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**MEASURING FINANCIAL STRESS INDEX FOR TURKEY**

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MEASURING FINANCIAL STRESS INDEX FOR TURKEY

TÜRKİYE'DE FINANSAL STRESİN ÖLÇÜLMESİ

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- 3) Principal Component Analysis
- 4) Portfolio Theory
- 5) GARCH Models

## **PREFACE**

This study is submitted in fulfillment of the requirements of the Master's Degree of Financial Economics program at Istanbul Bilgi University. The studies related to the measurement of financial stress index taking into account different market segments together has become important especially after the late 1990s. The previous studies were mostly focused on a single market and ignored the systemic impacts of it.

In this study, a financial stress index is constructed for Turkey by using a relatively new variable which is rarely used in the related literature. The objective is to predict the financial stress periods for Turkey by using different methods.

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## LIST OF ABBREVIATIONS

|           |   |
|-----------|---|
| ADF       | Augmented Dickey-Fuller   |
| AIC       | Akaike Information Criterion  |
| ARCH      | Autoregressive Conditional Heteroskedasticity                               |
| ARDL      | Autoregressive Distributed Lag  |
| BIS       | Bank for International Settlement   |
| BIST      | Borsa Istanbul  |
| BVAR      | Bayesian Vector Autoregressive  |
| CAPM      | Capital Asset Pricing Model   |
| CBRT      | Central Bank of Turkey  |
| CDS       | Credit Default Swap   |
| CISS      | Composite Index of Systemic Stress  |
| CNFSI     | China's Financial Stress Index  |
| CPI       | Consumer Price Index  |
| ECB       | European Central Bank   |
| E-GARCH   | Exponential Generalized Autoregressive Heteroscedasticity                   |
| EMBIG     | Emerging Market Bond Index Global   |
| EMBI +    | Emerging Market Bond Index Plus   |
| EM-FSI    | Emerging Market Financial Stress Index                                      |
| EMPI      | Exchange Market Pressure Index  |
| EWMA      | Exponentially Weighted Moving Average                                       |
| EUR       | Euro  |
| FED       | Federal Reserve   |
| FSI       | Financial Stress Index  |
| FX        | Foreign Exchange  |
| GARCH     | Generalized Autoregressive Conditional Heteroskedasticity                   |
| GDP       | Gross Domestic Product  |
| GJR-GARCH | Glosten-Jagannathan-Runkle Generalized Autoregressive<br>Heteroscedasticity |
| HQ        | Hannan-Quinn Information Criterion  |

|         |   |
|---------|---|
| HP      | Hodrick Prescott  |
| HPI     | House Price Index   |
| IMF     | International Monetary Fund                               |
| IPI     | Industrial Production Index                               |
| KCFSI   | Kansas City Financial Stress Index                        |
| LIBOR   | London Interbank Offering Rate                            |
| M2      | Currency in Circulation + Time Deposits + Demand Deposits |
| MS-BVAR | Markov-Switching Bayesian Vector Autoregressive           |
| OECD    | Organisation for Economic Co-operation and Development    |
| SD      | Standard Deviation  |
| SE      | Standard Error  |
| SIC     | Schwarz Information Criterion                             |
| TFSI    | Financial Stress Index for Turkey                         |
| TRLIBOR | Turkish Lira Interbank Offering Rate                      |
| TRY     | Turkish Lira  |
| TVAR    | Threshold Vector Autoregressive                           |
| US      | United States   |
| USD     | United States Dollar                                      |
| VAR     | Vector Autoregressive                                     |

## LIST OF SYMBOLS

|  |  |
|--|--|
| $C_t$  | Time-Varying Cross-Correlation Matrix of The Sub-Indices |
| $r_t^{banking}$                                | The Return for Banking Index                             |
| $r_t^{BIST100}$                                | The Return for BIST100                                   |
| $r_t^{housing}$                                | The Return for Residential Sales Prices                  |
| $\sigma_t^2$                                   | Conditional Variance                                     |
| d.f.   | Degrees of Freedom                                       |
| $n_t$  | Normal Distribution                                      |
| $\Delta e_t$                                   | The Change in the Real Exchange Rate                     |
| $\Delta RES_t$                                 | The Change in the Reserves                               |
| $\beta, \gamma, \Delta, \alpha_0, \alpha_1, I$ | Parameters   |
| $u_t$  | Residuals  |
| $\mu$  | Mean   |
| $\mu_{\Delta e}$                               | Mean of the Change in the Real Exchange Rate             |
| $\mu_{\Delta RES}$                             | Mean of the Change in the Reserves                       |
| $y_{it}$                                       | The Standardized Sub-Indices                             |
| $\tilde{y}_{it}$                               | The Transformed Sub-Indices                              |
| $x_t$  | The Raw Stress Indicator                                 |
| $\bar{x}_t$                                    | The Sample Mean of the Raw Stress Indicators             |
| $z_t$  | The Standardized Sub-Market Indicator                    |
| $\sigma$                                       | Standard Deviation                                       |
| $w_t$  | Vector of Time-Invariant Weights of the Sub-Indices      |
| $s_t$  | Vector of the Submarket Stress Indices                   |
| $w_t \circ s_t$                                | Hadamard Product   |
| $\rho_{ij,t}$                                  | Time-Dependent Cross-Correlations between Sub-Indices    |

|                   |   |
|-------------------|---|
| $\sigma_{ij,t}$   | Covariance  |
| $\sigma_{ij,t}^2$ | Variance  |
| $\sigma_{fsi}$    | Standard Deviation of Financial Stress Index for Turkey |
| $\mu_{fsi}$       | Sample Mean of Financial Stress Index for Turkey        |
| $i_t$             | Normalized Stress Index                                 |
| $I_{max}$         | The Maximum Value for the Financial Stress Index Sample |
| $I_{min}$         | The Minimum Value for the Financial Stress Index Sample |

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## **ABSTRACT**

The aim of this study is to construct a financial stress index for Turkey by using different methods to evaluate whether the financial stress index that is constructed is successful in terms of predicting stressful time periods properly for the period between 2003-2018. In the literature, the measurement of the Financial Stress Index is commonly based on the banking sector, the foreign exchange market, the stock market, the bond market, and the public sector. Likewise, these indicators are used in this study, and also housing market indicator is added because deterioration in the housing market can have a systemic impact on the economy due to its relationship with the other markets. In this way, this study will contribute to the literature in terms of adding a relatively new variable in the measurement of financial stress. The 3-month TRLIBOR, foreign exchange market pressure index, the return of the Borsa Istanbul stock price index, 2-year government bond yields, Credit Default Swaps, and residential sales prices are the sub-components of the measurement of the financial stress in Turkey. The weighting scheme of those variables is based on three different methods. The equal-variance method is the most commonly used one which assumes every single market component has equal importance for all the financial system and also each component acts independently from each other. However, the principal component analysis takes into account the co-movement of the sub-market indicators in calculating financial stress. The standard portfolio theory considers the time-varying cross-correlations among the different stress indices. Furthermore, to measure volatilities for the banking sector equity index, currency, and the stock market, generalized autoregressive conditional heteroskedasticity models are used.

**Keywords:** Financial Stress, Equal-Variance Weight, Principal Component Analysis, Portfolio Theory, GARCH Modelleri

## ÖZET

Bu çalışmanın amacı farklı metodlar kullanarak Türkiye için bir finansal stres endeksi oluşturmak ve 2003-2018 dönemi için oluşturulan bu stres endeksinin ilgili zaman aralığında stres dönemlerini doğru tahmin edip etmediğini araştırmaktır. Literatürde finansal stresin ölçümünde genel olarak bankacılık sektörü, döviz piyasası, hisse senedi piyasası, bono piyasası ve kamu sektörü kullanılmaktadır. Benzer şekilde bu çalışmada da bu piyasalar kullanılmış olup, ayrıca diğer piyasalarla etkileşimden dolayı sistemik etkiye sahip olduğu düşünülen konut fiyat endeksi çalışmaya dahil edilmiştir. Böylelikle finansal stresin ölçümünde görece yeni bir değişken eklenerek literature katkı sağlayacağı düşünülmüştür. 3-aylık TRLIBOR, döviz piyasası baskı endeksi, 2-yıllık devlet tahvili getirileri, Kredi Temerrüt Takası ve konut satış fiyatları Türkiye için finansal stresin ölçümünde kullanılan alt bileşenlerdir. Değişkenlerin ağırlıklandırılması üç farklı metoda dayanmaktadır. Her bir alt bileşenin birbirinden bağımsız hareket ettiğini ve eşit öneme sahip olduğunu varsayan eşit-varyans ağırlıklandırma metodu en yaygın kullanılandır. Bununla birlikte temel bileşenler analizi, alt piyasa göstergelerinin birlikte hareketini göz önünde bulundurur. Standard portföy teorisi ise farklı stres bileşenleri arasındaki zamana göre değişen çapraz korelasyonları dikkate alır. BIST bankacılık sektörü, hisse senedi endeksi, döviz piyasası ve BIS100 hisse senedi getirilerine ait volatilitelerin hesaplanmasında GARCH modelleri kullanılmıştır.

**Anahtar Kelimeler:** Finansal Stres, Eşit-Varyans Ağırlıklandırma, Temel Bileşenler Analizi, Portföy Teorisi, GARCH Modelleri

## INTRODUCTION

Before the 1980s the studies about the financial sector focused mostly on only a single market rather than trying to draw a holistic picture of financial system. This situation has started to change after the late 1990s with the studies taking into consideration the interrelationship between different market segments. As a result, the financial stress indexes which include several variables from various sub-markets have been constructed (Ekinci, 2013).

There are several definitions of financial stress in the literature. It is defined as “the force that is exerted on economic agents by uncertainty, and changing expectations of loss in financial markets and institutions” by Illing and Liu (2003). Although Hakkio and Keeton (2009) mention the difficulty of defining financial stress specifically, they explain the common characteristics that different financial stress periods share. In those periods, there is an increase in the uncertainty with respect to the fundamental values of financial assets, which is a sign of an increase in the volatility of asset prices or the deterioration in the outlook of the economy as a whole. Uncertainty about the investor behavior also increases which again results in rising volatility in asset prices. Information asymmetry is another sign of financial stress. Furthermore, there is a transition from risky assets to safe assets. According to Hakkio and Keeton (2009), every period of financial stress comprises at least one of these features.

The global financial crisis has revealed the weaknesses in the financial system, and the importance of monitoring and supervising role of the regulatory authorities have increased. The ECB, FED, IMF, OECD, and BIS have developed the financial stress indexes for different countries to assess and monitor their current states of the financial stability (Hakkio and Keeton, 2009; Cardarelli et al., 2011; Holló et al., 2012). The studies which investigate the relationship between financial stress and economic activity have also become more important after the crises. Holló (2012), in his study of the Hungarian financial system, develops a financial stress index, a Composite Index of Systemic Stress (CISS), and shows that when the CISS exceeds

a certain threshold level, there is a decline in industrial production. Aboura and Van Roye (2013) in their study for France reach a similar conclusion that an increase in financial stress leads to lower economic activity. Same results can be found in Van Roye's (2013) study of the financial stress and economic activity in Germany. He argues that rise in financial stress is associated with a significant plunge in GDP growth. The studies searching the causes of financial stress do not treat the indicators of the stress independently, but create composite indexes reflecting the developments in many different market segments as a whole by considering the increased co-movements in those markets. In the literature, the measurement of the Financial Stress Index (FSI) is commonly based on five indicators; the banking sector, the foreign exchange market, the stock market, the bond market, and the public sector. Likewise, these indicators will be used in this study, and also another indicator - housing market which is an important component of the financial stress index will be added. In order to choose the appropriate variables to be the representatives of these six sectors, the study will refer to the related literature and will use the most commonly used variables. In that sense, firstly, in order to calculate the riskiness of the banking sector, interbank cost of borrowing which is represented by 3-month TRLIBOR will be used. The important thing in calculating the stress level in the banking sector is to consider the interbank liquidity constraints and the measurement of the default probability of the banking sector. Furthermore, some ratios such as non-performing loan ratio, loan-to-deposit ratio, etc. could be useful in evaluating the stress levels in different periods for this sector. Secondly, the volatility of the foreign exchange market will be calculated by considering the exchange rates and foreign reserves. For this, the foreign exchange market pressure index (EMPI) is commonly used. Stock market volatility which reflects the investor behavior will be measured by using the historical volatility of BIST100. For the representative of the stress in bond markets, two-year government bond yields are used. Another important component of the FSI is the public sector which is mostly measured by the Credit Default Swaps (CDS). This is an important indicator for investors to assess the economic conditions in the countries. The five-year CDS spreads can be used to measure the default risk of a sovereign. Furthermore,

sovereign bond spreads - the difference between Turkey's 10-year government bond yield and 10-year US Treasury yield – can also be used. These are the main variables included in the measurement of FSI in Turkey. In addition to these variables, I will add the housing market because deterioration in the housing market can have a systemic impact on the economy due to its relationship with the other markets. After choosing the appropriate variables for Turkey, we need to decide which weighting scheme is better to explain the financial stress levels. The equal variance weight, the principal component analysis, and portfolio theory are the possible choices to be made. The equal-variance method is the most commonly used method which assumes every single market component has equal importance for the whole financial system. This method also assumes different sub-markets act independently from each other. However, the principal component analysis takes into account the co-movement of the sub-market indicators in calculating financial stress. However, the standard portfolio theory considers the time-varying cross-correlations among the different stress indices. I will calculate the FSI for these three different methods in order to see the differences in explaining power of the index. Apart from those, to measure volatilities generalized autoregressive conditional heteroskedasticity (GARCH (1,1)) models will be used.

In conclusion, the critical stress levels will be determined and it will be assessed whether the FSI that is calculated can be a good indicator for evaluating the economic conditions and estimating the stressful periods properly.

The remaining structure of the study is as follows. The first chapter includes the literature review. In the second chapter, the variables that are used in the measurement of the financial stress index for Turkey and the volatility measures are introduced. The construction and measurement of the financial stress index with three different approaches - equal-variance method, principal component analysis, and portfolio theory - is introduced in the following section. The fourth chapter includes the measurement of the financial stress index with the addition of the housing market indicator by using the same approaches in the third chapter. The conclusions and recommendations take place in the final part.

## **CHAPTER 1**

### **LITERATURE REVIEW**

As a representative of the financial stress, several indicators have been used since the 1980s. The slope of the yield curve, the credit risk, and the stock markets are some of them (Ekinici, 2013). However, the global financial crisis in the late 2000s in the US which spread over other countries has necessitated the detailed studies about the sources of financial stress. As a result, measuring financial stress can be seen as an attempt to elucidate the interrelations between the different market segments rather than focusing only on one indicator. However, there is no standard financial stress index which conforms to all countries or area that is investigated. Therefore, different indexes which reflect and consider the financial structure of the specific country examined have been developed. A financial stress index for developed countries is developed by Cardarelli et al. (2009). Balakrishnan et al. (2009), on the other hand, adapted it to the developing countries. Some of the indexes, in the literature, are country-specific (e.g., Illing and Liu, 2003; Holló, 2012; Aboura and Roye, 2013; Sun and Huang, 2016, Eraslan, 2017), some of them are constructed for several countries (e.g., Grimaldi, 2010; Roye, 2011; Paries et al., 2014; Vermeulen et al., 2014), and some of them investigate the relationship between the financial conditions and the economic activity (e.g., Hakkio and Keeton, 2009; Hatzius et al., 2010; Cardarelli et al., 2011). Financial stress indexes are also useful tools for policymakers for monitoring the financial stability, and make it possible to follow the sources of the stress, and provide alerts to risk managers to prevent or mitigate the effects of it (Oet et al., 2012).

Cardarelli et al. (2011) explored the effect of financial stress on the real economy. Their findings revealed that financial stress does not always result in an economic downturn, however, it often explains it properly. They constructed a financial stress index by using the variables from the banking, the securities, and the foreign exchange markets in 17 developed countries, but their particular attention was on the banking distress rather than the securities or the foreign exchange markets because of the longer recovery time requirement with related to the problems in the

banking sector. For them, more severe slowdowns in economic activities are associated with rapid credit expansion, rising housing prices, and increasing borrowing levels. They explain these downturns regarding the banking-dependent financial stress periods with the procyclicality of the leverage in the banking system in those countries.

A financial stress index for emerging economies (EM-FSI) is developed by Balakrishnan et al. (2009). They explicate the transition of financial stress from advanced to the emerging economies through trade and financial channels. According to them, profound changes in the asset prices, increases in uncertainty and risk, the liquidity constraints, and the stresses stemming from the banking sector are some of the main characteristics that the financial stress periods have in common. The index that they create includes the banking, the securities, and the exchange markets. Their contribution to the index that is developed by Cardarelli et al. (2009) is the inclusion of exchange market pressure index because it reflects the stress in emerging economies rather than the developed ones.

There are several studies which investigate the interaction between financial stress and economic activity. Hakkio and Keeton (2009) explain three possible ways that financial stress affects the real economy. When uncertainty about the financial asset prices rises, this would affect both households and the firm's decisions. In such a case, the household would prefer to delay their spending because of their future wealth concerns, businesses likewise would be more prudent about their investment and hiring decisions. Secondly, there may be an increase in financing cost through the rise in interest rates which in turn can lead both households and firms to decrease their spending, and the ultimate impact would be an additional deterioration in economic activity. Finally, financial stress may have an impact on diminishing economic activity through tightening credit standards of banks which means a further decline in spending. That is, during the times of financial crisis the willingness of banks to providing loan tendency will decline. The financial stress index – the Kansas City Financial Stress Index (KCFSI) – developed by Hakkio and Keeton explain the financial stress periods successfully and provides valuable

information about predicting changes in economic activity. Besides, it can also be a useful tool for policymakers in terms of making comparison possible with the current value of KCFSI and the known periods of financial stress in the previous periods. However, they do not provide an index which is capable of determining threshold levels of stress in the financial sector.

Elekdag and Kanlı (2010) analyze the relationship between financial stress and economic activity from the perspective of emerging markets. The impact of both external and internal financial stress shocks on Turkish economic activity is examined in a comparative way with the emerging economies. Their findings indicate that independent of being persistent or temporary, industrial production level is substantially affected by financial shocks which demonstrates the strong impact of financial stress on economic activity, is also proven with the latest global financial crisis. In their studies, they use a monthly composite index as an indicator of stress in the financial system. The comparative study of these authors reveals the sharper and faster contraction in the level of industrial production in Turkey after the global financial crisis. The sub-components of the index are foreign exchange market pressure index, comprising exchange rate and change in the level of central bank's reserves, JPMorgan Emerging Market Bond Index Global (EMBIG), a benchmark index for the bond performance in emerging market countries, stock returns as a proxy for the stress in equity market and implied volatilities of stock returns as a benchmark for uncertainty perception relating to these stock returns in financial markets, and finally banking sector beta, an indicator of banking sector stress, which is based on Capital Asset Pricing Model (CAPM).

Kaya and Açıdoğuran (2017), in their studies, fill a gap in the crises literature concentrating mostly on liquidity, banking, and debt crises but neglecting stock market. Since the volatility in oil prices not only affecting economic activity but also has a substantial impact on the financial sector, they incorporate that component to the financial stress index which they construct and examine the relationship between financial stress and oil prices with Autoregressive Distributed – Lagged (ARDL) Model. They follow Balakrishnan et al. (2009), Ekinçi (2012),

Illing and Liu (2006), and Aklan et al. (2015) in deciding components of financial stress index. Accordingly, five-year credit default spread, stock returns, exchange market pressure index, and interbank cost of borrowing spread are used, and August 2002 – September 2015 period is examined with a monthly frequency. Their results indicate the usefulness of the index in predicting financial crises, and in providing beneficial information to policy makers in decision making.

Eraslan (2017) also analyzes the relationship between financial stress and economic activity. According to him, measuring financial stress is important for both determining economic policies and assessing the vulnerabilities in the financial system. To reflect the development in different market segments, he uses five different components to construct a financial stress index for Turkey for the period August 2002 – April 2016 with a daily frequency. These are the stock market, bond market, banking sector, foreign exchange market, and the public sector. As a proxy for the Turkish stock market, the return of Borsa Istanbul benchmark stock price index and the historical volatility of BIST100 are used. There are two variables, that Eraslan mentions in his study, to measure the stress in Turkish bond markets. One is the government bond spreads, which is the difference between Turkish two-year benchmark Treasury bond and US two-year Treasury bond, and another is Emerging Market Bond Index Plus (EMBI +), which represents total returns for traded external debt instruments, and is used as a benchmark for emerging market sovereign debt. 3-month LIBOR and idiosyncratic risk of the banking sector, measured by banking sector stock market volatilities, are the two instruments for evaluating the stress level in the banking sector. The volatility in the foreign exchange market is measured by the equally weighted average of USD and EUR. Finally, five-year USD denominated CDS spreads are used for the stress component of the public sector. Dynamic Principal Component Analysis is combined with Static Principal Component Analysis in this study to show the significance of using time-varying weights of financial market indicators, and the results indicate the capability of the financial stress index in identifying the financial stress episodes successfully, and can be a useful tool for early warning for risk in the Turkish economy.

Akkan, Çınar, and Akay (2015) also investigate the financial stress and economic activity relationship for Turkey. According to them, a system which enables the prediction of financial stress previously can reduce the possibility of financial crises through the implementation of effective policy measures. The unfavorable impact of potential stress sources can be eliminated owing to an early warning system. In this sense, a financial stress index, which comprises different market segments, i.e., stock markets, foreign exchange markets, banking sector, and public sector, is used in their study to measure and to monitor instabilities in Turkish financial system. The one-way causal relationship from financial stress to economic activity is found according to the Granger Causality Test, and the results indicate that for the period January 2002 – October 2014 economic activity contracts when there is an increase in financial stress in Turkey.

A similar study is conducted to reveal the relationship between financial stress and economic activity by Kaya and Kılınç (2017) for the period of August 2002 – September 2015 by using monthly frequency data. By following the literature (Illing and Liu, 2006; Balakrishnan et al., 2009; Ekinçi, 2012; Akkan, 2015), they also constitute the financial stress index with the banking sector, foreign exchange market, security market, and public sector variables. Granger Causality Test and Vector Autoregressive (VAR) models are applied, and statistically significant relationship is found between financial stress and economic activity, which implies that financial stress index is successful in terms of reflecting crisis periods and directing economic activities.

Çamlıca (2016), on the other hand, constructs a composite index of systemic stress (CISS), combining the Central Bank of Turkey (CBRT)'s policy reaction function with a special financial stress index. He aims to measure the responsiveness of the CBRT's monetary policy to financial stress during the period January 2005 and October 2015 by considering the cross-correlations between different market segments and by applying to CBRT's policy interest rate. The variables of the index are money, credit, bond, equity, and forex markets. In estimating the CISS, the time-varying cross-correlations between different financial market segments are taken

into account. In this study, it is addressed that in the aftermath of the global financial crisis the importance of central banks' roles in controlling financial risks in early stages is increased, and early warning mechanisms against financial instabilities have become important. That is, there is a change in the strategy of central banks after the global crisis from 'clean after burst', in which financial issues are mostly disregarded and price stability becomes the main concern, towards 'lean against wind', in which central banks have an effective role in intervening in financial crises and preventing financial risks. The empirical research is based on evaluating whether central bank's responsiveness to financial stress has changed or not after heterodox tools that are used after mid-2010, and CBRT's effort to achieve both financial and price stability at the same time during this period is an evidence that CBRT's monetary policy is leaning more against financial stress compared to the previous period.

Çamlıca and Güneş (2016), in their studies, focus on methodological differences in measuring financial stress in Turkey. They apply the most widely used methods - equal variance weighting, principal component analysis, and portfolio theoretic weighting - in financial stress literature to compute the financial stress in Turkey for the period between 2002-2015. Their findings reveal the successful performance of these three different methods in explaining the financial stress terms during the period in question. To make a comprehensive study, they incorporate five sub-components to their index; the money market, the bond market, the banking sector, the security market, and the foreign exchange market. They also use daily frequency data to be able to reflect the real-time effects in financial markets. The comparison of the methods demonstrates the superiority of the portfolio theoretic weighting model among others in terms of taking time-varying correlations between sub-financial markets into consideration. Furthermore, this method considers the relations between financial stress and economic activity far more than other methods, and the recursive calculation provides a real-time index.

In this study, in addition to the main market segments that reflect the conditions of the financial system of Turkey, the residential sales prices are added to the financial

stress index. In the literature, there are some studies which incorporate that component to the index. Sun and Huang (2016) in their study constructed both financial stress index (CNFSI), which identifies the episodes of financial instability in China, and financial condition index (CNFCI), which provides information about the current financial state in China in order to measure the systemic risks. Their indices consist of four distinct markets which are banking, foreign exchange, stock, and debt markets. In order to find the contributing factors to the systemic financial stress, they suggest four leading indicators – credit, asset, monetary, and price – in addition to the main representors of China’s financial system. As a representative of those indicators growth rates of loans and deposits, house price index, growth rates of M2, and CPI inflation are used, and a combination of those indicators with CNFSI identifying the stress periods is an important step in terms of providing an early warning system for macroprudential regulations in China.

Kota and Saqe (2013), in their studies of the measurement of financial stress for Albania, also incorporate the variable of the housing market in addition to the banking sector, the money market, and the foreign exchange market since the problems in housing markets also have a tendency to lead to a systemic effect on the economy. Their study introduces the importance of taking into account using of an aggregated index which combines different market segments. Because by such an aggregated index the interaction between the markets can be followed, which makes it possible to follow systemic risk that is crucial for assessing the overall financial stability in a country. They define systemic risk as such that results in a financial system which is not well-functioning, and hindering economic growth and welfare by following Holló et al. (2011). According to them, increased uncertainty in financial markets which is reflected in terms of volatilities, liquidity constraints, the soundness of the banking sector, and the housing market trends are the common things that have to be considered when assessing the developments in financial markets. The effects of boom and bust in asset prices and credit growth on financial stability are analyzed in the literature in some studies. Borio and Lowe (2002), for example, discusses that in case of rapid credit growth, rapid increases in asset prices, and rapid increases in investment levels with simultaneous imbalances in

the other segments of financial markets stimulate the financial problems. The relation between asset prices, credit cycles, and developments in the real economy is revealed through their studies. Therefore, assessing the systemic impact of the deterioration in the housing market, that is the deviation of the housing price index from its trend, is an important tool for determining systemic stress, because, for Kota and Saqe (2013), it affects both financial systems via credit channel and real economy through the construction sector. That is, imbalances in the housing market would have a direct impact on other market segments.

Riiser (2005) in his study investigates some of the indicators that can be useful for forecasting banking crises in Norway. Correspondingly, he investigates the interrelation between asset prices and banking crises by applying to gap analysis, and the primary aim is to determine the indicators which have a predictive power of estimating banking-related crises. The argument is based on that during economic expansion, asset prices, and investment level increase, but that is not sustainable and at some point, the situation will reverse resulting in financial imbalances because of banks' ability to finance will be damaged. A similar study is conducted by Borio and Lowe (2002), and they evaluate the capability of the asset prices, credit to the private sector, and investment indicators in estimating banking crises at different time horizons. Their study reveals that credit gap alone is the best indicator in capturing stressful periods in the banking sector. On the other hand, a combination of these indicators improves the predictive ability and in that case credit gap together with real equity price give the best results. Riiser's study is different in the sense that he also adds house prices to those indicators. His results show that before banking crises for the period that is analyzed there is mostly a visible increase in real house price gap - the percentage change of the deviation of HPI from its trend which is deflated by CPI - which implies that house price gap is successful in terms of capturing the crises periods in the banking sector.

The issue of predicting financial stress through observing the changes in credit and asset prices is also studied by Misina and Tkacz (2009). The aim is to provide leading indicators with regard to financial stress. Credit measures, asset prices,

macroeconomic variables, and foreign variables are the explanatory variables that they use. As credit measures, they use the growth rate of total household credit, total business credit, and total credit / GDP, and as asset prices, they use stock prices, commercial and residential real estate indices, the average price to personal disposable income ratio, and the Canadian dollar price of gold. The question of whether some combination of credit expansion and upward movement in asset prices can be used to forecast financial stress is investigated by them by applying to both linear and endogenous threshold models, and the result is affirmative depending on the model used and the forecast horizon. In particular, they found that the incorporation of business credit to the index causes some improvements in prediction performance of the financial stress in both linear and non-linear models at the one- and two- year horizons and their results suggest that the best predictor of the Canadian stress index is domestic credit growth at all horizons within a linear framework whereas asset prices are better predictors when it is allowed for nonlinearities. Their results show the difficulty of predicting financial stress.

The relation between financial stress index (FSI) and financial crisis is studied by Vermeulen et al. (2014) for 28 OECD countries, and their results are different in the sense that they found a weak relationship between the start of a crisis and financial stress index. Their study, on the other hand, demonstrated the connection between FSI and the occurrence of a crisis. This relationship between financial stress and crises is also examined by Louzis and Vouldis (2013) in their study of developing a financial systemic stress index for Greece. They apply to the multivariate GARCH approach to capture the time-varying correlations between different markets. A survey is conducted for specifying the crises chronology for Greece among financial experts. According to the results, the index that they constructed is successful in identifying the crises periods and the stress levels in the Greek financial system.

There are several studies which investigate the negative relationship between financial stress and economic activity. Aboura and Van Roye (2013), in their study of the French economy, generated a financial stress index in order to evaluate the

real-time financial conditions with a dynamic approximate factor model. They mentioned three channels that financial stress has an impact on real economic activity; in stressful time periods banks' willingness to lend decrease, firms postpone their investment decisions, and funding costs of the private sector increase. They analyzed this relationship by applying Markov – Switching Bayesian Vector Autoregressive Model (MS-BVAR) in order to identify the regime switching-between low-stress regime and high-stress regime. The financial stress index, industrial production growth, inflation rate, and the short-term interest rates are the variables that they use for identifying the regime switching. The FSI that they constructed captures the significant events in the French economy, and the results also indicate that if the economy is in a high-stress regime, the probability of financial stress to affect the economic activity increases, whereas in a low-stress regime economic activity is almost unaffected. Their ultimate results demonstrate the usefulness of the index as an early warning tool in the French financial system.

In his study of Germany and the Euro area, Van Roye (2011), also used a dynamic factor model with regard to the construction of financial stress indicators. The impact of financial stress on business cycles is analyzed by applying to Bayesian VAR model (BVAR). According to the results, a significant decline in economic activity is associated with high financial stress.

The impact of financial stress on economic activity is also studied by Holló et al. (2011) by using econometric approaches – an autoregressive Markov-Switching model and a threshold bivariate VAR (TVAR) model, and their results also show that depending on the regime financial stress affects economic activity. That means in low-stress regime periods the effect of financial stress on economic activity is low whereas economic activity is highly affected when the economy is in a high-stress regime.

To evaluate the impact of financial stress shocks on real economic activity for Turkey, Güneş (2016), also applied a TVAR model by using the industrial production index as a representative of real economic activity. Since external shocks affect real economic activity more severely in high-stress regimes than the

low-stress regimes, the regime-dependent model was applied. In that sense, firstly TVAR model is estimated, then it is examined whether there is a threshold effect or not, and finally, impulse-response analysis is used to determine the asymmetric reactions caused by the financial stress shocks in both high- and low- stress regimes. The results revealed the negative effects of financial stress on economic activity. That is, industrial production is highly affected even in normal stress regimes. The impact, however, is more severe and prolonged in high-stress regimes.

None of the FSI studies on Turkey has used housing market as an indicator explaining the financial stress of the country. However, literature on various countries shows that house market index may be a significant variable in constructing FSI. Thus, the present study tries to fill this gap by using this additional variable in the construction of FSI for Turkey.

## **CHAPTER 2**

### **METHODOLOGY**

#### **2.1. Construction of a Composite Index of Financial Stress**

In the literature, different stress variables which reflect the characteristics of the country investigated are used to construct the financial stress index. Following the previous literature in Turkey, this study also uses the banking sector, the foreign exchange market, the stock market, the public sector, and the bond market as the main sub-components to be in the construction of the index in Turkey. The variables are in monthly frequency and comprise the periods between January 2003 and October 2018. The 3-month TRLIBOR, foreign exchange market pressure index, the return of the Borsa Istanbul stock price index, 2-year government bond yields, 5-year Credit Default Swaps, and residential sales prices are the variables representing the relevant markets. Furthermore, to measure volatilities for the banking sector equity index, currency, and the stock market, generalized autoregressive conditional heteroskedasticity (GARCH) models are used.

##### **2.1.1. Volatility Measures**

The financial time series have three fundamental characteristics. These are heavy kurtosis, volatility clustering, and the leverage effect (Özden, 2008). It is assumed that if the financial time series have at least one of these properties, then the constant variance assumption is not valid. The traditional econometric models are based on the constant variance assumption. However, the homoskedasticity assumption is not sufficient to reflect the characteristics of financial time series. Therefore, ARCH-GARCH models are developed, considering changing variance in time. Engle (1982) developed the Autoregressive Conditional Heteroskedasticity (ARCH) model in order to reflect the dynamic characteristics of financial assets, and then Bollerslev (1986) developed the Generalized Autoregressive Conditional Heteroskedasticity Model, which is the extension of ARCH model. However,

positive and negative shocks have a different impact on volatility. The GARCH model does not take into account the asymmetric effects of positive and negative shocks. The effects of the shocks are determined independently of the sign of the shocks. Therefore, Nelson (1991) introduced the E-GARCH model. The GJR-GARCH model is an alternative model which also takes into account asymmetric effects, introduced by Glosten, Jagannathan, and Runkle (1993).

In this study, in measuring volatility, nonlinear conditional variance models, GARCH (1, 1), E-GARCH (1, 1), and GJR-GARCH (1, 1), are used. The reason for using these models is to see the effects of fluctuations in index that is investigated on variance, and then the appropriate model is chosen with certain criteria. The one with the highest R-squared value, or the one with the lowest Akaike Information Criterion or Schwarz Information Criterion value, or the one with the highest log-likelihood value will be chosen. For all volatility measures monthly logarithmic returns are used for the period 31.03.2003 and 31.10.2018. The stationarity tests are conducted with the Augmented Dickey-Fuller Test (ADF). After it is decided that the stationarity condition is satisfied, the best conditional mean equation is determined for all of the indexes. Then, the conditional variance models are estimated with the three different models.

### **2.1.1.1. Generalized Autoregressive Conditional Heteroscedasticity Models**

#### **2.1.1.1.1. GARCH (1, 1) Model**

The conditional variance equation for GARCH (1, 1) model is as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \quad (2.1)$$

where  $\alpha_1$  parameter shows the effect of shocks on the volatility,  $\beta_1$  parameter shows the effect of the previous term volatility on the current term volatility. This equation is more successful in terms of capturing the volatility in financial asset returns data

compared to the ARCH (1) model<sup>1</sup> because there is an additional term in this model which takes into account that if there is large volatility in the previous time period, then the next time volatility will be predicted higher. That means large changes in asset prices will be followed by large changes and small changes will be followed by small changes, which is called volatility clustering.

#### 2.1.1.1.2. GJR – GARCH (1, 1) Model

In this model, the variance changes depend on the size and/or the sign of the shock. Therefore, this is an asymmetric GARCH model. The conditional variance equation for this model is as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \gamma u_{t-1}^2 I_{t-1} + \beta \sigma_{t-1}^2 \quad (2.2)$$

where  $I_{t-1} = 1$  if  $u_{t-1} < 0$  and 0 otherwise. The parameter  $\gamma$  can be negative or positive. The positive and statistically significant values of  $\gamma$  is an indicator of a leverage effect. That is, a large decrease in the price of a financial asset will affect the volatility of the returns more than a large increase within the price of a financial asset with the same magnitude.

#### 2.1.1.1.3. E - GARCH (1, 1) Model

This is another asymmetric GARCH model. Again, the shocks will affect variance differently depending on the size or the sign of the shock. The conditional variance equation for this model is as follows:

$$\ln(\sigma_t^2) = \alpha_0 + \beta \ln(\sigma_{t-1}^2) + \gamma \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha_1 \left( \frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} \right) \quad (2.3)$$

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<sup>1</sup>  $\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2$

There is also a leverage effect which implies that if  $\gamma$  is negative and statistically significant, then a decrease in returns will cause greater volatility than an increase in returns with the same magnitude.

#### 2.1.1.1.4. Volatility Measure for BIST100 Stock Market Returns

For monthly BIST100 Stock Market Returns, it is decided that GJR-GARCH (1, 1) is the most convenient model to apply. The results are as follows:

**Table 2.1. The Model Selection Criteria Results for BIST100 Stock Market Returns**

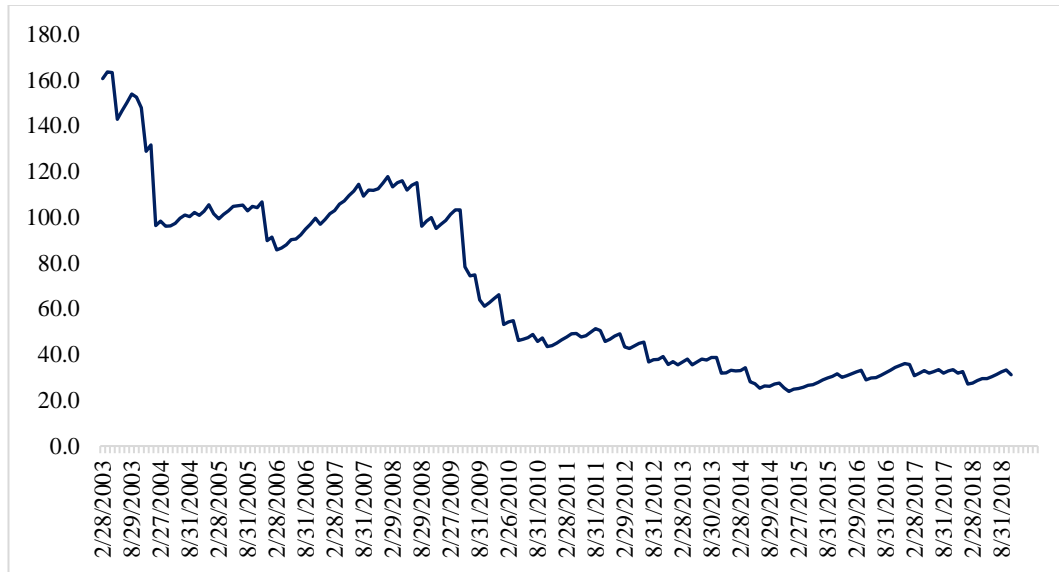
| MODEL            | AIC      | SIC      | R-Squared | Log Likelihood |
|------------------|----------|----------|-----------|----------------|
| GARCH (1, 1)     | 6.953377 | 7.021985 | -0.000787 | -653.0941      |
| GJR-GARCH (1, 1) | 6.889088 | 6.974849 | -0.004994 | -646.0188      |
| E-GARCH (1, 1)   | 6.966051 | 7.051812 | -0.001636 | -653.2918      |

According to those results, GARCH parameter  $\beta$  (1.027655) is highly significant with p-values 0.0000, which indicates that the volatility in the previous time period will have an effect on the volatility in the next time period. The ARCH parameter  $\alpha_1$  (-0.074434) is significant at 1% level with p-values 0.0000, which indicates the importance of the size of the shock on the volatility. The volatility of the BIST100 index has a positive contribution to the TFSI. The conditional variance equation for the BIST100 stock market returns are as follows:

$$\sigma_t^2 = 0.485220 - 0.074434 u_{t-1}^2 + 1.027655 \sigma_{t-1}^2 + 0.058204 u_{t-1}^2 I_{t-1} \quad (2.4)^2$$

<sup>2</sup> For details, see Figure A3.

**Figure 2.1. The volatility of the BIST100 Index**



### 2.1.1.2. Volatility Measure for BIST100 Banking Sector Index

For monthly BIST100 Banking Sector Index, it is decided that GJR-GARCH (1, 1) is the most convenient method to apply. The results are as follows:

**Table 2.2. The Model Selection Criteria Results for BIST100 Banking Sector Index**

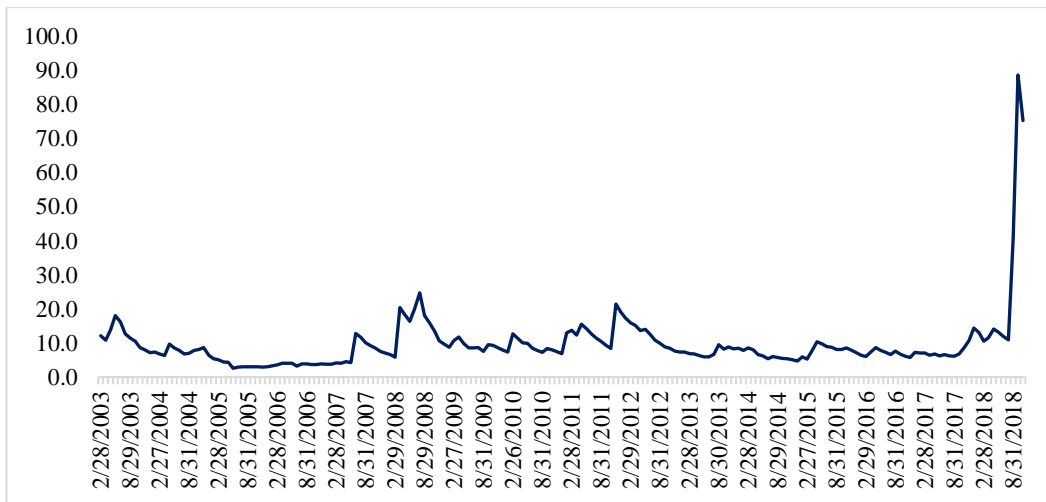
| MODEL            | AIC      | SIC      | R-Squared | Log Likelihood |
|------------------|----------|----------|-----------|----------------|
| GARCH (1, 1)     | 5.065565 | 5.151326 | 0.904288  | -473.6959      |
| GJR-GARCH (1, 1) | 5.000900 | 5.103813 | 0.904095  | -466.5851      |
| E-GARCH (1, 1)   | 5.011631 | 5.119224 | 0.903528  | -468.0414      |

According to those results, GARCH parameter  $\beta$  (0.873651) is highly significant with p-values 0.0000, which indicates that the volatility in the previous term has an impact on the volatility in the current term. In this way, if there is large volatility in the previous time period, then there will be a large amount of volatility in the next time period. The ARCH parameter  $\alpha_1$  (-0.031808), on the other hand, is not significant at the 10% level with p-values 0.1752. The coefficient ( $\gamma$ ) is positive with a value of 0.297232, which implies a leverage effect. It is also statistically

significant at 1% level with a p-value of 0.041. The existence of the leverage effect indicates that when there is a large decrease in the price of the financial asset, the return of the asset will be more volatile in the immediate future periods compared to the large price increase with the same magnitude because of the parameter  $I_{t-1}$ . In general, the volatility of the BIST100 index has a positive contribution to the TFSI. The conditional variance equation for the BIST100 banking sector index is as follows:

$$\sigma_t^2 = 0.432919 - 0.031808 u_{t-1}^2 + 0.873651 \sigma_{t-1}^2 + 0.297232 u_{t-1}^2 I_{t-1} \quad (2.5)^3$$

**Figure 2.2. Volatility of the Banking Sector Index**



### 2.1.1.3. Volatility Measure For Currency Basket Indicator

For monthly Currency Basket Indicator (0.5 USD/TRY + 0.5 EUR/TRY), it is decided that E-GARCH (1, 1) is the most convenient method to apply due to the following results:

<sup>3</sup> For details, see Figure A4.

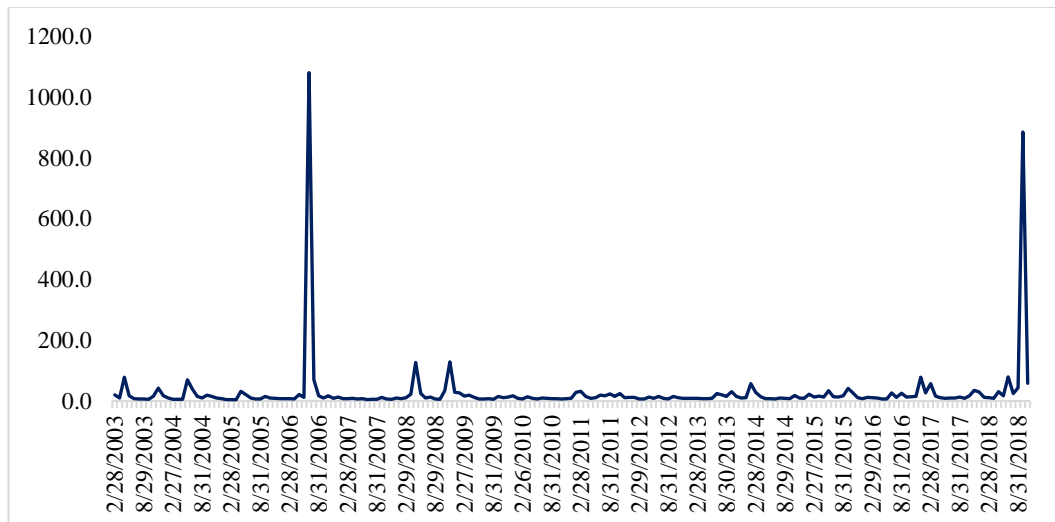
**Table 2.3. The Model Selection Criteria Results for Currency Basket Indicator**

| MODEL            | AIC      | SIC      | R-Squared | Log Likelihood |
|------------------|----------|----------|-----------|----------------|
| GARCH (1, 1)     | 5.631826 | 5.700434 | -0.007495 | -528.2075      |
| GJR-GARCH (1, 1) | 5.503794 | 5.589555 | -0.003247 | -515.1086      |
| E-GARCH (1, 1)   | 5.495344 | 5.581104 | -0.000572 | -514.3100      |

The statistically significant beta term at 1% level (0.0063) implies that past volatility helps to predict future volatility. The ARCH term ( $\alpha_1$ ), is also statistically significant at 1% level, has a p-value of 0.0049, which implies that the size of the shock also has a significant impact on the volatility of the currency basket. The volatility of the currency basket has a positive contribution to the TFSI. The conditional variance equation for the currency basket is as follows:

$$\ln(\sigma_t^2) = 1.221541 + 0.337155 \left( \frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} \right) + 0.605133 \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + 0.430395 \ln(\sigma_{t-1}^2) \quad (2.6)^4$$

**Figure 2.3. The volatility of the Currency Basket**



<sup>4</sup> For details, see Figure A5.

### 2.1.2. Variables

Choosing different market segments as the sub-components of financial stress, and incorporating the appropriate variables to the index requires considering certain criteria. Firstly, data must be available for a long period of time with a high frequency, and it has to encompass as much of the financial system volatility as possible. Namely, money markets, capital markets, banking sector, and foreign exchange markets (Holló et al., 2012) are good candidates in that sense. However, other market segments can also be included that is thought to be exploratory and to reflect the financial conditions of the specific country. Likewise, it is possible to extract unnecessary market segments that do not reflect country-specific characteristics. For example, Turkey is a country, which has experienced various types of monetary policies since 2001.<sup>5</sup> If we do not take into account the effects of changing monetary policies on other financial indicators, in particular on exchange rates, we can get misleading results. That is, if exchange rates are not determined by the market, and exchange targeting regime is implemented, we cannot incorporate the foreign exchange market to the index (Ekinçi, 2013). Therefore, it is important to choose a period when a certain policy is implemented consistently. Turkey has experienced many different monetary policies since 2000s. For the period between January 2000 and February 2001, exchange rate-based stability program is implemented. However, this system is terminated with the 2001 Crisis, which has resulted in some crucial structural changes in the monetary policy of Turkey. It is replaced with the floating exchange rate regime. Then, inflation targeting became the main objective of the CBRT and the implicit inflation targeting regime executed for the period between 2002-2005. After 2006 the CBRT adopted the explicit inflation targeting regime. In that sense, the variables that are

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<sup>5</sup> "Exchange rate peg between January 2000 and February 2001, the transition period between February 2001 and December 2001, and dual targeting including monetary targeting and implicit inflation targeting between 2002 and 2005, and explicit inflation targeting between 2006 and today" (Ekinçi, 2013).

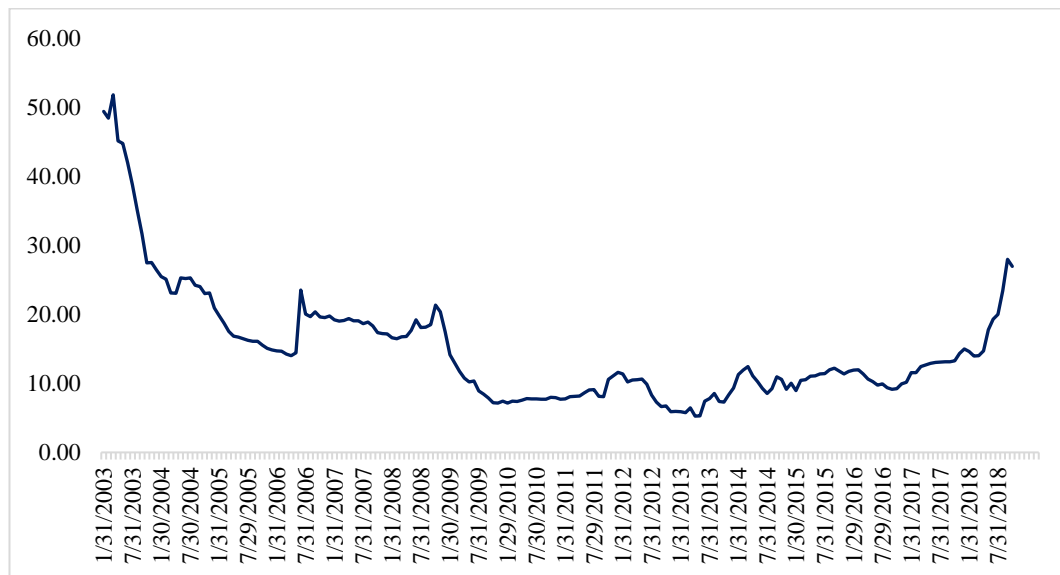
chosen in this study cover the periods in which the consistent monetary policy is implemented, which is the inflation targeting after 2002.

### 2.1.2.1. Banking Sector

Incorporating the banking sector to the index is important because of its close relationship with the real economy. Under financial stress, banks cannot carry out their role of intermediation, and of providing credit and liquidity to the financial system properly. In order to assess the soundness of the banking sector interbank cost of borrowing, and the volatility of the banking sector will be used. As a proxy for the interbank cost of borrowing, three-month TRLIBOR is used by following Eraslan (2017).

$$\text{Interbank cost of borrowing}_t = \text{three-month TRLIBOR}_t \quad (2.7)$$

**Figure 2.4. Values for 3-month TRLIBOR (Jan. 2003 – Oct. 2018)**



To determine the bank-specific risk, that is the idiosyncratic risk of the banking sector, the volatility of the banking sector equity index is used. In determining the

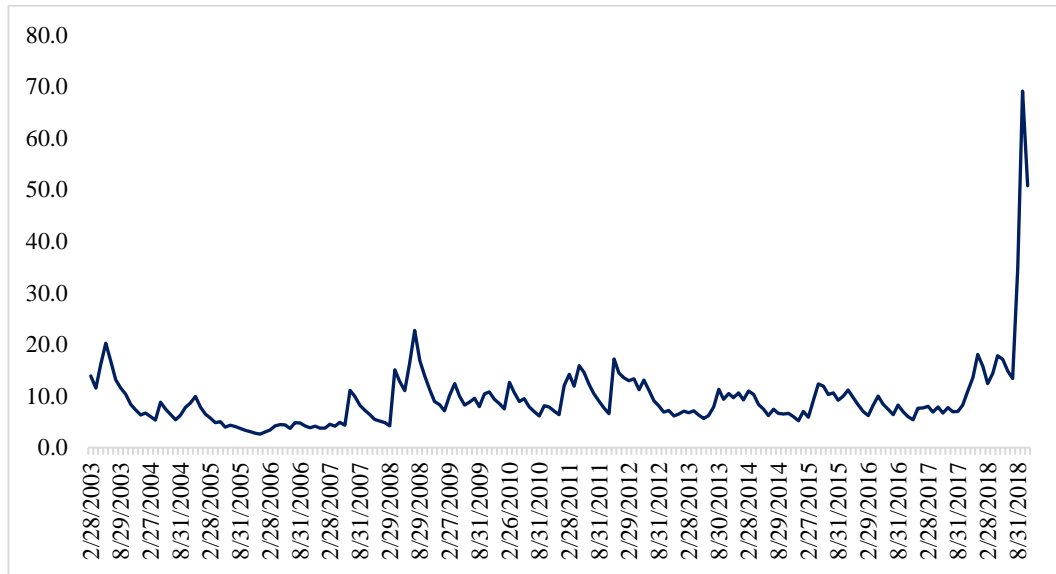
volatility in the banking sector, GJR-GARCH (1, 1) model is applied. The model is as follows:

$$r_t^{banking} = \mu + r_t^{BIST100} + u_t \quad (2.8)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta \sigma_{t-1}^2 + \gamma u_{t-1}^2 I_{t-1} \quad (2.9)$$

In those equations, the return for banking sector index is represented by  $r_t^{banking}$ , BIST100 return by  $r_t^{BIST100}$ , residuals by  $u_t$ , and conditional variance by  $\sigma_t^2$ . The formula in 2.2 shows the relative volatility in returns on bank stocks as opposed to the returns on the overall stock market.

**Figure 2.5. Values of the Banking Equity Index (Jan. 2003 – Oct. 2018)**



### 2.1.2.2. Foreign Exchange Market

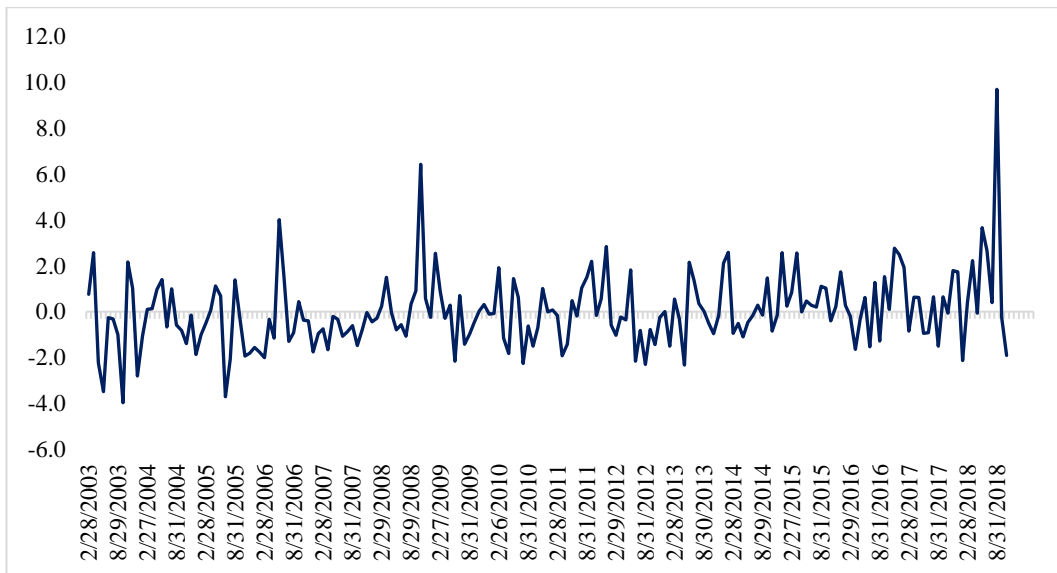
Fluctuations in exchange rates affect countries, in particular, the countries having a large amount of current account deficits and external debt. The firms in the real sector have also affected the volatilities in the exchange rates in case they use foreign-currency loans. Currency crises are associated with important devaluations

in the local currency, changes in reserve levels, and prominent changes in interest rates (Illing and Liu, 2003). Exchange market pressure index (EMPI) which includes both exchange rate depreciation and changes in international reserves will be used as a representative of the stress in the foreign exchange market (Balakrishnan et al., 2009). The formula for EMPI is as follows:

$$EMPI_t = \frac{(\Delta e_t - \mu_{\Delta e})}{\sigma_{\Delta e}} - \frac{(\Delta RES_t - \mu_{\Delta RES})}{\sigma_{\Delta RES}} \quad (2.10)$$

The changes in USD/TRY exchange rate is represented by  $\Delta e$  and the changes in international reserves for Turkey is represented by  $\Delta RES$ .  $\mu$  and  $\sigma$  denote the mean and standard deviation of the related variable, respectively. According to the formula 2.4, an increase in the real exchange rate and a decrease in reserves indicates that stress in the foreign exchange market escalates, and would have a negative impact on EMPI.

**Figure 2.6. Values for Exchange Market Pressure Index (Jan. 2003 – Oct. 2018)**



For capturing the stress in foreign exchange market, volatility of currency basket indicator, which comprises of equally weighted euro and dollar currencies (0.5 USD / TRY + 0.5 EUR / TRY), is also used. In measuring volatility of the currency

basket, E-GARCH (1,1) model is applied according to the following formulas (Eraslan, 2017):

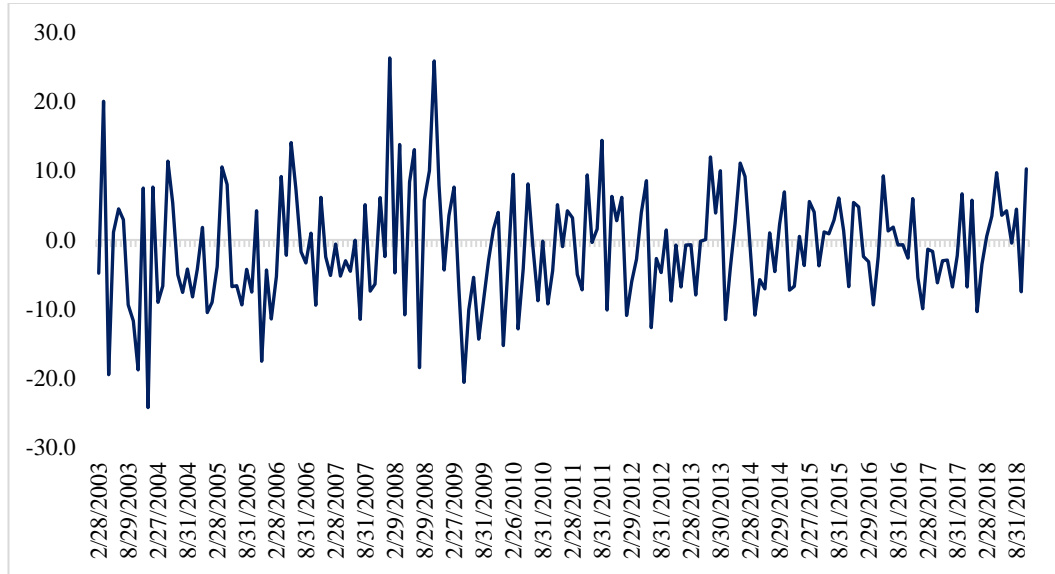
$$r_t = \mu + u_t \quad (2.11)$$

$$\ln(\sigma_t^2) = \alpha_0 + \beta \ln(\sigma_{t-1}^2) + \gamma \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha_1 \left( \frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} \right) \quad (2.12)$$

### 2.1.2.3. Stock Market

Equity crises are generally associated with steep declines in the overall market index in the literature. In such a case, the expected loss will rise, and there will be an increase in uncertainty regarding the returns of firms (Illing and Liu, 2003). There are several studies which incorporate stock market variables to the financial stress index (Illing and Liu, 2006; Balakrishnan et al., 2009; Cardarelli et al., 2009; Hakkio and Keeton, 2009; Ekinci, 2013; Vermeulen, 2014; Sun and Huang, 2016; Eraslan, 2017). Stress stemming from stock market-related events is seen as a crucial factor contributing to the financial crises. It is important to incorporate the variables in the index which take into account the time-varying characteristics of the asset price volatility. In that sense, in addition to Borsa Istanbul stock price index (BIST100), stock market return volatility is also used as a stress indicator in the equity market for Turkey.

**Figure 2.7. Values for Returns of BIST100 Index (Jan. 2003 – Oct. 2018)**



Forecasting volatility is crucial in order to counteract the risks in the financial markets. The volatility of BIST100 is measured by applying to the GJR-GARCH (1, 1) model.

#### 2.1.2.4. Housing Market

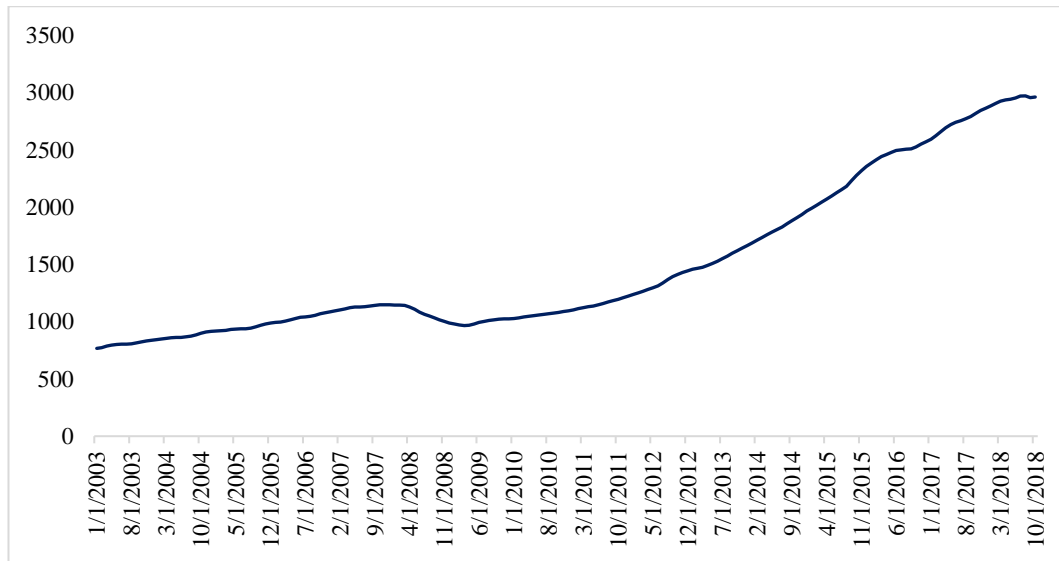
A steep increase in house prices can result in financial imbalances. Incorporating the housing market to the index can improve the predictive ability of crises. In that sense, following Kota and Saqe (2013) and Riiser (2005), the developments in the housing market is also monitored and the Residential Sale Prices are used as a proxy for this purpose. The beta of the housing sector is found with the following formula:

$$r_t^{housing} = \mu + r_t^{BIST100} + u_t \quad (2.13)$$

In this formula, the return for residential sale prices is represented by  $r_t^{housing}$ , BIST100 return by  $r_t^{BIST100}$ , and residuals by  $u_t$ . The formula in 2.13 shows the

relative volatility in returns on housing as opposed to the returns on the overall stock market.

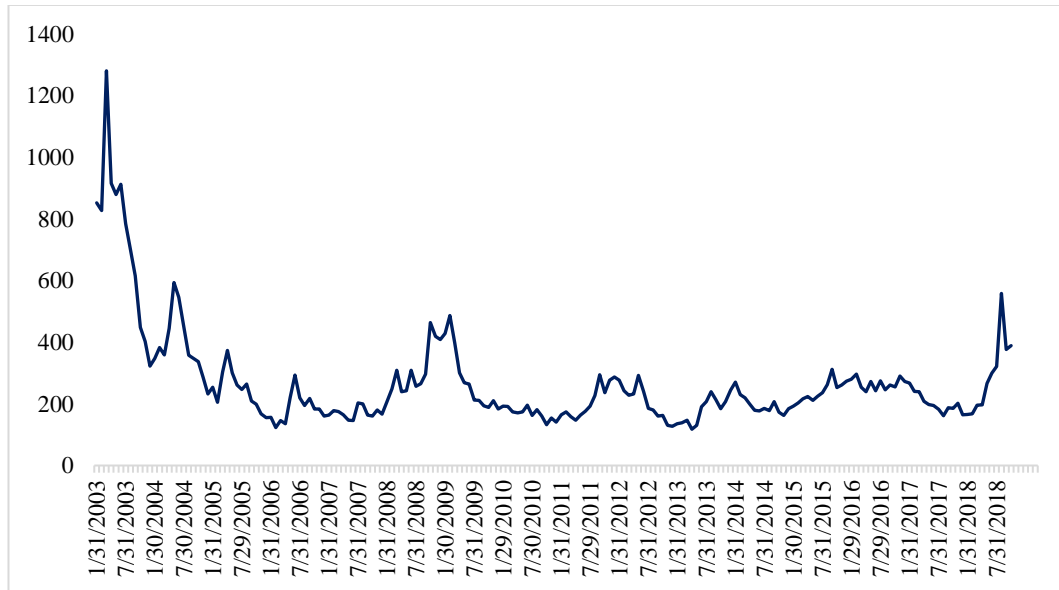
**Figure 2.8. Values for Residential Sale Prices (Jan. 2003 – Oct. 2018)**



#### **2.1.2.5. Public Sector**

As a representative of the public sector, Turkish five-year USD denominated credit default swaps (CDS), which shows the credit risk of the country, is used. The CDS is a protection against the borrower's default in return for a premium. That is, high levels of CDS premiums are associated with increased risk of default probability for sovereign debt. Increasing default probability leads to some problems on banks' balance sheet and the stress level in the financial system as a whole will be affected by that situation (Aboura and Roye, 2013). As a result, a high level of CDS contributes to TFSI positively.

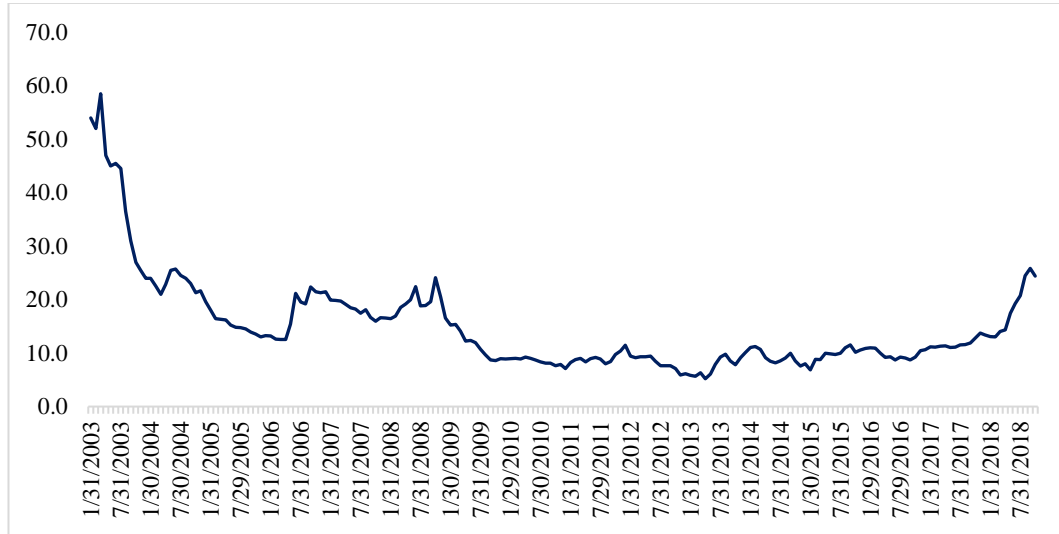
**Figure 2.9. Values for 5-year CDS (Jan. 2003 – Oct. 2018)**



#### **2.1.2.6. Bond Market**

A rise in interest rates in the bond market is associated with higher funding cost for companies which in turn affect the investment decision negatively (Eraslan, 2017). In measuring the stress in bond markets, generally long-term bond spreads are used but this data is only available for recent periods for Turkey. Therefore, in this study, Turkish two-year government bond yields are utilized for the long period analyzed. However, for the period of January 2003 – June 2006, this data is also unavailable. Since the correlation between the two-year government bond yields and 12-month TRY forward implied yields is 0.97, 12-month TRY forward implied yield is used for the period where the data is unavailable by following Güneş (2016).

**Figure 2.10. Values for Government Bond Yield (Jan. 2003 – Oct. 2018)**



The following table includes the summary of all the variables that are used in this study to generate the financial stress index for Turkey.

**Table 2.4. Summary of The Variables**

|                   |  |
|-------------------|--|
| 1. Banking Sector | Interbank Cost of Borrowing<br>(3-month TRLIBOR)<br>The Volatility of the BIST100 Banking Sector Index<br>Volatility Measure: GJR-GARCH (1, 1) |
| 2. FX Market      | The Volatility of the Currency Basket Indicator<br>(0.5 USD / TRY + 0.5 EUR / TRY)<br>Volatility Measure: E-GARCH (1, 1)                       |
| 3. Stock Market   | Borsa Istanbul Stock Price Index (BIST100)<br>The Volatility of the Stock Market Return<br>Volatility Measure: GJR-GARCH (1, 1)                |
| 4. Housing Market | The Beta of the Residential Sale Prices  |
| 5. Public Sector  | 5-Year USD Denominated Credit Default Swaps  |
| 6. Bond Market    | 2-Year Government Bond Yield   |

**Table 2.5. Statistical Summary of Non-Standardized Variables (Jan. 2003 – Oct. 2018)**

|                        | Mean     | Max.      | Min.     | Std. Dev. | Skewness | Kurtosis |
|------------------------|----------|-----------|----------|-----------|----------|----------|
| EMPI                   | 0.00     | 9.70      | -3.97    | 1.61      | 1.52     | 10.07    |
| 3M<br>TRLIBOR          | 14.97    | 51.75     | 5.25     | 8.42      | 2.00     | 7.98     |
| BIST100<br>Index       | 57461.59 | 119528.80 | 9475.09  | 26752.33  | 0.10     | 2.23     |
| Volatility<br>BIST100  | 66.41    | 164.04    | 22.16    | 38.17     | 0.63     | 2.15     |
| Volatility<br>Banking  | 9.63     | 88.69     | 2.57     | 8.83      | 6.30     | 51.73    |
| Volatility<br>Currency | 27.34    | 1080.77   | 43469.00 | 101.24    | 9.27     | 90.35    |
| CDS                    | 267.50   | 1281.25   | 117.81   | 162.63    | 3.09     | 14.67    |
| Bond<br>Yield          | 14.83    | 58.50     | 5.20     | 8.94      | 2.38     | 10.04    |

## **CHAPTER 3**

### **MEASURING FINANCIAL STRESS INDEX FOR TURKEY**

The selection of the weighting method is an important part of the construction process of the financial stress index. In the literature, mostly used prediction methods for measurement of financial stress index are equal-variance weight, principal component analysis, and portfolio theoretic weighting. The analysis is conducted compatible with the literature in this study in order to decide which method is better in capturing stressful periods correctly. Methodological comparison between alternative weighting schemes has been done before by Çamlıca and Güneş (2016), and their result suggests that all of these methods are successful in specifying the financial stress events. The financial stress index calculated with the portfolio theory weighting method, however, provides a more accurate ordering of stress levels by considering financial stress - economic activity relationship between distinct stress periods according to their results.

#### **3.1. Methods for Measuring the Financial Stress Index for Turkey**

##### **3.1.1. Variance - Equal Weights (VEW) Method**

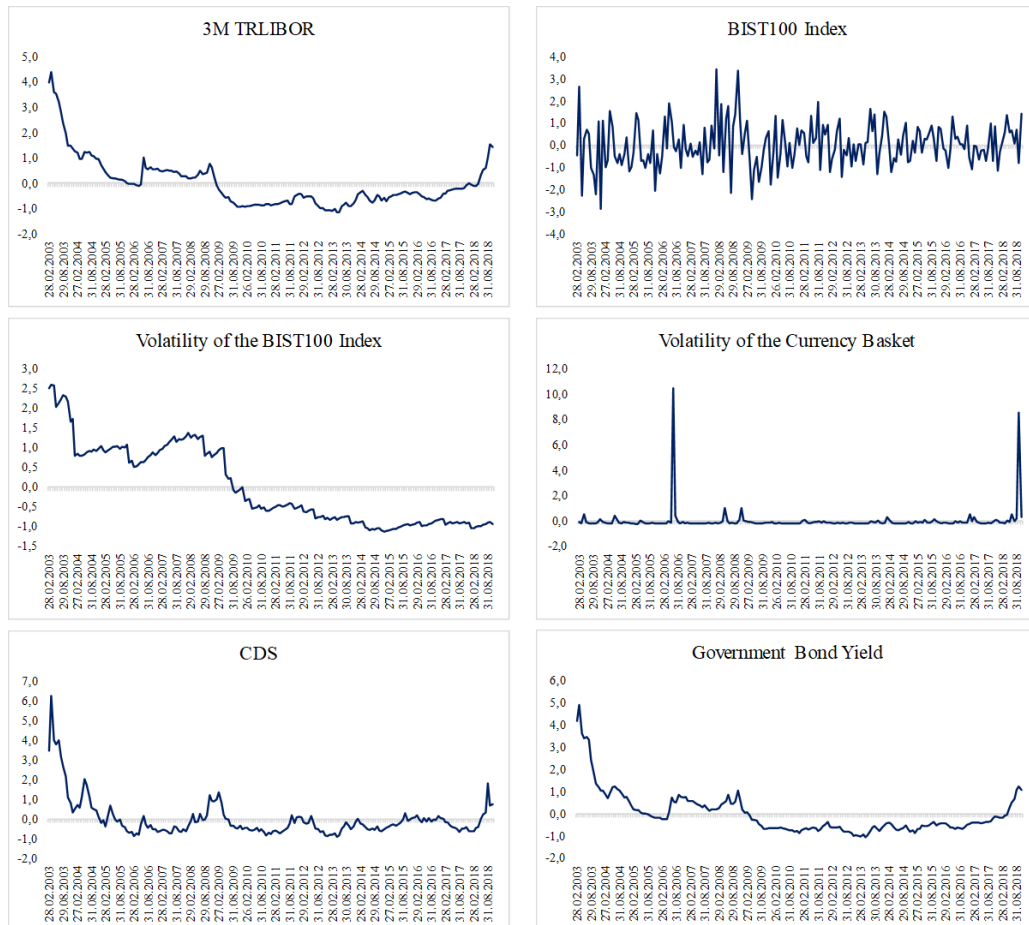
This method is the mostly applied method in the literature because of its easy applicability. In this weighting scheme, all sub-indices have equal weights, which means all sub-markets have equal importance in determining the stress periods in the whole financial system. In this method, the raw stress indicators are standardized by using the sample mean and standard deviation under the assumption of the normal distribution, which is also the main drawback of this method. For the standardization process, first, the mean of the series is subtracted from each observation, and then divided by the standard deviation according to the following formula:

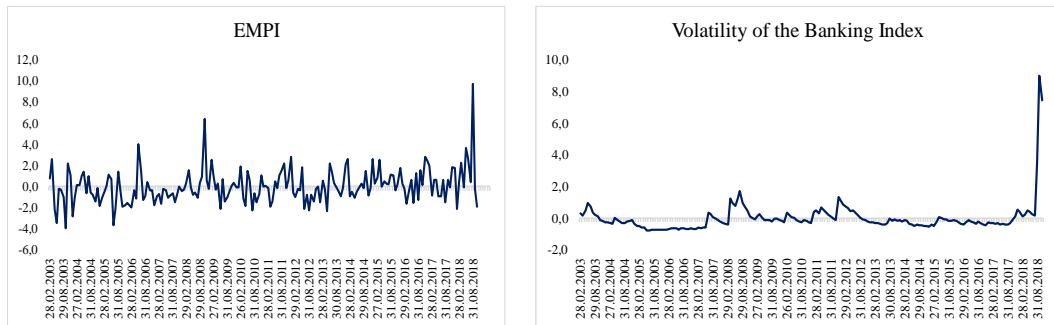
$$z_t = \frac{(x_t - \bar{x})}{\sigma} \quad (3.1)$$

where  $z_t$  represents the standardized and demeaned submarket stress indicator,  $x_t$  represents raw stress indicator for submarket,  $\bar{x}$  stands for the sample mean, and  $\sigma$  is the standard deviation. After this process, all the standardized components are simply aggregated (Balakrishnan et al., 2009). The formula including the arithmetic means of the submarket stress indicators is as follows (Çamlıca and Güneş, 2016):

$$VEW = (\sum_1^k z_k) / k \quad (3.2)$$

**Figure 3.1. Values for Standardized Variables (Jan. 2003- Oct. 2018)**





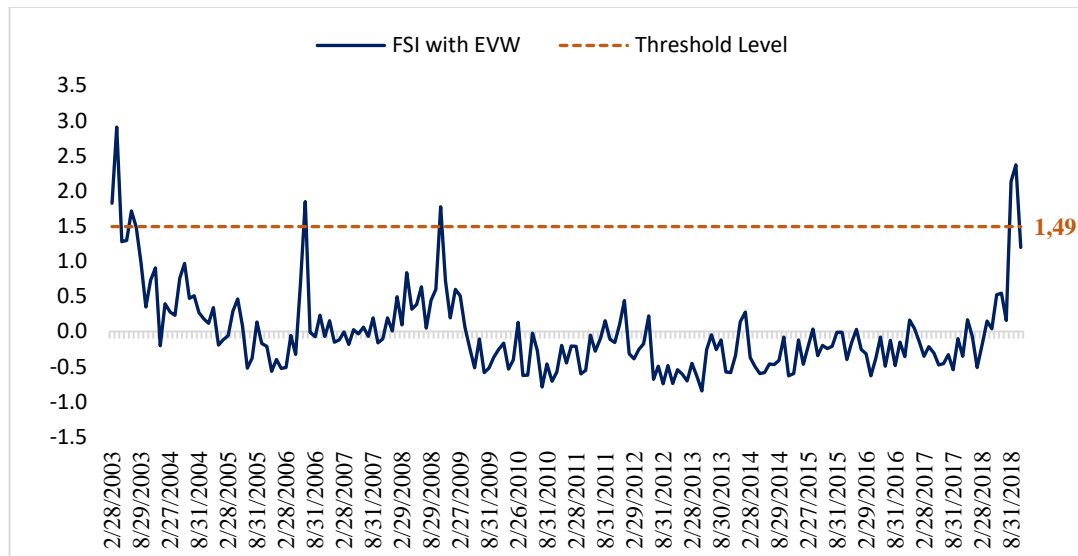
The following figure shows the ultimate results for the financial stress index constructed with eight subindices. According to the results, TFSI takes the highest value after the 2001 crisis. The Iraq War in April 2003 also contributes positively to the stress level in that period. Another period that stress level becomes apparent coinciding with the monetary tightening of FED's decision in 2006. FED's decision resulted in a slowdown in the global economy. The next financial stress period coincides with the global financial crisis in 2008. The crisis started at the US housing market spread over the entire global economy and the collapse of the Lehman Brothers in September 2008 intensified the effects of it. After the global financial crisis, there are no important stress events until August 2018, when high volatility in the exchange rate is experienced according to the results of this method. The financial crises periods are the ones in which extreme pressures are experienced. To determine the crises periods a threshold level, where the TFSI exceeds a certain threshold level, the following formulas are applied (Gerni et al., 2005):

$$fsi > 2.5 \sigma_{fsi} + \mu_{fsi} \quad (3.3)$$

$$fsi \leq 2.5 \sigma_{fsi} + \mu_{fsi} \quad (3.4)$$

where  $\sigma_{fsi}$  is the sample standard deviation and  $\mu_{fsi}$  is the sample mean of the financial stress indexes that are calculated for each of the three methods. If the formula 3.3 is satisfied, then this implies the existence of crisis; otherwise, there is no crisis. The results can be found in figure 3.2.

**Figure 3.2. Financial Stress Index for Turkey with Equal-Variance Weights Method**



### 3.1.2. Principal Component Analysis

One of the main drawbacks of variance-equal weight method is that it ignores the co-movements of submarkets, which implies that it overlooks the systemic dimension of the financial stress. Principal component analysis (PCA), on the other hand, considers the correlation between submarket stress indicators. In order to calculate the financial stress index with PCA, firstly we found the correlation matrix, which can be seen in Figure 3.1. Then, we calculated eigenvalues and eigenvectors and finally from those results we found the weights of each of the subcomponent which is incorporated into the calculation of the financial stress index for Turkey.

**Table 3.1. Correlation Matrix for Variables in TFSI for the Period of January 2003 and October 2018**

|                        | EMPI  | 3M<br>TRLIBOR | BIST100<br>Index | BIST100<br>Volatility | Banking<br>Volatility | Volatility<br>Currency | CDS  | Bond<br>Yield |
|------------------------|-------|---------------|------------------|-----------------------|-----------------------|------------------------|------|---------------|
| EMPI                   | 1     |               |                  |                       |                       |                        |      |               |
| 3M<br>TRLIBOR          | -0.04 | 1             |                  |                       |                       |                        |      |               |
| BIST100<br>Index       | 0.47  | 0.01          | 1                |                       |                       |                        |      |               |
| BIST100<br>Volatility  | -0.20 | 0.75          | -0.09            | 1                     |                       |                        |      |               |
| Banking<br>Volatility  | 0.10  | 0.22          | 0.08             | -0.07                 | 1                     |                        |      |               |
| Currency<br>Volatility | 0.08  | 0.16          | 0.03             | -0.00                 | 0.40                  | 1                      |      |               |
| CDS                    | 0.14  | 0.82          | 0.11             | 0.54                  | 0.23                  | 0.08                   | 1    |               |
| Bond<br>Yield          | 0.23  | 0.07          | 0.03             | 0.01                  | 0.06                  | 0.25                   | 0.17 | 1             |

The idea behind PCA is to transform a set of correlated variables into a smaller set of uncorrelated variables. One of the advantages of this method is that it reduces the number of the variables in the model by preserving the variance of the variables as much as possible that are incorporated into the model. The raw stress indicators are firstly standardized as in the case of variance-equal weight method (Güneş, 2016). The first principal component is the financial stress index in this case, and that explains the 22.10% of the variation of the raw stress indicators. Owing to this method, it is possible to reduce the number of standardized variables to a single index. In order to perform PCA, first the correlation matrix is calculated, and then the eigenvectors and eigenvalues. The eigenvalues show the amount of variance with regard to the given eigenvector. The overall results are shown in the following table:

**Table 3.2. The Weights Extracted from the Principal Component Analysis**

| Principal Component | Eigenvalues | Variance for Principal Components | Cumulative Variance |
|---------------------|-------------|-----------------------------------|---------------------|
| 1                   | 1.767878    | 22.10%                            | 22.10%              |
| 2                   | 1.575569    | 19.70%                            | 41.79%              |
| 3                   | 1.104930    | 13.81%                            | 55.61%              |
| 4                   | 0.928913    | 11.61%                            | 67.22%              |
| 5                   | 0.865795    | 10.82%                            | 78.04%              |
| 6                   | 0.657956    | 8.22%                             | 86.26%              |
| 7                   | 0.613188    | 7.67%                             | 93.93%              |
| 8                   | 0.485602    | 6.07%                             | 100.00%             |
| Total               | 8           |                                   |                     |

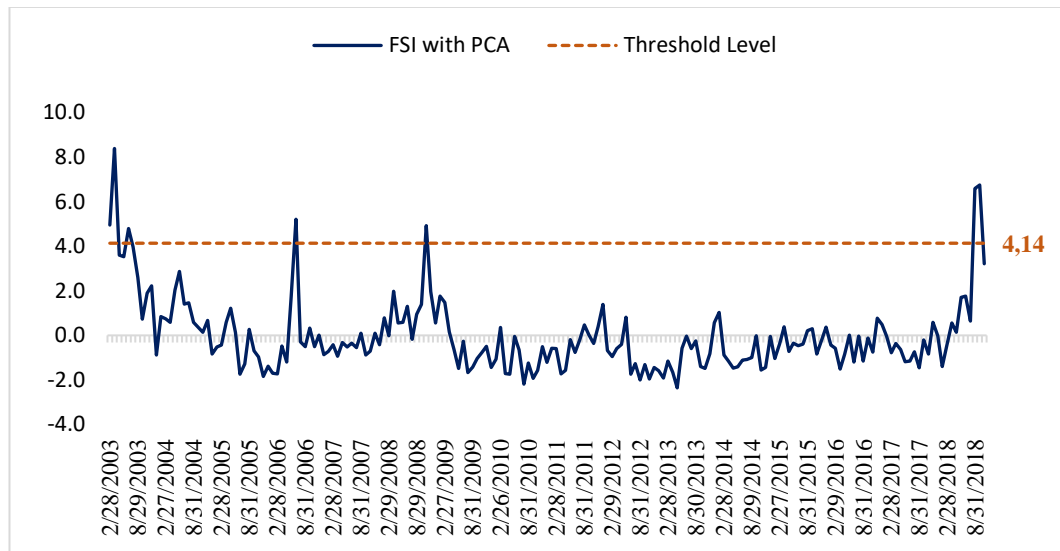
In this method, the first principal is accepted as the financial stress index, and the other indicators with regard to the sub-financial markets are given in the table. The importance of a factor is determined with the help of eigenvectors and standard deviation of its factor score, and this can be found from the eigenvalues which are shown in Table 3.3. According to those results, the most contributing factors to the principal components are CDS, EMPI, currency volatility, and 3-month TRLIBOR.

**Table 3.3. The Results for Principal Component Analysis**

| Principal Component      | Weights in PC1 |
|--------------------------|----------------|
| EMPI                     | 0,51           |
| 3M TRLIBOR               | 0,49           |
| BIST100 Index            | 0,39           |
| Volatility BIST100       | 0,18           |
| Volatility Banking Index | 0,42           |
| Volatility Currency      | 0,49           |
| CDS                      | 0,76           |
| Bond Yield               | 0,30           |

The results for the financial stress index with the PCA is shown in Figure 3.3. The negative values of the index indicate that financial stress is below its long-term average (Güneş, 2016).

**Figure 3.3. Financial Stress Index for Turkey with Principal Component Analysis**



### 3.1.3. Portfolio Theory

Holló (2012), in his study of the generation of financial stress index for the Hungarian financial system, applies the portfolio-based approach for the weighting scheme in aggregating the sub-indices which are the representative of the financial system of that country. The standard portfolio theory is also used in other studies by following Holló (Kota and Saqe, 2013; Louzis and Vouldis, 2013; Çamlıca and Güneş, 2016). Rather than giving equal weights to each market segments, this approach makes it possible to give more weights on stressful periods existing in different market segments at the same time. The rationale behind standard portfolio theory is that if highly correlated risky assets are incorporated into a given portfolio, the risk of the overall portfolio will increase as in the case of principal component analysis. However, the superiority of standard portfolio theory is that it considers time-varying cross-correlations between distinct market segment variables. High correlation among the sub-indices is an indicator of stress that exists in many market segments at the same time, which may end up with systemic risk. Accordingly, Holló's approach takes into account the time-varying cross-correlations among sub-indices which are the representatives of the systemic risk in the financial system

(Louzis and Vouldis, 2013). This method enables to determine systemic risk events and stressfull time periods. That is, in times of financial turmoil, there is a strong co-movement of stress indices in distinct market segments at the same time, which reflects its systemic characteristics. In such a case, more weights will be put on events and periods when the stress spreads over the various market segments simultaneously (Holló, 2012).

In the transformation of the raw stress indicators, the logistic transformation is used and the eight stress sub-indices are scaled from 0 to 1 by using the following formula (Kilimci et al., 2015):

$$\tilde{s}_{it} = 1 / [1 + \exp (-s_{it}) ] \quad (3.5)$$

where  $\tilde{s}_{it}$  is the transformed sub-indices,  $i = 1, 2, \dots, 8$  and takes the values from 0 to 1,  $s_{it}$  is the standardized sub-indices.

After logistic transformation, the financial systemic stress index is calculated by the following formula (see Holló et al., 2012; Louzis and Vouldis, 2013; Kota and Saqe, 2013; Çamlıca and Güneş, 2016):

$$\text{TFSI}_t = (w_t \circ s_t) C_t (w_t \circ s_t)' \quad (3.6)$$

where  $w_t = (w_1, w_2, \dots, w_8)^6$  is the vector of time-invariant weights of the sub-indices.  $s_t = (s_{1,t}, s_{2,t}, \dots, s_{8,t})$  is the vector of the submarket stress indices at time  $t$ ,  $(w_t \circ s_t)$  is the Hadamard-product, consisting of the product of subindex weight vector with the subindex vector at time  $t$ ,  $C_t$  is the  $8 \times 8$  the time-varying cross-correlation matrix of the subindices with coefficients  $\rho_{ij,t}$ .

---

<sup>6</sup> The weights are taken as equal. Holló et al. (2012), in their studies, found not a large difference between the weights that are calculated by taking into the consideration the relative importance of the variables in relation to the real economy and the equal weights.

$$C_t = \begin{bmatrix} 1 & \rho_{12,t} & \rho_{13,t} & \rho_{14,t} & \rho_{15,t} & \rho_{16,t} & \rho_{17,t} & \rho_{18,t} \\ \rho_{21,t} & 1 & \rho_{23,t} & \rho_{24,t} & \rho_{25,t} & \rho_{26,t} & \rho_{27,t} & \rho_{28,t} \\ \rho_{31,t} & \rho_{32,t} & 1 & \rho_{34,t} & \rho_{35,t} & \rho_{36,t} & \rho_{37,t} & \rho_{38,t} \\ \rho_{41,t} & \rho_{42,t} & \rho_{43,t} & 1 & \rho_{45,t} & \rho_{46,t} & \rho_{47,t} & \rho_{48,t} \\ \rho_{51,t} & \rho_{52,t} & \rho_{53,t} & \rho_{54,t} & 1 & \rho_{56,t} & \rho_{57,t} & \rho_{58,t} \\ \rho_{61,t} & \rho_{62,t} & \rho_{63,t} & \rho_{64,t} & \rho_{65,t} & 1 & \rho_{67,t} & \rho_{68,t} \\ \rho_{71,t} & \rho_{72,t} & \rho_{73,t} & \rho_{74,t} & \rho_{75,t} & \rho_{76,t} & 1 & \rho_{78,t} \\ \rho_{81,t} & \rho_{82,t} & \rho_{83,t} & \rho_{84,t} & \rho_{85,t} & \rho_{86,t} & \rho_{87,t} & 1 \end{bmatrix} \quad (3.7)$$

In order to find the  $\rho_{ij,t}$ , we calculate relative covariance and variance recursively with the exponentially weighted moving average method (EWMA). For the initial values of variances and covariances, sample values are used (Kilimci et al., 2015). The formulas are as follows:

$$\sigma_{ij,t} = \lambda \sigma_{ij,t-1} + (1-\lambda) \widetilde{s_{i,t}} \widetilde{s_{j,t}} \quad (3.8)$$

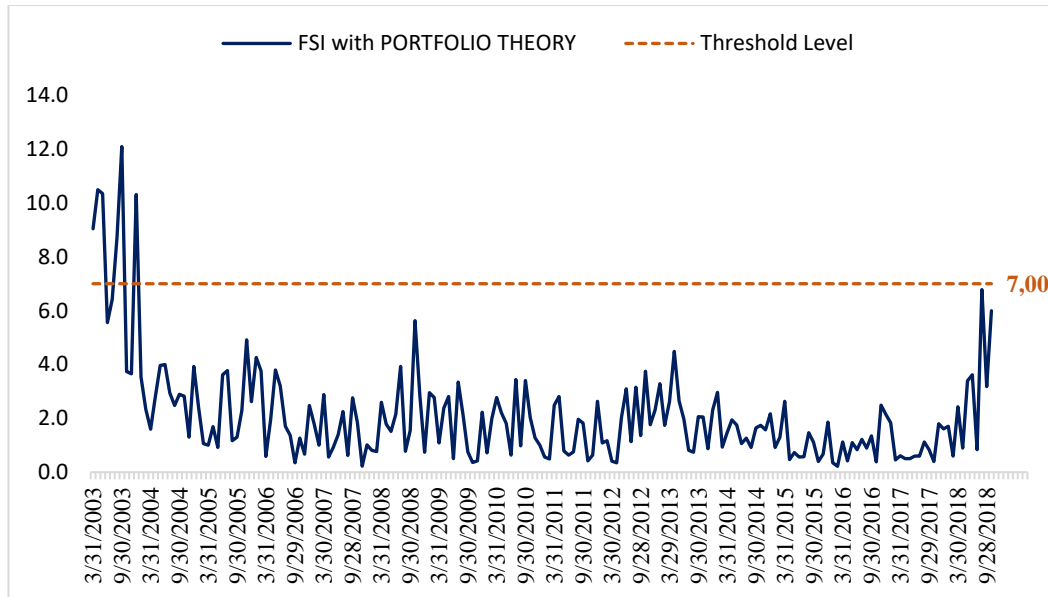
$$\sigma_{ij,t}^2 = \lambda \sigma_{ij,t-1}^2 + (1-\lambda) \widetilde{s_{i,t}}^2 \quad (3.9)$$

$$\widetilde{s_{i,t}} = (s_{i,t} - 0.5) \quad (3.10)$$

$$\rho_{ij,t} = \sigma_{ij,t} / (\sigma_{i,t} \sigma_{j,t}) \quad (3.11)$$

where  $i = 1, 2, \dots, 8$ ,  $j = 1, 2, \dots, 5$ ,  $i \neq j$ , and  $t = 1, \dots, T$ .  $\widetilde{s_{i,t}}$  is obtained by subtracting the theoretical mean of the sub-indexes. Lambda ( $\lambda$ ) coefficient is supposed to be a constant, 0.93, which is proposed by JP Morgan, is the optimum  $\lambda$  value for Turkey in calculation volatility with EWMA approach.

**Figure 3.4. Financial Stress Index with Portfolio Theory**



### **3.2. Comparison of the Methods and Evaluation of the Results**

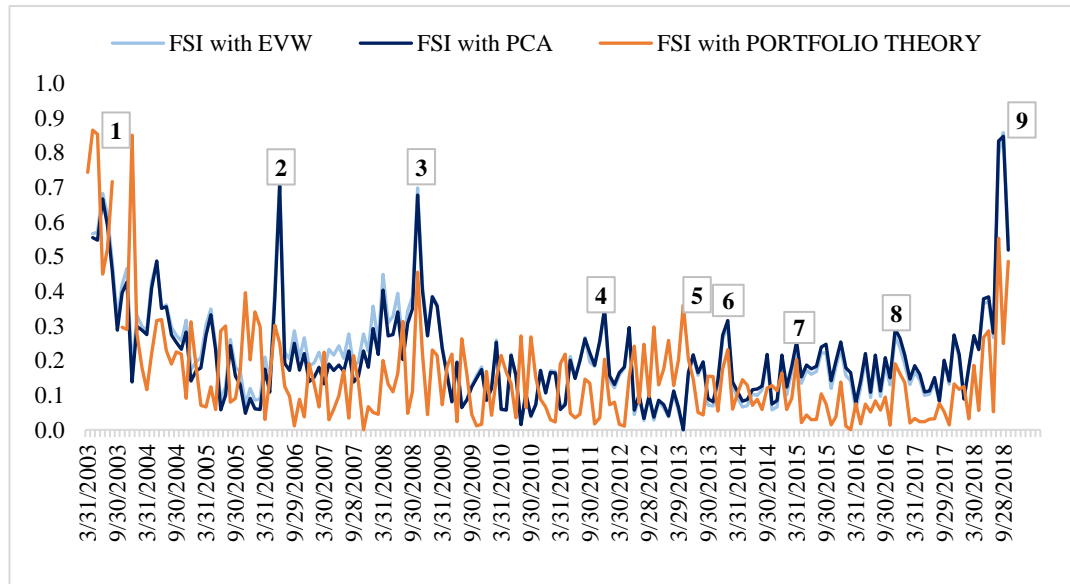
All of the three methods seem to be successful in terms of capturing the important financial stress periods in Turkey. However, these methods have some advantages and disadvantages. That is, the variance-equal weight method gives equal importance to all of the variables in the index and therefore does not provide information about the sources of the stress. Besides, it does not take into account the cross-correlations of the variables. Therefore, the stress levels which are calculated with the equal-variance method indicates a lower stress level compared to the other two methods. On the other hand, the principal component analysis takes into account the cross-correlations and ranks the variables in terms of their relative contribution to the stress level. Since the correlations are taken into consideration, the stress levels are higher compared to the equal-variance weight method. However, one of the drawbacks of this method is that it ignores the time-varying cross-correlations between variables. Portfolio theory, on the other hand, seems to fill this gap by considering changing correlations of the subindices with time.

In spite of some disadvantages that equal-variance weight method and principal component analysis, all of the three methods provide information about the stressful periods. However, there are no specific criteria for making a comparison in terms of evaluating the predictive power of these periods. For this reason, by following Güneş (2016), all of the financial stress indexes that are calculated in the previous sections are normalized with the following formula in order to make comparison possible by looking the responses of the financial stress indexes to the stress events.

$$\hat{i}_t = \frac{i_t - I_{max}}{I_{max} - I_{min}} \quad (3.12)$$

where  $\hat{i}_t$  is the stress index which is normalized,  $I_{max}$  is the maximum value for the financial stress index sample, and  $I_{min}$  is the minimum value. The evaluation is made according to the responses of the financial stress index to the known periods of stress events in Turkey during the period 31.03.2003 and 31.10.2018.

**Figure 3.5. Comparison of the Financial Stress Indexes**



The stress events that are specified in Figure 3.5 are as follows:<sup>7</sup>

1. Second Iraq War, April 2003

<sup>7</sup> See Güneş (2016).

2. FED's Monetary Tightening, 2006
3. The Collapse of Lehman Brothers, 15 September 2008
4. The Uncertainty of FED's Quantitative Easing, August 2011
5. FED's Explanation regarding Asset Purchases and Domestic Political Turmoil, May-September 2013
6. CBRT Monetary Policy Committee's Interest Rate Hike Decision, January 2014
7. High Volatility in USD/TRY Exchange Rate Level
8. July 15, 2016 Coup Attempt
9. Exchange Rate Volatility, August 2018

When we look at the results of Figure 3.5, all of the three methods seem to move together most of the time except for the period 5. In particular, this compatibility is apparent in high stress periods (periods 1, 2, 3, 9), which implies that these three methods are successful in terms capturing high stress periods, but their reactions to stress are different in low stress periods. Although the equal-variance method and principal component analysis react similarly in both low- and high- stress periods, the portfolio theory seems to dissociate from the other two approaches. This variation can be seen in period 5. After domestic political turmoil in 2013, the stress that is calculated by EVW and PCA increases, but the portfolio theory predicts the opposite.

## **CHAPTER 4**

### **THE MEASUREMENT OF THE FINANCIAL STRESS INDEX WITH THE ADDITION OF THE HOUSING SECTOR**

The deterioration in the housing market may have a systemic impact on the economy. Because of its close relation with other sectors and its increasing role in economic growth, in this part of the study, the housing price index, which is not a frequently used variable in the measurement of the stress level in Turkey, is added to the financial stress index indicators in order to evaluate whether the addition of such an index has any improvements in terms of the predictive power of financial stress for the period 31.01.2003 – 31.10.2018. There are different studies which incorporate the housing market to the measurement of the financial stress index (Roye and Björn (2011), Oet et al. (2012), Aboura and Roye (2013), Sun and Huang (2016)). However, the studies which include that sector is relatively restricted for Turkey. The housing credit spread is one of the indicators used as a proxy for stress in the housing market which is used by Roye (2011) and Aboura and Roye (2013). Aboura and Roye (2013) in their studies take the difference between interest rates for mortgages and the French government bond yields which have an average maturity of five years with the assumption that if there is an increase in spread level, then there will be an increase in the risk perception of banks relating to the housing loans. Therefore, this indicator has a positive contribution to the financial stress level. Sun and Huang (2016) in their study of China's financial instability, on the other hand, incorporates the housing price index and the real estate prosperity index in addition to the growth rates of deposits and loans, CPI inflation, and the growth rates of M2 as a representative of the asset prices and investments, respectively. They demonstrate that the HPI and the real estate prosperity index are among the relatively reliable indicators in providing early warnings for the instability in China's economy.

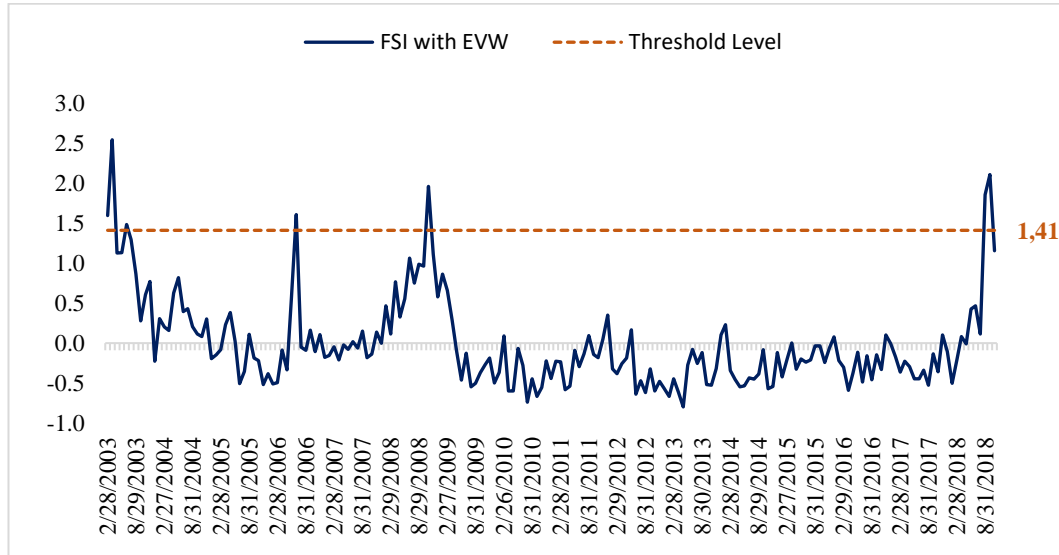
In this part of the study, a similar methodology in Chapter 2 and 3 is implemented. Accordingly, the equal-variance weights method, principal component analysis, and portfolio theory are applied with the addition of a new variable that is thought

to contribute to the stress level for the period in question. That is, as a representative of the stress in the housing market, the beta of the residential sales prices is used. The results are as follows:

**Table 4.1. Correlation Matrix for Variables in TFSI for the Period of January 2003 and October 2018 with Residential Sale Prices**

|                            | EMPI  | 3M<br>TRLIBOR | BIST100<br>Index | BIST100<br>Volatility | Banking<br>Volatility | Volatility<br>Currency | CDS   | Bond Yield | Residential<br>Sale Prices |
|----------------------------|-------|---------------|------------------|-----------------------|-----------------------|------------------------|-------|------------|----------------------------|
| EMPI                       | 1     |               |                  |                       |                       |                        |       |            |                            |
| 3M<br>TRLIBOR              | -0.03 | 1             |                  |                       |                       |                        |       |            |                            |
| BIST100<br>Index           | 0.35  | 0.00          | 1                |                       |                       |                        |       |            |                            |
| BIST100<br>Volatility      | -0.15 | 0.35          | -0.1             | 1                     |                       |                        |       |            |                            |
| Banking<br>Volatility      | 0.07  | -0.01         | 0.10             | 0.03                  | 1                     |                        |       |            |                            |
| Currency<br>Volatility     | 0.16  | 0.06          | 0.07             | -0.11                 | 0.14                  | 1                      |       |            |                            |
| CDS                        | 0.20  | 0.40          | 0.09             | 0.17                  | 0.19                  | 0.21                   | 1     |            |                            |
| Bond<br>Yield              | -0.01 | 0.86          | 0.02             | 0.43                  | 0.04                  | 0.07                   | 0.44  | 1          |                            |
| Residential Sale<br>Prices | 0.02  | 0.03          | 0.06             | 0.10                  | 0.14                  | 0.06                   | -0.04 | 0.06       | 1                          |

**Figure 4.1. Financial Stress Index for Turkey with Equal-Variance Weights Method with Residential Sale Prices**



**Table 4.2. The Weights Extracted from the Principal Component Analysis with Residential Sale Prices**

| Principal Component | Eigenvalues | Variance for Principal Components | Cumulative Variance |
|---------------------|-------------|-----------------------------------|---------------------|
| 1                   | 2.433953    | 27.05%                            | 27.05%              |
| 2                   | 1.650961    | 18.35%                            | 45.40%              |
| 3                   | 1.087091    | 12.08%                            | 57.48%              |
| 4                   | 0.950760    | 10.57%                            | 68.05%              |
| 5                   | 0.913352    | 10.15%                            | 78.20%              |
| 6                   | 0.667548    | 7.42%                             | 85.61%              |
| 7                   | 0.645087    | 7.17%                             | 92.78%              |
| 8                   | 0.512657    | 5.70%                             | 98.48%              |
| 9                   | 0.136678    | 1.52%                             | 100.00%             |
| Total               | 9           |                                   |                     |

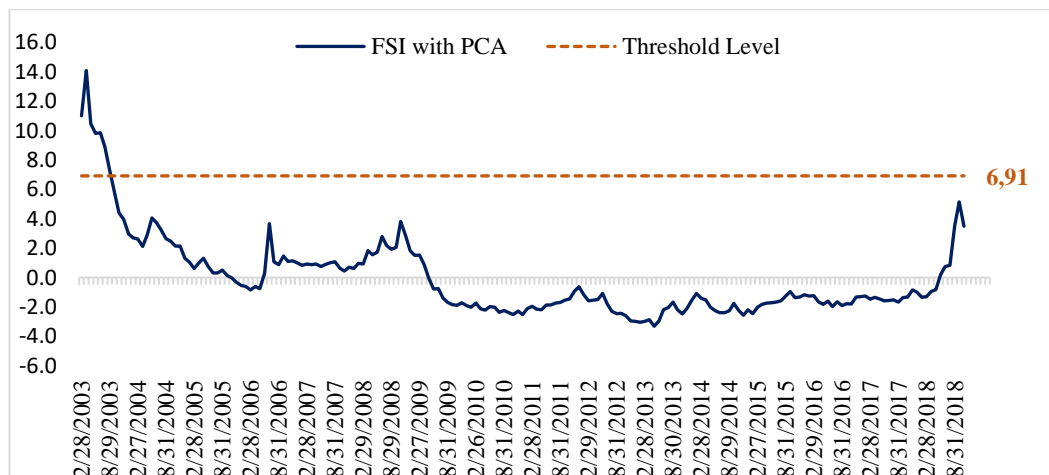
According to the results in Table 5.2, the six variables explain the 85.61% variation in the total sample. The weights which are separated in accordance with the relative importance in terms of their contribution to the ultimate financial stress index appears in Table 5.3.

**Table 4.3. The Results for Principal Component Analysis with Residential Sale Prices**

| Principal Component      | Weights in PC1 |
|--------------------------|----------------|
| EMPI                     | 0.05           |
| 3M TRLIBOR               | 0.88           |
| BIST100 Index            | 0.05           |
| Volatility BIST100       | 0.56           |
| Volatility Banking Index | 0.16           |
| Volatility Currency      | 0.16           |
| CDS                      | 0.65           |
| Bond Yield               | 0.92           |
| Residential Sale Prices  | 0.10           |

According to those results, the most contributing factors to the principal components are the bond yield, 3-month TRLIBOR, and CDS. But the contribution of EMPI and BIST100 Index is very low. It is seen that when we add the housing market indicator, the contributing factors are not evenly distributed as in the case of the first part of the study which does not include the residential sale prices. Rather, it is concentrated only on a few factors, which are bond yield and 3-month TRLIBOR, and ignores the importance of other factors which explain the stress periods. That is, the explanatory power of the overall financial stress is decreased in this case compared to the equal-variance weight method.

**Figure 4.2. Financial Stress Index for Turkey with Principal Component Analysis with Residential Sale Prices**



**Figure 4.3. Financial Stress Index for Turkey with Portfolio Theory with Residential Sale Prices**

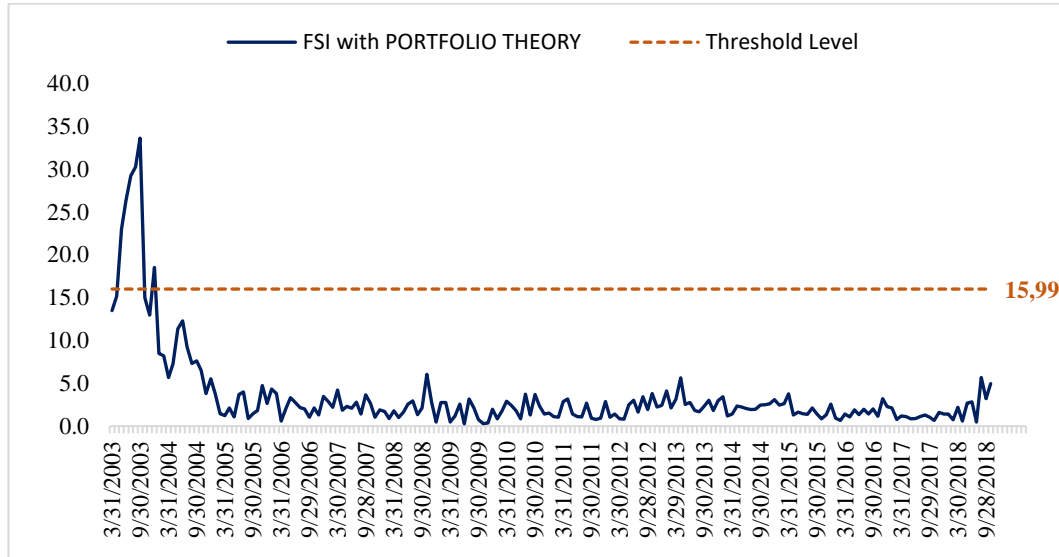
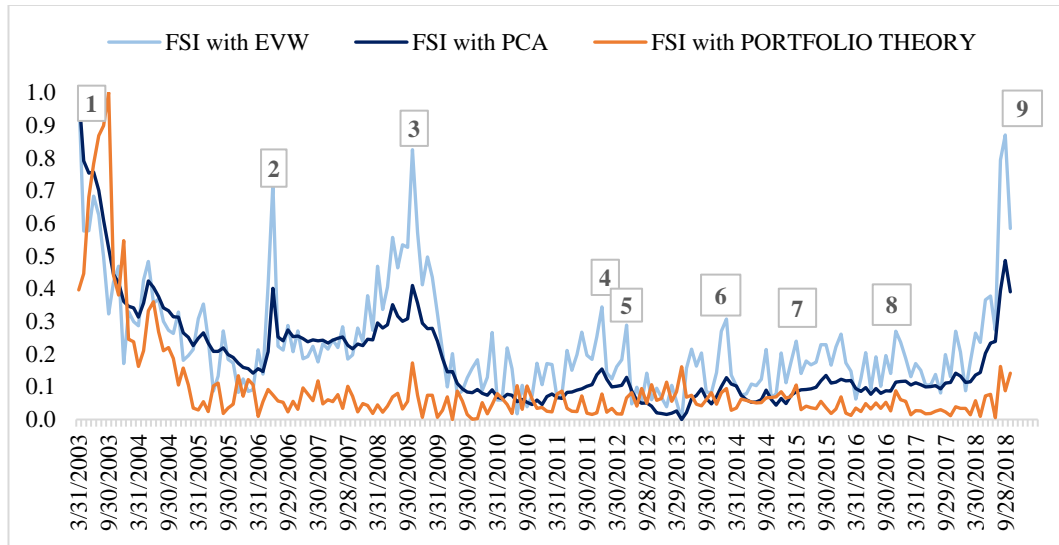


Figure 4.3 shows the financial stress index with portfolio theory. The addition of the housing sector seems to give more weight to the period after the 2001 crisis, and the Iraq War in 2003. However, it does not explain the global financial crises in 2008 and large fluctuations in August 2018. Furthermore, when we make a comparison among methods in overall, the addition of the housing sector decreases the explanatory power of the financial stress index. Since the residential sales prices are in an increasing trend in Turkey for the period in question, it does not give reaction to the stress. This can be seen in Figure 4.4.

**Figure 4.4. Comparison of the Financial Stress Indexes with Residential Sale Prices**



According to the result of Figure 4.4, the addition of housing sector seems to mitigate the effects of the crises in the principal component and portfolio theory-based approaches. However, this contradicts with our expectations because these are the methods which consider the systemic impacts of the stressful time periods. That is, in times of high financial instability, stress indicators in different market segments move together and the stress levels that are predicted by those method increases. Overall, adding the housing sector to the stress index impacts on the opposite direction and decreases the stress levels predicted by stress indices for Turkey.

## **CHAPTER 5**

### **CONCLUSIONS AND RECOMMENDATIONS**

This study includes a methodological comparison between three methods - the equal-variance method, the principal component analysis, and the portfolio theory. Furthermore, another comparison is made by incorporating the housing sector to the common market segments which are mostly investigated in the literature. The financial stress indexes constructed with respect to these methods are evaluated in terms of their ability of capturing the crises or financial stress periods for the period between January 2003 and October 2018. The results which are generated without the addition of the housing sector seem to capture the financial instability periods properly for all of the three methods, but their reflection of the severity of the crises is different. This is compatible with our expectations. That is, the stress level that is found with equal-variance weight method is less than the stress level which is calculated with the principal component or portfolio theory because of its deficiencies of taking equal weights for each subindex and ignoring the correlations among them. Another important observation is the fact that all of the FSI methods points to a crisis in 2018 in Turkey.

Then a financial stress index with the addition of a housing sector is generated by using the same methodology, but the explanatory power of the index is lessened, this effect is apparent when we add a threshold level to the financial stress index that is calculated by principal component analysis and portfolio theory. The results indicated that the housing sector mitigates the effects of other sectors in Turkey. The study by Charles et al. (2016) is helpful to explain these results. The devastating effect of the global financial crises demonstrated once again the importance of managing risks in the financial system efficiently. Because of the systemic dimension of the crises, it is of paramount importance to take into account the comovement of several subindices. Moreover, we cannot ignore the effects of financial crises on real economic activity. Therefore, in particular, after 2008, the studies which analyze this relationship have increased which aim at providing

information to policymakers with regard to the general outlook or direction of the economy. Although the studies have accelerated regarding the measurement of financial stress index, there is still a need for development in these areas. For this reason, a stress index is constructed by using three different methods. This study can be improved by investigating the relationship between financial stress and economic activity and rather than implying to linear impulse-response functions, regime-dependent studies can be conducted. Because the response of a shock on real economic activity would be different for normal and high stressful time periods. Although the studies which take into account this non-linear relationship have increased, there is still a gap in this field.

The financial stress indicators are important tools for policymakers for monitoring financial stability and for producing efficient policies. The financial stress index that is constructed for Turkey seems to be successful in terms of capturing both the internal and external shocks in the economy. The measurement of such an index also provides information about the sources of the shock, which can make it an important tool in decision-making.

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## APPENDIX

**Figure A1. Principal Component Analysis EViews Output without Residential Sale Prices**

Principal Components Analysis  
 Date: 04/21/19 Time: 23:09  
 Sample: 2003M02 2018M10  
 Included observations: 189  
 Computed using: Kendall's tau-a  
 Extracting 8 of 8 possible components

Eigenvalues: (Sum = 7.999831, Average = 0.9999789)

| Number | Value    | Difference | Proportion | Cumulative Value | Cumulative Proportion |
|--------|----------|------------|------------|------------------|-----------------------|
| 1      | 1.767878 | 0.192309   | 0.2210     | 1.767878         | 0.2210                |
| 2      | 1.575569 | 0.470639   | 0.1970     | 3.343447         | 0.4179                |
| 3      | 1.104930 | 0.176017   | 0.1381     | 4.448377         | 0.5561                |
| 4      | 0.928913 | 0.063118   | 0.1161     | 5.377290         | 0.6722                |
| 5      | 0.865795 | 0.207839   | 0.1082     | 6.243085         | 0.7804                |
| 6      | 0.657956 | 0.044769   | 0.0822     | 6.901042         | 0.8626                |
| 7      | 0.613188 | 0.127586   | 0.0767     | 7.514229         | 0.9393                |
| 8      | 0.485602 | ---        | 0.0607     | 7.999831         | 1.0000                |

Eigenvectors (loadings):

| Variable         | PC 1     | PC 2      | PC 3      | PC 4      | PC 5      | PC 6      | PC 7      | PC 8      |
|------------------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| EMPI             | 0.381080 | -0.416106 | -0.284717 | -0.217566 | 0.183849  | -0.217986 | 0.608445  | 0.318923  |
| _3M_TRLIBOR      | 0.370580 | 0.507710  | -0.174260 | -0.199364 | -0.110843 | -0.050125 | -0.352051 | 0.629325  |
| BIST100_INDEX    | 0.290572 | -0.354335 | -0.560210 | 0.088948  | 0.166142  | 0.458584  | -0.439720 | -0.192382 |
| VOLATILITY_BI... | 0.135139 | 0.586212  | -0.119009 | 0.109945  | 0.258774  | 0.509911  | 0.500934  | -0.184210 |
| VOLATILITY_B...  | 0.313575 | -0.083817 | 0.257324  | 0.865720  | 0.128762  | -0.078648 | -0.014840 | 0.236588  |
| VOLATILITY_C...  | 0.368936 | -0.193243 | 0.353056  | -0.109754 | -0.688593 | 0.444377  | 0.134678  | -0.008905 |
| CDS              | 0.574651 | 0.204933  | 0.008577  | -0.060748 | -0.058817 | -0.490542 | -0.074748 | -0.611830 |
| BOND             | 0.223803 | -0.116288 | 0.607975  | -0.357369 | 0.604273  | 0.188074  | -0.193960 | 0.030073  |

Kendall's tau-a:

|                  | EMPI      | _3M_TRLI.. | BIST100_L.. | VOLATILL.. | VOLATILL.. | VOLATILL.. | CDS      | BOND     |
|------------------|-----------|------------|-------------|------------|------------|------------|----------|----------|
| EMPI             | 1.000000  |            |             |            |            |            |          |          |
| _3M_TRLIBOR      | -0.032421 | 1.000000   |             |            |            |            |          |          |
| BIST100_INDEX    | 0.353146  | 0.003377   | 1.000000    |            |            |            |          |          |
| VOLATILITY_BI... | -0.151638 | 0.353934   | -0.101880   | 1.000000   |            |            |          |          |
| VOLATILITY_B...  | 0.073173  | -0.005741  | 0.096814    | 0.028819   | 1.000000   |            |          |          |
| VOLATILITY_C...  | 0.161882  | 0.059102   | 0.069346    | -0.110999  | 0.140155   | 1.000000   |          |          |
| CDS              | 0.200720  | 0.400991   | 0.091298    | 0.173252   | 0.194304   | 0.210064   | 1.000000 |          |
| BOND             | 0.109479  | -0.010413  | -0.032815   | -0.034166  | 0.087752   | 0.133570   | 0.124226 | 0.999831 |

## Figure A2. Principal Component Analysis EViews Output with Residential Sale Prices

Principal Components Analysis  
 Date: 05/01/19 Time: 11:15  
 Sample: 2003M02 2018M10  
 Included observations: 189  
 Computed using: Kendall's tau-a  
 Extracting 9 of 9 possible components

Eigenvalues: (Sum = 8.998086, Average = 0.9997874)

| Number | Value    | Difference | Proportion | Cumulative Value | Cumulative Proportion |
|--------|----------|------------|------------|------------------|-----------------------|
| 1      | 2.423499 | 0.784191   | 0.2693     | 2.423499         | 0.2693                |
| 2      | 1.639308 | 0.518469   | 0.1822     | 4.062808         | 0.4515                |
| 3      | 1.120839 | 0.114682   | 0.1246     | 5.183647         | 0.5761                |
| 4      | 1.006157 | 0.150192   | 0.1118     | 6.189804         | 0.6879                |
| 5      | 0.855966 | 0.193405   | 0.0951     | 7.045770         | 0.7830                |
| 6      | 0.662560 | 0.034252   | 0.0736     | 7.708330         | 0.8567                |
| 7      | 0.628308 | 0.103427   | 0.0698     | 8.336638         | 0.9265                |
| 8      | 0.524881 | 0.388315   | 0.0583     | 8.861519         | 0.9848                |
| 9      | 0.136567 | ---        | 0.0152     | 8.998086         | 1.0000                |

Eigenvectors (loadings):

| Variable         | PC 1     | PC 2      | PC 3      | PC 4      | PC 5      | PC 6      | PC 7      | PC 8      | PC 9      |
|------------------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| EMPI             | 0.029023 | 0.568809  | -0.240161 | 0.251912  | 0.018763  | 0.580644  | -0.125239 | 0.448321  | 0.017386  |
| _3M_TRLIBOR      | 0.566471 | -0.105806 | -0.133853 | 0.048815  | 0.134714  | -0.258373 | -0.212330 | 0.241838  | 0.677600  |
| BIST100_INDEX    | 0.032792 | 0.493937  | -0.119585 | 0.546188  | -0.075963 | -0.500539 | 0.350779  | -0.250731 | 0.010392  |
| VOLATILITY_BI... | 0.362140 | -0.298855 | 0.206253  | 0.205606  | -0.168878 | 0.413955  | 0.698529  | 0.013576  | 0.081979  |
| VOLATILITY_B...  | 0.099961 | 0.307761  | 0.550109  | -0.251592 | -0.638295 | -0.185696 | -0.061366 | 0.288208  | 0.025283  |
| VOLATILITY_C...  | 0.102963 | 0.391846  | 0.079935  | -0.591243 | 0.524470  | -0.082491 | 0.438018  | 0.078192  | 0.007118  |
| CDS              | 0.417751 | 0.260067  | -0.125899 | -0.244774 | -0.207443 | 0.291131  | -0.207958 | -0.714396 | 0.026192  |
| BOND_YIELD       | 0.588596 | -0.085879 | -0.080999 | 0.064667  | 0.088799  | -0.181482 | -0.126561 | 0.215395  | -0.729522 |
| HPI              | 0.067020 | 0.093294  | 0.732219  | 0.341466  | 0.462389  | 0.123361  | -0.270837 | -0.177590 | 0.012207  |

Kendall's tau-a:

|                  | EMPI      | _3M_TRLIBOR | BIST100_INDEX | VOLATILITY_BI... | VOLATILITY_B... | VOLATILITY_C... | CDS       | BOND_YIELD | HPI      |
|------------------|-----------|-------------|---------------|------------------|-----------------|-----------------|-----------|------------|----------|
| EMPI             | 1.000000  |             |               |                  |                 |                 |           |            |          |
| _3M_TRLIBOR      | -0.032421 | 1.000000    |               |                  |                 |                 |           |            |          |
| BIST100_INDEX    | 0.353146  | 0.003377    | 1.000000      |                  |                 |                 |           |            |          |
| VOLATILITY_BI... | -0.151638 | 0.353934    | -0.101880     | 1.000000         |                 |                 |           |            |          |
| VOLATILITY_B...  | 0.073173  | -0.005741   | 0.096814      | 0.028819         | 1.000000        |                 |           |            |          |
| VOLATILITY_C...  | 0.161882  | 0.059102    | 0.069346      | -0.110999        | 0.140155        | 1.000000        |           |            |          |
| CDS              | 0.200720  | 0.400991    | 0.091298      | 0.173252         | 0.194304        | 0.210064        | 1.000000  |            |          |
| BOND_YIELD       | -0.009963 | 0.856299    | 0.020770      | 0.428515         | 0.041709        | 0.069065        | 0.437183  | 0.998931   |          |
| HPI              | 0.015592  | 0.029663    | 0.063098      | 0.100023         | 0.144152        | 0.058145        | -0.036080 | 0.058764   | 0.999156 |

**Figure A3. Volatility of BIST100 Index EViews Output**

Dependent Variable: RETURN\_BIST100  
Method: ML - ARCH  
Date: 04/21/19 Time: 00:24  
Sample (adjusted): 2003M02 2018M10  
Included observations: 189 after adjustments  
Failure to improve likelihood (non-zero gradients) after 88 iterations  
Coefficient covariance computed using outer product of gradients  
Presample variance: backcast (parameter = 0.7)  
 $GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*RESID(-1)^2*(RESID(-1)<0) + C(5)*GARCH(-1)$

| Variable                  | Coefficient | Std. Error            | z-Statistic | Prob.    |
|---------------------------|-------------|-----------------------|-------------|----------|
| C                         | 0.546329    | 0.552841              | 0.988222    | 0.3230   |
| Variance Equation         |             |                       |             |          |
| C                         | 0.485220    | 0.591821              | 0.819877    | 0.4123   |
| RESID(-1)^2               | -0.074434   | 0.009842              | -7.562656   | 0.0000   |
| RESID(-1)^2*(RESID(-1)<0) | 0.058204    | 0.033106              | 1.758087    | 0.0787   |
| GARCH(-1)                 | 1.027655    | 0.000126              | 8152.790    | 0.0000   |
| R-squared                 | -0.004994   | Mean dependent var    |             | 1.111764 |
| Adjusted R-squared        | -0.004994   | S.D. dependent var    |             | 8.022877 |
| S.E. of regression        | 8.042883    | Akaike info criterion |             | 6.889088 |
| Sum squared resid         | 12161.34    | Schwarz criterion     |             | 6.974849 |
| Log likelihood            | -646.0188   | Hannan-Quinn criter.  |             | 6.923832 |
| Durbin-Watson stat        | 2.047934    |                       |             |          |

**Figure A4. Volatility of Banking Sector Index EViews Output**

Dependent Variable: RETURN\_BANKING  
Method: ML - ARCH  
Date: 04/21/19 Time: 00:49  
Sample (adjusted): 2003M02 2018M10  
Included observations: 189 after adjustments  
Convergence achieved after 29 iterations  
Coefficient covariance computed using outer product of gradients  
Presample variance: backcast (parameter = 0.7)  
GARCH = C(3) + C(4)\*RESID(-1)^2 + C(5)\*RESID(-1)^2\*(RESID(-1)<0) + C(6)\*GARCH(-1)

| Variable       | Coefficient | Std. Error | z-Statistic | Prob.  |
|----------------|-------------|------------|-------------|--------|
| C              | -0.402321   | 0.204057   | -1.971611   | 0.0487 |
| RETURN_BIST100 | 1.197062    | 0.024635   | 48.59234    | 0.0000 |

| Variance Equation         |           |          |           |        |
|---------------------------|-----------|----------|-----------|--------|
| C                         | 0.432919  | 0.255748 | 1.692754  | 0.0905 |
| RESID(-1)^2               | -0.031808 | 0.023462 | -1.355742 | 0.1752 |
| RESID(-1)^2*(RESID(-1)<0) | 0.297232  | 0.103648 | 2.867707  | 0.0041 |
| GARCH(-1)                 | 0.873651  | 0.059049 | 14.79538  | 0.0000 |

|                    |           |                       |          |
|--------------------|-----------|-----------------------|----------|
| R-squared          | 0.904095  | Mean dependent var    | 1.049715 |
| Adjusted R-squared | 0.903582  | S.D. dependent var    | 10.21331 |
| S.E. of regression | 3.171366  | Akaike info criterion | 5.000900 |
| Sum squared resid  | 1880.764  | Schwarz criterion     | 5.103813 |
| Log likelihood     | -466.5851 | Hannan-Quinn criter.  | 5.042593 |
| Durbin-Watson stat | 1.943173  |                       |          |

**Figure A5. Volatility of Currency Basket EViews Output**

Dependent Variable: RETURN\_CURRENCY  
Method: ML - ARCH  
Date: 04/21/19 Time: 01:01  
Sample (adjusted): 2003M02 2018M10  
Included observations: 189 after adjustments  
Convergence achieved after 21 iterations  
Coefficient covariance computed using outer product of gradients  
Presample variance: backcast (parameter = 0.7)  
 $\text{LOG}(\text{GARCH}) = \text{C}(2) + \text{C}(3) * \text{ABS}(\text{RESID}(-1) / @\text{SQRT}(\text{GARCH}(-1))) + \text{C}(4) * \text{RESID}(-1) / @\text{SQRT}(\text{GARCH}(-1)) + \text{C}(5) * \text{LOG}(\text{GARCH}(-1))$

| Variable           | Coefficient | Std. Error            | z-Statistic | Prob.    |
|--------------------|-------------|-----------------------|-------------|----------|
| C                  | 0.559561    | 0.258597              | 2.163839    | 0.0305   |
| Variance Equation  |             |                       |             |          |
| C(2)               | 1.221541    | 0.432644              | 2.823432    | 0.0048   |
| C(3)               | 0.337155    | 0.119757              | 2.815322    | 0.0049   |
| C(4)               | 0.605133    | 0.084413              | 7.168747    | 0.0000   |
| C(5)               | 0.430395    | 0.157458              | 2.733385    | 0.0063   |
| R-squared          | -0.000572   | Mean dependent var    |             | 0.659231 |
| Adjusted R-squared | -0.000572   | S.D. dependent var    |             | 4.180101 |
| S.E. of regression | 4.181295    | Akaike info criterion |             | 5.495344 |
| Sum squared resid  | 3286.847    | Schwarz criterion     |             | 5.581104 |
| Log likelihood     | -514.3100   | Hannan-Quinn criter.  |             | 5.530088 |
| Durbin-Watson stat | 1.815105    |                       |             |          |