FORECASTING BIST-100 PRICE INDEX

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BUĞRA YETGİNER

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_____

Prof. Dr. Tülin Gençöz

Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science/Arts / Doctor of Philosophy.

_____

Prof. Dr. Nadir Öcal

Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

_____

Assist. Prof. Dr. Dilem Yıldırım Kasap

Supervisor

Examining Committee Members

Assist. Prof. Dr. Ayşegül Çorakçı (Çankaya U., ECON) _____

Assist. Prof. Dr. Dilem Yıldırım Kasap (METU, SOC) _____

Assist. Prof. Dr. Ömer Kağan Parmaksız (METU, SOC) _____

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Name, Last name : Buğra Yetginer
Signature :

ABSTRACT

FORECEASTING BIST-100 PRICE INDEX

Yetginer, Buğra
M.Sc. Department of Economics
Supervisor: Assist. Prof. Dr. Dilem Yıldırım Kasap
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The ultimate goal of this study is to forecast the BIST-100 Price Index using its mostly significative macroeconomic and financial determinants. For this aim, we have adopted an exhaustive search algorithm which takes the advantage of theoretical candidate variables to find the possible effects of these variables on the BIST-100 Price Index. The algorithm, which is built in the form of linear ARIMAX models, is to exploit every possible combination of explanatory variables to capture the behaviour of the index over the time period from 2002 to 2013 using monthly based data. To this end, best models have been obtained out of a huge number of models with regard to Akaike and Bayesian information criteria. The model with minimum AIC value outperforms the model with minimum BIC value with respect to root mean square error measure. Moreover, the 2Y Turkish bond interest rate, the DAX and Bovespa Indices are the best explanatory variables found to estimate the index. Besides, out-of-sample testing has been implemented over the 2014-2015 time period.

Keywords: BIST-100, ARIMAX, Forecast, Exhaustive search algorithm, Finance.

ÖZ

BIST-100 Fiyat Endeksi Tahminlemesi

Yetginer, Buğra
Yüksek Lisans İktisat Bölümü
Tez Yöneticisi: Yrd. Doç. Dr. Dilem Yıldırım Kasap
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Bu çalışmanın amacı BIST-100 endeksinin tahminini gerçekleştirmek ve öncelikli makro ve finansal belirleyicileri bulmaktır. Bu amaç için, bu değişkenlerin Borsa İstanbul üzerindeki muhtemel etkilerini bulmak üzere teorik aday değişkenleri kullanan kapsamlı arama algoritması benimsenmiştir. ARIMAX modeli formatında oluşturulan algoritmanın amacı her bir açıklayıcı değişkenin her bir kombinasyonundan yararlanarak 2002-2013 zaman dilimi boyunca BIST-100 endeksi davranışlarını aylık verilerle yakalamaktır. Bu amaçla, Akaike ve Bayesian bilgi kriterleri nezdinde en iyi modeller algoritma kapsamında oluşturulan bir çok model arasından elde edilmiştir. Minimum Akaike değerli model, minimum Bayesian değerli modele göre kök ortalama kare hatası değeri gözetilerek daha üstün olmaktadır. Dahası da, iki yıllık gösterge tahvil, DAX ve Bovespa Endeksleri BIST-100 Fiyat Endeksini tahminlemek için en iyi açıklayıcı değişkenler olarak bulunmuştur. Bunun yanında, 2014-2015 zaman diliminde örneklem dışı validasyon gerçekleştirilmiştir.

Anahtar Kelimeler: BIST-100, ARIMAX, Öngörü, Kapsamlı arama algoritması, Finans.

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LIST OF ABBREVIATIONS

ADF: Augmented Dickey-Fuller

AIC: Akaike Information Criteria

AR: Autoregressive

ARIMA: Autoregressive Integrated Moving Average

BIC: Bayesian/Schwartz Information Criterion

BIST-100: Borsa Istanbul-100

BRIC: Brazil, Russia, India, China

CBRT: Central Bank of the Republic of Turkey

EGARCH: Exponential Generalized Autoregressive Conditional Heteroscedasticity

FED: Federal Reserve System

GARCH: Generalized Autoregressive Conditional Heteroscedasticity

GDP: Gross Domestic Product

IMF: International Monetary Fund

ISE: Istanbul Stock Exchange

MA: Moving Average

MAE: Mean Absolute Error

RMSE: Root Mean Squared Error

TSI: Turkish Statistical Institute

TRY: Turkish Lira

US: United States

USD: United States Dollar

VAR: Vector Autoregressive

VECM: Vector Error Correction Model

CHAPTER 1

INTRODUCTION

The main functions of stock markets are providing liquidity and allocation of capital; moreover, they may promote economic development by providing the needed funds to firms quoted in national stock markets. Thus, stock markets play an important role as an economic indicator in increasing corporations' capital through Initial Public Offering. There are numerous studies in the literature investigating stock markets such as the one by Garcia and Liu (1999), who studied macroeconomic determinants of stock market development. They observed that real income level, savings or investment rate and financial intermediary development have a positive and significant relationship with stock market development, which is represented by market capitalization. However, aside from the degree of development of stock market, this study involves stock market behavior.

Mathematicians and economists have thoroughly focused on stock market behavior and its future path for many purposes such as making profits and understanding its reactions to various external effects. Since its nature is quite random and unpredictable in high frequency of time, those indices may well provide a great deal of income with lots of risks, of course. However, instead of short run, this study takes into account a very long period of time to gain predictive information of reasonable macroeconomic and financial variables to estimate and forecast the BIST-100 Price Index.

Studies in literature have generally focused on the relation of stock market movements with other economic factors. Some studies including Fama (1981), Chen et al. (1986), Cutler et al. (1988) and Hondroyiannis and Papapetrou (2001) investigate the economic dynamics behind the stock market movements and try to shed light on the relationship. These studies elaborate on the topic, thinking wide variety of economy depicted in many variables which are assumed to be external. However, there are studies which are more specific to find out one or two economic variables' effects on stock markets. As searched in the study of Ozcelebi and Yildirim (2016), the

relationship between exchange rates and stock market is investigated for several countries including Czech Republic, Hungary, Poland and Turkey. Lin et. al (2009) studied the relationship between oil price shocks and stock market in the Greater China region (China, Hong Kong and Taiwan).

Our study is about to forecast the BIST-100 Price Index using the financial and macroeconomic determinants. With regard to the modeling technique, the vital part of this study is to combine the model selection procedure and determination of optimal AR and MA roots at the same time. For this purpose, after finding out what degree of lag of explanatory variables are highly correlated with the index, the algorithm is run in order to produce a huge number of models and next, to obtain best models with optimal AR and MA orders. In order to do this, our algorithm is built so as to benefit from every possible combination of explanatory variables in a way that they are placed in alternative models as subgroups while AR and MA orders are defined simultaneously for each model. In other words, any explanatory variable is used alone and also together with every other explanatory variable generating every possible subset of explanatory variables in alternative models and this fashion continues until the obtainment of the full model, in which all variables take place. Mathematically, in this framework there are 32.767 models, which indicates 2^15-1 as a number, since we have 15 different explanatory variables for the study.

The major contributions of the study are twofold. The first one is related with its methodology, which uses an exhaustive search algorithm resulted in an optimal model with a subset of explanatory variables. Second, given the scarcity of the studies on the topic in Turkey, a potential framework is constructed for modeling and forecasting purposes in this study.

The rest of the paper is organized as follows; Chapter 2 reviews the literature for stock market behavior through macroeconomic and financial variables, Chapter 3 provides a brief overview of stock market structure and history in Turkey. Chapter 4 describes the data in detail and Chapter 5 discusses the methodology we implement. Substantive empirical findings are discussed in Chapter 6 and finally Chapter 7 concludes the st

CHAPTER 2

LITERATURE REVIEW

Although vast amount of research in literature has been conducted related to many stock markets, we can infer that there exists puzzling empirical findings which intrigue academics to study further about stock market reactions against changes in macroeconomic and financial indicators. In these studies, the industrial production index, exchange rates, trade balance, short and long term interest rates, inflation rate, monetary base, foreign stock market performance, oil price and gross domestic product are the ones used in many studies in order to examine the relationship.

One of the earliest contributions to the literature in detecting the negative relationship between stock market and inflation was conducted by Fama (1981). Through the money demand theory and the quantity theory of money, he concluded that the spurious relationship between inflation and stock market is the result of a fall in anticipated growth rate that lowers the demand for real money which is accommodated by a rise in the price level. Geske and Roll (1983) extends Fama's findings discussing government expenditure which is not met with the revenue due to the decrease in stock prices since tax revenue collected from personal and corporate incomes is related to stock prices. They argued that monetizing the debt stemmed from the deficit by printing currency is the cause of the negatively correlated relationship between inflation and stock prices. This finding is obtained empirically in this study following a chain of macroeconomic events starting from the decrease in stock prices through fiscal and monetary linkages. Furthermore, Kaul (1986) extends the deficit-induced monetary growth stated by Geske and Roll to counter-cyclical and pro-cyclical monetary growth. He concluded that counter-cyclical monetary policy and money demand is the reason for the spurious relationship between stock prices and inflation through the monetary sector equilibrium process. These studies pay attention to the fact that money plays an important role for explaining the spurious relationship. However, Anari and Kolari (2001) found that the long-run fisher elasticity of stock

prices with regard to good prices is greater than unity for some countries they study. This result confirms the argument that stocks are hedging inflation in the long-run.

With the attempt to explore the relationship with other indicators, Chen et al. (1986) studied many economic factors to see whether macroeconomic risks are awarded in stock market. Their results showed that during industrial production, changes in the risk premium, twists in the yield curve are found to be significant, measures of unanticipated inflation and changes in expected inflation are stated as weakly significant. Moreover, per capita consumption and oil price which is important for many production processes are no means for stock market changes in their study. Similarly, Hondroyiannis and Papapetrou (2001) studied the dynamic interactions whether economic activity affects the performance of stock market. They found that while real stock returns respond negatively to interest rate shocks, a depreciation of the currency leads to higher real stock returns. Furthermore, they concluded that a positive oil price shock depresses real stock returns. Pearce and Roley (1984) attempted to test efficient market hypothesis that only the unexpected part of any announcement moves stock prices. In this study, underlying the importance of agents' expectations to market, surprises in monetary policy have a significant effect on stock prices whereas there is no support that surprises in inflation and real activity can affect stock prices. Peiro (2016), Hsing et al. (2012) and Gan et al. (2006) have common findings in their studies that industrial production (GDP) and interest rates significantly affect stock market while a lower ratio of government spending to GDP, lower inflation and depreciation of the currency are also accountable for the changes in stock market as stated by Hsing et al. (2012). Likewise, Kwon and Shin (1999) finds that production level, exchange rate and money supply have long-term relationship with stock market and noted that stock price lags behind economic activities.

There are also studies examining the effects of quantitative easing programs on stock prices. As stated in the early studies, conventional monetary policies and monetary surprises can affect stock prices while unconventional monetary policy is in question. Unconventional monetary policies are implemented due to impaired stock price channel of monetary transmission mechanism in the face of Zero Lower Bound which

is called the liquidity trap in economic literature. Ruano (2014) showed that federal fund rate doesn't work through the asset prices during the QE program and that unconventional policy has no direct effect on stock prices. Furthermore, quantitative easing policy has been implemented by Bank of Japan to tackle the recession and deflation which lasted for more than ten years. As stated by Kurihara (2007), during the QE program, interest rates do not influence Japanese stock prices similar to the US case. However, the exchange rate between yen and dollar and the US stock prices are found to be significant in the study implying the importance of assets and liabilities of firms in foreign currency and suggesting the interdependence between two countries' stock market.

In the case of emerging economies, so called BRIC countries are studied by Gay, Jr. (2016). The results of the study does not match with the hypothesis in this study that exchange rate and oil price do not reveal a significant relationship for stock prices warranting further research. Furthermore, Maghyereh (2004), Basher and Sadorsky (2006) has argued oil price shocks and oil price risks respectively for emerging economies and the latter finds strong evidence that oil price risk impacts stock returns stating that emerging economies are more likely to expose oil price risk since they are more likely to be energy consumers compared to developed economies. More comprehensively, Gunasekarag et al. (2004) studied stock market in Sri Lanka and according to the study inflation, money supply and treasury bill rate were found to exert a significant lagged influence on the stock market while major proportion of variability in the market index was explained by its own. Accordingly, another study which is conducted by Patel (2012) showed that exchange rates, industrial production index, money supply and inflation are the major factor effects on the stock market for the Indian stock market. These two findings show that some of emerging economies' stock market can move in response to the change in economy as matured markets do. Besides, Pretorius (2002) studied the interdependence in emerging stock markets giving attention to the contagion effect, economic integration and stock market characteristics. The results of this study showed that bilateral trade, growth differential of industrial production and regional similarities play a significant role in the interdependence. Authors also proved the contagion effect to some degree finding a

significant coefficient for the dummy variable which stands for the 1998 emerging market crisis in the study.

Turkey can be classified as an emerging market while the relationship between stock market and macroeconomic and financial factors of Turkey can be analyzed in this respect. Erdogan and Ozlale (2005) studied time varying effects of macroeconomic variables and found that the depreciation of the domestic currency led to the decrease in stock markets for the period of financial crisis in 1994. It's also stated in the study that the relationship reversed afterwards implying firms in Turkey seem to compensate expensive import for their exports by increasing their competitiveness. Besides, industrial production is found to be in positive relationship with the stock market for most of the period. Furthermore, Muradoglu et al. (1999) examined Istanbul Stock Exchange through three sub-periods in order to analyze how macroeconomic variables affect Istanbul Stock Exchange in terms of risk and return. Their findings indicate that before the crisis, the year of 1994, depreciation of the exchange rate and higher interest rates increase volatility in the stock market while the significant negative relationship between interest rates and stock returns is found implying the possible substitution effect. Furthermore, they find that during the crisis none of macroeconomic variables are important for explaining the determinants of risks while money growth rate and depreciation of the exchange rate bear predictive power after the crisis period. They also note that, after the crisis, unlike the period before the crisis the negative coefficient of depreciation of the exchange rate is obtained implying higher depreciation increase the risk. Analyzing short and long run dynamics, Muradoglu and Metin (1996) states that Turkish Stock Market is not efficient since publicly available information is not incorporated into stock prices finding the result that growth rate of interest rates, money supply and exchange rates affect stock return with a significant lag. Finally, a different method compared to traditional econometric methods is applied for Turkey. Boyacıoglu and Avcı (2010) adopted an adaptive network-based fuzzy inference system which is a mixture of fuzzy logic and neural networks. They used traditional macroeconomic variables and also the indices of Bovespa, Dax and Dow Jones Industrial Average as an input in their model. They obtained a successful model with regard to low RMSE value and high R-square.

Besides traditional econometric techniques such as ARIMA, VAR and VECM models which are commonly used by the mentioned studies above, there are also studies that concentrate on forecast implementing advance statistical methods. Chen et al. (2003), Enke and Thawornwong (2005) adopted probabilistic neural network and information gain technique respectively to improve trading strategies for mentioned stock markets in these studies. Wei Huang et al. (2005) showed that the support vector machine is a promising type of tool for forecasting stock market movement direction using many traditional macroeconomic variables as input. Chen (2008), examined the usefulness of various macroeconomic variables in predicting recessions in the stock market and used the Markov-switching model and the Bry-Boschan dating method. He concluded that, yield curve spreads and inflation rate are the most useful predictors of recessions in the US stock market. Volatility forecast is also popular in academic and business environment and GARCH family are widely used. In order to test conditional volatility of stock market on macroeconomic variables, David Morelli (2002) studied ARCH process and concluded that volatility in macroeconomic variables is not significant for explaining the stock market volatility. Zivanemoyo Chinzara (2011) argued the macroeconomic risk and its relationship with stock market volatility using symmetric and asymmetric GARCH process and finds that treasury bill rate, exchange rate and gold price are significant for the study. Similarly, Attari (2013) showed that interest rate, inflation and GDP have highly important effects on stock market volatility estimating EGARCH equation.

Our study aims to predict BIST-100 Price Index movements and obtain dependable forecast using monthly macroeconomic and financial indicators. The linear ARIMAX model we have built is selected out of huge numbers of models to make point estimation with regard to a relevant index. The major contributions of the study are twofold. The first one is related with its methodology which uses an exhaustive search algorithm resulted in an optimal model. Second, given the scarcity of the studies regarding stock market forecast in Turkey, a potential framework is constructed for modeling and forecasting purposes in this study.

CHAPTER 3

A BRIEF HISTORY AND OVERVIEW OF BORSA ISTANBUL

The first official stock market is established with the name of "Stock exchange of Debenture bonds of Dersaadet" in 1866 to finance the costs of the Crimean War. Domestic debenture bonds which is issued to finance the war were freely traded providing a way to construct a real stock exchange market. After some period later, Turkish securities market was closed and reopened with a new name "Esham ve Tahvilat Borsası" in 1906. During the republican period, with the decrees concerning stock exchange, the stock market was regulated and started to serve under the name of Istanbul Securities and Foreign Currency Exchange. In 1936, the Turkish stock market was located in Ankara by the government intervention. But then, it was relocated in Istanbul in 1941. Until the beginning of 2012, the stock market was served with the name of Istanbul Stock Exchange Market which was inaugurated at the end of 1985 with the regulation issued by the Council of Ministers. At the beginning of 2012, Istanbul Stock Exchange Market and Istanbul Gold Exchange were merged and transformed into a new legal entity under the name of Borsa Istanbul.[1]

Borsa Istanbul trading hours are 09:15–12:30 for the first session and 14:00–17:40 for the second session, on workdays. Borsa Istanbul price indices are computed and published throughout the trading session while the return indices are calculated and published at the close of the session only. The indices are: Borsa Istanbul National-All Shares Index, Borsa Istanbul National-30, Borsa Istanbul National-50, Borsa Istanbul National-100, sector and sub-sector indices, Borsa Istanbul Second National Market Index and Borsa Istanbul Investment Trusts Index. Borsa Istanbul National-100 Index contains both the Borsa Istanbul National-50 and Borsa Istanbul National-30 Index and is used as a main indicator of the national market.[2]

[1] Source: Borsa Istanbul

[2] Source: Borsa Istanbul

The time series with regard to our estimation period, from January 2002 to December 2013, is trending upward with a few booms and busts and these can be analyzed by economic cycles and global environment that may well affect Turkish economy within the specified period.

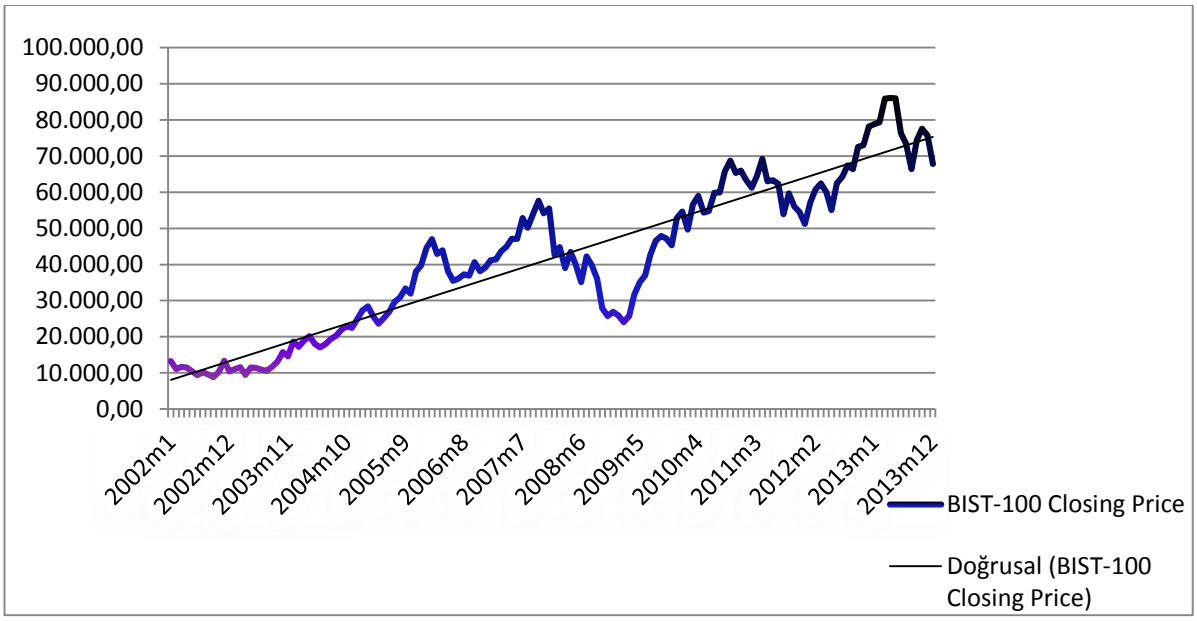

Figure 1: BIST-100 Price Index, Raw Data

Source: Borsa Istanbul

We start the analysis from the year of 2002 considering the fact that Turkish economy experienced economic crisis in the year of 2001 which is triggered by the political turbulence and expanded by the volatility in USD/TRY parity stemmed from excessive demand for dollar and high debt stock, mainly. (H. A. Simsek, 2007). As a result of that crisis in Turkey, ISE index declined almost by 15% creating an outlier in the data. This trough in the stock market which is not triggered by any economic variable can disrupt our results if we include it in our data set knowing the fact that linear models are not robust for outliers since the regression line passes through sample means. On the other hand, there are also extreme cases within the our working period including the financial crisis of 2007-2008 but we allow that kind of points to be included in our study in order to see whether the model can catch the performance of the stock market from the view of economic cycles.

Looking at the Figure 1, we observe that there are four conspicuous points addressing the years of 2006, 2007, 2010 and 2013 that are substantially higher than the linear trend line. On the other hand, there are three remarkable troughs during the years of 2008-2009, 2011 and 2013. However, in overall, the stock market is cycling around an upward trend during the sample period.

To begin with, between the years of 2002 and 2006, the stock market is increasing and this upward trend ends up with the peak in January 2006 and the index begun to fall in the same year. That period can be attributed to the new macroeconomic outlook in Turkey after the crisis of 2001. After that experience in the economy, 18. Stand-By agreement with IMF was started to execute in a steady political environment compared to previous years with a new government. This program briefly targets sustainable economic growth with no inflationary pressures practicing macroeconomic and financial stability, structural reforms and healthy debt position. Besides, provided funds into the economy by this agreement and CBRT's monetary targeting for future inflation which is started in 2002 can be counted as a promising economic improvement for the achievement of the mentioned targets. These developments in the economy can also be indicated in terms of numbers as one can see from the Table 1. prepared by Mahfi Egilmez. Lowering inflation and budget deficit year by year and average 7 % growth between 2002-2006 can be perceived as a return of the program.

Table 1. Basic Economic Indicators of Turkey over 2002-2014

Year	GDP (Billion USD)	Per Capita Income (USD)	Growth (%)	Inflation (%)	Budget Deficit (%)	Current Account Deficit (%)
2002	231	3.492	6.2	29.8	-11.2	-0.3
2003	305	4.565	5.3	18.4	-8.8	-2.5
2004	390	5.775	9.4	9.3	-5.4	-3.7
2005	482	7.036	8.4	7.7	-1.5	-4.6
2006	526	7.597	6.9	9.6	-0.5	-6.1
2007	649	9.247	4.7	8.4	-1.6	-5.9
2008	742	10.444	0.7	10.1	-1.8	-5.7
2009	617	8.561	-4.8	6.8	-5.5	-2.2
2010	732	10.079	9.2	6.4	-3.6	-6.2
2011	774	10.444	8.8	10.5	-1.3	-9.7
2012	786	10.497	2.2	6.2	-2.2	-6.0
2013	823	10.822	4.2	7.4	-1.2	-7.9
2014	800	10.404	2.9	8.2	-1.3	-5.7

Source: Mahfi Egilmez's Blog

In the light of Fama's study and findings mentioned in Chapter 2, we can also say that, with the mentioned economic programs and developments, positive anticipation for the future economic activity might cause household not to demand money implying the changes in the composition of investment and consumption. However, in the beginning of 2006, CBRT shifted the monetary policy regime from monetary targeting to inflation targeting. At the same time, ISE reached its peak point between the year of 2002 and January 2006. That leap in the stock market may be referred to the policy regime shift since the market might perceive this change in the monetary policy as a promising tool against future inflation. In the same year, we also observe a fall in May 2006 which can be referred to the shock in exchange rates against emerging markets which is stemmed from the shortage of the liquidity in global economy sourced by the cont. of interest rate hike.

CBRT's inflation targeting program started in the beginning of 2006 and other domestic improvements seems to be effective for the expectations of future economic activity until the beginning of global financial crisis in 2007 since we observe another

upward trend after the exchange rate shock. As we see the change in the trend of ISE in 2007, global financial crisis started to affect the Turkish economy in this year. Except small ups and downs between September 2007 and January 2009, the trend of ISE Price Index is downward overall. That financial crisis started in USA affected the world economy for a long time and decreased the global and domestic aggregate demand which means a fall in GDP, international trade thus a fall in stock markets. Exit plans for developed countries' central bank including FED were to implement expansionary monetary policies in order to boost aggregate demand and the confidence for the future economic activity. This monetary expansion caused to increase global liquidity which was fruitful for the Turkish economy since the country's economic growth considerably relies on capital inflows because of the shortage of sufficient domestic savings. This situation help Turkish economy to rebound again as we see upward trend in the graph starting in January 2009 and lasted until the mid of 2011.

Finally, there is a downturn after the mid of 2011 and upward trend starting at the beginning of 2012 which ends up with the peak in March 2013. Checking the Table 1. again, we see a decline for the current account deficit in 2012 which may imply that the capital flows from Turkey to home. Along this indicator, GDP growth and inflation also decreased implying that aggregate demand of Turkish economy relies on the foreign capital, significantly. Conversely, in 2013, there is an increase in the current account deficit, GDP growth and inflation and this time the inverse situation may happened. Other from the economic activity, Moody's upgrade for Turkish government bond rating to Baa3 in May 2013 and the corruption scandal happened in December 2013 are the important incidents that can affect Turkish stock market positively and negatively, respectively. These mentioned events in home and abroad may well affect the economy through exchange rates and capital flows.

CHAPTER 4

DATA

The data in this study is obtained from various institutions including Thomson Reuters, IMF, Turkish Statistical Institute and Borsa Istanbul. Monthly basis leading macroeconomic and financial indicators are used as an input for the time span between 2002 and 2013 in our model. Data that is not available in monthly basis but daily basis for some variables is transformed to monthly series by using a simple arithmetic means. Finally, all data is transformed to logarithmic form.

Table 2. Categories Of Explanatory Variables

Category	**Leading Indicators**
Macroeconomic Indicators	Consumer Price Index Industrial Production Index (seasonally adjusted) USD/TRY Exchange Rate M1 Money Supply M2 Money Supply Trade Balance
Financial Indicators	Deposit Interest Rate US 1-Year Bond Interest US 10-Year Bond Interest Dow Jones Industrial Price Index Bovespa Price Index Dax Price Index Brent Oil Price Ounce Gold Price Turkey 2-Year Bond Interest

The data of the variables above is sourced from many institutions; with regard to macroeconomic variables, all data is taken from IMF database except Trade Balance which is obtained from TSI. Financial data including Dow Jones Industrial Price Index, Bovespa Price Index, Dax Price Index, Brent Oil and Gold prices are sourced from Thomson Reuters. Finally, deposit interest rates, U.S 1-Year and U.S 10-Year, Turkey

2-Year bond interest rates are obtained from IMF database, Federal Reserve and Borsa Istanbul, respectively.

The remaining part of this chapter will discuss briefly the possible links between explanatory variables and stock prices separately with theoretical hypothesis concerning why they are in this study.

4.1. Macroeconomic Indicators

Consumer Price Index stands for inflation in our study as a macroeconomic indicator and it is included for the argument that stocks should maintain their value in the face of an inflation period. In this regard, this variable plays an important role since Fisher framework postulates that nominal rates of return should compensate inflation as stated in Ely and Robinson (1997). Besides, since inflation in Turkey has been a serious problem for a long time, that index may provide high benefits for our results.

Industrial production index is typically used for real economic activity and since it can imply economic contractions and expansions; thus it can be a useful indicator for our purposes thinking that stock price is closely related to future cash flows and expectations.

The appreciation and depreciation of USD/TRY is also an important issue for firms in Turkey and their cash flow due to holding dollar denominated assets and debt and production costs priced in terms of dollar. Also, the study conducted by Gonenç, Buyukkara and Koyuncu (2003) which investigates the effects of balance sheet exposure and exchange rate variability on investments for the firms listed in Borsa Istanbul shows the importance of the exchange rate for Turkish firms.

Monetary aggregates M1 and M2 are used in this study paying attention to monetary transmission mechanism. As it is well known, an increase in monetary growth causes excessive money supply through open market operations and leads bond prices to rise and interest rates to fall. This mechanism causes stock prices to rise in the short run

due to falling interest rates at which future cash flows are discounted, as stated and showed by impulse-response functions in Rapach (2001). Besides, Thorbecke (1997) also found the significant effect of monetary shocks on stock prices discussing the theory which posits that expansionary monetary policy has implications on stock prices increasing future cash flows or decreasing discount rate.

Finally, trade balance is considered as a good proxy for economic performance of the country regarding international competition and exports which can affect stock prices as indicated in the study of Kwon and Shin (1998).

4.2. Financial Indicators

Deposit interest rate is used in this study for commercial banks' interest rate payments to investors thinking theoretically inverse relationship that is stated in Alam and Uddin (2009). This inverse relationship comes from the fact that people switch their capital decreasing the demand for share in the face of rising deposit interest rates and high deposit interest rate can also induce to raise lending interest rate of banks which means an increase in cost of funding for investors, thus decrease in investments, as stated again in mentioned study.

Turkey 2-year Bond interest rate is put in an appearance for substitution effect between stocks and bonds while the US bond interest rate can imply Federal Reserve monetary policy through monetary transmission mechanism which can affect foreign direct and portfolio investments in Turkey, thus stock market, similar to other emerging economies.

Furthermore, while Brent Oil prices are used to capture production costs, as stated in many studies mentioned in Chapter 2, which can affect future cash flows, Ounce Gold price may help forecast the stock market considering implied negative relationship between gold and stock prices since gold, as a precious metal, maintains its value against systematic risks and is seen as a safe haven as stated in the study of Shahzadi and Chohan (2011). Dow Jones Industrial and Dax indices are thought to be important

variables for our study for the reasons that the US possesses the biggest economy's index so bearing the power of influence on all markets worldwide while high volume trade exists between Germany and Turkey causing increase in financial integration as stated in Vuran (2010). Brazil's economy which possesses well enough similarities with Turkish economy in terms of macroeconomic structures as posited again in Vuran (2010), Bovespa is used, aiming to benefit the similarity for prediction purposes.

Finally, the BIST-100 Price Index is placed in our model as a dependent variable since our ultimate goal is to forecast its future path with regard to the mentioned macroeconomic and financial variables.

CHAPTER 5

FRAMEWORK AND METHODOLOGY

The model adopted in this study in order to evaluate the topic empirically is in the form of linear ARIMAX model which is derived from traditional ARMA models.[3] This section will discuss our model framework and model selection procedure which consists of exhaustive search algorithm in details. Other model selection procedures which are commonly used in empirical research will be also discussed.

5.1. Modeling

Mathematically, our model can be defined as:

$$\phi(L)(1-L)^{d}Y_t = X_{t-k} + \theta(L)\varepsilon_t$$

where L is a lag operator and the terms $\phi(L)$ and $\theta(L)$ are the polynomials which stand for $(1-\phi_1 L-\phi_2 L^2- \ldots-\phi_p L^p)$ and $(1+\theta_1 L+\theta_2 L^2 \ldots+\theta_q L^q)$, respectively. Other terms Y_t, X_{t-k} and ε_t stand for the BIST-100 Index, design matrix that includes explanatory variables and the disturbance term, respectively.

This modeling framework is a special case of ARIMA models with the use of explanatory variables. With the order of the above mentioned autoregressive and moving average polynomials, p and q, and d the difference operator which is called integration order alternatively, our ARIMAX (p,d,q) model is constructed.

5.2. Model Selection Procedures

When we look at some of the popular scientists' quotations about variable/model selection, we can observe that the simplest model which can depict the reality is the best model among all possible models. As stated by Albert Einstein and William of

[3] See Box and Jenkins (1970) for further details.

Ockham respectively, “Everything should be made as simple as possible, but no simpler.” and "Entities should not be multiplied unnecessarily." are the quotations that underline the importance of simple but meaningful modeling.

As details given in Kadane and Lazar (2004), well-known model selection techniques including forward/backward and stepwise sequential testing are the ways of modeling relying on t and F tests. Forward testing starts with a null model and adds variables if they are significant with regard to t and F tests. Conversely, backward testing starts with a full model and eliminates insignificant variables one by one until there is no need to discard any variable. In case of stepwise algorithm, it calculates F statistics for every candidate predictors allowing the researcher to use both forward and backward modeling methods. However, backward and forward model selection procedures suffer from the fact that they do not consider every possible combination of variables as a subset. In other words, once a variable is eliminated through the systematic selection process, it cannot take a place in the model again (Kadane and Lazar, 2004). Additionally, several weaknesses of the stepwise method is discussed in Ratner (2003).

Beside the mentioned modeling techniques, shrinkage and model averaging methods also exist in the relevant literature. The aim of the shrinkage technique is to reduce the variance for estimation process in order to produce more reliable results. As stated in Tibshirani (1996), ordinary least squares method is fragile in terms of prediction accuracy because of large variance. This problem can be tackled by shrinking some coefficients to zero meaning some variables are excluded at the cost of bias. In the case of model averaging, this method takes a set of competing models into consideration in order to incorporate the uncertainty instead of using a single winning model as mentioned in Wan et al. (2010). In order to produce a different solution to this uncertainty which stems from conditioning on a single model over all possible models, Raftery et al. (1997) combines Occam’s Window algorithm and Markov chain Monte Carlo approach. Besides, Hansen (2007) developed and proved that his Mallows model average estimator achieves the lowest possible squared error in the class of model average estimators. Finally, as our study benefits from the information criteria which are called Akaike and Bayesian Information Criteria, Mallows’ Cp and these

mentioned information criteria are used with different methods through a long history of model selection (Hansen, 2007).

For our modeling purposes, we adopted an exhaustive search technique in order to obtain best models considering AIC and BIC values. The smaller these values are, the better we are for reaching optimum model that fits well the actual values and predicts accurately the future behavior of the target variable. AIC and BIC values can be defined as:

$$AIC_i = -2MLL_i + 2k_i$$
$$BIC_i = -2MLL_i + k_i \, logT$$

where MLL_i is the maximum log likelihood, k_i is the number of parameters of model i and T is the sample size.

As mentioned before in Chapter 1, the vital part of our study in terms of methodology is to determine optimal regressors and AR and MA roots simultaneously to reach the best models with regard to minimum AIC and BIC values. To do this, we designate such an algorithm that builds the models which are produced from all possible combinations of the variables placed as regressors in our alternative models. These every possible combinations of regressors are defined in our study in a way that our regressors mentioned in Chapter 4 are used alone and also together with every other regressor creating alternative subgroups. This fashion continues until all regressors take place in the model which means that there is no further alternative subgroup combination. In other words, this method builds all one-variable models, all two-variable models, and so on, until the last all-variable model is generated (Ratner, 2003). After building this huge number of models, one of them can be chosen out of all possible models (Knuth, 2005). At the same time, our algorithm calculates the optimum AR and MA roots in the mentioned alternative models. By doing so, optimum AR and MA roots are calculated for every possible model with the procedure of Hyndman and Kahandakar (2008). In this technique, there are four possible models to start with; ARIMAX (0,d,0), ARIMAX (1,d,0), ARIMAX (0,d,1) and ARIMAX

(2,d,2). Since the term d is specified earlier with the results of unit root tests, it is not calculated in our algorithm. However, this method allows p and q values vary by ±1 up to twelve, as we study with the monthly series, to find a new minimum AIC value. At the end of the process, the ultimate AR and MA roots has been determined for all our possible models since this method cannot calculate better AIC values further. After implementing our model selecting procedure, we have obtained the best model with regard to the AIC value among all possible models. (Njegovan, 2005). Besides, our alternative best model is also obtained with regard to the BIC value. Finally, these two best models have been used to do estimation and forecast process

CHAPTER 6

EMPIRICAL RESULTS

This part of the study demonstrates the empirical findings which are acquired from the best models in terms of the AIC and BIC values that we have built through the aforementioned algorithm. In this chapter, ADF and Ng and Perron (2001) unit root tests are implemented in order to test the stationarity which is important to obtain reliable results in an econometric sense. After discussing preliminary analysis, we will discuss the estimation results and the validation exercise at the end of the chapter.

6.1. Preliminary Analysis

Starting with the unit root tests ADF and Ng and Perron (2001), we have explored whether our explanatory variables of the ARIMAX model are stationary or not. To this end, ADF test is implemented having the null hypothesis of a unit root and the test is constructed with the constant and the trend. The result of the test indicates that while there is no stationary variable at 5% significance level regarding the version of testing with only the constant, consumer price index and the Dax Price Index displays stationarity at 5% significance level regarding the version of testing with the constant and the trend. Ng and Perron (2001) unit root test which is developed to enhance the power of tests regarding small size distortions and to modify the truncation lag selection process is also implemented in our study as an another stationarity test technique. In this test, four different tests named MZa, MZt, MSB and MPT exist. While MZa and MZt unit root tests have the null hypothesis of a unit root, MSB and MPT unit root tests have the null hypothesis of non-existence of a unit root. For these four tests, we cannot reject the null hypothesis for the MZa and the MZt tests, which means that all variables used in these two tests are non-stationarity. On the other hand, using MSB and MPT tests, we have rejected the null hypothesis of a non-existence of a unit root which again means that all variables used in these tests are non-stationary.

Table 3. ADF Unit Root Test Results

Variables	**With Intercept**	**With Intercept and Trend**
BIST 100 Monthly Closing Price	-1.26	-1.94
Bovespa Price Index	-1.57	-1.04
Brent Oil Price	-1.7	-2.7
Consumer Price Index	-1.19	-3.98*
Dax Price Index	-2.19	-3.06*
Deposit Interest Rate	-2.48	-2.79
Dow Jones Industrial Price Index	-1.08	-2.61
Industrial Production Index	-1.59	-2.52
M1 Money Supply	-1.83	-1.97
M2 Money Supply	-2.08	-1.07
Ons Gold Price	-1.49	-0.48
Trade Balance	-2.43	-2.21
Turkey 2-Year Bond Interest	-2.08	-2.28
US 10-Year Bond Interest	-1.45	-2.53
US 1-Year Bond Interest	-0.72	-2.17
USD/TRY Exchange Rate	-0.91	-1.83
Critical Values		
1%	**-3.47**	**-3.47**
5%	**-2.87**	**-2.87**
10%	**-2.57**	**-2.57**

Note: * indicates rejection of the null hypothesis at 5 % significance level

Table 4. Ng and Perron Unit Root Test Results (With Intercept)

Variables	$\mathbf{MZ_a^{GLS}}$	$\mathbf{MZ_t^{GLS}}$	$\mathbf{MSB^{GLS}}$	$\mathbf{MP_T^{GLS}}$
BIST 100 Monthly Closing Price	0.28	0.23	0.81	41.55
Bovespa Price Index	0.09	0.09	0.97	53.79
Brent Oil Price	0.38	0.33	0.88	48.51
Consumer Price Index	1.3	2.54	1.96	263.47
Dax Price Index	-2.14	-0.75	0.35	9.33
Deposit Interest Rate	0.33	0.31	0.95	55.76
Dow Jones Industrial Price Index	-1.76	-0.55	0.31	9.35
Industrial Production Index	0.94	0.93	0.99	68.35
M1 Money Supply	1.02	1.12	1.1	83.33
M2 Money Supply	0.95	1.14	1.2	95.95
Ons Gold Price	0.65	1.01	1.54	144.84
Trade Balance	0.24	0.18	0.59	62.41
Turkey 2-Year Bond Interest	0.16	0.15	0.92	50.0
US 10-Year Bond Interest	-2.08	-0.9	0.43	10.74
US 1-Year Bond Interest	0.33	0.21	0.63	28.45
USD/TRY Exchange Rate	-1.83	-0.56	0.31	9.15
Critical Values				
1%	**-13.8**	**-2.58**	**0.17**	**1.78**
5%	**-8.1**	**-1.98**	**0.23**	**3.17**
10%	**-5.7**	**-1.62**	**0.27**	**4.45**

Note: * indicates rejection of the null hypothesis at 5 % significance level

Table 5. Ng and Perron Unit Root Test Results (With Intercept and Trend)

Variables	**MZ_a^{GLS}**	**MZ_t^{GLS}**	**MSB^{GLS}**	**MP_T^{GLS}**
BIST 100 Monthly Closing Price	-8.12	-1.96	0.24	11.4
Bovespa Price Index	-3.56	-1.14	0.32	22.57
Brent Oil Price	-10.14	-2.19	0.22	9.28
Consumer Price Index	-2.33	-0.94	0.4	33.24
Dax Price Index	-5.32	-1.56	0.29	16.9
Deposit Interest Rate	-2.93	-1.09	0.37	28.05
Dow Jones Industrial Price Index	-7.65	-1.84	0.24	12.2
Industrial Production Index	-8.57	-2.06	0.24	10.67
M1 Money Supply	-2.08	-0.92	0.44	38.11
M2 Money Supply	-1.46	-0.68	0.46	44.45
Ons Gold Price	-2.58	-0.68	0.26	21.86
Trade Balance	-3.45	-0.84	0.35	27.54
Turkey 2-Year Bond Interest	-5.09	-1.38	0.27	17.03
US 10-Year Bond Interest	-11.77	-2.38	0.2	7.98
US 1-Year Bond Interest	-2.97	-1.19	0.4	30.12
USD/TRY Exchange Rate	-8.91	-1.99	0.22	10.67
Critical Values				
1%	**-23.8**	**-3.42**	**0.143**	**4.03**
5%	**-17.3**	**-2.91**	**0.168**	**5.48**
10%	**-14.2**	**-2.62**	**0.185**	**6.67**

Note: * indicates rejection of the null hypothesis at 5 % significance level

6.2. Estimation Results

In accordance with the results of our algorithm, the models with the minimum Akaike and Bayesian information criteria has been obtained as optimal models for our estimation and forecast process. With regard to the model with minimum AIC, ARIMAX (12,0,3) is selected and the Bovespa and Dax Price Indices, Turkey 2-Year Bond Interest are the variables used in this model as explanatory variables out of our fifteen variables, which are used in the algorithm. Moreover, with respect to the signs

and the significance of these mentioned explanatory variables, all variables are consistent with the economic theory. While the coefficient of the Bovespa and Dax Price Indices have positive signs implying the BIST-100 Price Index moves in the same direction with these indices, the negative coefficient of Turkey 2-Year Bond Interest is showing the possible substitution effect between stock market and government bond returns in Turkish economy.

In the case of the model with minimum BIC, ARIMAX (1,0,0) model is selected out of a huge number of models through our algorithm. In this model, Turkey 2-Year Bond Interest is used again together with Dow Jones Industrial Price Index and deposit interest rates as an explanatory variable. With the significance of all variables used in the model, the coefficients of the explanatory variables are consistent with economic theory as in the model with minimum AIC. While the coefficient of Dow Jones Industrial Price Index is positive implying the BIST-100 Price Index moves in the same direction with that index giving a room for the comment that the US possesses the power of influencing the world markets, the coefficient of Turkey 2-Year Bond and deposit interests at lag five are negative revealing possible substitution effect again.

Depending on the results we have obtained in the eye of those two models, they are totally consistent with our expectations which are mentioned in Chapter 4 with regard to economic theory. Besides, no variable except deposit interests estimates our target variable with any lag in this model, which means that the target variable responds immediately against the changes in these variables.

Table 6. Summary Stats of Selected Models

Summary Statistics	The Best AIC Model	The Best BIC Model
Log-Likelihood	212.53	183.74
RMSE	0.05	0.06
MAE	0.03	0.05
AIC/BIC[4]	-386.93	-357.49
$\chi^2(6)$[5]	5.28 [0.5]	3.81 [0.7]
$\chi^2(12)$[6]	1.7 [0.99]	7.98 [0.78]

[4] AIC value for the best AIC model and BIC value for the best BIC model.
[5] White test for heteroscedasticity.
[6] Breush Godfrey LM test for serial autocorrelation.

Table 7. Selected Model

Variables	The Best AIC Model	The Best BIC Model
Bovespa Price Index(0)	0.14 [0.08]***	-
Dax Price Index(0)	0.85 [0.00]*	-
Turkey 2-Year Bond Interest(0)	(-) 0.33 [0.00]*	(-)0.45 [0.00]*
Deposit Interest Rate(-5)	-	(-)0.33 [0.00]*
Dow Jones Industirial	-	0.95 [0.00]*
AR(1)	0.46 [0.00]*	(-)0.41 [0.00]*
AR(2)	(-)0.09 [0.6]	-
AR(3)	(-)0.28 [0.03]**	-
AR(4)	(-)0.29 [0.00]*	-
AR(5)	0.03 [0.71]	-
AR(6)	(-)0.16 [0.049]**	-
AR(7)	(-)0.03 [0.71]	-
AR(8)	(-)0.18 [0.03]**	-
AR(9)	(-)0.04 [0.66]	-
AR(10)	(-)0.03 [0.71]	-
AR(11)	(-)0.1 [0.21]	-
AR(12)	(-)0.15 [0.03]**	-
MA(1)	(-)0.86 [0.00]*	-
MA(2)	0.15 [0.52]	-
MA(3)	0.4 [0.03]**	-

Note: p values are in square brackets, significance *at 1 %, ** at 5 % and *** at 10 %.

Apart from our expectations for the variables' signs with respect to the result of the study, there are the studies that share common findings with our study. Alam and Uddin (2009) found that there is a negative relationship between prevailing deposit interest rates and stock prices for many developed and developing countries in their study. For the foreign stock market indices, Vuran (2010) showed that Dax and Bovespa price indices are cointegrated with ISE Price Index finding positive coefficients of these two indices in the cointegration equations. Furthermore, it can be inferred that Bovespa Price Index is a significant variable for the prediction of our target variable under the favor of QE program because we know that excessive increase in global liquidity provided by the developed countries' central banks boosted developing countries' economy including Turkey through capital flows. Thus, the presence of the similarity between Turkey and Brazil in terms of macroeconomic structure, as stated in Vuran (2010), may give a room for this possibility implying these two stock markets move together owing to the simultaneous capital flows to these countries; what is more, Bovespa Price Index takes a place in our model with no lag. On the other hand, there are the studies that the result of these studies contradicts with our findings. Gunasekarag et al. (2004) and Patel (2012) studied Sri Lanka and Indian stock market, respectively. Although these two stock markets function in the emerging economy, their common findings indicate that inflation and money supply are the major variables for explaining the stock market movements in these countries.

Additionally, in order to show how our estimation fits the observations between the time period 2002-2013, we plot actual and fitted values for both models as shown in the graphs below. With regard to RMSE and MAE values, the model with minimum AIC outperforms the model with minimum BIC. Moreover, both models succeed to capture the behavior of the BIST-100 Price Index movement in terms of turning points and variance.

From the Figure 2 and Figure 3, it can be observed that best models we have obtained estimate the ups and the downs in the stock market correctly for the most of the period. While the models signal the directions in the time period correctly, we observe some

extreme points existed in the years of 2002, 2007 and 2008 which can make the estimation harder. Nevertheless, the best AIC model perfectly estimates the extreme points occurred in the stock market in October and November 2002. In these months, Turkey 2-Year Bond Interest seems to be an effective predictor compared to other regressors in the model since its sequential changes for these months is quite high. What is even important is that this change for the Turkish Bond interest rate is negative for the peak and positive for the trough. Thus, it can be deduced that the substitution effect between Turkish bond and the stock market is in charge for these extreme points. The best BIC model also estimates these extreme points well but not good as the best AIC model does. It is maybe because of that since Turkish economy experienced attractive bond interest rates compared to deposit interest rates in our sample period, significant changes in this interest rate can make investors change their composition of investment and lead them to the stock market more effectively.

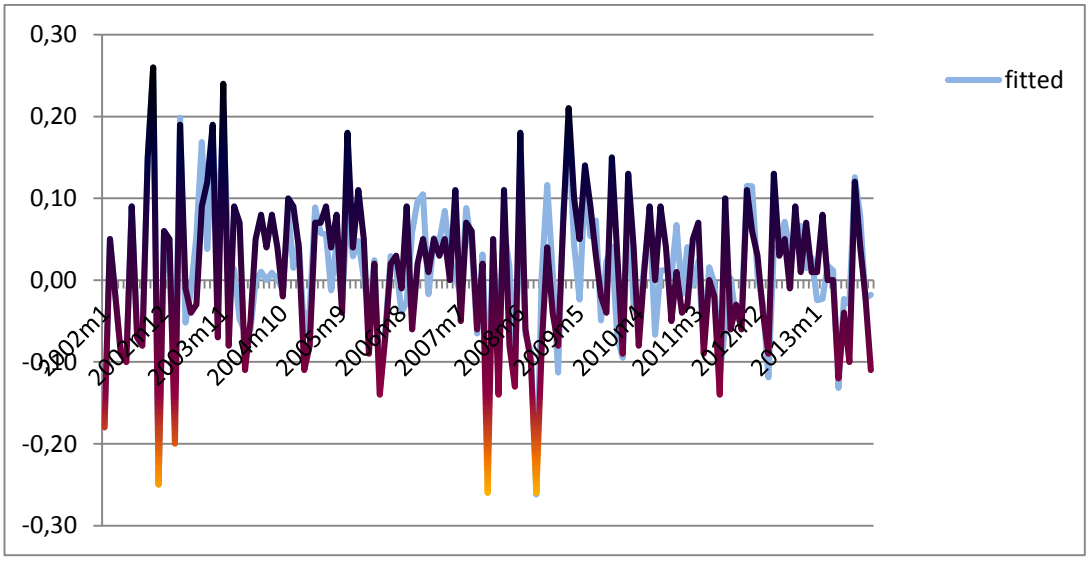

Figure 2 The Best AIC Model, First Difference, Fitted Values

The effect of the global financial crisis on Turkish economy can also be observed by looking at these figures for the extreme points of the stock market occurred in the years 2007 and 2008. Global and domestic weak demand, low confidence to future economic activity and the deterioration of corporates' cash flows can also ruin stock markets' performance as they can expose present economic well-being as well as anticipations

toward future. In a macroeconomic perspective, deterioration of the trade volume between Europe countries and Turkey as a result of the weak demand stemming from the global financial crisis can increase Turkey's current account deficit, thus deteriorate Turkish economy. Given this statement, it seems logical that the best AIC model that includes Dax Price Index outperforms the best BIC model for the estimation of these extreme points since the economic integration between Germany and Turkey exists.

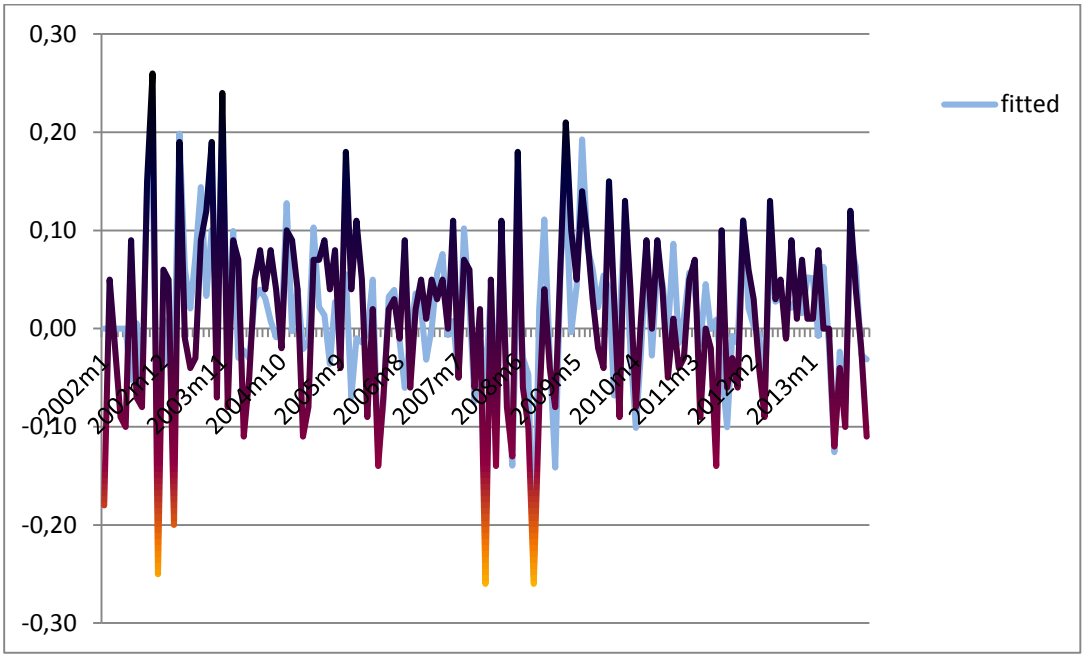

Figure 3 The Best BIC Model, First Difference, Fitted Values

In consideration of reliable estimations for sample period, we do further validation exercises for the time period between 2014 and 2015. Oppositely, the model with minimum BIC yields slightly more reliable forecast than the model with minimum AIC taking into account RMSE and MAE values as shown in the table below. Moreover, when we look at both the Figure 4 and Figure 5 below which show the best AIC and the best BIC models' forecast performances, there exist forecast attempts that predict well the direction of change but not the point. For instance, there is a salient gap between actual and forecast value for November 2014 in the Figure 4. For this date, we observe a significant drop in Bovespa Price Index as other variables in the model remain almost intact compared to this index. As a result of this, our forecast

error can be arised from this fact while the best BIC model which does not include Bovespa Price Index as a variable forecast Turkish stock market movement almost perfectly for this date which is shown in the Figure 5. Furthermore, we also observe a significant gap between actual and forecast value for July 2015 in the Figure 5. The substantial drop in Dow Jones Industrial Price Index and the increase in Turkey 2-Year Bond Interest rate for this date make the gap between actual and forecast value since these variables' coefficient positive and negative, respectively. When we look at the forecast of the best AIC model, which doesn't include Dow Jones Industrial Price Index as a variable, we observe a smaller difference between actual and forecast values in the Figure 4 compared to the other forecast error. As a consequence, these forecast errors imply that although we know the relations from our best models, unpredictable changes in the predictors can increase or decrease the power of the point forecasts for the specific dates even we forecast correctly the direction of changes.

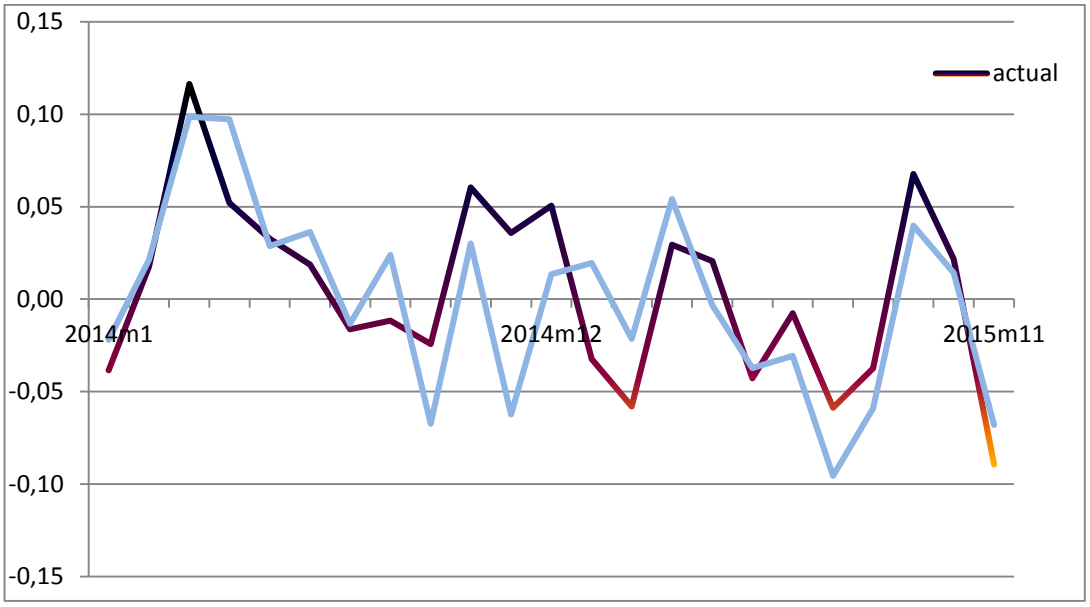

Figure 4 The Best AIC Model Forecast

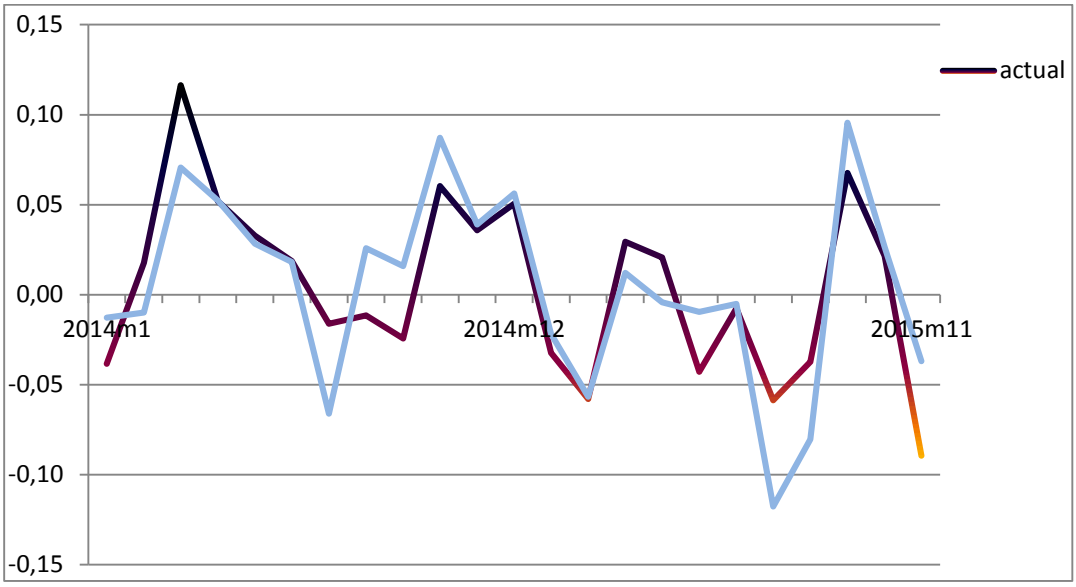

Figure 5 The Best BIC Model Forecast

In sum, both model yield good prediction performance for our forecast period and this can also be observed from the statistics shown in the Table 8.

Table 8. Predicted Values for Selected Models

	Actual Values	The Best AIC Model Forecast	The Best BIC Model Forecast
2014m1	-0.04	-0.02	-0.01
2014m2	0.02	0.02	-0.01
2014m3	0.12	0.10	0.07
2014m4	0.05	0.10	0.05
2014m5	0.03	0.03	0.03
2014m6	0.02	0.04	0.02
2014m7	-0.02	-0.01	-0.07
2014m8	-0.01	0.02	0.03
2014m9	-0.02	-0.07	0.02
2014m10	0.06	0.03	0.09
2014m11	0.04	-0.06	0.04
2014m12	0.05	0.01	0.06
2015m1	-0.03	0.02	-0.02
2015m2	-0.06	-0.02	-0.06
2015m3	0.03	0.05	0.01
2015m4	0.02	0.00	0.00
2015m5	-0.04	-0.04	-0.01
2015m6	-0.01	-0.03	-0.01
2015m7	-0.06	-0.10	-0.12
2015m8	-0.04	-0.06	-0.08
2015m9	0.07	0.04	0.10
2015m10	0.02	0.01	0.03
2015m11	-0.09	-0.07	-0.04
RMSE		**0.034**	**0.03**
MAE		**0.027**	**0.024**

CHAPTER 7

CONCLUSION

In this study, we have adopted exhaustive search algorithm to make the best forecast of the BIST-100 Price Index movement depending on monthly macroeconomic and financial data. All variables are obtained for the period January 2002 to December 2013 and the target variable is estimated for the same period. We also do forecast exercise for the period January 2014 to December 2015. In order to search for stationarity, ADF and Ng and Perron unit root tests are executed on logarithmic transformed data. According to the results of the unit root tests, all variables in logarithmic form are differenced in first order. With the examination of what lag order of our explanatory variables are highly correlated with the target variable setting each independent variable's lag one to twelve, final form of the variables have been obtained to use them in the algorithm.

The best models are determined on the basis of minimizing AIC and BIC through our exhaustive search procedure that calculates optimal AR and MA roots and the most influential explanatory variables at the same time. ARIMAX (12,1,3) and ARIMAX (1,1,0) models have been used as the best models with respect to AIC and BIC, respectively. The Bovespa and Dax Price Indices, and Turkey 2-Year Bond Interest are selected for the best AIC model while Turkey 2-Year Bond Interest, deposit interests and Dow Jones Industrial Price Index are selected in the case of the best BIC model.

With regard to estimation and validation exercises, RMSE and MAE values are respected as a measure of how explanatory variables replicate the behavior of the target variable in predetermined time periods. The both models we have constructed are outstanding considering the fact that these two measures are pretty close to zero. The best AIC model have slightly lower RMSE and MAE values for the estimation period

which make this model better. For validation purposes, this time the best BIC model seems to make better forecast when compared to the best AIC model having lightly lower RMSE and MAE values. In addition, the both models are successful in capturing turning points.

In conclusion, observing the results, we can infer that Turkish stock market does not seem to move along with the real economic variables. Instead, our study shows that the country's stock market is sensitive against the changes in the foreign stock markets and alternative investment tools which are found to be significant in both statistical and economic sense.

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APPENDICES

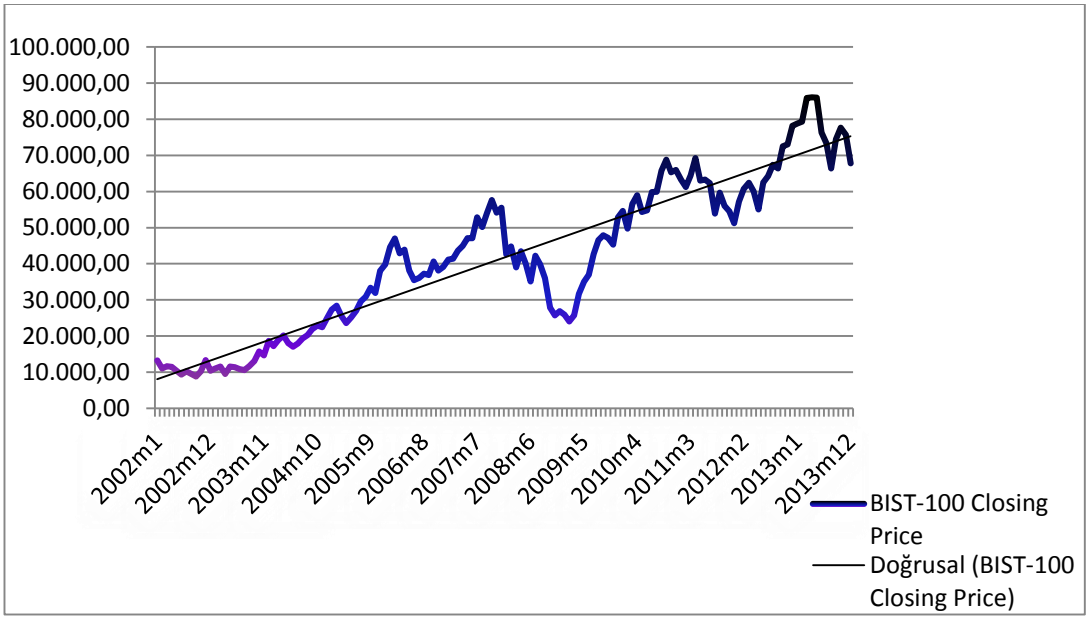
Appendix A. Turkish Summary/Türkçe Özet

Hisse senedi piyaslarına bakıldığında, bu piyasaların sermaye dağılımı ve firmalara likidite sağlama gibi ana fonksiyonları aracılığıyla ekonomik kalkınmaya katkı sağlayabileceği ihtimal dahilindedir. Hisse senedi piyasasına kote olan firmalar, bu piyasa aracılığı ile yatırımlarına fon sağlayıp uzun dönemli yatırımlarını gerçekleştirebilirken piyasa oyuncuları borsaya kote olan firma kağıtlarının alım satımını yaparak volatilite ortamında yüksek karlar elde edebilmektedirler. Diğer yanda, bu çalışmanın kapsamı Türkiye'de borsanın takibi için kullanılan en yaygın fiyat endeksi olan BIST-100 endeksini makroekonomik ve finansal değişkenler ile belirlenen zaman içerisinde analiz etmek ve tahminlemektir. Literatüre bakıldığında, bu amaç için kullanılan en yaygın değişkenlerin sanayi üretim endeksi, döviz kurları, kısa ve uzun vadeli faizler, ticaret dengesi, enflasyon oranı, parsal büyüklükler, petrol fiyatları ve diğer hisse senedi piyasası endeksleri olduğu görülmektedir.

Çalışmamızın kapsamında yer alan Ocak 2002-Aralık2013 zaman aralığı boyunca, BIST-100 fiyat endeksinin ekonomik döngüler ve ekonomide şok etkisi yaratan çeşitli gelişmeler ile beraber hareket ettiğini ve yükselen bir trend etrafında şekillendiğini gözlemliyoruz. İlgili fiyat endeksinin, hem yurtiçi hem de global faktörler neticesinde etkilenebileceği gözardı edilmemelidir.

2002-2013 yılları arasında gerçekleşen BIST-100 fiyat endeksi hareketleri dikkate alındığında ilgili zaman serisinin 2002-2006 yılları arasında yükselen bir trende sahip olduğu ve söz konusu zaman aralığının son döneminde aynı yıl içerisinde zirve yaptıktan sonar düşüşe geçtiği gözlemlenmektedir. Bahse konu yükselen trendin, 2001 krizi sonrasında uygulanmaya başlayan makroekonomik politikalar ile ilişkisi olduğu

ihtimal dahilindedir. Türkiye'de yaşanan 2001 krizi sonrası IMF birlikteliğinde uygulanmaya başlanan 18. Stand-By anlaşmasının içeriği ile beraber sürdürülebilir ekonomik büyüme hedeflenmiştir. Bu amacın yanı sıra, söz konusu büyümenin enflasyon baskısı olmaksızın gerçekleşmesi, yapısal reformalar ve idare edilebilir borç stoku unsurları önem arz etmektedir. Ayrıca 2002'de Türkiye Cumhuriyet Merkez Bankası tarafından uygulanmaya başlanan parasal hedefleme programının ve 18. Stand-By anlaşması neticesinde sağlanan fonların ekonomiye, dolayısıyla Türkiye borsasına ivme kazandırabileceği gerçeğiyle söz konusu yıllardaki yükselen borsa trendi, bahsi geçen ekonomik gelişmeler ile bağdaştırlabilir.



Grafik EK. A. 1 BIST-100 Fiyat Endeksi, Hamveri

Kaynak: Borsa Istanbul

2006 yılından itibaren, Türkiye Cumhuriyet Merkez Bankası para politikasının parasal hedeflemeden enflasyon hedeflmesine geçmesi, geleceğe ilişkin enflasyon beklentilerinde olumlu bir değişikliğie sebebiyet verebilecek olması göz önünde bulundurulduğunda, bu gelişme Türk borsası için anlam ifade etmektedir. 2006 yılı Şubat ayı itibarıyla gerçekleşen söz konusu endeksin sıçrayışında, bahsi geçen para politikasının ekonomideki bekleyişler nezdinde etkili olabileceği değerlendirilebilirken yine aynı yılın ikinci yarısına girilirken borsada yaşanan aşağı

yönlü hareket, faiz artışlarının devamı olacağı yönündeki gelişmeler neticesinde meydana gelen küresel likidite azlığı ile bağdaştıralabilir. Özellikle Türk ekonomisi gibi gelişmekte olan ülke borsalarının, yabancı sermaye giriş çıkışlarının yaratacağı volatilite ortamında ani hareketler gerçekleştirebileceği gözardı edilmemelidir.

Yine yukarıdaki grafik incelendiğinde, 2007 yılında Amerika Birleşik Devletleri kaynaklı yaşanan derin finansal krizin, Türk borsası üzerindeki etkisi söz konusu senede BIST-100 endeksinde yaşanan aşağı yönlü trend değişikliği ile gözlenlenebilmektedir. Yaşanan derin finansal krizin küresel talebi baskılaması neticesinde uluslararası ticaret hacminin düşmesi, yaşanan ekonomik güvensizlik ortamında tüketim harcamalarının azalması sonucu ekonomik aktivitenin düşmesi söz konusu olmaktadır. Amerika Birleşik Devletleri kaynaklı yaşanan bu kriz neticesinde, toplam talebin tekrar canlandırılması ve ekonomik aktivitenin hızlandırılması amacıyla başta yine söz konusu ülkenin merkez bankası ve diğer gelişmiş ülke merkez bankaları geleneksel olmayan genişletici para politikaları uygulamışlardır. Bu politikalar neticesinde küresel likidite bolluğu ortaya çıkmış olup, uluslarası sermaye hareketlerinin Türkiye gibi gelişmekte olan ülkelere doğru gerçekleşmesi ilgili ülkelerin borsalarını etkileyebilmektedir. 2009 yılı Ocak ayı itibarıyla Türk borsasında yaşanan yukarı yönlü trend değişikliğinin kalıcı olmasında, küresel likidite bolluğunun söz sahibi olabileceği ifade edilebilir.

Ekonomik gelişmelerin yanı sıra, ulusal ve uluslararası yaşanan siyasi ve toplumsal olayların borsayı etkileyebileceği günümüz küresel dünyasında söz konusudur. Türk borsası için, 2013 yılında yaşanan yolsuzluk skandalı ve yine aynı yıl uluslararası derecelendirme kuruluşu olan Moody's not artırımının sırasıyla 2013 yılı Aralık ve Mayıs aylarında yaşanan iniş ve çıkışlarda etkili olabileceği ihtimal dahilindedir.

Çalışmamızın kapsamını oluşturan borsa hareketlerinin makroekonomik ve finansal değişkenler ile öngörülmesi hususunun, ilgili literatürde pek çok yazar tarafından araştırmaya konu olduğu gözlemlenirken, bu çalışmalara konu olup dışsal kabul edilen değişkenlerin aynı yön ve istatistiksel anlamlılıkla hareketi araştırılan borsa endekslerini etkilemediği yapılan literatür taraması sonucunda anlaşılmıştır. Bu

bağlamda, söz konusu makroekonomik ve finansal değişkenlerin her ülke için aynı etkiye sahip olmayabileceği gerçeği altında, ülke ekonomisinin hangi aşamada olduğu, kronik ekonomik sorunlarının varlığı, para politikası çeşitliliği gibi ekonomi için hayati unsurların ekonomiler arasındaki farklı oluşu, bu çalışmalar kapsamında örtüşmeyen sonuçların alınmasına sebebiyet verebilir.

İlgili literatürün önde gelen çalışmalarına bakıldığında, Fama (1981) enflasyon ile borsa hareketinin negatif yönlü ilişkisini incelemiş olup, bu ilişkinin aslında para talebi ve gelecekte öngörülen ekonomik aktivitenin doğrusal ilişkisi sayesinde oluştuğunu göstermeye çalışmıştır. Chen ve diğerleri (1986) tek bir değişkenden çok, ekonomi genelinde birden çok değişken kullanarak bu değişkenlerin ekonomi genelinde teşkil ettiği risklerin borsaya yansıması hususunu araştırmıştır. Çalışmanın bulgularında sanayi üretim endeksi, risk primindeki değişiklikler, verim eğrisindeki hareketlilik istatistiksel olarak anlamlı bulunurken, beklenen enflasyondaki değişiklikler söz konusu değişkenler kadar etkili olamamıştır. Yine öncü çalışmalardan sayılabilecek bir çalışmanın yazarları olan Pearce and Roley (1984), etkin piysalar hipotezini makroekonomik değişkenler nezdinde test etmiştir. Bu çalışmada elde ediken bulgularda, iktisadi bireylerin geleceğe yönelik beklentileri ve para politikasında sürpriz değişiklikler anlamlı şekilde borsayı etkilerken, enflasyonda ve ekonomik aktivitede yaşanan değişiklikler anlamlı şekilde borsayı etkilememektedir. Bu çalışmaların yanı sıra, gelişmekte olan ekonomileri konu alan çalışmalar da literatürde mevcut olup, Gunasekarag ve diğerleri (2004) ve Patel (2012) gelişen ekonomi borsalarının söz konusu değişkenler ile olan hareketine çalışmalarında yer vermişlerdir. Bu çalışmada elde edilen ortak bulgulara bakıldığında, enflasyon ve para arzı değişkeni söz konusu çalışmalara konu olan borsaları etkilememektedir. Dahası da, söz konusu bulgular gelişmiş ekonomiler nezdinde varılan sonuçlarla ortak özelliklere sahip olup, bu durum gelişmiş ve gelişmekte olan ekonomi borsalarının makroekonomik ve finansal boyutta yaşanan değişikliklere verdiği tepkilerin aynı olabileceğini açığa çıkarmaktadır.

Bu konuda Türkiye adına yapılan çalışmalara bakıldığında, özellikle döviz kuru ve faiz oranlarının borsayı etkilediğine yönelik ampirik bulgular mevcuttur. Erdogan ve

Ozlale (2005) ve Muradoglu ve diğerleri (1999), söz konusu değişkenlerin Türkiye'de yaşanan borsa hareketliliğinin analizinde anlamlı olarak endeksin yönünü etkilediği bulgusunun içerildiği çalışmalardır. Diğer yandan, Muradoglu ve Metin (1996), faiz, parasal büyüme ve döviz kuru gibi kamuya açık değişkenlerin borsayı etkilediği sonucunu elde ederek Türk borsasının etkin çalışmadığı sonucunu elde etmiştir.

İlgili literatür kapsamında kullanılan ekonometrik ve matematiksel tekniklere bakıldığında farklı yöntemler karşımıza çıkmaktadır. Vektör hata düzeltme modeli, vektör otoregresif model gibi sık kullanılann ekonometrik yöntemler dışında ileri matematiksel ve istatistiki yöntemlerin çeşitli ülkelerin borsalarının tahmininde kullanıldığını görmekteyiz. Örneğin Chen (2003) ve Enke ve Thawornwong (2005), çalışmalarının kapsamında, hisse senedi piyasalarında alım satım stratejilerinin geliştirilmesi amacıyla olasılıksal yapay sinir ağları modeli ve bilgi kazanma tekniği gibi ileri istatistiksel yöntemler uygulamışlardır. Bunun yanı sıra, Wei Huang (2005), geleneksel makroekonomik değişkenleri girdi değişken olarak kullanıp, destekçi vektör makinesi tekniği ile hisse senedi piyasasının tahminine çalışmasında yer vermiştir. Chen (2008), markov rejim değişikliği tekniğini bir çok makroekonomik değişken ile birlikte kullanarak borsada yaşanan resesyonların tahminini gerçekleştirmiştir. Bu çalışma sonucunda getiri eğrisi ve enflasyon oranı ilgili borsanın tahmininde en önemli değişkenler olarak tespit edilmiştir. Ayrıca hisse senedi piyasalarında yaşanan volatilitenin modellenmesi adına kullanılan ARCH, GARCH, E-GARCH gibi yöntemler literatürde yerini almaktadır. Örneğin, David Morelli (2002) çalışmasında ARCH sürecini konu ederek makroeonomik değişkenlerin borsada yaşanan volatiliteyi açıklamadığı sonucunu elde etmiştir. Söz konusu bulguya karşıt ampirik sonuçlar elde eden Zivanemoyo Chinzara (2011) ise makroekonomik risklerin borsada yaşanan volatilite ile ilişkisinin olduğunu, bono faizi, döviz kuru ve altın fiyatı değişkenlerinin bu ilişkide rol oynadığını GARCH sürecini kullanarak tespit etmiştir. Attari (2013), çalışmasında E-GARCH modelini kullanarak enflasyon ve gayri safi yurtiçi hasıla verilerinin önemli derecede hisse senedi piyasası oynaklığını açıklamakta yeterli olduğunu göstermiştir.

Literatür taraması neticesinde ilgili çalışmalarda sık kullanılan verilerin derlenerek, aşağıdaki tabloda görülen değişkenlerin kullandığımız algoritmaya girdi olarak servis edilmesi söz konusudur.

Tablo EK. A. 1. Açıklayıcı Değişkenlerin Kategorileri

Kategori	**Bağımsız Değişkenler**
Makroekonomik İndikatörler	Tüketici Fiyat Endeksi Sanayi Üretim Endeksi (mevsimsellik düzeltildi) USD/TRY Döviz Kuru M1 Para Arzı M2 Para Arzı Ticaret Dengesi
Finansal İndikatörler	Mevduat Faiz Oranı US 1 Yıl Vadeli Tahvil Faizi US 10 Yıl Vadeli Tahvil Faizi Dow Jones Sanayi Fiyat Endeksi Bovespa Fiyat Endeksi Dax Fiyat Endeksi Brent Petrol Fiyatı Ons Altın Fiyatı Turkey 2 Yıl Vadeli Gösterge Tahvil Faizi

Bu çalışmada kullanılan değişkenlere ilişkin veriler bir kaç kuruluştan temin edilmiştir. Makrokonomik değişkenlerin verileri, TÜİK'den elde edilen ticaret dengesi verileri hariç, IMF'in internet sitesinden temin edilirken Dow Jones, Bovespa, ve Dax borsaları endekslerinin yanı sıra Brent petrol ve Ons altın fiyatı da Thomson Reuters aracılığı ile sağlanmıştır. Son olarak Amerika Birleşik Devleti kısa ve uzun vadeli faiz oranları Federal Rezerv resmi internet sitesinden temin edilmiştir.

Bu çalışmanın amacı BIST-100 Fiyat Endeksinin makroekonomik ve finansal veriler ile tahmin edilmesi ve başarılı bir şekilde gerçekleştirilecek olan tahmin süreci sonrasında örneklem dışı öngörüde bulunmaktadır. Bu amaç nezdinde doğrusal ARIMAX modelinin baz alındığı bir algoritma geliştirilmiş olup, uygulanan algoritma neticesinde elde edilen çok sayıda model arasında en uygunu seçilerek tahmin ve öngörüde bulunulmuştur. Bu çalışmanın temel katkılarının, kullanılan geniş kapsamlı arama algoritması sonucunda uygun modellerin elde edilmesi ve Türk Borsası

özelinde yapılacak ileri tahmin çalışmalarına modelleme hususunda katkı sağlayabileceği olduğu söylenebilir.

Kullanılan yöntem gözetildiğinde, çalışmamızda ARIMAX modelinin kullanılması ile beraber bu modelin baz alındığı bir algoritma geliştirilmiştir. Tahmin ve öngörü amaçları dikkate alındığında optimal denklemin elde edilmesi, bu çalışma için hayati önem taşımaktadır. Geliştirilen algoritmanın çalışma prensibi, modele girdi olarak sağlanan her bir makroekonomik ve finansal değişkenlerin tüm olası kombinasyonları ile beraber geliştirilecek olan modeler üretmesidir. Bağımsız değişkenlerin tüm olası ikili, üçlü vb. kombinasyonları farklı modellerde yer alırken, söz konusu modeller için aynı zamanda optimal AR ve MA kökleri belirlenmektedir. Eş zamanlı olarak gerçekleştirilen bu iki amaç neticesinde elde edilen modeller arasından en küçük AIC ve BIC değerli modeller en iyi modeller olarak seçilmiştir. Diğer yandan, algoritma, optimal AR ve MA değerleri için ARIMAX (0,d,0), ARIMAX (1,d,0), ARIMAX (0,d,1) ve ARIMAX (2,d,2) modelleri arasından minimum AIC/BIC değerine sahip moedli baz almakta ve AR ve MA değerlerini +-1 olarak değiştirip yeni modellere AIC/BIC değerine sahip modeli baz model olarak seçmekte ve süreç düşük değere sahip model kalmayıncaya kadar devam etmektedir.

Tablo EK. A. 2. En İyi Model Sonuçlar

Variables	The Best AIC Model	The Best BIC Model
Bovespa Price Index(0)	0.14 [0.08]***	-
Dax Price Index(0)	0.85 [0.00]*	-
Turkey 2-Year Bond Interest(0)	(-) 0.33 [0.00]*	(-)0.45 [0.00]*
Deposit Interest Rate(-5)	-	(-)0.33 [0.00]*
Dow Jones Industirial	-	0.95 [0.00]*
AR(1)	0.46 [0.00]*	(-)0.41 [0.00]*
AR(2)	(-)0.09 [0.6]	-
AR(3)	(-)0.28 [0.03]**	-
AR(4)	(-)0.29 [0.00]*	-
AR(5)	0.03 [0.71]	-
AR(6)	(-)0.16 [0.049]**	-
AR(7)	(-)0.03 [0.71]	-
AR(8)	(-)0.18 [0.03]**	-
AR(9)	(-)0.04 [0.66]	-
AR(10)	(-)0.03 [0.71]	-
AR(11)	(-)0.1 [0.21]	-
AR(12)	(-)0.15 [0.03]**	-
MA(1)	(-)0.86 [0.00]*	-
MA(2)	0.15 [0.52]	-
MA(3)	0.4 [0.03]**	-

Not: p değerleri köşeli parantez içerisinde yer almaktadır: * % 1'de, ** % 5'te ve *** % 10'da anlamlı.

Yöntemsel olarak tartışılan söz konusu çalışmamız algoritmasının çıktısı olan en iyi iki model sonuçlarına yukarıda yer verilmiştir. Elde edilen en iyi AIC modeli nezdinde ulaşılan sonuçlara bakıldığında hedef değişkenimiz olan BIST-100 Fiyat Endeksi hareketlerini en iyi açıklayan değişkenlerin, 2 yıl vadeli gösterge tahvil faizi ve Bovespa ve Dax Fiyat Endeksleri olduğu bulunmuştur. Değişkenler özelinde elde edilen katsayıların yönüne bakıldığında söz konusu yabancı borsa endekslerinin Türk borsası ile aynı yönde değiştiği, 2 yıl vadeli gösterge tahvil faizinin ise olası ikame etkisi dikkate alınarak negatif yönde ilişkide olduğu gözlenmiştir.

En iyi BIC modeli dikkate alındığında elde edilen en iyi AIC modelinde kullanılan değişkenlerden sadece 2 yıl vadeli gösterge tahvil faizinin içerdiği görülmektedir. En iyi AIC modelinde farklı olarak, Türkiye'deki kullanılan mevduat faiz oranının ve Dow Jones Sanayi Fiyat Endeksinin Türk borsasını en iyi açıklayan değişkenler olarak görmekteyiz. Yine ilgili değişkenlerin işaretlerine bakıldığında mevduat faizi ve borsa arasında tespit edilen negatif ilişki neticesinde olası ikame etkisinden söz edilebilirken, Dow Jones Sanayi Fiyat Endeksi ile BIST-100 fiyat endeksi hareketlerinin aynı yönlü olması, dünyanın en büyük ekonomisine sahip borsanın diğer borsalara da yön verebileceği durumunu açığa çıkarmaktadır.

Gerek iktisadi, gerekse istatistiksel açıdan anlamlı bulunan değişkenlerin öngörü gücünü ortaya koymak ve çalışmanın amacını gerçekleştirmek adına örneklem dışı validasyon çalışması yapılmıştır. 2014-2015 yılları için yapılan örneklem dışı validasyon çalışmasının sonuçları aşağıdaki tablodan görülebilirken düşük RMSE ve MAE değerleri elde edilen modellerin gücünü doğrular niteliktedir.

Tablo EK. A. 3. Seçilen Modellerin Öngörüleri

	Actual Values	The Best AIC Model Forecast	The Best BIC Model Forecast
2014m1	-0.04	-0.02	-0.01
2014m2	0.02	0.02	-0.01
2014m3	0.12	0.10	0.07
2014m4	0.05	0.10	0.05
2014m5	0.03	0.03	0.03
2014m6	0.02	0.04	0.02
2014m7	-0.02	-0.01	-0.07
2014m8	-0.01	0.02	0.03
2014m9	-0.02	-0.07	0.02
2014m10	0.06	0.03	0.09
2014m11	0.04	-0.06	0.04
2014m12	0.05	0.01	0.06
2015m1	-0.03	0.02	-0.02
2015m2	-0.06	-0.02	-0.06
2015m3	0.03	0.05	0.01
2015m4	0.02	0.00	0.00
2015m5	-0.04	-0.04	-0.01
2015m6	-0.01	-0.03	-0.01
2015m7	-0.06	-0.10	-0.12
2015m8	-0.04	-0.06	-0.08
2015m9	0.07	0.04	0.10
2015m10	0.02	0.01	0.03
2015m11	-0.09	-0.07	-0.04
RMSE		**0.034**	**0.03**
MAE		**0.027**	**0.024**

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☐

Uygulamalı Matematik Enstitüsü ☐

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YAZARIN

Soyadı :
Adı :
Bölümü :

TEZİN ADI (İngilizce) :

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1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. [X]
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