtosis (H0: the sample data are from normal distribution). As it can be observed from the summary table, all p values for the tests are below critical percentage except Jarque-Bera Test result for institutional investors, which is plausible since the number of samples is low comparing to the individual investors and their stock decisions are less normally distributed.

Table 4. Diagnostic Test Results for Individual and Institutional Investors

Type of Test	Individual investors	Institutional investors
LM Test for Autocorrelation	88.08	103.02
	(0.02)	(0.05)
ARCH-LM Test (eff)	16.50	10.59
	(0.01)	(0.06)
Jarque-Bera Test (eff)	5.92	3.21
	(0.05)	(0.20)

Note: The p values are in parentheses.

4.4.3 Granger Causality

Granger causality is a statistical concept used to determine whether future outcomes of a variable can be predicted or forecasted based upon its own history and in addition, considering the history of another variable. Contrary to its name, granger causality does not contain causality as in the philosophical sense. Thus, when there is granger causality, the term 'granger cause' is often used. Our variables are also tested with the Granger causality in order to reveal the granger causality among the variables. The test is run for all possible combinations and three significance levels. The results for individual and institutional investors are summarized in Table 5 and Table ***6***, respectively.

Table 5. Granger Causality Test for Individual Investors

	efficiency	divers	turnover	mcap	size	interest	volume	volatility	Overall
efficiency	-	13.21**	9.35*	5.69	13.63**	32.83***	7.69	2.89	93.41***
	-	(0.021)	(0.096)	(0.338)	(0.018)	(0.000)	(0.174)	(0.716)	(0.000)
divers	17.64***	-	21.35***	45.31***	98.47***	0.89	51.62***	9.94*	320.37***
	(0.003)	-	(0.000)	(0.000)	(0.000)	(0.971)	(0.000)	(0.077)	(0.000)
turnover	17.75**	12.97**	-	27.18***	73.24***	4.98	8.75	13.31**	220.16***
	(0.003)	(0.024)	-	(0.000)	(0.000)	(0.418)	(0.119)	(0.020)	(0.000)
mcap	3.01	9.49*	3.45	-	1273.83***	21.68***	9.97*	9.06	1380.55***
	(0.699)	(0.091)	(0.632)	-	(0.000)	(0.000)	(0.076)	(0.106)	(0.000)
size	3.86	4.53	6.23	11.19**	-	13.10**	3.41	5.51	70.42***
	(0.570)	(0.476)	(0.284)	(0.048)	-	(0.022)	(0.637)	(0.356)	(0.000)
interest	3.62	6.61	9.29*	12.88**	172.53***	-	2.37	8.79	227.32***
	(0.605)	(0.251)	(0.098)	(0.025)	(0.000)	-	(0.795)	(0.118)	(0.000)
volume	28.2***	6.27	8.18	5.95	16.49***	5	-	13.75**	86.41***
	(0.000)	(0.281)	(0.146)	(0.311)	(0.006)	(0.415)	-	(0.017)	(0.000)
volatility	27.17***	2.23	0.77	7.75	105.8***	13.29**	7.11	-	248.64***
	(0.000)	(0.816)	(0.979)	(0.171)	(0.000)	(0.0208)	(0.213)	-	(0.000)

Note: Test statistics values for granger causality. The probabilities are in parentheses.
*** indicates significance at 1% level.
** indicates significance at 5% level.
* indicates significance at 10% level.

As observed from the Table 5, for individual investors, portfolio diversification, turnover rate, portfolio size and interest rate granger cause efficiency for various significance level, which means the past values of those variables contribute to the forecasting of the present and future values of efficiency. When the reverse causality is explored for efficiency, it is seen that the portfolio diversification and turnover rate have also causality with efficiency which creates mutual granger causality. Apart from those implications, past values of efficiency have strength on predicting the current and future outcomes of trade volume and volatility in 1% significance level. From the table, with 1% significance level, interest rate is the most successful variable to predict efficiency which is expectable because interest rate has vital importance of economic outlook just like market

efficiency. Turnover rate, portfolio diversification and size follow as variables strongly granger-causing efficiency which can be interpreted that components of the market naturally has power to forecast efficiency as they also are partly in the definition of efficiency illustrated in previous section.

Almost all variables except interest rate which is certainly exogenous, would help to forecast the future outcomes of portfolio diversification while the future values of only turnover rate and market value can be predicted by the past values of portfolio diversification. Turnover rate's future values can be forecasted by the help of past values of efficiency, market cap, portfolio diversification, portfolio size and market volatility which is not a surprise since the definition of turnover rate directly or indirectly contains those variables. As expected, future or current outcome of interest rate can be predicted by past values of market cap and portfolio size which both are the variables having some indicators on overall economy. Future values of volume and volatility can be forecasted by the help of past values of efficiency and portfolio size. Lastly, from 72 causality combination, for individual investors, the ones whose granger causality is mutual are follows as: efficiency-portfolio diversification, efficiency-turnover rate, portfolio diversification-turnover rate, portfolio diversification-market cap, market cap-portfolio size, market cap-interest rate and portfolio size-interest rate.

Table 6: Granger Causality Test for Institutional Investors

	efficiency	divers	turnover	mcap	size	interest	volume	volatility	foreigners	Overall
efficiency	-	11.28**	7.68	3.39	16.24***	38.61***	11.23**	2.71	9.66*	113.45***
	-	(0.046)	(0.175)	(0.640)	(0.006)	(0.000)	(0.047)	(0.744)	(0.085)	(0.000)
divers	1.6	-	7.17	5.92	25.31***	3.87	8.06	1.19	12.41**	76.19***
	(0.901)	-	(0.208)	(0.314)	(0.000)	(0.569)	(0.153)	(0.946)	(0.030)	(0.001)
turnover	21.1***	5.11	-	14.38**	31.25***	12.29**	8.7	8.07	4.01	106.96***
	(0.0008)	(0.402)	-	(0.013)	(0.000)	(0.031)	(0.122)	(0.153)	(0.548)	(0.000)
mcap	13.44**	105.24***	8.69	-	1281.62***	26.59***	17.97***	7.86	0.45	1382.37***
	(0.02)	(0.000)	(0.122)	-	(0.000)	(0.000)	(0.003)	(0.164)	(0.994)	(0.000)
size	8.81	14.93**	6.82	11.46**	-	10.82*	5.64	4.73	13.33**	80.78***
	(0.117)	(0.011)	(0.235)	(0.043)	-	(0.055)	(0.343)	(0.449)	(0.021)	(0.000)
interest	1.18	15.8***	1.57	17.31***	168.07***	-	3.37	10.33*	8.23	214.19***
	(0.946)	(0.007)	(0.905)	(0.004)	(0.000)	-	(0.643)	(0.066)	(0.144)	(0.000)
volume	22.57***	3.01	22.77***	8.6	24.05***	4.85	-	17.36***	1.62	105.42***
	(0.000)	(0.698)	(0.000)	(0.126)	(0.000)	(0.434)	-	(0.004)	(0.899)	(0.000)
volatility	22.82***	9.63*	10.27*	8.6	73.68***	14.81**	6.83	-	4.1	221.2***
	(0.000)	(0.087)	(0.068)	(0.126)	(0.000)	(0.011)	(0.234)	-	(0.536)	(0.000)

foreigners	9.05	5.18	12.07**	2.82	60***	8.18	2.08	1.12	-	169.08***
	(0.107)	(0.394)	(0.034)	(0.727)	(0.000)	(0.146)	(0.839)	(0.952)	-	(0.000)

Note: Test statistics values for granger causality. The probabilities are in parentheses.
*** indicates significance at 1% level.
** indicates significance at 5% level.
* indicates significance at 10% level.
1 the gap is tested for certain cases (institution etc.)

When it comes to institutional investors, surprisingly, the picture dramatically changed. Different from the table of granger causality table for individual investors, there is additional variable which is share of foreigners. As observed from the table 6, for institutional investors, along with trade volume and share of foreigners; portfolio diversification, portfolio size and interest rate granger cause the efficiency like they do for the individual investors for various significance level, which means the past values of those variables contribute to the forecasting of the present and future values of efficiency. If the reverse causality is explored for efficiency, it is seen that only trade volume has also causality with efficiency which creates mutual granger causality. From the table, with 1% significance level, interest rate and market size are the most relevant variables to predict efficiency which is expectable because those variables have vital importance of economic outlook just like market efficiency.

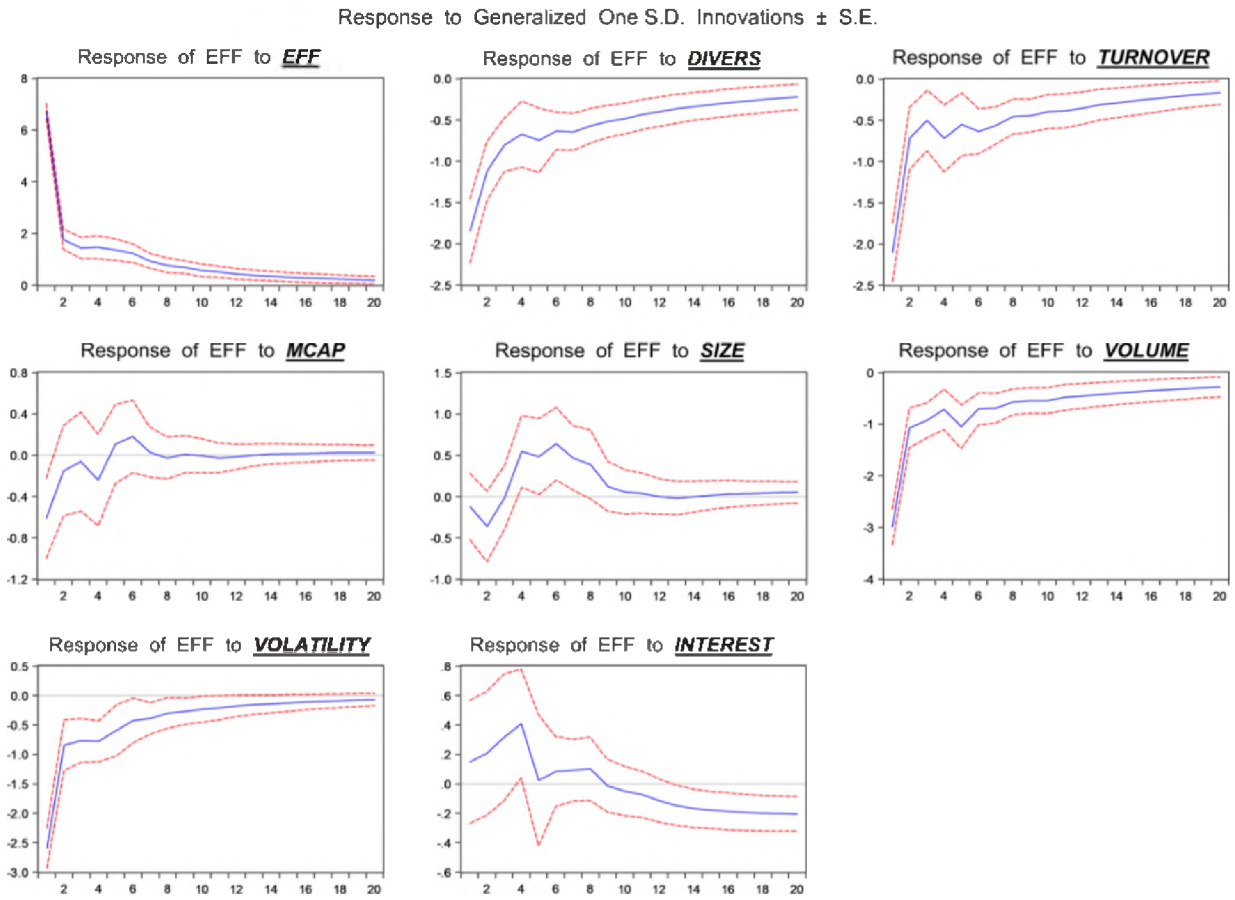
On the contrary for individual investors, for institutional investors, almost none of the variables except market size and share of foreigners would help to forecast the future outcomes of portfolio diversification. It can be portrayed because institutional investors are expected to be much better on diversifying their stocks than individual investors which would make the predicting diversification free of other variables unlike for the individual investors. Turnover rate's future values can be forecasted by the help of past values of efficiency, market cap, portfolio size and interest rate. Future or current outcome of interest rate can be predicted not only by past values of market cap and portfolio size which is totally expected, but also portfolio diversification and market volatility. This surprising result can be justified as that the institutional investors' decisions on their portfolio diversification has an impact on interest rate and market volatility due to the large magnitude of their stocks. Lastly, from 72 causality combination, for the institutional investors, the ones whose granger causality is mutual are follows as: efficiency-trade volume, portfolio diversification-portfolio size, market cap-interest rate, market cap-portfolio size, portfolio size-interest rate, portfolio size-share of foreigners and interest rate-volatility.

When looking at overall which all indicates granger causality for 1% significance level, both for individual and institutional investors, it can be claimed that the model granger cause the variables separately. Past values of the model would contribute to the forecasting the future/current outcomes of the variables.

4.4.4 Impulse Responses

An impulse response analysis is typically a tool to analyze the interactions between the variables in the model. The magnitude and the period of that a certain variable responds to one standard deviation shock on each variable is illustrated in Figure 3 in detail. In our analysis, we concentrate on the responses of efficiency to the impulses on all variables from two different perspectives, individual and institutional investors.

Figure 3. Response of Efficiency to Various Shocks (Individual Investors)

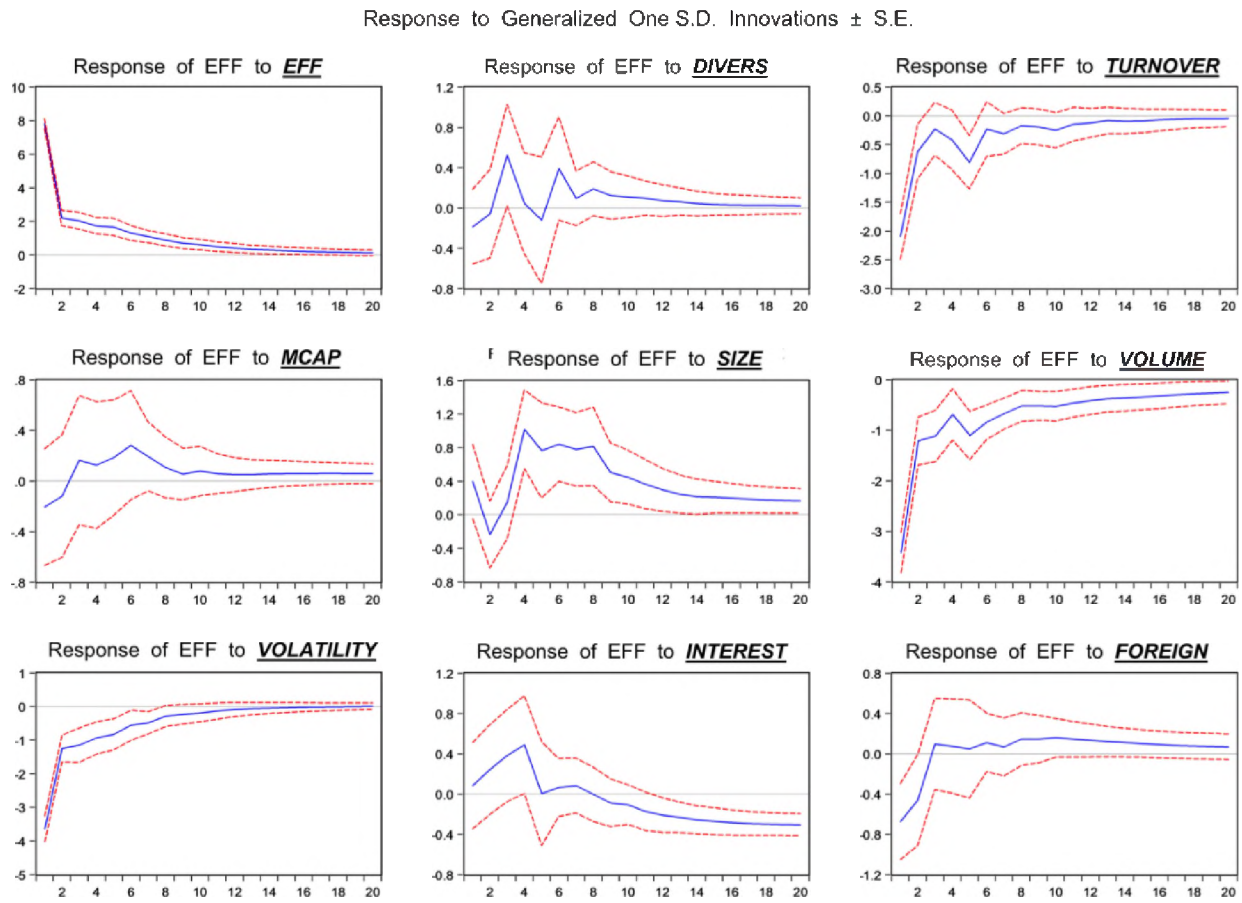


The responses of the efficiency to shocks on the determinants; change in the variables can be seen in Figure 3 and Figure 4 for individual investors and institutional investors, respectively. It is demonstrated that the change in the *Number of Stocks in the Portfolio* shock affects the efficiency positively both in the short run and the long run. In the short-run, the response is sharply positive which means that the market efficiency responses rapidly increase towards the shock of *portfolio diversification*. Despite relatively fluctuant decline for a very short time, it is approaching to the zero by continuing to increase in the medium run. It converges its permanent level after twenty periods (almost two years). Intuitively, as the number of stocks increases, which can be translated the size of the market increases, the adjusted return of beaters and beatens would converge to each other which increases efficiency in both short and long term. The same interpretation can be observed for the *Turnover Rate*, *Total Trade Volume* as well as the *Market Volatility* as well with a little more fluctuation in the medium-run. The shock on any of those determinants will lead a raise the size of the market which in turn make difficult to upsurge for market beaters. Similarly, the shock of the change in the market cap value affected efficiency positively in the short-run and

after reduction for a short period, it even surpasses zero. However, in the long-run it loses its velocity and reduced by approaching to zero again which will be its permanent level after eight days.

The response of the efficiency on the shock of the other variables; specifically, to the *change in Portfolio Size* and the *country interest rate* is also illustrated in the figure. In the very short-run, the shock of the change in the portfolio size affects efficiency negatively which swiftly turns positive in medium-run and protect its level. After 6 days -the period for the maximum level the efficiency has ever get- it started to decline and approaches zero. Surprisingly, efficiency responses first positively to the shock in the country interest rate which can be interpreted that the individual investors use the market as escape point while interest rate make difficult to invest goods of properties, which increases the number of investors, therefore the efficiency. However, after 5 days, efficiency responses with a sharp decline as expected. Even though it stabilizes by little for a short period, its continuous diminishing period starts and it reaches below zero. It means that the shock in interest rate have permanently a negative impact on efficiency as the adverse relationship was observed in previous sections.

Figure 4: Response of Efficiency to Various Shocks (Institutional Investors)



From the institutional side, the responses become more fluctuated in the medium and more stable in the long-run. Efficiency responses with two sharp rise and fall on the shock the change in the number of stocks before it approaches to the zero which is its permanent level in the long-run. In the case of shock of Turnover rate, on the other hand, efficiency follows similar path as in the individual investors with sharp rise in the short-run, a little fluctuated decline in the medium-run and continues diminishing increase by approaching to the zero in the long-run.

The response of the efficiency for the institutions on the Total Trade Volume, Market Volatility and the interest rate is almost same for the individuals. For the case of the shocks on the change in Portfolio Size and change in Market Cap Value for the institutions, the response of efficiency follows similar path with the individuals with a small difference: the permanent levels those two variables get stays little bit up from the zero for the institutions while it almost reaches zero for the individuals. Lastly, for the shock of foreigners' share which is exclusively for the institutions, efficiency responses surpass zero by positively and rapidly increasing in the short-run, and it

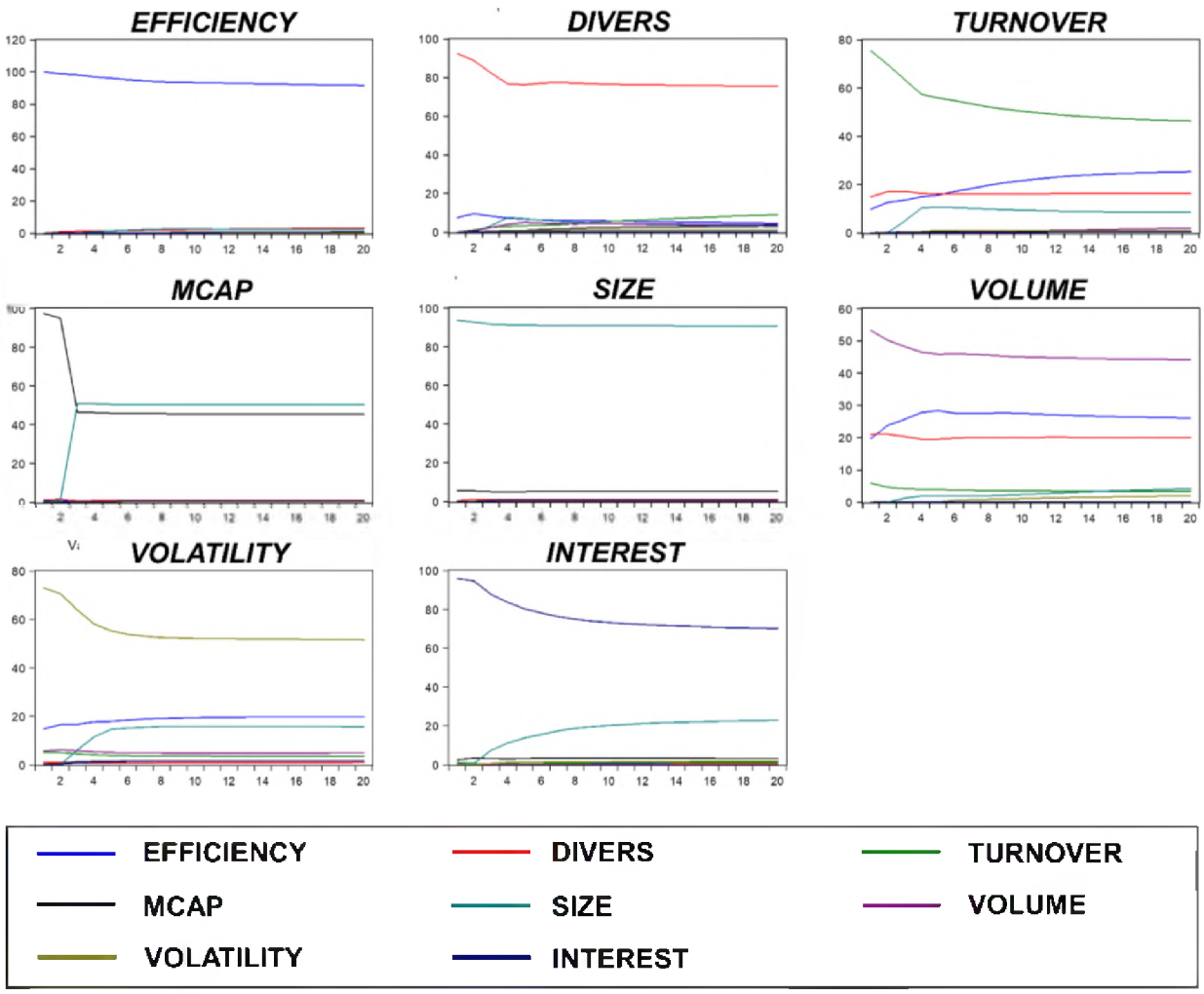
reaches its permanent level which is little above zero in the long-run after very small fluctuations in medium-run.

4.4.5 Variance Decomposition

One of the implications of the structural vector error correction model is variance decompositions. It indicates the amount of information each variable contributes to the other variables in the auto regression. In other words, it determines how much of the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables. The forecast variance decompositions are summarized in Figure 5 for individual investors and in **Error! Reference source not found.** for institutional investors.

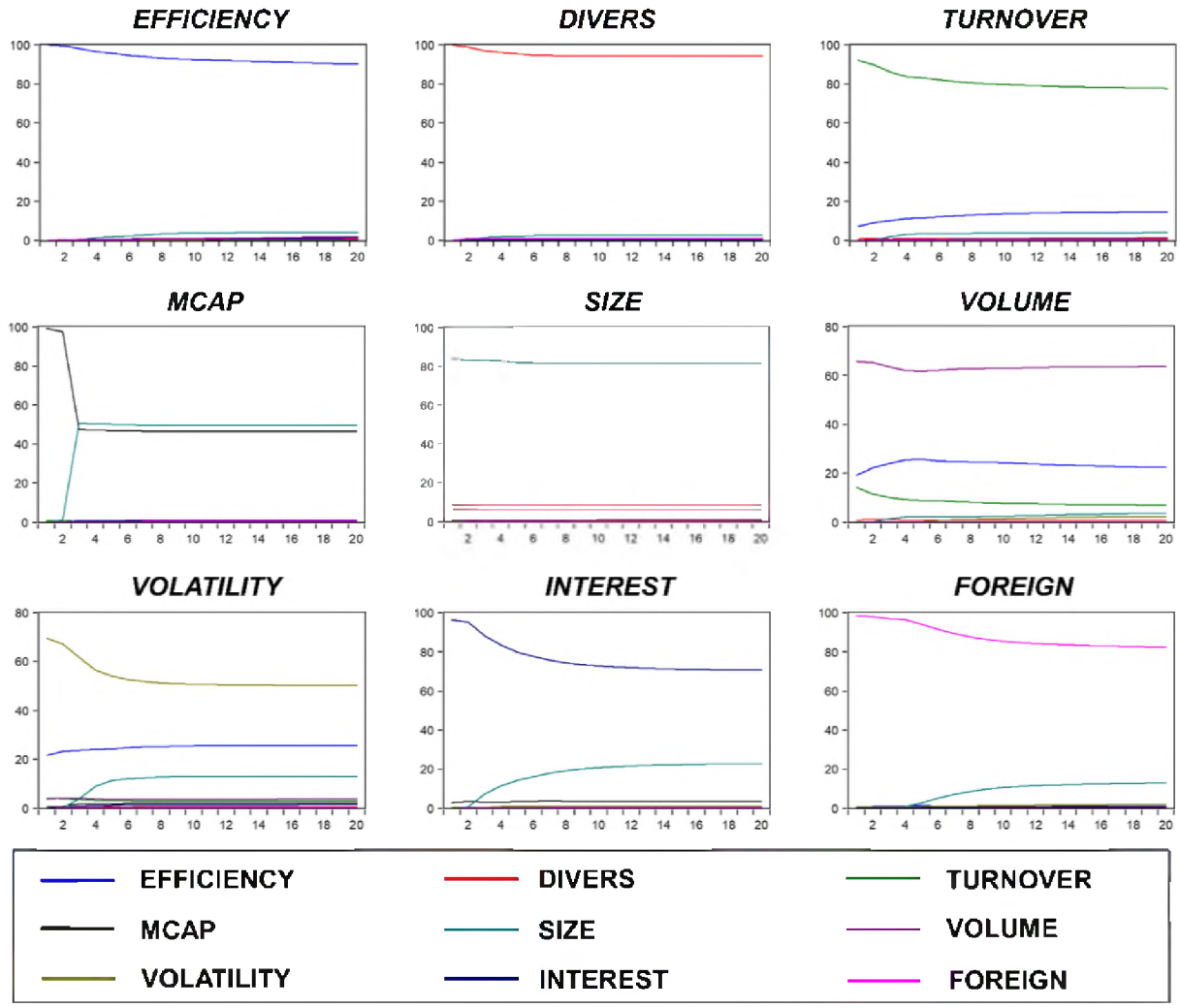
As it can be observed from the Figure 5, for individual investors, for instance, over 50% of the forecast error variance of turnover rates can be explained by exogenous shocks to the efficiency, portfolio diversification and portfolio size while almost 100% of the forecast error variance of efficiency can be explained by exogenous shocks to only the efficiency. The forecast error variance of market cap can be explained by exogenous shocks to portfolio size and market cap itself. One of the most variety is present in the forecast error variance of volume, %40 of which can be explained by exogenous shocks to volume itself while 30% of which can be explained by exogenous shocks to efficiency and 20% of which can be explained by exogenous shocks to portfolio diversification. Lastly, exogenous shocks to efficiency plays great role to explain the forecast error variance of volatility with 20%.

Figure 5. Variance Decomposition to Each Determinant for Individual Investors



For institutional investors, on the other hand, the story goes a little bit differently from individual investors. For example, only 20% of the forecast error variance of turnover rates can be explained by exogenous shocks to the efficiency while 40% of the forecast error variance of volume size can be explained by exogenous shocks to the efficiency and turnover rates. In terms of the in the forecast error variance of market change, the story is the same with individual investors; half of which can be explained by the exogenous shocks to portfolio size. Unlike in individual investors, only 20% exogenous shocks to volume can be explained by exogenous shocks to efficiency. Lastly, exogenous shocks to portfolio size plays great role to explain the forecast error variance of interest rate with 20%, which is also quite similar with individual investors.

Figure 6. Variance Decomposition to Each Determinant for Institutional Investors



5 Concluding Remarks

In this study, we try to contribute to the discussions over market efficiency which is one of the most interesting subjects in finance theory not only in the world but also in the academic literature. Though there are some studies related with the efficiency of certain markets exist in literature, questions like what is behind the efficiency concept and what is the current situation of efficiency in emerging markets, as a case study Borsa Istanbul-Turkey, remain unanswered. Hence, we aim to illuminate this void by determining the variables having an impact on the efficiency of stock markets. We take Borsa Istanbul as a case and examine its efficiency with the selected variables and definitions of efficiency between 2008 and 2012.

In data collection and methodology, in Borsa Istanbul, five years daily data of 30,550 investors of which 5,550 are institutional and 25,000 are individual are collected between 2008-2012. Along with provided alternative definitions of the market efficiency, for this study, we take the *'Adjusted Return of Market Beaters-Beatens'* definition which defines the efficiency based on the investors who beat the market and who are beaten by the market. The performance of Borsa Istanbul regarding those three definitions are provided with detailed graphics for five years. Right after we provided ten factors that we believe in behind market efficiency, additional variables -turnover rate and adjusted return- and hot to obtain them mathematically are introduced. Then, those 10 variables for individual investors and 11 variables for institutional investors are regressed by using various types of statistical estimators (OLS, Newey-West and Prais-Winston) in order to eliminate statistical complications (autocorrelation, heteroscedasticity) and increase the robustness of the model, separately. Since the model is a time series model, additional tests and analysis are conducted to check if the model is an appropriate time-series (stationary etc.). Lastly, multiple deep analyses are followed to have better insight about how the determinants have an impact on efficiency.

As a result, we find that the efficiency is significantly affected by turnover rate, market volatility, share of foreign investors and interest rate. We also find that the efficiency of Borsa Istanbul is increasing in the time of the study, 2008-2012. For future works, more detailed study can be conducted in panel structure to have better analysis for the market.

References

Anagnostidis, P., Varsakelis, C., & Emmanouilides, C. J. (2016). Has the 2008 financial crisis affected stock market efficiency? The case of Eurozone. *Physica A: Statistical Mechanics and Its Applications*, *447*, 116–128.

Barber, B. M., & Odean, T. (2000). Trading Is Hazardous to Your Wealth: The Common Stock Investment Performance of Individual Investors. *The Journal of Finance*, *55*(2), 773–806.

Basu, S. (1977). INVESTMENT PERFORMANCE OF COMMON STOCKS IN RELATION TO THEIR PRICE-EARNINGS RATIOS: A TEST OF THE EFFICIENT MARKET HYPOTHESIS. *The Journal of Finance*, *32*(3), 663–682.

Beltratti, A., Bortolotti, B., & Caccavaio, M. (2016). Stock market efficiency in China: Evidence from the split-share reform. *The Quarterly Review of Economics and Finance*, *60*, 125–137.

Chaudhuri, S. K. (1991). Short-run Share Price Behaviour: New Evidence on Weak Form of Market Efficiency. *Vikalpa*, *16*(4), 17–21.

Damodaran, A. (2003). *Investment philosophies : successful strategies and the investors who made them work*. Wiley, Hoboken, NJ.

Del Brio, E. B., Miguel, A., & Perote, J. (2002). An investigation of insider trading profits in the Spanish stock market. *The Quarterly Review of Economics and Finance*, *42*(1), 73–94.

Easley, D., & O'Hara, M. (1992). Adverse Selection and Large Trade Volume: The Implications for Market Efficiency. *The Journal of Financial and Quantitative Analysis*, *27*(2), 185.

Fama, E. F. (1991). Efficient Capital Markets: II. *The Journal of Finance*, *46*(5), 1575–1617.

Hameed, A., Ashraf, H., & Siddiqui, R. (2006). Stock Market Volatility and Weak-form Efficiency: Evidence from an Emerging Market [with Comments]. *The Pakistan Development Review*, Vol. 45, pp. 1029–1040.

Ito, M., Noda, A., & Wada, T. (2016). The evolution of stock market efficiency in the US: a non-Bayesian time-varying model approach. *Applied Economics*, *48*(7), 621–635.

Jamaani, F., & Roca, E. (2015). Are the regional Gulf stock markets weak-form efficient as single stock markets and as a regional stock market? *Research in International Business and Finance*, *33*, 221–246.

Malkiel, B. G., & Fama, E. F. (1970). EFFICIENT CAPITAL MARKETS: A REVIEW OF THEORY AND EMPIRICAL WORK*. *The Journal of Finance*, *25*(2), 383–417.

Muradoglu, G., Taskin, F., Bigan, I., & Taylor, P. (2000). Causality Between Stock Returns and Macroeconomic Variables in Emerging Markets. *Russian and East European Finance and Trade*, *36*(6), 33–53.

Rizvi, S. A. R., & Arshad, S. (2014). Investigating the efficiency of East Asian stock markets through booms and busts. *Pacific Science Review*, *16*(4), 275–279.

Rizvi, S. A. R., Dewandaru, G., Bacha, O. I., & Masih, M. (2014). An analysis of stock market efficiency: Developed vs Islamic stock markets using MF-DFA. *Physica A: Statistical Mechanics and Its Applications*, *407*, 86–99.

Robert D. Gay Jr. (2008). Effect of macroeconomic variables on stock market returns for four emerging economies: Brazil, Russia, India, and China. *International Business & Economics Research Journal (IBER)*, *7*(3), 3–10.

Tahaoglu, C., & Guner, N. (2010). An Investigation of Returns to Insider Transactions: Evidence from the Istanbul Stock Exchange. *SSRN Electronic Journal*.

Urquhart, A., & McGroarty, F. (2016). Are stock markets really efficient? Evidence of the adaptive market hypothesis. *International Review of Financial Analysis*, *47*, 39–49.

Varli, Y. (2018). Evaluation of Market Efficiency and Trading Behavior of Investors: Evidence From Borsa Istanbul. *Finansal Araştırmalar ve Çalışmalar Dergisi*, *10*(18), 153–165.